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Towards sustainability through housing functions: a systems perspective for the study of Swiss tenants' residential mobility

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E quando miro in cielo arder le stelle;
Dico fra me pensando:
A che tante facelle?
Che fa l'aria infinita, e quel profondo
Infinito seren? che vuol dir questa
Solitudine immensa? ed io che sono?
Così meco ragiono: e della stanza
Smisurata e superba,
E dell'innumerabile famiglia;
Poi di tanto adoprar, di tanti moti
D'ogni celeste, ogni terrena cosa,
Girando senza posa,
Per tornar sempre là donde son mosse;
Uso alcuno, alcun frutto
Indovinar non so. [...]

Canto notturno di un pastore errante dell'Asia
Giacomo Leopardi
Recanati, 1829-1830

Acknowledgements

I invite the reader to look at this thesis as a system, rather than as a collection of printed characters on a white sheet. This manuscript is the result of interrelations between people, ideas and events at different temporal and spatial scales, channelled in such a way as to formulate incomplete answers or new questions.

There is something fascinating about revealing the underlying structure of a system; in a sense, striving to achieve a greater understanding of its behaviour has much to do with the quest for meaning addressed by Leopardi. My doctoral research has in fact been a quest for meaning; it started from the need to disentangle the complexity of the system under study, and ends today with a meta-analysis of the elements—or subsystems—of 'my' system, which have shaped and reshaped the content of this thesis as millions of hands work matter.

HERUS Lab, the system in which my research was embedded. I thank my supervisor, Professor Claudia R. Binder, for the energy she put into keeping the lab together, despite the challenges related to the disciplinary but also physical distance to which the pandemic exposed us. Thank you for opening me the door to the research world, for teaching me what you know, for supporting my ideas until the very end, and for giving me confidence and independence.

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As it emerges, during these four years of research I have had the invaluable opportunity to contribute to shaping systems that interconnect incredible minds and souls, but also to join existing ones. Many thanks to the communities of open-minded individuals and researchers I have encountered at conferences such as ICEP, SSC, or SBE. Exploring affinities with other disciplines gave me the opportunity to reflect on the hybrid nature of this research and of the researcher herself.

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Coming now to the *supersystem* structures, I acknowledge the privilege of having studied at EPFL, a place that offered an endless source of stimuli and a top-level infrastructure, including access to an incredible collection of books, courses, seminars, and several other resources. Many

thanks to all the people who make this enormous system work on a daily basis and who have always been there for me; Caroline Bühler, Sandra Bottà, Sandrine Perroud, Esther Van Der Velde, Pierre Amey, and Monica Rodrigues. In this context, special recognition goes to the *Réseau romand de mentoring pour femmes*, whose workshops have taught me and will continue to teach me how to navigate and reshape the patriarchal system that persists in academic institutions. During my PhD, I have witnessed changes in the structure of EPFL in response to a growing movement of people questioning the status quo, bringing to light interconnected issues of gender and racial discrimination, and calling to action. These are the first steps toward a just transition that leaves none of us behind.

Leave no one behind – this is the conviction that supported me through the difficult years of COVID-19. And I have been tremendously lucky to never be left behind. For this, I would like to say *thank you*, to Laura, Elena P., Massimo, and Pekka, for making the most difficult moments small dark spots in a bright day; *thank you*, to Elena V., Irene, Martin, Selma, Sara, Angie, and Fra, for recreating an Italian family in Switzerland; *thank you*, to my long-time friends Edoardo, Valentina, Paul, Davide, Chiara, Filip, Katia, and Jessica, for whom distance never mattered, and never will; *thank you* to my Shanghai friends, Beatrice, Eleonora, Antonino, Andrea, Nunzia, and Maurizio, who encouraged me to become the person that I am today; *thank you*, to my teachers and professors, and in particular to Mr. Burgat, for our magical conversations in beautiful Revigliasco; *thank you*, to my family, for gifting me with endless curiosity and love for life—you live and will live forever in me.

Thank you, to Bastian Valentin Wilding, with whom no mountain is too high to climb.

Lausanne, December 2021

Preface

In 1972, the Club of Rome sent a powerful message to humanity: there are limits to our growth. Nearly fifty years later, the results of the Working Group 1 published in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) are undeniable. We don't have much time left to act. People's voices are rising in the weeks preceding the UN Climate Change Conference COP26, asking all of us, in different ways, to contribute to sustaining our shared life on this planet.

Our responsibilities have so far been bounded to our professions, which delineated our competences and roles in society. However, the climate crisis and the complex societal challenges that humanity is facing and will increasingly face require thinking beyond and across the boundaries of our academic and professional fields.

During my architectural studies at the Polytechnic University of Torino, I often challenged the role of the architect in the paradoxically increasingly fragmented landscape of disciplines shaping the highly interconnected built environment. At the end of my Bachelor in 2013, I advocated for the need for a professional able to orchestrate, supervise and bind the knowledges of different stakeholders while carefully considering the social, environmental, cultural and political impact of the final artefact. I completed my Master in 'Architecture Construction City' in 2015 with the renewed conviction that architects' responsibility goes far beyond the provision of walls and roofs; that buildings are instruments of communication and education; that their material form is the expression of power conflicts (e.g. between a nation, the architects who reshape it, and its citizens) and has the power to influence behaviours (e.g. the use of space, energy consumption); and therefore, that our designs carry with them a traded-off vision of what the world ought to be—which will endure, impose itself, but be appropriated and reshaped by people.

The dynamic interrelations between society, environment, humans and the material form determine what is considered heritage, sustainable, healthy, quality architecture and for whom. Looking today at the interests of the architect I was starting to be, I realise that my fascination for the discipline was and is rooted in the possibility to *navigate* and *design* these interrelations. In other words, it appears that I have unconsciously first and willingly then decided that my contribution to society and the planet would have consisted in reconciling humans and the built environment.

What field could be more pertinent than housing to investigate the interactions, synergies and conflicts between inhabitants, buildings and the broader environmental and societal contexts. Housing is first and foremost a basic need; it is a shelter, a haven, a place where to feel rooted; it can be a symbol of status, of the self, or an investment. Housing affordability, availability, adequacy are indicators of the quality of life in a city, of the economy of a country and of its political agenda. Housing supply can (dis)empower residents by limiting or enabling their agency to choose, maintain, and/or adapt space for their well-being. Dreams of the ideal home can express themselves via dwelling forms that have a considerable impact on the planet. While my Master thesis triggered my desire to dig deeper into these dynamics, it also confronted me with a complexity that I had no tools to govern.

It therefore comes as no surprise that the laboratory where I chose to conduct the research presented in this doctoral thesis is called 'Human-Environment Relations in Urban Systems' (HERUS). Studying human-environment relations requires a plethora of competences which profoundly differ from what I had acquired before joining HERUS. Although I had gained experience in collaborating with engineers and designers during my double-master degree at Alta Scuola Politecnica[1], the notions of inter- and transdisciplinarity were new to me, and so were qualitative methods (i.e. how to conduct qualitative research and perform data analyses), quantitative methods (statistics are not taught in architectural programs), agent-based modelling (I had no experience with Python nor modelling) or theories of knowledge (i.e. what epistemology do architects adopt?). However, my curiosity was much more powerful than methodological obstacles. I was thrilled by the idea of acquiring skills that, blended with my understanding of space, could enable me to uncover the leaks that make the provision of sustainable dwellings—understood in their human and environment dimensions—a 'wicked problem'.

The course *Sustainability Assessment of Urban Systems*, where I worked as teaching assistant over the four years of PhD, contributed to this quest by providing me with tools to acknowledge, explore, and make explicit the complexity of the notion of sustainability. The challenges faced when teaching environmental engineering students that sustainability is *normative* revealed the mindset barriers that must be broken before entering the practitioners' realm. These barriers stem from the lack of a systems perspective. The problem-solving paradigm taught in Polytechnic Universities is increasingly being questioned, but alternatives are still not made available to students. The most important lenses acquired during this doctoral research were therefore the ones of systems science.

The encounter with Donella Meadow's book '*Thinking in Systems: A Primer*' (2008) had the strongest influence on this dissertation. Systems science and its universal language made it possible to reorganise existing disciplinary knowledge and, accordingly, provide new tools for practitioners to be aware of and account for the otherwise difficult-to-reconcile environmental and sociocultural dimensions of housing sustainability. Digging into the complexity of the housing system, however, required a high dose of motivation; it implied acknowledging the several multi-scale and multi-actor obstacles to sustainability measures while being aware of the urgent need to implement them. This feeling of urgency was strengthened by the COVID-19 pandemic, during which people found themselves spending most of their time in residential environments that, as shown by our work, are not but must be ready to accommodate the sociocultural needs so far offered by our urban systems. Notwithstanding these challenges, I firmly believe that the results of this passionate enquiry have the potential to empower researchers, practitioners and students to embrace systems complexity rather than urge for its simplification, and thereby to find new pathways to manage the inertia and long-term impact of the built environment.

In summary, this preface had the scope to make my 'bias' explicit to the reader. As introduced, and as s/he will soon notice, this is not an architectural dissertation, but reflects the need to use all types of knowledge available to respond to challenges that need fast but informed responses. As my quest for tools to reconcile humans and their built environment found support in systems science, I am committed to keep investigating the potential of its applications, hopefully providing the current as well as future practitioners with tools to handle complexity—driven by the desire to change the system towards sustainability.

Lausanne, October 2021

[1] On transversal topics, such as climate change. The program of ASP Alta Scuola Politecnica can be found at this link: https://www.asp-poli.it/. Accessed 16.10.2021

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Abstract

Problem. Housing is a major contributor to Switzerland's carbon footprint and energy consumption, but it is also a basic need. Research on climate change mitigation strategies has so far paid insufficient attention to households' preferences and their contribution to housing sustainability. Depicting residential preferences requires an understanding of the multilevel, context-specific, and interrelated determinants of the match between households and dwellings, which are made explicit in the residential mobility process.

Goal. The goal of this thesis is to clarify the determinants of residential mobility and their interrelations to illuminate the effects of measures aimed at reducing housing's environmental footprint while meeting the needs of its households.

Methods. This research employs a systems and transdisciplinary approach to explore, dig into and disentangle the complex relations governing the residential mobility process. It starts by conceptualising residential preferences and dwelling forms as the manifestations of the housing human and material subsystems, which are determined by the system's *function*. The applicability of this framework to residential mobility is explored by sequentially gathering and integrating qualitative and quantitative data on the tenants of three Swiss multifamily housing owners. This empirical basis is used to develop an agent-based model (ABM) of households' residential dynamics for the exploration of the emergent effects of housing sustainability measures.

Results. *Firstly*, the present work shows that several functions coexist in the housing realm, each of which determines, for given elements of the societal and environmental supersystems (e.g. culture, location), different residential preferences and dwelling forms. *Secondly*, empirical investigations demonstrate that the notion of function offers analytical support to the study of Swiss tenants' residential mobility, as it permits the identification of linkages between the qualities of residential environments and residents' characteristics, their residential satisfaction, and triggers to move. In particular, functions help explain the observed preference for larger dwellings and the low propensity of shrinking households to relocate. Furthermore, this notion enables the observation of the effects of the exceptional circumstances posed by the COVID-19 on residential preferences, and the increased desire for a place for 'self-representation'. *Lastly*, using this empirical and context-specific knowledge, the thesis introduces the agent-based model ReMoTe-S. Simulation experiments show that measures to reduce space consumption are insufficient if not accompanied by an offer of dwellings that simultaneously meet and reshape households' preferences. They also reveal that these preferences cannot be fulfilled via the direct correspondence between desired and current housing characteristics, as housing functions result from several compromises between them. These results invite practitioners and citizens to collectively reimagine the way housing functions express themselves in dwelling forms with a lower environmental footprint.

Conclusions. This thesis offers a platform for systemic co-inquiry that enables researchers and practitioners to navigate the complex interactions at play for the provision of sustainable housing. To limit human-induced global warming, the approaches and tools used must rapidly permeate practice and teaching in architecture.

Keywords: Housing system, residential mobility, residential preferences, housing functions, systems science, systems approach, rental housing, sustainability, Switzerland

Résumé

Problématique. Le logement est l'un des principaux responsables de l'empreinte carbone et de la consommation d'énergie en Suisse, mais il constitue également un besoin fondamental. La recherche sur les stratégies d'atténuation du changement climatique n'a, jusqu'à présent, pas accordé suffisamment d'attention aux préférences des ménages et à leur contribution à la durabilité du logement. L'étude des préférences résidentielles nécessite une compréhension des facteurs multi-niveaux, spécifiques au contexte et interconnectés, lesquels déterminent la correspondance entre les ménages et le logement, et sont rendus explicites dans le processus de mobilité résidentielle.

Objectif. L'objectif de cette thèse est de clarifier les facteurs qui déterminent la mobilité résidentielle et leurs interrelations, afin d'éclairer les effets des mesures visant à réduire l'empreinte environnementale du logement tout en répondant aux besoins de ses habitants.

Méthodes. Cette recherche utilise une approche systémique et transdisciplinaire pour explorer, approfondir et démêler les relations complexes qui régissent le processus de mobilité résidentielle. Elle commence par conceptualiser les préférences résidentielles et les formes d'habitation comme étant les manifestations des sous-systèmes humains et matériels du logement, déterminés par la *fonction* du système. L'applicabilité de ce cadre conceptuel à la mobilité résidentielle est ensuite explorée en recueillant et en intégrant séquentiellement des données qualitatives et quantitatives sur les locataires de trois grands propriétaires de logements multifamiliaux en Suisse. Cette base empirique est utilisée pour développer un modèle basé sur les agents, ou *agent-based model* (ABM), simulant les dynamiques résidentielles des ménages dans le but d'explorer les effets émergents des mesures de durabilité.

Résultats. *Premièrement*, ce travail démontre que plusieurs fonctions coexistent dans la sphère du logement. Chacune de ces fonctions détermine différentes préférences résidentielles et formes d'habitation, selon les éléments des supersystèmes sociétaux et environnementaux pris en considération, comme par exemple la culture ou la localisation géographique. *Deuxièmement*, les enquêtes empiriques démontrent que la notion de fonction offre un soutien analytique à l'étude de la mobilité résidentielle des locataires suisses, dans la mesure où elle permet d'identifier les liens entre les qualités de l'environnement résidentiel et les caractéristiques des résidents, leur satisfaction résidentielle et les facteurs déclenchant leur déménagement. En particulier, les fonctions permettent d'expliquer la préférence pour les grands logements et la faible propension des ménages à déménager lorsque leur taille diminue. De plus, cette notion permet d'observer les effets sur les préférences résidentielles des circonstances exceptionnelles liées au COVID-19, et le désir accru d'un lieu d'« autoreprésentation ». *Troisièmement*, à partir de ces connaissances empiriques et contextuelles, la thèse introduit le modèle à base d'agents ReMoTe-S. Les simulations montrent que les mesures visant à réduire la consommation d'espace sont insuffisantes si elles ne sont pas accompagnées d'une offre de logements qui satisfasse et en même temps remodèle les préférences des ménages. Les expériences révèlent également que ces préférences ne peuvent pas être satisfaites via la correspondance directe entre les caractéristiques résidentielles souhaitées et actuelles, étant donné que les fonctions du logement résultent de plusieurs compromis entre celles-ci. Ces résultats invitent les praticiens et les citoyens à réimaginer collectivement la manière dont les fonctions du logement se traduisent dans des formes d'habitation avec une empreinte environnementale réduite.

Conclusions. Cette thèse offre une plateforme de « co-investigation systémique » qui permet aux chercheurs et aux praticiens de naviguer parmi les interactions complexes en jeu dans la provision de logements durables. Dans le but ultime de limiter le réchauffement climatique, les approches et les outils utilisés doivent rapidement être communiqués à la pratique et à l'enseignement de l’architecture.

Mots-clés : Système de logement, mobilité résidentielle, préférences résidentielles, fonctions du logement, science des systèmes, approche systémique, logement locatif, durabilité, Suisse

Kurzfassung

Problemstellung. Das Wohnen trägt wesentlich zum CO2-Fussabdruck und zum Energieverbrauch der Schweiz bei, ist aber auch ein Grundbedürfnis. Die Forschung zu Strategien zur Eindämmung des Klimawandels hat den Präferenzen der Haushalte und ihrem Beitrag zur Nachhaltigkeit des Wohnens bisher zu wenig Beachtung geschenkt. Die Darstellung von Wohnpräferenzen erfordert ein Verständnis der mehrstufigen, kontextspezifischen und miteinander verknüpften Determinanten der Übereinstimmung zwischen Haushalten und Wohnungen, die im Umzugsprozess in den Vordergrund treten.

Ziel. Ziel dieser Dissertation ist es, die Determinanten der Wohnmobilität und ihre Zusammenhänge zu klären, um die Auswirkungen von Massnahmen zu beleuchten, die darauf abzielen, den ökologischen Fussabdruck des Wohnens zu reduzieren und gleichzeitig die Bedürfnisse der Haushalte zu erfüllen.

Methoden. Diese Forschungsarbeit wendet einen systemischen und transdisziplinären Ansatz an, um die komplexen Beziehungen, die den Prozess der Wohnmobilität bestimmen, zu erforschen und zu entwirren. Zunächst werden Wohnpräferenzen und Wohnformen als Erscheinungsformen der menschlichen und materiellen Teilsysteme des Wohnens begriffen, die durch die Funktion des Systems bestimmt werden. Die Anwendbarkeit dieser Modellvorstellung auf die Wohnmobilität wird durch die sequentielle Erhebung und Integration von qualitativen und quantitativen Daten über die Mieter von drei grossen Schweizer Mehrfamilienhausbesitzern untersucht. Auf dieser empirischen Basis wird ein agentenbasiertes Modell (ABM) des Umzugsverhaltens von Haushalten entwickelt, um die Auswirkungen von Nachhaltigkeitsmassnahmen auf das Wohnen zu erforschen.

Ergebnisse. *Erstens* zeigt sich, dass im Bereich des Wohnens mehrere Funktionen koexistieren, die bei gegebenen Elementen der gesellschaftlichen und ökologischen Supersysteme (z.B. Kultur, Standort) unterschiedliche Wohnpräferenzen und Wohnformen bestimmen. *Zweitens* demonstrieren empirische Untersuchungen, dass das Konzept der Funktion die Untersuchung der Wohnmobilität von Schweizer Mietern analytisch unterstützt. Es erlaubt, Zusammenhänge zwischen den Qualitäten des Wohnumfelds und den Eigenschaften der Bewohner, ihrer Wohnzufriedenheit und den Auslösern für einen Umzug zu identifizieren. Die Funktionen helfen insbesondere, die beobachtete Präferenz für grössere Wohnungen und die geringe Umzugsneigung von schrumpfenden Haushalten zu erklären. Darüber hinaus ermöglicht dieses Konzept die Erfassung der Auswirkungen der aussergewöhnlichen Umstände von COVID-19 auf die Wohnpräferenzen und den verstärkten Wunsch nach einem Ort der "Selbstdarstellung". *Drittens* wird auf der Grundlage dieses empirischen und kontextspezifischen Wissens das agentenbasierte Modell ReMoTe-S vorgestellt. Simulationsexperimente zeigen, dass Massnahmen zur Verringerung des Flächenverbrauchs unzureichend sind, wenn sie nicht mit einem Wohnungsangebot einhergehen, das den Präferenzen der Haushalte entspricht und sie gleichzeitig mitgestaltet. Die Experimente zeigen auch, dass diese Präferenzen nicht durch eine direkte Entsprechung zwischen gewünschten und aktuellen Wohnungsmerkmalen erfüllt werden können, da die Wohnfunktionen ein Ergebnis von Kompromissen zwischen ihnen sind. Diese Ergebnisse laden Praktiker und Bürger dazu ein, sich gemeinsam vorzustellen, wie sich Wohnfunktionen in Wohnformen mit einem reduzierten ökologischen Fussabdruck ausdrücken.

Fazit. Diese Dissertation bietet eine Plattform für eine systemische Zusammenarbeit, die es Forschern und Praktikern ermöglicht, die komplexen Wechselwirkungen zu verstehen, die bei der

Bereitstellung von nachhaltigem Wohnraum eine Rolle spielen. Um die vom Menschen verursachte globale Erwärmung zu begrenzen, müssen die verwendeten Ansätze und Instrumente rasch in die Praxis und die Architekturlehre einfliessen.

Schlagworte: Wohnsystem, Wohnmobilität, Wohnpräferenzen, Wohnfunktionen, Systemwissenschaft, Systemansatz, Mietwohnungen, Nachhaltigkeit, Schweiz

Riassunto

Problema. Il settore residenziale è uno dei maggiori responsabili dell'impronta di carbonio e del consumo energetico della Svizzera, ma l'abitare è, al contempo, un bisogno fondamentale. La ricerca sulle strategie di mitigazione del cambiamento climatico ha finora prestato insufficiente attenzione alle preferenze delle famiglie e al loro contributo alla sostenibilità del settore abitativo. Lo studio delle preferenze residenziali richiede una comprensione dei fattori multilivello, specifici al contesto e interconnessi che determinano la corrispondenza tra le famiglie e le abitazioni, resi espliciti nel processo di mobilità residenziale.

Obiettivo. L'obiettivo di questa tesi è quello di chiarire i fattori che determinano la mobilità residenziale e le loro interrelazioni, al fine di esplicitare gli effetti delle misure volte a ridurre l'impronta ambientale delle abitazioni e al contempo soddisfare le esigenze dei loro abitanti.

Metodi. Questa ricerca fa ricorso a un approccio sistemico e transdisciplinare con l'obiettivo di esplorare, approfondire e districare le complesse relazioni che governano il processo di mobilità residenziale. Inizia concettualizzando le preferenze residenziali e le forme abitative come manifestazioni dei sottosistemi umani e materiali dell'abitare, determinate dalla *funzione* del sistema. L'applicabilità di questo quadro concettuale alla mobilità residenziale è poi esplorata raccogliendo e integrando, in sequenza, dati qualitativi e quantitativi sugli inquilini di tre grandi proprietari di patrimoni immobiliari multifamiliari in Svizzera. I risultati della ricerca empirica servono come base allo sviluppo di un modello basato su agenti (ABM) delle dinamiche residenziali delle famiglie, utile all'esplorazione degli effetti emergenti di misure di sostenibilità del comparto abitativo.

Risultati. *In primo luogo*, questa tesi dimostra che molteplici funzioni coesistono nella sfera abitativa, ognuna delle quali determina diverse preferenze residenziali e forme abitative, in relazione agli elementi del sistema sociale o ambientale (ad esempio la cultura o la localizzazione geografica). *In secondo luogo*, le indagini empiriche dimostrano che la nozione di 'funzione' offre un supporto analitico allo studio della mobilità residenziale degli inquilini svizzeri, in quanto permette di identificare i legami tra le qualità degli ambienti residenziali e le caratteristiche dei residenti, la loro soddisfazione residenziale e le cause che li spingono a traslocare. In particolare, le funzioni aiutano a spiegare la preferenza per abitazioni più grandi e la scarsa propensione al trasloco dei nuclei familiari in caso di riduzione nel numero dei loro membri. Inoltre, questa nozione permette di osservare gli effetti sulle preferenze residenziali delle circostanze eccezionali poste dal COVID-19, che rimarcano il maggior desiderio di un luogo di 'auto-rappresentazione'. *In terzo luogo*, utilizzando queste conoscenze empiriche e contestuali, la tesi introduce il modello ad agenti ReMoTe-S attraverso il quale si evidenzia che le misure volte a ridurre il consumo di spazio abitativo sono insufficienti, se non sono accompagnate da un'offerta di abitazioni che soddisfano e al contempo rimodellano le preferenze dei loro abitanti. Inoltre, queste preferenze non possono essere soddisfatte attraverso una diretta corrispondenza tra le caratteristiche degli edifici desiderate e quelle attuali, poiché le funzioni abitative risultano da diversi compromessi tra queste. I risultati incentivano i professionisti e i residenti a ripensare collettivamente il modo in cui le funzioni residenziali si traducono in forme abitative a bassa impronta ambientale.

Conclusioni. Questa tesi offre una piattaforma per 'co-inchieste sistemiche' che permette a ricercatori e professionisti di approfondire le complesse interazioni nella progettazione e produzione di edilizia ad elevata sostenibilità. Gli approcci e gli strumenti utilizzati in questo

lavoro dovranno informare la pratica progettuale e l’insegnamento, con l’obiettivo ultimo di limitare il riscaldamento globale.

Parole chiave: Sistema abitativo, mobilità residenziale, preferenze residenziali, funzioni abitative, scienza dei sistemi, approccio sistemico, alloggi in affitto, sostenibilità, Svizzera

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Glossary

ABM	Agent-based modelling, agent-based model
CLD	Causal loop diagram
CIAM	Congrès internationaux d'architecture moderne (International Congresses of Modern Architecture)
COVID-19	Coronavirus disease 2019
FSO	Federal Statistical Office (BfS in German; OFL in French)
IPCC	Intergovernmental Panel on Climate Change
NRP73	National Research Programme 73
ReMoTe-S	Residential Mobility of Tenants in Switzerland (ABM)
SDG	Sustainable Development Goal
SHEF	Shrinking Housing’s Environmental Footprint (project title)
SNSF	Swiss National Science Foundation
TD	Transdisciplinary, transdisciplinarity
UN	United Nations
UN-Habitat	United Nations Human Settlements Programme

Disclaimer

This work is a paper-based thesis. It adheres to the guidelines for 'theses made of combined articles' as laid out by the Doctoral Commission of the École Polytechnique Fédérale de Lausanne (Cdoct 109 [Nov 2015]).[2] According to these guidelines, an introduction must delineate the red line of the thesis by putting it into context and outlining the global objectives of the research (Part I). Each section should then consist of one or more research articles, conference proceedings, book chapters or reports that were or are to be published, and where the contribution of the doctoral candidate is described into detail (Part II to Part IV). The thesis should then conclude with the summary of the main contributions and the possibilities for future development (Part V).

The main body of this doctoral thesis includes four published peer-reviewed journal articles, one submitted manuscript (second round of review) and one peer-reviewed conference paper. Manuscripts are composed of a targeted review of the literature, an illustration of the methods employed for the investigation, its results, as well as a discussion of the limitations and contribution of the study to theory and practice. The avenues for future research highlighted in each publication form a thread linking each to the next.

The manuscripts in body text have been reformatted to match the layout of the thesis. More specifically (i) the sections, tables and figures numbering have been adapted to the document; (ii) references have been combined with those at the end of the thesis; (iii) a small number of typos have been corrected. The four published journal articles are Open Access, distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Table 1.1 provides the detailed references to the papers. The list is complemented by five key publications (two peer-reviewed book chapters, two journal articles and one report) that were produced during the doctoral research and are cited in the thesis. The full list of publications can be found in the Curriculum Vitae at the end of this thesis.

[2] For more information on the Doctoral Regulations and the Doctoral Commission's decisions regarding theses made of combined articles see: www.epfl.ch/education/phd/regulations/edoc-doctoral-commission-decisions-cdoct/. Accessed 23.10.2021

Table 1.1. Overview of manuscripts in chronological order.

#	Manuscripts in body text
1	**Pagani, A.**, & Binder, C. R. (2021). A systems perspective for residential preferences and dwellings: housing functions and their role in Swiss residential mobility. *Housing Studies*. https://doi.org/10.1080/02673037.2021.1900793
2	**Pagani, A.**, Baur, I., & Binder, C. R. (2021). Tenants' residential mobility in Switzerland: the role of housing functions. *Journal of Housing and the Built Environment*. https://doi.org/10.1007/s10901-021-09874-5
3	Karlen, C., **Pagani, A.**, & Binder, C. R. (2021). Obstacles and opportunities for reducing dwelling size to shrink the environmental footprint of housing: tenants' residential preferences and housing choice. *Journal of Housing and the Built Environment*. https://doi.org/10.1007/s10901-021-09884-3
4	**Pagani, A.**, Hansmann, R., Fritz, L., Kaufmann, V., & Binder, C. R. (2021). How the first wave of COVID-19 in Switzerland affected residential preferences. *Cities & Health*. https://doi.org/10.1080/23748834.2021.1982231
5	**Pagani, A.**, Ballestrazzi, F., Massaro, E., & Binder, C. R. (2021). ReMoTe-S. Residential Mobility of Tenants in Switzerland: an agent-based model. *Journal of Artificial Societies and Social Simulation*. *In review.*
6	**Pagani, A.**, Ballestrazzi, F., & Binder, C. R. (2021). Shrinking housing's size: Using agent-based modelling to explore measures for a reduction of floor area per capita. In M. Czupryna and B. Kaminski (Eds.), *Advances in Social Simulation*. Springer Proceedings in Complexity. https://doi.org/10.1007/978-3-030-92843-8_21
#	**Additional manuscripts referenced in the thesis**
7	Meirelles, J., **Pagani, A.**, Athanassiadis, A., & Binder, C. R. (2020). Sustainability issues in urban systems from a metabolic perspective. In C. R. Binder, E. Massaro, & R. Wyss (Eds.), *Sustainability Assessment in Urban Systems* (pp. 261–289). Cambridge University Press. https://doi.org/10.1017/9781108574334.013
8	**Pagani, A.**, Laurenti, R., Binder, C. R., Hellweg, S., & Heeren, N. (2020). Sustainability assessment of the housing system: exploring the interplay between the material and social systems. In C. R. Binder, E. Massaro, & R. Wyss (Eds.), *Sustainability Assessment in Urban Systems* (pp. 384–416). Cambridge University Press. https://doi.org/10.1017/9781108574334.018
9	**Pagani, A.**, Gonzalez, D., Clément, G., Karlen, C., Bourdon, V., & Laffitte, S. (2020). *Citizen Think Tank. Mon logement à l'épreuve du confinement : Quelles orientations pour l'après ?* https://www.coronacitizenscience.ch/wp-content/uploads/2020/08/CTT_-Rapport_Logement-1.pdf
10	Fritz, L., Vilsmaier, U., Clément, G., Daffe, L., **Pagani, A.**, Pang, M., Gatica-Perez, D., Kaufmann, V., Santiago Delefosse, M., & Binder, C. R. (2021). Explore, engage, empower: A transformative mixed methods study tackling the COVID-19 lockdown. *Humanities and Social Sciences Communications*. *In review.*
11	Hansmann, R., Fritz, L., **Pagani, A.**, Clément, G., & Binder, C. R. (2021). Activities, housing situation, gender and further factors influencing psychological strain experienced during the first COVID-19 lockdown in Switzerland. *Applied Psychology: Health and Well-Being (AP:HWB)*. https://doi.org/10.3389/fpsyg.2021.735293

PART I

Introduction

This introductory section comprises four chapters.

Chapter 1 presents the issues that motivated this research; it illustrates the key role of housing for sustainable development in cities more generally, and more specifically in the Swiss context. It then identifies entry points for providing sustainable housing in Switzerland, and outlines on this basis the overall objective of the thesis.

Chapter 2 highlights gaps in the literature and in the design practice that hinder our ability to address the issues presented in Chapter 1, pointing more specifically to the need to explore, dig into and disentangle the complexity of the housing system. To begin, the chapter illustrates some of the experiments and research conducted since the late 1950s on possible solutions to accommodate the dynamics of the housing demand, underlying the ever-present need to provide tools that enable housing actors to *explore* their complexity and act accordingly. As these tools require a better understanding of residential preferences and choices, the chapter then proposes to *dig into* their complexity; a concise overview of the fragmented studies on residential mobility is provided, which uncovers the need for a systems perspective to reorganise existing knowledge. Consequently, and lastly, the chapter succinctly introduces the field of system science, its affinities with architecture and housing studies, and the untapped potential of applying its universal principles to *disentangle* the complexity of the housing system.

Chapter 3 illustrates the structure of the research, i.e. how the three gaps identified in Chapter 2 are interlinked to objectives and research questions, as well as the contributions that were produced to address each of them.

Finally, Chapter 4 sheds light on the way the research was designed to meet each and the overarching thesis objective(s). It introduces the larger project that framed the doctoral investigation, clarifies the approach chosen for conducting the research, and describes the strategy of inquiry, i.e. the sequence of methods used in the thesis.

1 Motivations

1.1 Global challenges of housing in cities

Cities are home to more than half of the world's population. The pace of growth is unprecedented: from 3% in 1800, the global share of urban dwellers has reached 56% by 2020 (Meirelles et al., 2020; Seto et al., 2014; World Bank, 2020). Despite occupying a relatively small percentage of the earth’s land (about 3%), cities are responsible for three quarters of global energy consumption and carbon emissions (Bai et al., 2016). They must also ensure an adequate standard of living for the 4.35 billion human beings who inhabit them (Universal Declaration of Human Rights, 1948), a goal that is still far from being achieved considering the persistent challenges of meeting housing needs (Lawrence, 2021d; UN-Habitat, 2015). With the aim to “provide a comprehensive framework to guide and track urbanization around the globe” and work as accelerator of the United Nations 2030 Agenda for Sustainable Development and the Sustainable Development Goals, a New Urban Agenda was adopted during the United Nations Conference on Human Settlements (Habitat III) in 2016 (UN-Habitat, 2017, 2020b, 2020a, p. x). A novelty of the Agenda is its focus on housing “at the centre” of city planning and development, which recognises that:

> Clearly a lot of what has gone wrong with cities is related in one way or another to housing. The way housing is being produced and consumed has shaped urban growth, regretfully, in many cases, by producing cities that are fragmented, unequal and dysfunctional. The sustainable future of cities and the yields of urbanization will therefore strongly depend on facing and tackling the housing problems (UN-Habitat, 2015, p. 3).

Left in the background for almost 20 years, housing problems are central to sustainable development, i.e. meeting inhabitants’ needs without compromising the needs of future generations both locally and globally (Alberti, 1996; UN-Habitat, 2016; UNECE, 2015). On the one hand, the life cycle of dwellings is responsible for the consumption of natural resources and the production of waste and emissions; on the other hand, housing is a critical factor for the quality of life of present and future dwellers, including their health, security, access to services and cultural identity (Chiu, 2004; Evans et al., 2016; UN-Habitat, 2012a). Given the many interrelated dimensions (social, environmental, economic, cultural), spatial scales (dwelling, neighbourhood, settlement, region, country), temporal scales (from design to demolition), actors (residents, architects, planners, builders, property owners, municipalities), and tenure types (tenancy, ownership), the sustainability of housing is a complex notion, and even more complex are the targets set for it.

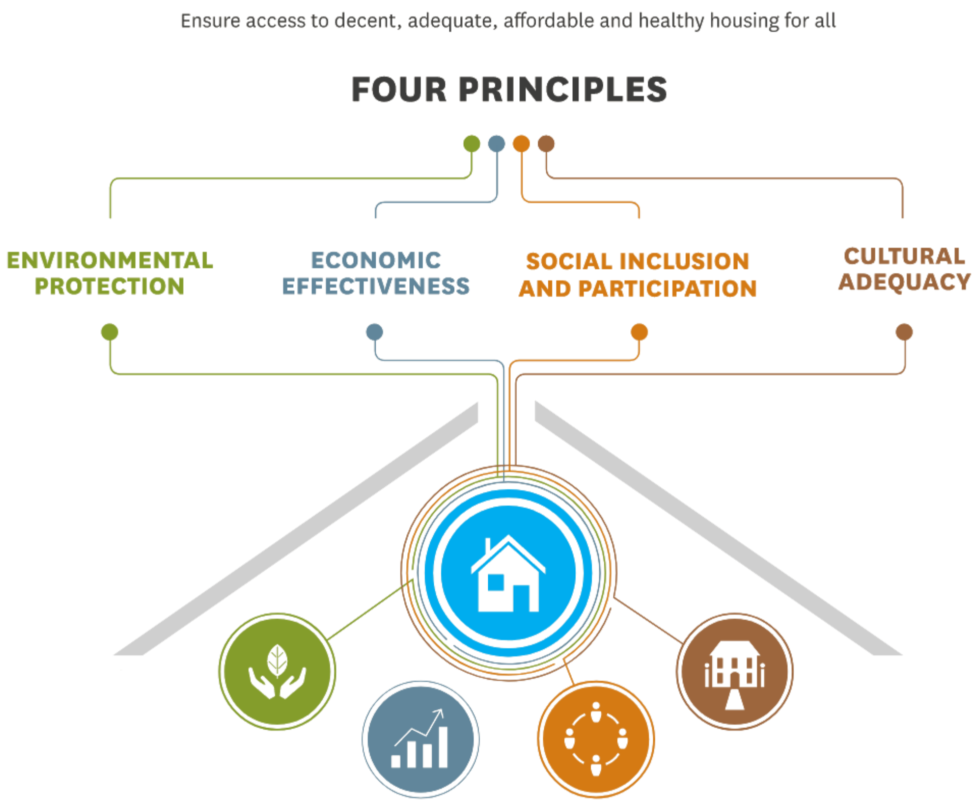


Figure 1.1. The four principles of the Geneva UN Charter on Sustainable Housing (UNECE, 2015), according to which housing should (i) "be planned, constructed and used in a way that minimizes the environmental impact and promotes environmental sustainability" (environmental protection); (ii) "be both a sustainable element in a vibrant economy as well as a sector for meeting people's needs" (economic effectiveness); (iii) allow for engaging and negotiating "civic involvement, social inclusiveness, public health, transparency and a concern for ethical processes" (social inclusion and participation); (iv) account for "cultural identity, value and emotional well-being" (cultural adequacy).

Notably, a plethora of terms are used to characterize sustainable housing across its dimensions, scales and tenure types; housing should be adequate, affordable, accessible, resource-efficient, safe, resilient, well-connected, well-located, decent, of good quality, inclusive, diverse, secure and healthy (UN-Habitat, 2012a, 2017; UNECE, 2015); it should also be attractive and adaptable (Lawrence, 2021e), acceptable (Chiu, 2004), appropriate (Swiss Confederation, 2018), sufficient (Lorek & Spangenberg, 2019), aesthetic and culturally sound (Jones, 2012; see Figure 1.1). Because "perceived needs are socially and culturally determined" (World Commission on Environment and Development, 1987), conflicts between their interpretations, implications, and prioritizations can arise. Firstly, targets can be interpreted very differently by each of the housing actors, e.g. what is considered 'adequate' for a inhabitant can diverge from what the architect or policy-maker designed or prescribed as adequate housing, or even between households (Franklin, 2001; Lawrence, 2009; Pattaroni, Thomas, et al., 2009). Also, the goals can themselves be conflictual and require trade-offs (Nilsson et al., 2016); for instance, the urgency to reduce individual space consumption—i.e. 'sufficiency' (Lorek & Spangenberg, 2019)—may run counter to the need to ensure the physical, mental and social health and well-being of residents (Foye, 2017; Harris & Nowicki, 2020, p. 594). Moreover, not all constituent goals of sustainable housing are given the same importance; this is made explicit for instance in the building sustainability assessment tools (BSATs) as only a few of the various indicators they include cover the sociocultural aspects of housing (see the analysis by Andrade & Bragança, 2016; Winston & Pareja Eastaway, 2008). In fact, despite a recent trend towards a more comprehensive coverage of different sustainability aspects (Adamec et al., 2021), research on and provision of 'environmentally sustainable' housing is often prioritized at the expenses of the social, cultural and economic dimensions (Prochorskaite et al., 2016). However, as argued by Chiu (2004, p. 66), "housing should focus on both the people and the environment rather than just one of them;" attributing a lower value to what constitutes 'home' for its inhabitants can engender a disconnection between 'building' (i.e. physical form) and 'dwelling' (i.e. inhabiting), thereby contributing to alienation, homelessness, and placelessness (Lawrence, 2021d). It becomes therefore clear that, notwithstanding the diversity of definitions, a sustainable residential sector must be understood as one that meets the needs of its present and future inhabitants while reducing its impact on the environment.

Because estimating how best to respond to the needs of urban dwellers is, in addition to normative, highly dependent on the cultural, political, economic and social contexts (Chiu, 2004; Lawrence, 1995, 2012b; Lawrence & Barbey, 2014), it is essential to clarify the setting in which these responses should be provided.

1.2 Housing sustainability in the Swiss context

In response to the growing threat of climate change, Switzerland has set several targets to reduce its energy consumption and CO_2 emissions. Regarding the former, Swiss voters accepted the new Energy Act in 2017, which aims to reduce energy per capita by 43% by 2035 compared with the year 2000 (SFOE, 2020); in addition, the Swiss Federal Office of Energy has been promoting the project '2000-Watt Society', which envisions a limit of 2000W per person of primary energy use by 2050.[3] Concerning emissions, Switzerland is committed to the Kyoto Protocol and the Paris Agreement, and has set climate policy targets for the year 2020 (i.e. a 20% reduction of CO_2 emissions compared with 1990), 2030 (i.e. a 50% reduction) and 2050 (i.e. carbon neutrality; FOEN, 2020b) accordingly. Considering that housing is the second top contributor to the total carbon footprint and energy consumption after transportation in Switzerland (IEA, 2018a, 2018b; Pang et al., 2020), the real estate sector has been asked to meet increasingly higher standards and comply with stricter regulations (see Feige et al., 2013; FOEN, 2020a). Consequently, housing research in the Swiss context has increasingly been focusing on the best strategies to tackle environmental challenges (Nägeli et al., 2020); however, findings reveal that, to achieve them, a better understanding of resident's preferences is first needed (Lawrence, 2009; Roca-Puigròs et al., 2020).

On the rise over the last three decades, the mismatch between the dwellings supplied and the desires and needs of households has had direct and indirect interrelated consequences for housing sustainability (Lawrence, 2014; Figure 1.2). A first example is urban sprawl. An analysis of 25 Swiss cities and two regeneration projects in Zurich and Neuchatel has shown that the attractiveness of urban areas for predominantly smaller households with higher purchasing power can reduce the availability of housing in the centres; reinforcing the tendency of families to move to the suburbs, these dynamics have significant consequences on the carbon footprint (Pang et al., 2020; Rérat, 2012b).[4] A second related example regards the rising number of small households,

[3] More details on the 2000-Watt Society can be found at the following link: https://www.2000watt.swiss/english.html
[4] The analyzed cities lost one-tenth of their inhabitants in 30 years, while the number of households increased by 15 per cent (Rérat, 2012b).

which is of primary concern in Switzerland. In fact, single person households comprise more than a third of all Swiss households (FSO, 2019a). As shown by several studies, declining household size can have detrimental consequences on the environment (Bradbury et al., 2014; Williams, 2007) and potentially undermine the efforts of Switzerland to achieve its climate goals (according to recent studies, the average floor space area should go from 46 to 41 square meters per capita FSO, 2019b; Roca-Puigròs et al., 2020). While other forms of shared accommodation could be provided to tackle inefficient use of space (e.g. cohousing; Bradbury et al., 2014; Lorek & Spangenberg, 2019; Williams, 2007), these solutions might be insufficient if they fail to meet residents' preferences (e.g. in terms of visual and acoustic privacy, personalisation of space; Ellsworth-Krebs, 2020). Furthermore, residents' dissatisfaction can lead to dwelling obsolescence, which "[...] put[s] at risk the success of regeneration and market renewal strategies. This will mean more demolition, public costs, and disruption for people and their communities" (Kintrea, 2007, p. 336; Lawrence, 2009).

It transpires that providing sustainable housing in Switzerland means reconciling a reduction in CO_2 emissions and energy consumption with meeting the preferences and needs of its residents. However, depicting residential preferences is not an easy endeavour in a market where housing costs affect about a fourth of households in their ability to meet basic needs (in 2009; Hugentobler, 2017), where vacancy rates are below 'natural' (from a national average of 1.72% down to 0.1% in the city of Zurich; FSO, 2019b; Zimmermann, 1992), and whose share of tenants is the highest amongst OECD countries (60%; Hugentobler, 2017; OECD, 2019b); i.e. depending on opportunities and constraints, the desires of residents can deviate from what is available and finally selected (Booi & Boterman, 2019; van Ham, 2012). Therefore, aligning the constitutive dimensions of sustainable housing cannot be approached as a problem-solving task, but requires instead exploring, digging into and disentangling the complex interrelations shaping the housing system and bringing about the issues introduced in this chapter.

Figure 1.2. Implications of failing to meet residents' needs (in grey) in relationship to the United Nations Sustainable Development Goals (SDGs; in colour). The issues of urban sprawl, increasing space consumption and obsolescence are interrelated (through e.g. vacancy, housing shortage) and affect in several ways the goals to achieve sustainability (e.g. demolition, disruption of communities).

1.3 Entry points for providing sustainable housing in Switzerland

In summary, housing is a key element in addressing the looming challenges posed by the urbanization process. Such challenges are "complex, dynamic and universal but specific to each resident, household, and societal context" (Lawrence, 2021d, p. 110); the lack of consensus on what they are, on which should be dealt with first, and on the approach to do so qualifies them as 'wicked' problems (Rittel & Webber, 1973; Scholz, 2011). Tackling them requires a conceptualization of cities—and therefore housing—as *complex systems*, driven by 'urban agents who have cognitive abilities' (Box 1; Gatzweiler et al., 2017, p. 41; Macmillan et al., 2016; Schweber & Leiringer, 2012). Accordingly, households' preferences and needs, i.e. the way households *want* to live, are acknowledged for their power to shape and being shaped by the urban environment and housing depending on several contextual factors.

The phenomena previously described in the Swiss context—namely urban sprawl, housing space consumption, and building obsolescence—are symptoms of the lack of knowledge on the interdependencies, emergence, dynamics and context of the system that residential preferences and mobility are embedded in (see Pattaroni, Thomas, et al., 2009). Considering housing's long-life service and incubation time (from the design to the use phase) and the fast pace of change in residents' socio-demographics, this knowledge is crucial for the provision of housing congruent with the needs of present and future generations. In response to this need, as scholars, we are called to provide ready-to-use tools to navigate the complex interrelations between households and dwellings—and therefore the 'interrelated purposes that impinge upon the quality of the [residential] environment' (Lawrence, 1995, p. 1663). As architects, designers, residents, policy-makers, builders, or more simply humans, we are called to participate in this investigation but also to reflect upon how the resulting systemic knowledge will change the way we design our world (Blizzard & Klotz, 2012). Responding to this call, however, cannot be successful if knowledge remains fragmented between 'lay people' and 'experts', their disciplinary silos, and their often-divergent interpretations of sustainability (Lawrence, 2021b). Therefore, adopting a systems perspective for the study of housing sustainability requires inter- and transdisciplinary, interconnected, integrated and inclusive approaches (Blizzard & Klotz, 2012; Davies & Oreszczyn, 2012; Eker et al., 2018; Fritz, 2020; Gatzweiler et al., 2017; Lawrence, 2010, 2021b; Schweber & Leiringer, 2012; Zimmermann et al., 2018).

Box 1. Housing: a complex system

Just as the "whole is more than the sum of its parts" (Binder, Hutter, et al., 2020; von Bertalanffy, 1968, 1972, p. 407), housing is more than 'four walls and a roof' (UN-Habitat, 2020a). Complexity in housing does not refer solely to the number of components that shape the system (actors, normative perspectives, dimensions) but also to its dynamics, meaning the "counterintuitive behaviour […] that arises from the interactions of the agents over time" (Sterman, 2006, p. 506). For instance, in the framework of residential mobility studies (i.e. the decision to move and select a dwelling), the macrolevel outcome of households-dwellings interactions can exhibit emergent, unpredictable and delayed effects, some of which are briefly described in this section, i.e. urban sprawl, space consumption, vacancy rate, building obsolescence (see for example the well-known segregation model of Schelling, 1971).

1.4 Overarching objective of the thesis

Providing sustainable housing in an increasingly urbanized world is a complex endeavour; sustainability is defined in manifold and sometimes conflictual ways which can themselves be interpreted and weighted very differently depending on the culture, values, needs, and power of the housing stakeholders. The result of housing provision is a physical form (i.e. the dwelling), whose adequacy, quality, or acceptability is assessed by its final users in relation to their preferences and needs, eventually hindering or supporting its (un)success (i.e. if cultural or social conventions diverge from rather than align with new 'performant' housing solutions). Therefore, the correspondence between the supply and demand of housing is a key determinant of its environmental and sociocultural sustainability.

As several dynamic and contextual factors (e.g. demographic trends, geographical location) shape the provision of and preferences for dwelling forms in unpredictable ways, the main claim of this thesis is that a systems approach to the study of the reciprocal relationships between households' preferences and dwellings is crucial to rethinking, designing and providing sustainable housing. These relationships are made explicit in the relocation process, during which residents decide to leave their dwelling and relocate to a new one.

On this basis, the **overall goal of this thesis is to clarify the determinants of residential mobility and their interrelations to illuminate the effects of measures aimed at reducing housing's environmental footprint while meeting the needs of its households**. To do so, it shows the contribution of a systems approach to exploring, digging into and disentangling the complex relations between residential preferences and dwelling forms in the decision to move and the selection of a new dwelling. More specifically, **it focuses on the central role played by the system's *function(s)* in orchestrating these interrelationships**. As the latter are context-depend, the proposed systems conceptualisation is explored in the framework of three Swiss multifamily rental housing owners.

This thesis proposes new ways to fill the enlarging gap between research and practice in the built environment, as highlighted by Lawrence (1987a, 2021b). It articulates the knowledge of housing stakeholders in a systemic way, which makes it possible to account for and integrate the relative value that different groups attach to housing. More specifically, it proposes a new transdisciplinary and inclusive language from which tools for reflection and action are derived, enabling to account for the system as a *whole*.

2

Existing approaches and gaps

2.1 Exploring complexity: tools for research and practice

> If we turn to an architectural magazine, we encounter the presentation of a series of buildings which have been photographed and published *without people*. (De Carlo, 1980, p. 74; emphasis added)

Giancarlo De Carlo (1919–2005) was one of the members of Team 10, a group consisting of the 'new generation' of young architects who organised the 10th International Congress of Modern Architecture (CIAM) in Dubrovnik in 1956 (Curtis, 1996). Breaking with their 'rationalist' fellows and their negligence for inhabitants' values and identities, the group was concerned with conceiving an architecture that was more suited to its context, able to establish a "new and more democratic relation between the resident and the architect," and attentive to the role of meaning and identity.[5] In parallel with the Team 10 group, the importance of accommodating the (changing) needs of users was advocated by several architects, including the Dutch designer John Habraken (1928–). Habraken argued for the importance of empowering residents to co-construct their domestic space; in practice, this was achieved by providing 'supports' (i.e. infrastructure), on and between which residents could build 'infills', using their own knowledge and skills (Habraken, 1972).[6]

Alongside architectural and design experiments, research was conducted on the relationship between the built environment and its users, and in particular on the notions of participation, flexibility and adaptation. Between 1981 and 1995 the scientific quarterly 'Architecture & Comportement' (architecture and behaviour; EPFL, Lausanne, Switzerland) provided contributions ranging from the history and origins of the distribution of areas within the domestic space (Eleb-Vidal & Debarre-Blanchard, 1987), possible approaches to overcome the incompatibility between housing material durability and the changing values of its users (Perrinjaquet et al., 1986), ways to create dialogues between users, designers and computers (Tweed & Woolley, 1992), and eventually addressed open questions to the architectural profession (Gauvain & Altman, 1982). However, while Habraken's ideas have rarely been applied in large-scale housing programs (Lawrence, 2021d), and technical challenges have undermined the success of other flexible housing solutions (Marchand, 2012)[7], neither does research seem to

[5] For more information on the history, the protagonists and projects of Team 10 see http://www.team10online.org/

[6] The repository 'Spatial Agency' is a valid tool to explore the interrelationships between the concepts, projects, organisations, and events described in this chapter. Link: https://www.spatialagency.net/. Accessed 08.07.2021

[7] See the Casa Patriziale in Carasso (1967-1970) by Luigi Snozzi and Livio Vacchini (Marchand, 2012)

have helped to overcome the numerous shortfalls that still impede the supply of quality housing today, leaving the objectives of UN-Habitat out of reach (UN-Habitat, 2016).

Recently, innovative housing solutions have seen the day in the Swiss rental housing context (Pattaroni & Marmy, 2016). An example of their application is the *Mehr als Wohnen* cooperative in Zurich ('more than living' in German), which comprises more than 400 eco-friendly, people-centred, non-profit dwellings which bring together households of different sizes and composition. For a reduced average floor area per capita of only 35 m^2, the cooperative offers shared spaces, common rooms for various activities, offices and extra bedrooms to rent. In addition, some of the buildings include 'cluster' apartments, which consist of eight to twelve individual rooms with a private bathroom and a shared living and dining room.[8]

Although promising, initiatives like *Mehr als Wohnen* are led predominantly by cooperatives, which represent only 7.5% of the rental housing stock in Switzerland, and whose functioning strongly differs from the dominating private rental market (FSO, 2020b; Rabinovich, 2009). In the latter, housing choices are "defined by the providers of housing according to conventional interpretations of real estate professionals and property investors"—sometimes questioned for their divergence with sustainability ethics (Lawrence, 2021d, p. 109; Palmer, Instone, et al., 2015).[9] These 'conventional' interpretations have to face the fast pace at which society is changing, and with it the increasingly diverse housing demand (e.g. smaller households, changes in lifestyle, increasing affluence) as well as its unpredictable impact on housing volume, requirements, and location (Jansen, 2014a), and consequently on housing sustainability (Figure 1.2).

While one way to respond to uncertainty and counteract the risk of obsolescence is to work at the micro-scale—i.e. design projects that provide each tenant with the possibility to adapt their built environment to their needs—another (compatible) approach is to use simulation tools. Accounting for the interaction between several interrelated components (e.g. residents' preferences, demographic changes, rents, dwellings life cycle), these tools make it possible to explore and assess *what-if* scenarios (or measures), whose macro-scale effects might be otherwise unpredictable on the long-term (Sun et al., 2016).

In the Swiss context, computer models have been developed to simulate and assess the impact of climate-related policies (see for instance Nägeli et al., 2020; Roca-Puigròs et al., 2020). However, just like the CIAM before Team 10, none of the existing models accounts for inhabitants' preferences and their effects. Furthermore, direct applications of residential dynamic models from other contexts is not a viable option, considering, as introduced in Chapter 1, that housing is culturally determined.

Therefore, to summarise,

- More than 60 years have passed since Team 10 explicitly stated the need for architects and urban planners to account for residents' culture, values and identity in housing design.

[8] More information on the cooperative *Mehr als Wohnen* can be found at this link: https://www.mehralswohnen.ch/; *CODHA* is another cooperative where the concept of 'cluster' was applied, as detailed here: https://www.codha.ch/fr/soiree-cluster-12-04-16. Accessed 08.07.2021

[9] In the book chapter 'Housing matters for all', Lawrence (2021d) discusses the example of the redevelopment of the brownfield site of Hammarby Sjöstad in Sweden, where residents were treated as housing 'consumers' instead of participants, resulting in 'green' and 'low-carbon' but unethical buildings (i.e. buildings that overlook variables such as affordability, adaptability, social inclusiveness).

- The solutions proposed at the time are still far from being implemented at the large scale today. With the exception of the experiments of some innovative non-profit cooperatives in Switzerland, housing supply still fails to accommodate residential preferences and their dynamics.
- The management of the Swiss housing stock would benefit from tools allowing stakeholders to explore and assess the effects of the dynamic interrelations between the multiple variables at play in the provision of sustainable housing.
- While simulation models exist to evaluate climate-related strategies in the Swiss context, none includes residential preferences dynamics, thereby hindering the possibility to observe their macro-level effects on housing sustainability.

Therefore, the following gap emerges:

Gap 1 There is a need for context-specific tools enabling housing stakeholders to design, explore and assess measures for the provision of sustainable housing, understood as dwellings that meet the needs of their inhabitants while reducing their environmental footprint.

More specifically, these tools must make explicit the reciprocal and dynamic interactions between households and dwellings in order to observe their emergent macro-level effects on targeted indicators (e.g. residential satisfaction, vacancy rate). To provide such tools, however, we first need to dig into complexity and get a better understanding of the demand, i.e. residents' preferences, and its relationship with the supply, i.e. dwellings. These relationships are made explicit in the relocation process, where households decide to move and where to move.

2.2 Digging into complexity: residential mobility

Numerous studies can be found under the keyword 'residential mobility'. Scholars in geography, sociology, demography, psychology and economics have investigated the relocation process through their disciplinary lenses, and by means of various approaches and perspectives (Mulder, 1996). In his work on residential mobility, Rérat (2016, 2020) grouped four of these perspectives into two categorisations. The first separates the macro-analytic perspective, which aims to explain broad patterns of migration, from the micro-analytic perspective, which, starting with the seminal work in urban sociology by Peter H. Rossi (1955), focuses on the household as a unit of analysis and its motivations for moving (Cadwallader, 1992; Dieleman, 2001; Wong, 2002).[10] The second categorization opposes a 'deterministic' perspective to one that considers households as decision-makers with freedom of choice (i.e. 'humanistic'; Boyle et al., 1998). In addition to these four perspectives, the author introduces five theoretical approaches, namely the neo-classic, behaviourist, structuralist, humanistic, and institutional approach. These approaches differ by the extent to which utility, quality of life, social constraints, beliefs or values and intermediaries in the housing market (e.g. real estate agents) are considered as central to unravelling the relocation process (Rérat, 2020).

Several attempts have been made to transcend the divisions in the numerous subfields and specializations on residential mobility, which "express themselves so differently that it seems as if they are speaking different languages"; in fact, this fragmentation on the one hand renders it

[10] In this framework, mobility has also been studied as the result of trade-offs between the preferences and needs of several household members (Coulter et al., 2012; Rérat et al., 2014).

difficult “for researchers from different traditions to judge the value of each other’s work and place it in perspective” (Mulder, 1996, p. 210), on the other hand it makes it “nearly impossible and maybe not even desirable to develop a single theory” (van Ham, 2012, p. 48). The introduction of the concept of *housing choice* supports efforts to achieve integration between such diverse points of views (Rérat, 2016, 2020).

Housing choice is most commonly conceptualised as consisting of two or three stages, which assume that a household first develops an intention to move (set-off by a ‘trigger’ event) and then searches for and/or selects its dwelling (Mulder, 1996); the final choice results from comparing the household’s requirements and preferences to a range of housing options, defined by macro-level opportunities and constraints (e.g. housing vacancies), and micro-level resources and restrictions (e.g. household’s salary; Clark & Lisowski, 2017; Mulder & Hooimeijer, 1999; van Ham, 2012). Therefore, housing choice can be studied in relationship to households’ profiles (e.g. socio-economic variables, lifestyles), their trajectories (e.g. occupational, educational, marital and housing careers), and the determinants of their relocation decisions (e.g. triggers to move, residential preferences, residential satisfaction; Rérat, 2016, 2020). However, and despite the growing body of literature, recursive relationships between these conditions remain conceptually and empirically poorly understood (Box 2; Dieleman, 2001).

Box 2. Interactions and gaps: residential satisfaction and housing features

Residential satisfaction has been widely investigated using linear and nonlinear regressions, an array of predictors, different conceptualizations, and in relationship to several stages of the relocation process (Jiang et al., 2017, 2020; Lu, 1998, 1999; Phipps & Carter, 1984). Despite this conspicuous amount of research, relevant gaps in the understanding of the interaction between residential satisfaction and the determinants of the move and selection of a dwelling still need to be filled. For example, on the one hand, dissatisfaction has largely been cited as a motivation for relocating; several studies have shown that specific housing characteristics can indirectly—through *dissatisfaction*—or directly (e.g., room stress) trigger ‘adjustment’ moves (see, e.g., Clark & Onaka, 1983; Diaz-Serrano & Stoyanova, 2010; Kwon & Beamish, 2013; Speare, 1974). On the other hand, it has also been found that certain events in the life course can more strongly influence the decision to move regardless of the residents’ level of satisfaction with the dwelling (Wong, 2002). Furthermore, although satisfaction can be broken down in terms of dwelling, neighbourhood and location features, “household may not necessarily perceive the characteristics in terms of [these] specific categories.” (Wong, 2002, p. 231). These shortcomings highlight the need to reconsider the way in which the study of residential preferences and satisfaction has so far been approached in relation to housing characteristics.

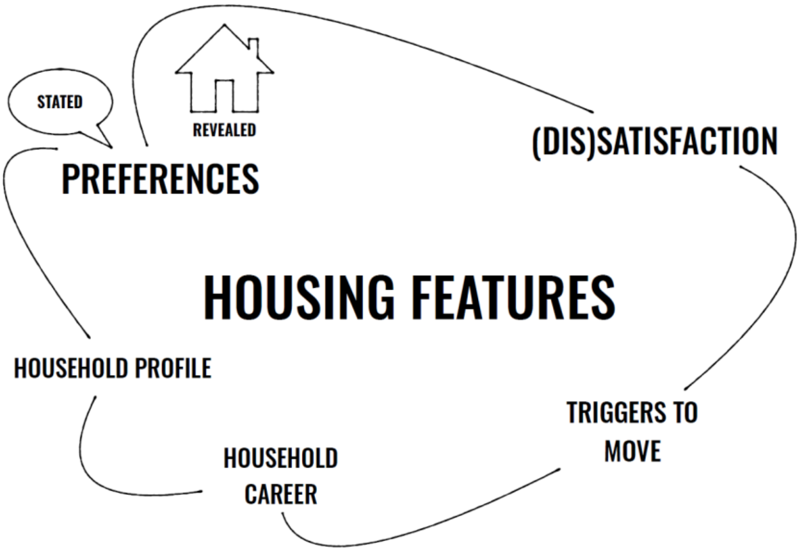


Figure 2.1. Housing features in the decision to move and the selection of a dwelling. Characteristics of dwellings, neighbourhood and relative location are intertwined with several determinants of residential mobility (e.g. triggers to move, households' lifestyle). Linkages are shown for illustrative purposes and are not exhaustive.

Difficulties in understanding housing choice are highly dependent on the nature of the object under study. Housing is 'a composite good' (Clark & Dieleman, 1996; van Ham, 2012); it can be described using a multitude of qualitative and quantitative characteristics, which are subjectively weighted, assessed and traded-off (if 'substitutable') in relation to contextual factors (Dieleman, 2001; Lawrence, 2009; Pattaroni, Thomas, et al., 2009; Thomas & Pattaroni, 2012). Used as proxies for residential preferences, the large number of housing features poses great analytical challenges; for instance, it has long been demonstrated that events triggering the move can alter preferences for one or more housing attributes (Clark & Onaka, 1983), whilst certain housing features have been found to generate both satisfaction and dissatisfaction (Marans, 1976). In addition, in societies where basic housing needs have been predominantly met, preferences for certain housing characteristics might differ more strongly between households due to tastes or values than due to socio-demographic and socio-economic variables used so far as predictors (Jansen, 2014a). This complexity is worsened by the discrepancy between *stated* and *revealed* preferences (Timmermans et al., 1994), whereby the aspirations of households—i.e. their unconstraint 'ideal' dwelling—and the features of the dwelling they actually chose can greatly differ (van Ham, 2012; Figure 2.1).

From this overview, it emerges that the study of residential mobility and housing choice would benefit from the application of a systems perspective, according to which the several interrelated components that constitute housing and orchestrate the relocation process can be conceptualised as interconnected elements organised in a system's structure. In particular, such a perspective would make it possible to explore and potentially identify overarching concepts organising the multitude of housing features, including their subjective and objective evaluations.

The advantages of 'reconceptualising' residential mobility and housing choice are not limited to theoretical considerations. Achieving a holistic understanding of the dynamic match between aspirations and reality would make it possible to re-evaluate the *attractiveness*, *hosting potential*, or *repulsion* of certain locations and thus support the design of more effective housing programmes (Kaufmann, 2011; Lawrence, 2009; Pattaroni, Thomas, et al., 2009; Rérat, 2012c;

Thomas & Pattaroni, 2012). Moreover, a systemic (and therefore enhanced) knowledge of the determinants of the relocation process is crucial to dig into and tackle impellent sustainability challenges—an application which exhibits a strong potential but has been hardly explored. For instance, to the knowledge of the authors, no study has been so far conducted on whether and how the COVID-19 pandemic and the consequent 'condensation' of urban functions in our dwellings has affected residential preferences. This understanding would contribute to the provision of housing able to meet changing requirements, thereby reducing dissatisfaction, mobility and its emotional and monetary costs (Goodman, 1976; Hartig & Lawrence, 2003; Stokols, 1992). Furthermore, and as introduced in Chapter 1, a better grasp of residential preferences would be key to address the pressing need to reduce the increasing floor space per capita in Switzerland, and the related resources and energy consumption (Heeren & Hellweg, 2018a; Williams, 2002, 2007). At present limited, knowledge on the determinants of space consumption would offer support to the provision of housing solutions that reduce individual space consumption while remaining attractive to different types of households (Dowling & Power, 2012; Ellsworth-Krebs, 2020).

In summary,

- Residential mobility has been studied by several disciplines and by means of different lenses, which focused on different analytical scales and conceptualized the relocation process and its agents in distinct ways.
- Attempts to transcend disciplinary silos still exhibit relevant gaps and a holistic knowledge of the interaction between the determinants of residential mobility is lacking. This is predominantly due to the fact that housing is a composite good, the study of which is based on several features (e.g. dwelling, neighbourhood, location) that are subjectively categorized, weighted and assessed.
- In light of this fragmentation, the study of the determinants of the relocation process would benefit from the application of a systems perspective. This perspective would make it possible to investigate interactions at different systems levels, simultaneously allowing for the emancipation from and the consideration of micro-level housing features.
- An enhanced understanding of the determinants of residential mobility is key to digging into and addressing urgent sustainability challenges, particularly when what is important to households runs counter to environmental requirements and vice versa. Such a knowledge could support the identification of obstacles and opportunities for a reduction in floor space per capita, or the provision of housing that enables households to cope with residential stress e.g. COVID-19.

Therefore, the following gap emerges:

Gap 2 A systems understanding of the large number of determinants of residential mobility, the different ways in which they interact and their contribution to housing sustainability is needed.

To achieve such an understanding, the system's complexity needs to be disentangled first. This implies observing and redefining each of the system's component using systems science lenses.

2.3 Disentangling complexity: the contributions of systems science

It has long been argued that failure in tackling complex issues is due to our difficulty in understanding and conceptualizing systems (Gibb & Marsh, 2019; Macmillan et al., 2016; Mobus & Kalton, 2015; Sterman, 2012). One of the major causes of this failure, however, is overlooking the *existence* of systems themselves. In order to study the dynamics that lead to the formation of the tip of the iceberg, it is first necessary to understand what happens below the surface, i.e. in the remaining 90% of its mass (Gibb & Marsh, 2019; Kim, 1999; Monat & Gannon, 2015). We illustrate this statement through a study conducted by Rérat (2012b) on the feasibility of the compact city model in Switzerland—a model to counter urban sprawl via urban densification. The author introduces two existing interpretations of residents' suburban housing choices; the first looks at urban sprawl as the result of a 'vicious circle' of push and pull factors, driven by people's needs and desires (Figure 2.2). Based on this diagram, one would conclude that "the compact city is neither workable nor desirable" (Rérat, 2012b, p. 121). However, although this approach attempts to uncover the underlying mechanisms of urban sprawl, it does not fully account for the issue's complexity; for instance, a clear preference for the suburbs would not explain the extremely low vacancy rate in Swiss cities (e.g. 0.1% in Zurich; FSO, 2020a). A second and compatible interpretation of the phenomenon additionally considers the role played by the second demographic transition (i.e. ageing population, declining fertility rate, instability of couples, etc.) in influencing urban dynamics; accordingly, the increase in the number of small households, their higher purchasing power, and their preference for city centres, have altogether led to an absolute decrease in the population of Swiss cities in concomitance to a greater housing shortage; "[t]hus urban sprawl did not simply occur because people began to prefer the suburbs, but also due to the lack of housing within cities" (Rérat, 2012b, p. 123). By considering different variables, this argument *supports* the feasibility of the compact cities. The example suggests how 'simplistic and erroneous mental models' (Sterman, 2012, p. 23) can lead to wrong conclusions (e.g. that densification runs counter to residential aspirations), and even misguide decisions. In light of this knowledge, the question of how to move beyond "partial or narrow perspectives" and holistically conceptualize, understand, and disentangle systems and their complexity arises (Gibb & Marsh, 2019, p. 3). Answers to this question can be found in systems science.

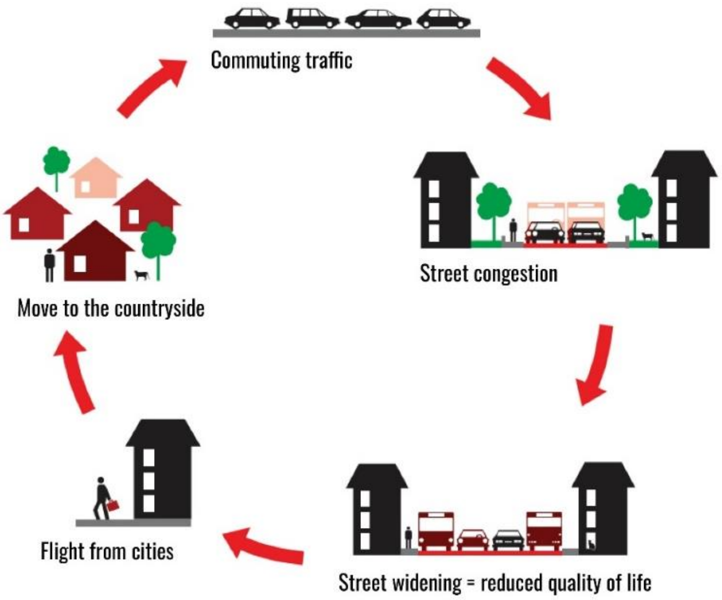


Figure 2.2. Agglomeration traffic: the vicious circle. Adapted from Rérat (2012b) and the Office des ponts et chaussées du canton de Berne (2004)

Defined as a “unifying and explanatory” way to look at all parts of the world “beyond the boundaries of any particular science” (Mobus & Kalton, 2015, p. 5), systems science allows for the identification of *universal principles* helpful to build representations that are “effective for problem-solving” (François, 2011, p. 610; Heylighen, 1990, p. 423; M’Pherson, 1974; von Bertalanffy, 1972). While its origins can be traced back to European philosophy, its formalization in a systems theory started only after the Second World War, when several streams of thought emerged (e.g. general systems theory, cybernetics, social systems theory; see Binder, Hutter, et al., 2020). Critical to systems theory and shared by all streams is the notion of holism, whereby the ‘whole’ is necessary for understanding the parts, and no element of the system can be analysed or understood in isolation (M’Pherson, 1974; von Bertalanffy, 1972). Therefore, thinking in systems requires going beyond the atomistic ‘divide-and-conquer’ approach, to look at the interconnections and feedback between the elements that shape the system under study (Mobus & Kalton, 2015; Box 3). Based on these premises, a group of thirty individuals under the name of ‘Club of Rome’ gathered in the Accademia dei Lincei in 1968, with the goal to:

> [...] foster understanding of the varied but interdependent components-economic, political, natural, and social-that make up the global system in which we all live; to bring that new understanding to the attention of policy-makers and the public worldwide; and in this way to promote new policy initiatives and action. (Meadows et al., 1972, p. 9)

The first phase of their project on the predicament of mankind used the pioneering work of Professor Forrester and colleagues in the field of system dynamics to explore whether growth was compatible with the limits of our planet, leading the publication of the well-known report “*The Limits to Growth*” (Meadows et al., 1972). Nearly fifty years later, and in light of the global debate it spurred, one would expect systems science to have permeated any field of research; however, this is far from being the case.

Box 3. The Blind Men and the Matter of the Elephant.

Beyond Ghor, there was a city. All its inhabitants were blind. A king with his entourage arrived nearby; he brought his army and camped in the desert.
He had a mighty elephant, which he used to increase the people’s awe.
The populace became anxious to see the elephant, and some sightless from among this blind community ran like fools to find it.
As they did not even know the form or shape of the elephant, they groped sightlessly, gathering information by touching some part of it.
Each thought that he knew something, because he could feel a part. . . .
The man whose hand had reached an ear . . . said: “It is a large, rough thing, wide and broad, like a rug.”
And the one who had felt the trunk said: “I have the real facts about it. It is like a straight and hollow pipe, awful and destructive.”
The one who had felt its feet and legs said: “It is mighty and firm, like a pillar.” Each had felt one part out of many. Each had perceived it wrongly. . . .
This ancient Sufi story was told to teach a simple lesson but one that we often ignore: The behavior of a system cannot be known just by knowing the elements of which the system is made.

After Meadows (2008, p. 7) and adapted from Idries Shah (1970, p. 25)

Resistance to the application of a systems perspective to the field of architecture is shown for instance in the opposition to the work of the architect and mathematician Christopher Alexander (Dawes & Ostwald, 2017; Steenson, 2014). Critical of modern architecture, in his article "*Systems Generating Systems*", which appeared on the review *Architectural Design* in 1968, Alexander (1968) writes:

> In a properly functioning building, the building and the people in it together form a whole: a social, human whole. The building systems which have so far been created do not in this sense generate wholes at all. (p. 605)

While discussing the ideas behind the word 'system' and the implications of their use for the work of designers, the architect makes the distinction between the *system as a whole* (i.e. the holistic behaviour of the system) from the *generative system* (i.e. a kit of parts e.g. columns, beams, panels, put together according to 'rules'). With the aim to unveil and 'invent' generating systems, Alexander went on to propose 253 universally repeatable 'patterns' for the design of houses, public buildings, neighbourhoods, streets, gardens, etc. (1977).

Like Alexander, the architect and co-founder of environment-behavior studies (EBS), Amos Rapoport (1929–), was interested in exploring the patterns, linkages and interactions between people and residential environment (see, e.g., Rapoport, 1987, 1994, 2000). In his research, he defined housing as a "system of settings within which systems of activities […] take place [...] This system, in turn, is embedded, in different ways, into larger systems of settings (e.g. blocks, compounds, neighbourhoods, settlements and sometimes even regions)" (Rapoport, 2000, p. 147). Clearly based on systems thinking, this definition is presented as crucial to compare dwellings across cultures (Figure 2.3).

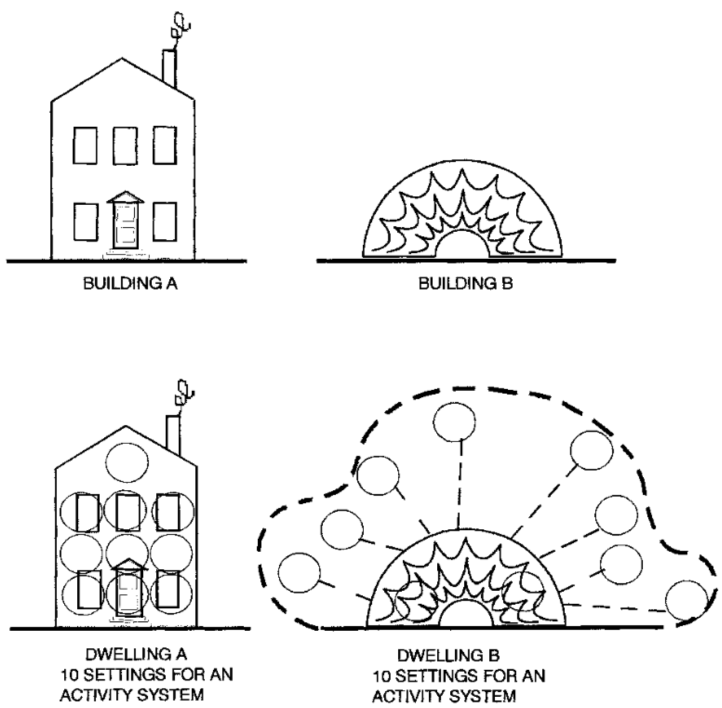


Figure 2.3. "The two buildings above cannot be compared as dwellings. The two systems of ten settings each define the dwelling and form the units suitable for cross-cultural comparison." After Rapoport (2000, p. 147)

The work and thinking of Alexander (1968, 1977, 1979) and Rapoport (1969, 1987, 2000)—and with them of several scholars in the fields of people-environment studies, architectural psychology, and environment-behavior studies—is inscribed in a post-war period characterised on the one hand by the desire to respond to the "inability of modern architecture, contemporary design education and the design culture to address human needs" (Beckley, 2000; Franklin, 2001, 2006), and on the other hand by the growing popularity of systems science for its ability to tackle issues related to the environment and society (Meadows et al., 1972). These scholars and practitioners, however, were running counter to established design approaches (Menges & Ahlquist, 2011), the persistence of which may help to understand why, despite various attempts to link knowledge and techniques from systems science and design, "a coherent interdisciplinary *practice* did not emerge until recently" (Jones, 2020, p. 29; emphasis added). Therefore, although a growing body of research is demonstrating the potential of applying systems lenses to the study of the complex interrelationships of the housing system (see e.g. Eker et al., 2018; Eskinasi, 2014; Gibb & Marsh, 2019; Macmillan et al., 2016), this cross-fertilisation remains at present largely unexplored.

Conceptualising housing as a system would require first and foremost identifying its components—including its elements and their interrelations, its behaviour(s), and its function(s). This process can be a daunting task; in fact, according to Meadows (2008, p. 17), "the least obvious part of the system, its function or purpose, is often the most crucial determinant of the system's behavior." Surprisingly, and possibly linked to the need to move away from 'functionalism' in its architectural guise, the lack of use and research of the concept of *function* in the works presented in this chapter highlights a significant gap. It emerges that the study of the housing system should start from identifying what the housing *function(s)* is, or are—a search that could potentially lead to an enhanced understanding of the dynamic relations between households and dwellings.

In summary,

- Too simple or wrong mental models can misguide our understanding of complex phenomena and the actions we undertake to tackle them.
- Systems science allows for a holistic understanding of the system under study. It proposes universal principles that are helpful to build representations to tackle complex issues.
- Systems are not new to architecture and housing studies. To counteract the lack of consideration of human aspects in modern architecture, it was necessary to take into account a plethora of variables influencing the residential environment. This was made possible by the notion of 'system'.
- Although appealing to several scholars and despite the growing interest in its application, a systems perspective is still far from breaking into the housing realm. Overcoming this delay entails benefitting from analytic lenses understandable beyond disciplinary boundaries and that allow for taming the emergent behaviours of the system (e.g. residential preferences, built form), heretofore not well understood.
- For this purpose, the principles of systems science should be formally introduced to housing studies. This entails identifying the housing system's components and in particular its *function*, which is the key determinant of the way the system behaves.

Therefore, the following gap emerges:

Gap 3 A formal application of the universal language of systems science to the study of housing is missing; such an application requires identifying the function of the system as a key determinant of its behaviour.

This gap is the root of the problem, the foundation that, once laid, will allow the construction of each building's floor of this doctoral thesis.

3

Research structure

Chapter 2 highlights fundamental lacunae in housing research and practice that must be tackled when seeking to meet the key challenge of providing sustainable housing. In particular, it argues that in order to support an understanding of the tip of the iceberg, the volume beneath the water must first be explored. The path followed by this thesis therefore starts with Gap 3, progressively contributing to fill Gap 2, and eventually Gap 1; these gaps are strongly interconnected, meaning that the investigation of each directly and indirectly supported the results filling the others (Figure 3.1). This chapter clarifies this path by outlining the doctoral thesis structure. First, it details the objectives pursued to fill each gap and the research questions formulated to address them; then, it indicates the associated outputs (i.e. manuscripts; Table 1.1), each of which corresponds to a chapter organised in a section (i.e. 'Part'); lastly, it elucidates the audience to which each manuscript is addressed.

This thesis starts with setting the theoretical framework of the research, meaning the conceptualization of housing as a system:

Conceptualizing housing as a system: the application of universal principles

Gap 3

A formal application of the universal language of systems science to the study of housing is missing; such an application requires identifying the function of the system as a key determinant of its behaviour.

Objective 1

To provide an operational framework of the housing system and explore its applicability to the study of Swiss tenants' residential mobility.

Research question 1

How does the concept of housing function contribute to the understanding of the relationship between residential preferences and dwellings?

This Gap, Objective and Research question are addressed in **Part II**, where **Chapter 5** contains the post-print of **Manuscript #1**, 'A systems perspective for residential preferences and dwellings: housing functions and their role in Swiss residential mobility'. The manuscript presents an operational framework for identifying the housing systems components and in particular its functions (i.e. *what is the system for*?). A potential application of the proposed framework is exemplified in the context of the residential mobility of Swiss tenants. By proposing a new key to understanding and investigating the interactions between residential preferences and dwellings, and more generally housing, the manuscript targets a broad audience, including scholars and students in the constituent disciplines of people-environment studies as well as the wide spectrum of professional figures in the housing sector (e.g. policy-makers, architects).

The findings of Chapter 5—and in particular (i) the identification of a range of housing functions and (ii) the exploration of their role in the relocation process—provide the basis for digging into the complex interactions between the determinants of residential mobility:

Investigating the system's interrelationships: the determinants of residential mobility

Gap 2

A systems understanding of the large number of determinants of residential mobility, the different ways in which they interact and their contribution to housing sustainability is needed.

Objectives 2

a) To achieve a systems understanding of the interactions between the determinants of Swiss residential mobility, focusing on the role played by housing functions in orchestrating them.

b) To use this knowledge to better understand Swiss tenants' preferences for and choices of dwelling size and thereby identify obstacles and opportunities for reducing the latter.

c) To use this knowledge to provide insights into the extent to which Swiss residents' preferences were affected by the first wave of COVID-19 as a means to identify ways to promote and maintain healthy residential environments.

Research questions 2

a) *What role do housing functions play in orchestrating the factors determining the moves of Swiss tenants?*

b) *What determinants of Swiss households' relocation decisions present opportunities or obstacles for reducing housing size?*

c) *How were residential preferences, i.e. housing functions, affected by the first wave of COVID-19 in Switzerland?*

These gap, objectives and research questions are addressed in **Part III**, which comprises three chapters.

Chapter 6 contains the post-print of **Manuscript #2**, 'Tenants' residential mobility in Switzerland: the role of housing functions', which pursues Objective 2a and responds to Research question 2a. The manuscript presents a multi-step theoretical model of tenants' decision to relocate and explores its linkages by means of empirical analyses of survey data. By contributing to existing theories and approaches in the field of residential mobility and housing choice, the paper predominantly targets scholars in the field and with interest in e.g. residential satisfaction, triggers to move, residential preferences. However, the approach adopted and the results of the manuscript can be applied to more practical issues of relevance for a broader public, as shown by Chapter 7 and Chapter 8.

Chapter 7 contains the post-print of **Manuscript #3**, 'Obstacles and opportunities for reducing dwelling size to shrink the environmental footprint of housing: tenants' residential preferences and housing choice', which pursues more generally Objective 2a and more specifically Objective 2b. The paper investigates tenants' preferences for and choices of housing size to identify obstacles and opportunities for reducing it. In particular, it focuses on the role of housing functions in determining past decision to move to a larger or smaller dwelling and on the willingness to reduce housing size in the future. Several recommendations are highlighted in the paper, whose results are addressed especially to policy-makers and practitioners.

Chapter 8 contains the post-print of **Manuscript #4**, 'How the first wave of COVID-19 in Switzerland affected residential preferences', which also addresses Objective 2a, but more specifically Objective 2c. The paper investigates the extent to which residents' ideal housing functions were affected by the first wave of COVID-19 in Switzerland and relates the observed changes to several variables such as socio-demographic characteristics, changes in leisure activities, and respondents' environment conditions. As the paper aims to contribute to the provision of residential environments that maintain and promote residential health and well-being, its discussion and conclusion sections address specifically national- and local-level decision makers, housing owners, practitioners and professionals (i.e. architects) as well as residents.

The multi-step model illustrated in Chapter 6 serves as a basis to implement a computer model for the exploration of the effectiveness and effects of housing sustainability measures and therefore to fill the first gap identified in this thesis. In addition, it complements the knowledge gained in Chapter 7:

Simulating residential mobility: an agent-based model to navigate complexity

Gap 1

There is a need for context-specific tools enabling housing stakeholders to design, explore and assess measures for the provision of sustainable housing, understood as dwellings that meet the needs of their inhabitants while reducing their environmental footprint.

Objectives 3

a) To provide an empirically-based and context-specific model simulating the interactions between dwellings and household, thereby allowing for a holistic understanding of their reciprocal influence.

b) To explore emerging effects of changing model parameters on environmental and sociocultural indicators of sustainable housing.

c) To simulate and compare measures targeting a reduction of individual space consumption.

Research questions 3

a) *How to model the recursive effects between households and dwellings in the context of Swiss rental housing?*

b) *What are the effects of changing quantitative and qualitative dwelling attributes on individual space consumption, residential satisfaction and vacancy rate?*

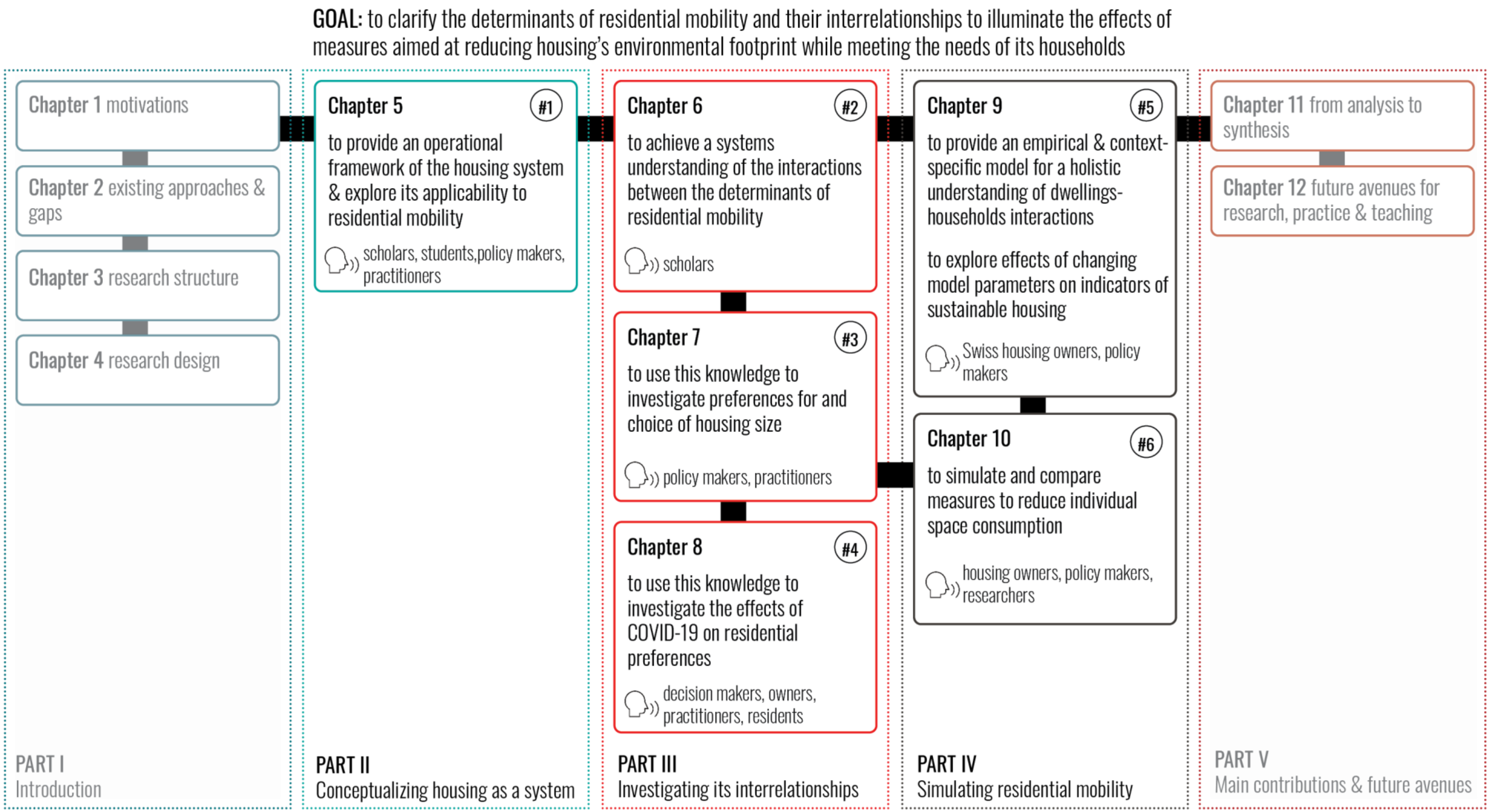
c) *Which measures are the most successful in reducing floor space per capita?*

These gap, objectives and research questions are addressed in **Part IV**, which is divided into two chapters. **Chapter 9** contains the pre-print of **Manuscript #5**, ‘ReMoTe-S. Residential Mobility of Tenants in Switzerland: an agent-based model’, which aims to achieve Objective 3a and 3b and respond to Research questions 3a and 3b. The paper outlines an approach for modelling the recursive effects between households and dwellings based on the explicit empirically-based assumptions formulated in Chapter 6. The utility of the resulting agent-based model is illustrated through two applications, which explore the effects of changing qualitative and quantitative dwelling features on several indicators of housing sustainability. The model is addressed in particular to Swiss property owners and policy-makers, who need to formulate measures based on a holistic understanding of the complex and context-specific system articulating the match between households’ preferences and the dwellings available to them.

Chapter 10 contains the pre-print of **Manuscript #6**, ‘Shrinking housing’s size: Using agent-based modelling to explore measures for a reduction of floor area per capita’, which fulfils objective 3c and tackles the corresponding Research question 3c. This conference paper uses the model introduced in Manuscript #5 to investigate measures for a reduction of floor space per capita, one of the major drivers of energy consumption in housing. While the manuscript mainly targets housing owners and policy makers, it suggests additional work to be carried out by researchers.

By feeding into each other, the three sections contribute to the overall objective of this thesis, which is to clarify the determinants of residential mobility and their interrelations to illuminate the effects of housing sustainability measures, focusing on the housing function as key orchestrator of the system under study.

Figure 3.1. The structure of the thesis. Emphasis is put on the results sections. The circles indicate the manuscripts number. The colour code refers to the sections of this thesis. The black lines show the interconnections between chapters.



4
Research design

Typically, the description of the research design would start by illustrating the researcher's worldview (Crotty, 1998); it would clarify her epistemological and ontological positions, which influence the choice of methodology that, in turn, delimits the range of methods to choose from (Audouin, 2019, p. 65). This chapter instead follows an atypical flow, resulting from the framing of the doctoral thesis within a larger research project that required the coordination and integration of inter- and transdisciplinary contributions, thereby limiting the freedom of choice of methods. It therefore begins with a summary of the objectives and structure of the research project in which this thesis was embedded (i.e. *research context*). This contextualisation is followed by a description of the *research approach* adopted in the project, where differences between the epistemological positioning of the research project and the thesis are rendered transparent. The last subchapter details the sequence of methods used to achieve both the project and thesis goals (i.e. *research strategy*).

4.1 Research context

The majority of the empirical research conducted for this thesis was embedded in the research project entitled "*Shrinking Housing's Environmental Footprint (SHEF)*", financed by the National Research Programme 73 "Sustainable Economy: resource-friendly, future-oriented, innovative" (NRP73). The goal of National Research Programmes is to help to "deliver scientifically proven solutions to Switzerland's most pressing problems."[11] Interdisciplinary and transdisciplinary, NRPs comprise several projects bringing together scientific partners with collaboration and implementation partners from practice. Knowledge transfer and the communication of results are highly valued and happen at several scales, i.e. among research partners, between research projects, with the NRP Steering Committee (composed by policy-makers, practitioners, scholars), as well as with the larger public. Outputs are disseminated via multiple channels such as scientific open-access publications, reports, but also in the process of knowledge production (e.g. workshops, group discussions, surveys), thereby supporting cross-fertilisation.

[11] A description of NRPs is available here: https://www.snf.ch/en/ELxP53n5RBBa08a2/funding/programmes/national-research-programmes-nrp. Accessed 20.08.2021

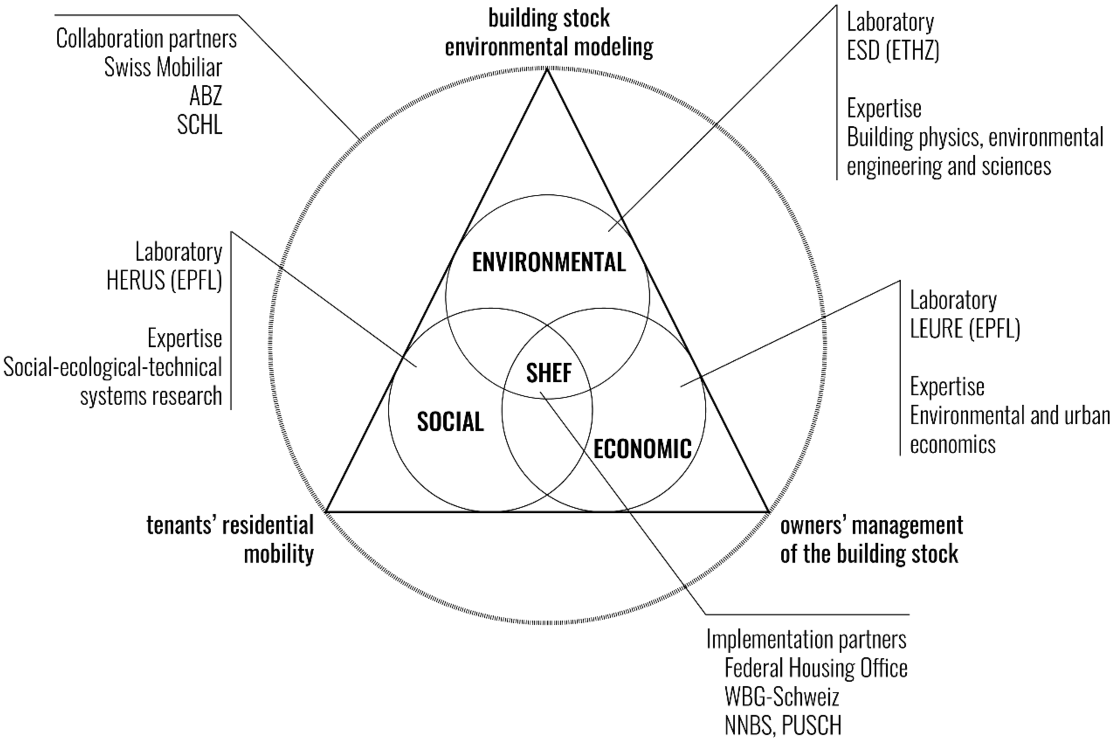


Figure 4.1. The project Shrinking Housing's Environmental Footprint (SHEF) brought together three dimensions of housing's sustainability, investigated by three laboratories with different expertise. The regular exchange with collaboration partners allowed to gather and share qualitative and quantitative data on owners, tenants and the building stock. In addition to these actors, the implementation partners played an important role in achieving SHEF's goal, i.e. to develop measures to shrink housing's environmental footprint.

The Federal Council mandated the Swiss National Science Foundation to carry out the National Research Programme 73 in spring 2016, with the goal to conduct research that "takes account of all natural resources and stages of the value chain and adopts a holistic view of the environment, the economy and society."[12] Under this umbrella, SHEF project aimed to identify and promote practical measures that dwellers, property owners and public authorities could implement to reduce the environmental footprint of housing while preserving its social and economic qualities. For this purpose, the project involved three research groups from two Swiss universities: (i) the Laboratory of Environmental and Urban Economics (LEURE, EPFL), which used its economic expertise to study the decision of housing owners to refurbish, demolish and construct buildings and dwellings (i.e. economic perspective); (ii) the Laboratory on Human-Environment Relations in Urban Systems (HERUS, EPFL), which used its knowledge of social-ecological-technical systems to investigate the residential decisions of tenants regarding when and where to move (i.e. social perspective); and lastly the Chair of Ecological Systems Design (ESD, ETH Zürich), which, based on its building physics, environmental engineering and sciences expertise, was in charge of the environmental modelling of the building stock (i.e. environmental perspective; Figure 4.1). Focus was put on Swiss multifamily rental housing, and in particular the housing stock of three *collaboration partners*: the insurance company and institutional property owner Swiss Mobiliar (Schweizer Mobiliar Asset Management AG), along with two of the country's largest housing cooperatives—ABZ (Allgemeine Baugenossenschaft Zürich) and SCHL (Société Coopérative

[12] The website of the NRP73 can be accessed at the following link: http://www.nfp73.ch/en. Accessed 20.08.2021

d'Habitation Lausanne). These housing owners manage approximatively 10,000 dwellings: 3,500 across the country (Swiss Mobiliar), 5,000 in the canton of Zurich (ABZ) and 2,100 in the canton of Vaud (SCHL).[13] This partnership played a key role across the entire research process starting from the study design, where housing owners discussed together with researchers on e.g. the need of the project, the type of data useful for their decision-making process, as well as ideas for workshops, survey and other methods. In particular, on the researchers' side, working with practitioners implied having access to qualitative and quantitative data on the building stock as well as on the housing actors (owners, tenants), their values, priorities, and decisions. On the partners' side, the regular meetings with the research team allowed them to gain insights on their tenants (e.g., preferences, characteristics) as well as their and others' building stock (e.g. management, environmental footprint). This mutual support was enriched by the collaboration with *implementation partners* such as the Federal Housing Office at the national level, the Swiss association of housing cooperatives at the housing-owner level (Wohnbaugenossenschaften Schweiz / Coopératives d'habitation Suisse WBG-Schweiz), as well as two non-profit organisations concerned with sustainable construction and training (Sustainable construction network Switzerland NNBS, Praktischer Umweltschutz Schweiz PUSCH). The implementation partners played an important role in the elaboration of visions for the future of housing and in the discussion of associated measures to achieve them.

The economic, social and environmental research contributions, the collaboration partners' data and feedback, and the implementation partners' expertise were integrated by means of an agent-based model (ABM). The ABM paired three models simulating households' residential mobility (including their life course and residential preferences), the life cycle of dwellings (e.g. construction, demolition), and the associated footprints (e.g. material, energy). This combination allowed for the exploration and assessment of measures to increase space, building and equipment efficiency while making their impacts on comfort, costs or resources transparent (see Appendix D).

To coordinate such an ambitious project, the research had to be carefully designed to integrate social science with natural science and engineering methods, leaving a narrower margin of manoeuvre to the design of the individual investigations. Nevertheless, the research approach, epistemology and theoretical perspective adopted in this thesis were consciously chosen, as the next subchapter explicates.

Box 4. The Swiss Corona Citizen Science project

One of the investigations that contributed to the overall goal of this thesis was conducted outside of SHEF, in the framework of the project "Swiss Corona Citizen Science." The project was initiated right after the first measures to reduce the spread of COVID-19 were taken by the Swiss Confederation, in March 2020, and ended shortly after their easing, in June 2020. The research team was composed of four groups—i.e. the Laboratory on Human-Environment Relations in Urban Systems (HERUS), the Laboratory of Urban Sociology (LASUR) and the Idiap Research Institute at the École Polytechnique Fédérale de Lausanne (EPFL), as well as the Institute of Psychology at the University of Lausanne (UNIL). The project pursued three main goals from three different perspectives: from a

[13] The project description is available here: http://www.nfp73.ch/en/projects/building-construction/ecological-footprint-in-the-housing-sector. Accessed 20.08.2021

scientific perspective, to investigate how different Swiss residents' groups experienced and coped with the COVID-19 crisis; from a *citizen perspective*, to discuss and develop a reflexive relationship towards one's situation, and access to existing support tools to navigate the crisis; from a *collective perspective*, to enable mutual learning and co-produce strategies to cope with present and future crises. To achieve these goals, the study consisted of four research components: a country-wide survey, semi-structured interviews, a mobile crowdsourcing application, and an interactive citizen science format (i.e. Citizen Think Tanks, CTTs; for details on the mixed method study see Fritz et. al, 2021).

The exceptional circumstances imposed by the spread of the virus brought the conditions of our residential environments to the forefront; I therefore joined the research team during the design of the first component (the survey) to introduce a set of questions evaluating the ideal housing functions for a dwelling pre- and post-pandemic. The notion of function was later taken up during the three CTTs on the future of housing, which I was asked to organise and moderate (see Appendix E; Pagani, Gonzalez, et al., 2020).

4.2 Research approach: from SHEF project to the doctoral thesis

4.2.1 SHEF project

Commonly, scientific research and professional practice is based on ontological frameworks that overlook the complexity of the natural and human-made environment in favour of a "narrow vision of so-called experts [who address] topics isolated from their societal context" (Lawrence & Després, 2004, p. 398). Therefore, the novelty of SHEF project relied in dismantling such obstacles by means of a *systems approach*. According to Bai and colleagues (2016, p. 72), a systems approach is about:

- developing new conceptual models accounting for the dynamic relations in the system;
- using systems tools and simulation models to better understand, explore, and manage the system's complexity;
- integrating and gathering various sources of data (qualitative, quantitative, visual, etc.) in conceptual and simulation models;
- engaging stakeholders in the co-production of knowledge across (interdisciplinary) and beyond sector boundaries (transdisciplinary);
- "thinking explicitly about suites of linked responses rather than singular silver bullets."

As it transpires from this definition, *inter*- and *transdisciplinary* enquires are intertwined with systems thinking (Bai et al., 2016; Lawrence, 2021a; Scholz, 2011). Interdisciplinarity "integrates information, data, methods, tools, concepts, and/or theories from two or more disciplines focused on a complex question, problem, topic, or theme" (National Research Council, 2014, p. 45). Transdisciplinarity (TD), instead, extends beyond scientific knowledge to deal with complex societal problems related to and requiring the knowledge and values of agents from both the scientific and the non-scientific world (e.g. representatives of the private sector, public administrations, non-governmental organizations, citizens; Lawrence, 2010, 2021a; Scholz, 2011).[14]

Typically, three types of knowledge are produced in TD processes: (i) systems knowledge, i.e. how the problem observed originated, developed, and is interpreted; (ii) target knowledge, i.e. the multiple goals desired respective to this problem; (iii) transformation knowledge, i.e. possible means of action to shape the transition from the current to the desired situation (Hadorn et al., 2008; Pohl & Hirsch Hadorn, 2007). Accordingly, SHEF project aimed to produce knowledge about (i) the housing system, including the dynamics of its actors and buildings, (ii) the housing-related desires and needs of and targets set by each stakeholder (including tenants, owners, policy-makers, and scientists), and (iii) the measures to adopt to achieve them.

To generate TD knowledge, the project employed a theoretical perspective known as *pragmatism*. Rather than focusing on ontologies and epistemologies, pragmatism implies the use of all approaches available to help us understand the problem at stake, i.e. to tackle the urgent need to reduce the environmental footprint of Swiss housing (Audouin, 2019; Creswell, 2009, p. 10). This perspective opens the door to “multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis” (Creswell, 2009, p. 11), thereby meeting the project’s need to reconcile the epistemological positioning of each researcher.

4.2.2 The thesis

As illustrated by Figure 4.1, the structure of SHEF could have accommodated three *disciplinary* scientific investigations (e.g. in environmental engineering, economics, sociology), each contributing to the production of shared outcomes (e.g. the agent-based model) to meet the project common goal. This choice would have resulted in three ‘disciplinary’ doctoral researches located in an ‘inter- and transdisciplinary’ project. Instead, like a nesting doll, this doctoral thesis contributed to the ‘social’ (or rather ‘sociocultural’) project component by following a *systems approach*.

However, while the larger project had to balance the stances of natural and social scientists, this thesis explicitly predilected the need to *understand* over the one to *predict*, i.e. the epistemic position known as constructivism. Accordingly, it viewed residential mobility and its effects on sustainability as processes emerging from the way households handle practical problems in their realities; furthermore, it considered the multiplicity of perspectives on these realities (e.g. of tenants, owners, scholars as well as ourselves); lastly, it acknowledged that knowledge production is about constituting realities in which the producer of knowledge is situated and embodied, and facts and values cannot be separated (Charmaz, 2009).

In line with this positioning, the purpose of the research methods was reshaped when needed. Furthermore, emphasis was put on the relevance of the context in which research was conducted, and therefore on the empirical assumptions on which it was based, and the consequent lack of

[14] For a reflection over the development of transdisciplinary, multiagency, and multi-context programmes, see the publication produced in the framework of the programme ‘*Complex Urban Systems for Sustainability and Health (CUSSH)*’, which aimed to enable city decision-makers to select and implement optimal actions for sustainability and health (Osrin et al., 2021). Another interesting example of an interdisciplinary action research project on housing is ‘*INVESTIMMO: A decision- making tool for long-term efficient investment strategies in housing maintenance and refurbishment*’, which was conducted under the EU-FP5 Competitive and Sustainable Growth Programme from 2001 to 2004. Among other outputs, the project delivered a simulation tool that architects, engineers, investors, property owners and local authorities could use in decision-making processes regarding when, where and how to invest in the maintenance and refurbishment of housing (Lawrence, 2009). For more details, see https://cordis.europa.eu/project/id/G1RD-CT-2000-00371. Accessed 24.08.2021

generalisability of its results. Overall, while responding to the need to systematize knowledge and generate and test hypotheses, this thesis attempted to acknowledge the reductionist nature of the proposed models, emphasising that multiple realities and indeterminacy exist (Charmaz, 2006).

4.3 Research strategy

In line with the systems, inter- and transdisciplinary approach and the pragmatic perspective outlined in the previous subchapter, the research conducted in this thesis followed a mixed methods strategy of inquiry. Also defined as 'integrated', mixed methods research "involves the use of [qualitative and quantitative] approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative research" (Creswell, 2009, p. 4). This strategy made it possible to explore, via several research methods, the suitability of systems concepts for the study of residential mobility. In addition, the diversity of empirical data was relevant to address the gap in context-specific knowledge on the determinants of residential mobility of Swiss cooperative and non-cooperative tenants. Lastly, the methods adopted sometimes served diverse project purposes; for instance, the survey was also used to gather missing data relevant for other SHEF researchers.

Qualitative and quantitative data were gathered and integrated *sequentially*, meaning that the variables explored in the previous step were used as a base for studying the following one. A desk research was first conducted on the housing system, which was synthetised in a framework allowing for the identification of the systems components and interactions (i.e. function, behaviour and structure; Step 1). The framework's applicability to the study of residential mobility was then explored during two small group discussions involving the tenants of our project partners in Zurich (N= 8) and Lausanne (N = 10; Step 2). The qualitative exploration served to elaborate the questionnaire of the tenants' survey (N = 878; Step 3). The analyses of survey data were used to build the skeleton of and feed the agent-based model, as well as to define the measures to simulate (Step 4). In addition, building upon the findings of Step 3 and with the goal to respond to the exceptional circumstances posed by the spread of the COVID-19, a survey was conducted in the framework of the Swiss Corona Citizen Science project (N = 5378; Box 4; Step 5). Figure 4.2 provides an overview of this sequential logic, including the methods and the outputs.

In the following, we concisely describe each of the methods adopted. We focus specifically on its purpose from a scientific and non-scientific perspective (i.e. lay-people; e.g. owners, tenants), on the outputs produced, and on the researcher's *a priori*—as part of the constructivist paradigm and the related need to render explicit one's positionality and the motivations that guide the investigations. A rich illustration of the methods of data collection and analysis can be found in the "materials and methods" section in each manuscript under Part II, Part III and Part IV. Each step that involved the interaction with or the data collection on humans was designed respecting the basic principles of research ethics, and received approval by the Human Research Ethics Committee (HREC) at EPFL.[15]

[15] A description of the HREC can be found at the following link: https://www.epfl.ch/research/ethic-statement/human-research-ethics-committee/. Accessed 26.08.2021

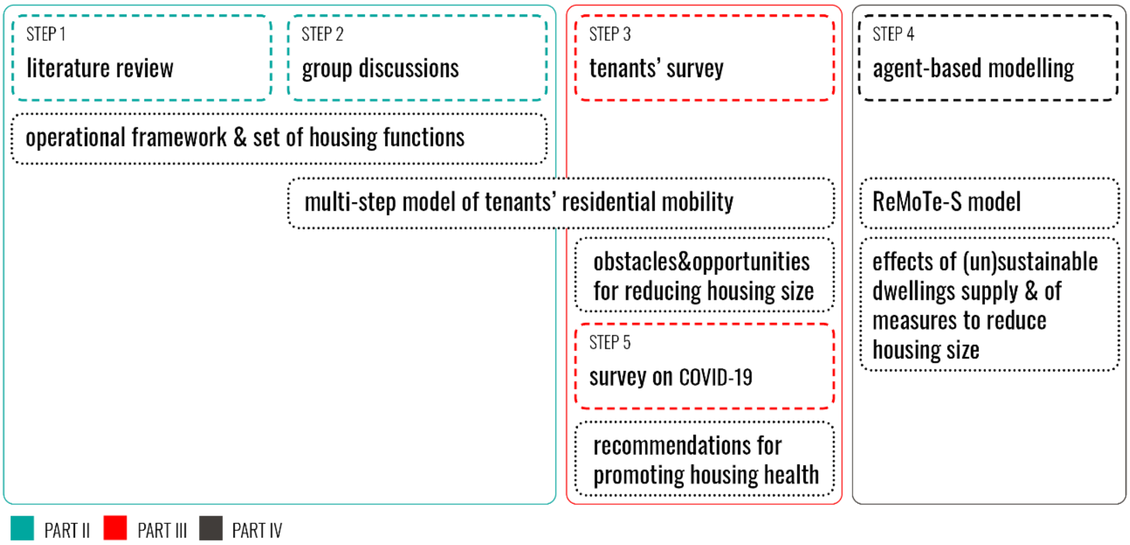


Figure 4.2. Research procedure. Dashed lines indicate the research methods whilst the outputs are in dotted lines. Colours refer to the sections of the thesis in which the outputs are organised.

Step 1. Qualitative literature review

Purpose (scientific): Conceptualise the housing system using systems science terminology and identify the system's components (i.e. elements, structure, function, behaviour) with the goal to achieve an enhanced understanding of the interactions between residential preferences and dwelling forms.

Purpose (non-scientific): Provide housing stakeholders with an inclusive and holistic vocabulary to redefine and design a socioculturally and environmentally sustainable housing system.

Output: An operational framework of the housing system, including a set of housing functions and examples of possible behaviours of the material and human subsystems.

A priori: The choice of keywords in the search, the languages of the reviewed publications, the geographical areas screened were all influenced by my background in architecture, my interest for social sciences and anthropology, and by my Western education and spoken languages. In particular, having carried out my Master thesis on the relationship between collective memory and housing heritage protection, the qualitative research was influenced by my knowledge of the role played by memory and meanings in housing, which oriented the investigation towards the exploration of the subjective and collective meaning of housing, house, home, and dwelling.

Full description: Part II, Chapter 5

Step 2. Qualitative exploratory group discussions

Purpose (scientific): (i) explore the determinants of the decision to move and to select a dwelling among a small sample of the tenants of the three project partners; (ii) investigate the credibility of the housing functions and, subsequently, their utility for the study of the relocation process; (iii) support the formulation of the survey questionnaire (Step 3).

Purpose (non-scientific): Provide owners with a first picture of the preferences and needs of their tenants, beyond financial criteria. Inform participants about the project and stimulate reflection upon their own housing choices.

Output: A set of hypotheses on the relationships between housing functions, the determinants to move and to select a dwelling, and tenants' residential satisfaction.

A priori: The discussion was guided by questionnaires, which served to formulate (for the tenant) and collect (for the researcher) first individual reflections and guide the following group discussion. Questions were based on previously-acquired knowledge on residential mobility, which framed the discussion, e.g. we followed the assumption that the decision process consisted of two steps (i.e. the decision to move and the one to select a dwelling). Furthermore, the framework's applicability to the study of residential mobility was explored by providing the set of housing functions as identified in Step 1, rather than by gathering data on meanings and inductively evaluating the pre-defined set of functions.

Full description: Part II, Chapter 5

Additional material: Group discussion questionnaire (Appendix A; the German version and the detailed reports and analyses are available upon request).

Step 3. Tenants' survey on residential mobility

Purpose (scientific): Gather information on the preferences and residential mobility criteria of the tenants of the three project partners. More specifically, (i) explore the hypotheses laid down in Step 2 with the intent to formulate a set of assumptions for the agent-based model (Step 4); (ii) use the dataset to investigate households' choices related to housing size.

Purpose (non-scientific): Provide the owners with a better picture of their occupants' preferences and related housing sustainability issues (e.g. floor area per capita); raise the respondents' awareness on their residential decisions, including the relevance of sustainability criteria in their choice and the sustainability features available in their dwellings.

Output: A quantified multi-step model of tenants' residential mobility; a set of obstacles and opportunities for reducing housing size.

A priori: The survey questionnaire was constructed based on the framework developed in Step 1 and the hypotheses derived from the group discussions in Step 2, therefore inheriting their *a priori*.

Full description: Part III, Chapter 6 and Chapter 7

Additional material: Survey questionnaire (Appendix B); three reports for our collaboration partners (Appendix C).

Step 4. Agent-based modelling

Purpose (scientific): Design an empirically-based and context-specific agent-based model of the residential mobility of a subpopulation of Swiss tenants renting from three housing owners; explore the sensitivity of the model outputs to changes in targeted parameters.

Purpose (non-scientific): Provide a tool to learn about, assess, and discuss emerging effects of measures to achieve sustainability, understood in its environmental and sociocultural dimensions.

Output: ReMoTe-S, an agent-based model of the residential mobility of tenants in Switzerland; assessment of the effects of (un)sustainable housing supply and of measures aimed at shrinking housing's environmental footprint via household- and dwelling-related indicators.

A priori: The assumptions underlying the model design and the measures simulated were based on the findings of Step 3, therefore inheriting its *a priori*. Moreover, the model was developed according to a constructivist (i.e. learning, understanding) instead of a deterministic (i.e. predicting) stance; this choice was made transparent when discussing its validity and goal.

Full description: Part IV, Chapter 9 and Chapter 10

Additional material: ODD protocol, which describes the model into detail.[16]

Step 5. Survey on COVID-19[17]

Purpose (scientific): Explore how the first wave of COVID-19 affected residents and their environment.

Purpose (non-scientific): Simulate participant's reflection on their residential situation, i.e. their desires regarding their pre- and post-pandemic dwelling.

Output: Recommendations for the provision of housing that ensures the health and well-being of its residents; content to be used as a base for the Citizens Think Tanks on housing.

A priori: The questions on housing functions were added in a pre-structured survey and based on the findings of Step 1, 2 and 3, therefore inheriting their biases.

Full description: Part III, Chapter 8

Additional material: Scientific publication on the project's mixed method design (Fritz et al., 2021); report on the CTTs on housing (Pagani, Gonzalez, et al., 2020; see Appendix E).

[16] The protocol is available from CoMSES OpenABM at this link: https://www.comses.net/codebase-release/45117bff-8627-4ab9-a4e4-bb26e79a662e/

[17] N.B. As my contribution to the survey design was limited to a set of questions, the description does not refer to the full survey purpose and outputs but to the items used in our analysis (see Box 4).

PART II

Conceptualising housing as a system: the application of universal principles

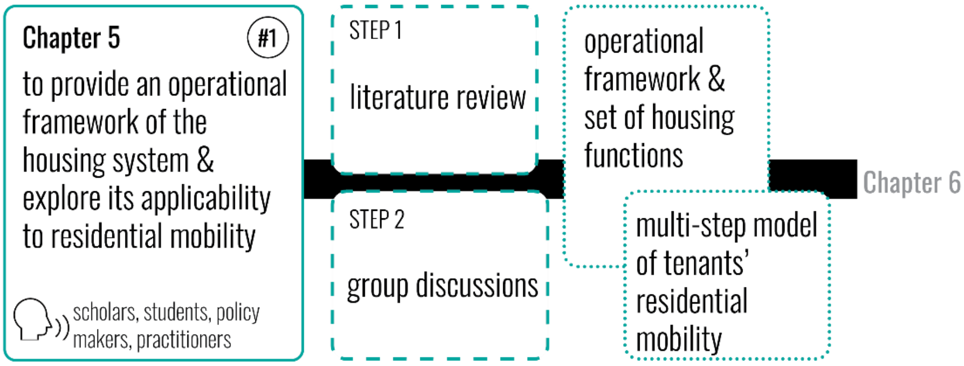


Figure II. The content of Part II. The full-lined box summarises the goal of the manuscript (#) and the audience to whom its results are addressed. Dashed lines indicate the methods used as described in the research design. Dotted lines highlight the research outputs.

5

A systems perspective for residential preferences and dwellings: housing functions and their role in Swiss residential mobility

Authors: Pagani, A., & Binder, C. R.

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Contributions: A.P. performed the literature review, designed and conducted the group discussions, analysed the qualitative data and wrote the paper (original draft, review and editing). C.R.B. supervised the work, contributed to the elaboration of the conceptual and operational framework of the housing system, provided support in the organisation and implementation of the empirical study and critically revised the manuscript.

Abstract

Worldwide, there is an urgent imperative to provide a housing supply that is environmentally sustainable as well as acceptable and desirable for its users. A holistic and integrative understanding of the relationship between households' residential preferences and dwellings is needed to achieve this goal. This paper addresses this gap by conceptualizing and operationalizing housing as a system whose human and material behaviours are determined by its function. Following a qualitative literature review to identify what housing functions are and investigate their effects on the housing system, we explore the applicability of such functions in Swiss tenants' residential mobility. Results show that multiple functions co-exist in the housing realm, each of which determines various human (i.e. residential preferences) and material (i.e. dwelling forms) behaviours that vary according to given societal and environmental structural elements (e.g. geography, culture). We also observe that housing functions potentially provide the missing link between the determinants of tenants' residential mobility.

Keywords:

Housing system, housing function, residential preferences

5.1 Introduction

Sustainability is a core issue of current societal debates, which necessarily extend to housing studies and architecture. Although numerous countries are working to reduce energy consumption and CO_2 emissions in the residential sector, there is an urgent imperative to considerably increase 'appropriate' or 'adequate' housing supply to meet the needs of its current and future inhabitants (Acioly & Horwood, 2011; Lucon et al., 2014). A built environment that is appropriate—or congruent with and supportive of the culture, values and needs of users (Franklin, 2001; Rapoport, 1977)—has long been considered a key determinant of households' quality of life (Acioly & Horwood, 2011).

Notwithstanding their relevance, considerations of the private realm of the dwelling and its liveability have often been omitted from the sustainability debate (Franklin, 2001). This oversight is of particular importance inasmuch as what practitioners or researchers define as adequate may be not satisfactory from inhabitants' perspectives (Onibokun, 1974). Moreover, although this shortcoming was clearly identified in Europe and America in the 1960s and 1970s (e.g. Turner, 1976), the mismatch between housing stock and households' preferences has continued to increase over the last three decades (Lawrence, 2012b, 2014). In most industrialized countries, this situation has been exacerbated by phenomena such as population ageing, labour market globalization and increasing mobility, which have not been translated into the provision of more diverse kinds of housing units (Lawrence, 2014).

In this context, only a minority of architects have demonstrated concerns about the growing gap between buildings and their users (Franklin, 2001). The apparent lack of interest in the ways in which people use space and the progressive 'dismissal of housing from the mainstream concern of architecture' have been compensated by contributions of disciplines not involved in the design and planning of space (Franklin, 2001, p. 86).

Interest in the relationship between people, place and space rose in the late 1960s in the US, where researchers in people–environment studies, also known as environment–behaviour studies, adopted a cross-cultural approach to explore interactions between people and their environments (Franklin, 2001, 2006; Lawrence, 2012b). Such scholars acknowledged the urgency to better understand the 'sociophysical relations and processes' that structure the built environment (Studer & Vliet, 1987, p. 166).

Despite the abundant publications on the topic, the convergence of interests on and discourses about the relationships between the design, interpretation and experience of the physical forms of housing in an integrative and holistic conceptual framework has yet to be achieved (Franklin, 2006). As an appropriate research methodology for accomplishing this type of study has long been sought, a new perspective can be offered through the adoption of a *systems perspective*.

Systems science is a metascience that provides a 'somewhat unique mode of inquiry in revealing […] how all kinds of systems work' (Mobus & Kalton, 2015, p. 3). Often overlooked by housing researchers and practitioners, the application of systems science lenses can bring about a comprehensive view on how residential preferences and dwellings influence each other. In order to achieve this new understanding, systems terminology and concepts have to be introduced to housing studies, people–environment studies and architecture. More specifically, attention has to be brought to the *function* of the housing system for its role as a primary determinant of the system's behaviour (Meadows, 2008).

In this paper, we introduce an operational framework to grasp the complex interactions between residential preferences and dwellings. We adopt a systems perspective in order to focus on the role of the housing system's *function* in determining how the system behaves. To exemplify a potential application of the proposed framework, we explore the role of housing functions in influencing residential mobility in Switzerland. More specifically, this paper addresses the following research question:

How does the concept of housing function contribute to the understanding of the relationship between residential preferences and dwellings?

To provide an answer to this question, we proceed as follows. We first introduce our theoretical framework, including our conceptualization of the housing system and the theoretical and geographical context of our exploratory study. Secondly, we describe the methods and materials used to conduct this research. Thirdly, we structure the findings in two parts. In the first part, we use our conceptualization of the housing system as a basis for the identification and classification of nine different housing functions. In the second part, we advance a set of hypotheses on the roles these functions play in households' decisions to move and select new dwellings based on an analysis of two exploratory group discussions with tenants in Lausanne and Zurich. Finally, we critically review the results and discuss their contribution to research and their implications for practice.

5.2 Theoretical framework

5.2.1 Housing, households and systems

The interdisciplinary field of systems research reached the built environment in the 1970s. Early conceptualisations of housing processes described them as subsystems of the larger environmental system that result from the interaction of people and products (i.e. systems elements) through the medium of roles and responsibilities (i.e. interrelationships; Turner, 1976). According to Rapoport (1990), these subsystems form the primary anchor for the household and provide primary *functions* (Coolen, 2006).

These systems-based conceptualizations have been criticized for overlooking a key structural component: the social organizations and institutions that influence the system (Franklin, 2006)f. Although housing was defined as a 'socio-spatial system' that merged the physical unit and the social unit, the latter was predominantly understood as being comprised only of the household (Saunders & Williams, 1988). Applying Giddens's structuration theory (1984), Binder (2007) introduced a framework for the analysis of human–environment systems that accounts for the interaction between human action, the natural and technical environments, and the social structure encompassing legislative, cultural and economic systems (i.e. 'rules' and 'resources').

Merging these findings, housing can be conceptualized as a subsystem of the coupled societal and environmental system (i.e. supersystems). The former comprises such aspects as the housing market, its culture, and construction techniques, whereas the latter includes, for instance, geographical location and local materials. At the heart of the micro-level are the material and human subsystems, which are in turn structured by elements such as dwelling features (e.g. size) and the residential biography or life course trajectory of a household (Mulder & Hooimeijer, 1999).

Table 5.1. Systems science terminology and definitions, and examples of their relevance to housing.

Terminology	Definition	Relevant to housing (examples)		SRC
System	'[…] interconnected set of elements that is coherently organized in a way that achieves something.'	Housing system		[1]
Structure	Elements and interrelationships	Macro-level (supersystem)	Societal, environmental (e.g. market, geography)	[2]
		Micro-level (subsystem)	Human, material (e.g. residential biography, dwelling size)	
		Inter-relationships	Across and within levels (e.g. society-human, human-material)	
Behaviour	Attributes that result from the structure variables	Human subsystem: residential preferences		[2]
		Material subsystem: dwelling forms		
Function, sub-functions	Teleology of the system	Supersystem: meaning		[2]
		Housing system: range of social and personal functions		
Boundary	'[…] permeable for inputs from and outputs to the environment. It defines the system's identity and autonomy.'	Encompasses dwelling, neighbourhood, relative location		[3]

Sources of definitions (SRC) 1. Meadows (2008, p. 11); 2. Gero & Kannengiesser (2004); 3. Bossel (1999, p. 20).

These systems interact with each other at both the micro- and macro-levels and provide feedback across levels. For instance, a feedback relationship exists between society at large and individual needs, desires and motives (Gauvain & Altman, 1982). Households' preferences are also interlinked with the structural formal properties of housing through decision-making rules (e.g. the decision to move to a dwelling) and processes (e.g. design, construction and use of domestic spaces; Lawrence, 2012; Rapoport, 2000). This 'material reality' is determined by the technologies and materials available in a given environment (Table 5.1, Figure 5.1).

To fully conceptualize the housing system, it is not sufficient to solely consider its subsystems, their elements, or interconnections; rather, its function must also be understood (Meadows, 2008). The function of an object is its teleology (i.e. *what is the object for*?): it determines how the system behaves or manifests itself (i.e. *what it does*) and the structure that allows the behaviour to happen (i.e. *what it is*; Figure 5.1; Gero & Kannengiesser, 2004, p. 374; Meadows, 2008).

As systems can be nested within other systems, there can be sub-functions within functions (Meadows, 2008). While 'meaning' has been identified as the most important function of the built environment (Rapoport, 1988), multiple (and sometimes conflictual) social and personal functions can be fulfilled by and give meaning to a dwelling (Lawrence, 1987b, 2012b).

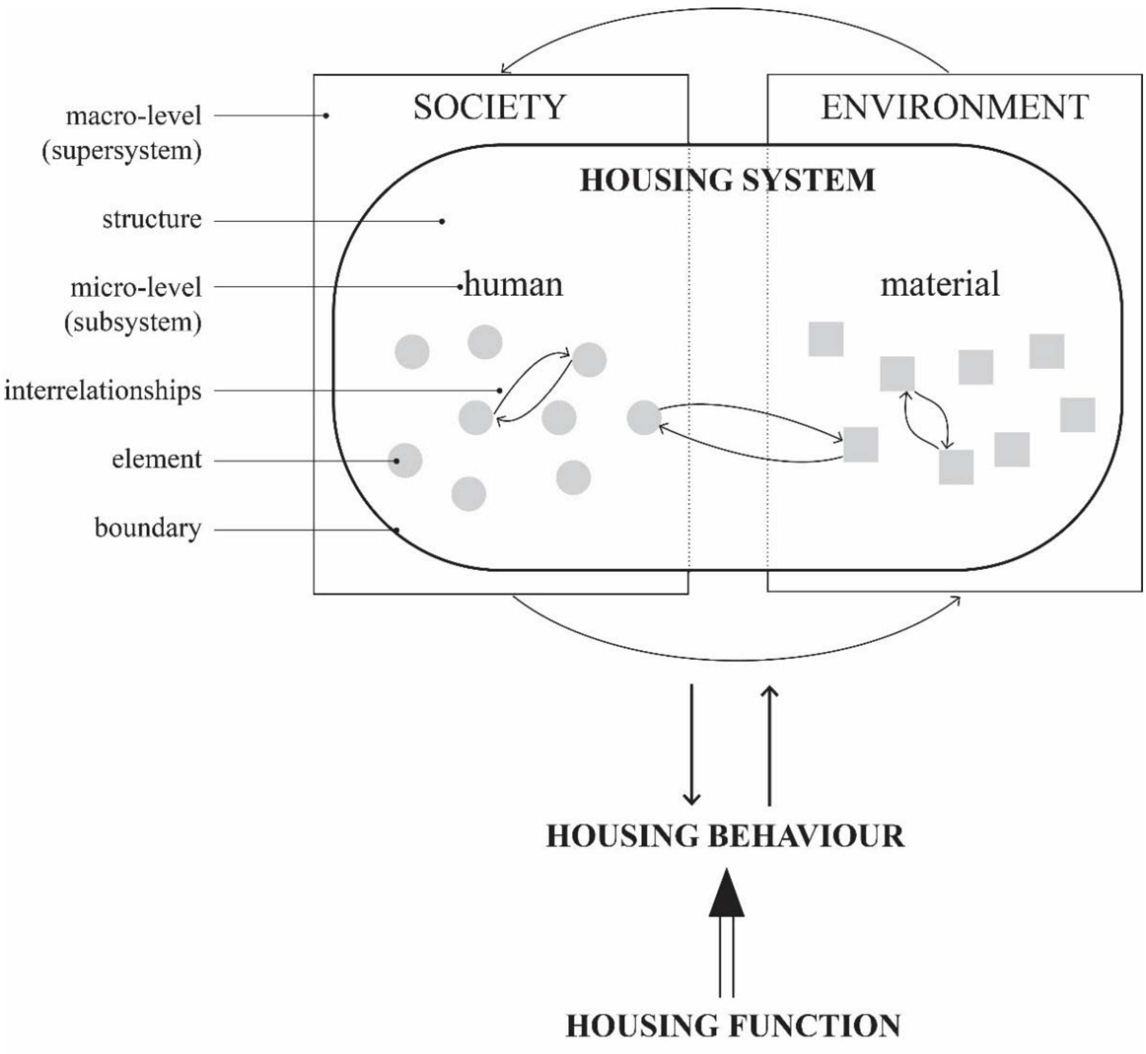

Figure 5.1. A framework for the housing system. The function of the system determines its behaviour, which is exhibited by and brings about the structure's configuration. This structure comprises at the macro-level the societal and environmental supersystems and at the micro-level the human and material subsystems. Super- and subsystems interact with each other between and across levels. Feedbacks between the micro- and macro-level are not represented.

Despite extensive uses of the concept, a systems analysis to identify housing functions and understand how they relate to residential preferences and dwellings (i.e. systems behaviour) is absent in the literature and needs further investigation.

By enabling identification of the deep meanings that influence households' residential strategies, the field of residential mobility offers ideal ground for exemplifying the findings of such analysis (Lawrence, 2009).

5.2.2 Residential mobility

Residential mobility has been studied by a broad range of scholars. Researchers have advanced varying conceptualizations of the relocation process, many of which share the assumption that the individual first decides to move and then chooses where to relocate (i.e. the two-stage choice approach; Brown & Moore, 1970; Clark & Onaka, 1983; Mulder, 1996; Mulder & Hooimeijer, 1999; Rossi, 1980). Two terms are commonly used to define the factors that determine these decisions, namely *push* and *pull factors* (Hasu, 2018; Moon, 1995). Several studies have investigated the extent to which these factors are mediated by the concept of residential *satisfaction* (Lu, 1998). To illustrate the conceptualization of residential mobility adopted in this paper, below, we provide a concise overview of these three concepts and introduce the assumptions formulated on their relationships with housing functions.

Push factors are the determinants for a household to move. Also defined as 'triggers', they comprise a plurality of micro- and macro-level factors, which can arise from the environment as well as the educational, labour, family, or housing life-course trajectory of a given household (Brown & Moore, 1970; Clark & Onaka, 1983; Mulder, 1996; Mulder & Hooimeijer, 1999; Rossi, 1980).

Pull factors are the determinants for selecting a new dwelling. The characteristics of a dwelling, neighbourhood and relative location (i.e., the elements of the material subsystem; Table 5.1) have long been prioritized as categories of pull factors. These features commonly define the building typologies used by practitioners (e.g. 'multi-family residential') or researchers (e.g. sustainability assessments; Berardi, 2012).

Residential *satisfaction* plays a role in both the decision to move and that to select a new dwelling. Findings from previous studies largely cite dissatisfaction with one's dwelling, neighbourhood or location as a motivation for moving (Brown & Moore, 1970; Clark, 2012; Clark & Lisowski, 2017; Mulder, 1996), whereas increasing household residential satisfaction has been widely proposed as the purpose of the move itself (and therefore of the selection; Lu, 1998; Mulder & Hooimeijer, 1999).

However, the relationships between *push factors, pull factors* and *satisfaction* are more complex than is often assumed (Lu, 1998). As observed by Brown & Moore (1970) and confirmed by later empirical research, push factors are not all equally influential and effective in triggering a household move and generally have 'unequal correlations' with how satisfied households are with their dwellings (Clark & Lisowski, 2017; Lu, 1998; Wong, 2002, p. 227). Furthermore, the categories into which dwelling characteristics are grouped are often found to differ from what households perceive as the determinants of their satisfaction (Wong, 2002, p. 231).

Introducing the concept of housing functions to the study of residential mobility may offer keys to disentangle the presented complexity. Previous studies have argued that during the selection process, occupants seek to make the best possible match between where they live and how they want to live (Thomas & Pattaroni, 2012). The former (i.e. 'where') is the current dwelling form, which corresponds to the behaviour of the material subsystem; the latter (i.e. 'how') are the residential preferences for the 'ideal' dwelling, corresponding to the behaviour of the human subsystem. As both are determined by the system's function (Figure 5.1), their match can be translated into the level of correspondence between a household's ideal housing function and that of its current dwelling. Based on this conceptualisation, a system of relationships between housing functions, push and pull factors, and residential satisfaction can be considered and explored.

5.2.3 Housing in Switzerland

Like most other European countries, Switzerland has experienced a significant increase in the mobility of its population in recent decades (Pattaroni, Kaufmann, et al., 2009). This shift is particularly apparent because Switzerland is a country of tenants, who have been demonstrated to be more mobile than owners (Clark, 2012; Dieleman, 2001; Rossi, 1980). In fact, Switzerland has the largest share of tenants among OECD countries (OECD, 2019b). The country's housing market is dominated by rented dwellings belonging to private individuals and companies (i.e.

insurance companies, pension funds, investment funds, etc; see Table 5.2). The large share of rental housing is remarkable considering that the Swiss rent control legislation has been limiting landlords' ability to raise rents and evict tenants at will for the last 80 years.

Over time, a decrease in the number of private landlords—who owned more than two thirds of the housing rental stock in 1990 (Lawrence, 1996)—and an increase in anonymous building owners (e.g. limited liability companies) have led to a greater prevalence of negotiations between stewards, caretakers and tenants at the expense of direct landlord-tenant relations (Lawrence, 1996). At the present stage, it is rare for housing stock builders to take explicit account of residents' aspirations and lifestyles (Lawrence, 2009, p. 201).

Although Swiss rules governing housing tenancy allow little-to-no residential participation in shaping their living environments (Rabinovich, 2009), there are multiple ways of being both tenant and owner. Among these is the housing cooperative system, which is dominated by 'large' or 'open' cooperatives that operate like property developers with a 'social purpose' (Rabinovich, 2009, p. 133). Cooperatives provide rents approximately 20% lower than those in the private rental market (Pattaroni & Marmy, 2016), which is of high importance considering the combination of high rents and a lower than 'natural' vacancy rate in many Swiss cities. In this regard, Lausanne (in the canton of Vaud) and Zurich (in the homonymous canton) evince the worst vacancy rates at 0.4% and 0.1%, respectively, and Zurich has the highest rental prices (Hugentobler, 2017).

In sum, large tenant proportions, increasing mobility rates, and the growing negligence of inhabitants' needs make the Swiss rental market a promising setting for an exploration of the determinants of residential mobility and the application of the operational framework proposed in this study.

Table 5.2. The Swiss housing market.

Occupancy status of dwellings, 2017	**%**
Tenant or sub-tenant	56.5
Cooperative member	2.9
Condominium/apartment owner	12.0
House owner	26
Other	2.6
Type of owners of rented dwellings, 2019	**%**
Private individuals	49.2
Public sector	3.8
Cooperative	8.4
Construction company or real estate agency	6.6
Other joint stock company/limited liability company/corporation	31.8
Other	0.1

Data source: Swiss Federal Statistical Office (FSO).

5.3 Methods

5.3.1 Interdisciplinary literature review

Housing functions

To inform our identification of housing functions, we performed a qualitative literature review of the definitions and meanings of ‘house’ and ‘home’.

Our analysis focused on the interdisciplinary literature of people–environment studies (including architectural psychology, environmental psychology, environment–behaviour studies) and the disciplines contributing to this body of research, namely architecture, sociology, anthropology, psychology, environmental studies, geography, spatial planning, economics, demography, and housing, urban and cultural studies.

To select the most useful publications to define what housing functions are, we followed a three-step procedure. The first step was a meta review aimed at exploring the heterogeneity of meanings attributed to housing and commonly-employed terminologies across disciplines. Searches were conducted in Google Scholar and Web of Science using combinations of keywords covering (i) the object under study (e.g. home, dwelling, house, residential), (ii) its system’s structure and interconnections (e.g. system, culture, decision-making), (iii) its behaviour (e.g. residential preferences), and (iv) its functions (e.g. meaning, use, function; see Table 5.1). In the second step, we followed a snowball sampling approach (Noy, 2008), which entailed the examination of the reference lists of the first set of publications, a manual search of journals, and research of individual authors. The third step was a deep exploration of the functions identified in the two previous steps.

Table 5.3 illustrates the criteria applied for the inclusion and exclusion of publications. As systems science and people–environment studies gathered momentum in the 1950s and 1960s, the earliest publication dates to 1955. The distribution of the sample in time is homogeneous, with 2000 being the average publication year.

By applying the principle of saturation (Onwuegbuzie et al., 2012), 39 publications were eventually selected to define housing functions: 28 journal publications, seven books and four book chapters. This variety of article types was needed to avoid overlooking the publishing traditions in each field. Diversity was also present in terms of thematic foci and geographical regions, although Europe and North America predominated among the latter. Secondary sources (i.e. literature reviews) were also selected, which enlarged the boundaries of our literature search.

The analytical procedure entailed examining and categorizing the literature by applying a synthetic approach for qualitative studies (Fritz & Binder, 2018; Noblit et al., 1988). More specifically, while collecting the material, we first organized information according to author name, his/her discipline, thesis or argument, and assumption(s) (Repko & Szostak, 2016). We then extracted definitions of housing functions, which were considered in light of the question ‘what is housing for?’ (Gero & Kannengiesser, 2004). Lastly, we inductively derived nine definitions of housing functions following an iterative process (analysis, cluster, discussion of the findings; Fritz & Binder, 2018). The obtained definitions were organized in a table.

Table 5.3. Criteria for the inclusion and exclusion of publications.

Criterion for inclusion	Explanation
Disciplinary and topical focus	People–environment studies and constituent disciplines focusing on (i) housing, (ii) its system, (iii) its behaviour, and (iv) its function(s)
Definition of *function* in literature	A function of an object must provide an answer to the question 'what is the object for?' (Gero & Kannengiesser, 2004). We therefore used 'what is housing for?' as the guiding question. In parallel, we explored the behaviour of the housing system, looking for possible answers to the question 'what does housing do?'
Predominant languages	English, French
Time span	1955–2020
Geographical regions	A wide geographical area was covered. A search on the system's behaviour was conducted in relation to specific environmental and social structures.

Adapted from Fritz & Binder (2018).

Housing function-behaviour-structure

Gero's (1990) function-behaviour-structure (FBS) framework was used to investigate the role of the nine housing functions in determining possible human and material behaviours of the housing system (i.e. residential preferences and dwellings) for given societal and environmental structural elements. Developed in the design field, the FBS framework describes 'different aspects of a design object' through its function, behaviour and structure (Gero & Kannengiesser, 2004, p. 374).

5.4 Qualitative exploratory group discussion

To explore the utility of the selected housing functions for the study of Swiss households' residential mobility, we organized two small group discussions with the tenants of three large housing owners: the insurance company and institutional property owner Swiss Mobiliar (Schweizer Mobiliar Asset Management AG), along with two of the country's largest housing cooperatives—ABZ (Allgemeine Baugenossenschaft Zürich) and SCHL (Société Coopérative d'Habitation Lausanne). Collectively, these owners manage approximatively 10,000 dwellings: 3,500 across the country (Mobiliar), 5,000 in the canton of Zurich (ABZ) and 2,100 in the canton of Vaud (SCHL). The two group discussions took place in Lausanne and Zurich.

5.4.1 Sampling and instrumentation

To organize the discussions, we first defined the sample universe, which included all tenants who were not determined to be vulnerable adults or children. Subsidized tenants were also excluded from the sample as, considering that the public rental housing represents a very small share of the Swiss housing market (see Table 5.2), a targeted search would have been needed to get in contact with them.

Table 5.4. Characteristics of the sample.

	Lausanne		Zurich	
	SCHL	Mobiliar	ABZ	Mobiliar
Total	5	5	6	2
Males	2	3	3	1
Females	3	2	3	1
Age range[a]	25 - 65+	26 - 46	40 - 65+	34 - 65+
Tenant since (year)[a]	*missing*	2016 - 2018	*missing*	2016 - 2018
Nationality[b]		IT, CH, PL, PO, UK		CH

[a] Only data for Mobiliar tenants were accessible; the age range for the cooperatives is an approximation.
[b] Abbreviations refer to official ISO Country Codes.

Not aiming for representativeness, we adopted a convenience sampling strategy and sourced the samples accordingly (Patton, 1980; Robinson, 2014).[18] We obtained a total of ten participants in Lausanne and eight in Zurich (Table 5.4).

Compared to Lausanne, Zurich offered a different dataset characterized by tenants of higher age, coming predominantly from housing cooperative systems, and living in a distinct language region (French versus German-speaking part of Switzerland).

We structured the content of the discussions around the following five themes:

1. Push factors – exploration of reasons for leaving the former dwelling, including the level of satisfaction prior to the trigger (open-ended questions);
2. Housing functions – ranking of the nine housing functions; match between current and ideal function at the time of the move (yes/no); change in housing function between former and current dwelling (yes/no);
3. Dwelling characteristics – comparison between the characteristics of the household's former and current dwelling (open-ended questions);
4. Pull factors – exploration of reasons for choosing the current dwelling (open-ended questions); and
5. Lessons learnt during the discussion – change in opinion, feedback gathering.

Concerning point 2, tenants were asked to rank the housing functions from 1 (most important) to 9 (least important) depending on the extent to which their current dwelling fit the description provided by the researchers. If one or more functions were equivalent, they could be accorded the same rank. If one or more did not apply to their dwelling, it/they could be discarded.

5.4.2 Analysis

The analysis was carried out in two steps. We explored first whether the housing functions derived from the literature were 'credible'. Based on tenants' rankings, we performed word counting and organized the functions in a table. The table columns indicated the amount of times the functions were ranked as the first, second and third most important (#1-2-3) or as the seventh, eighth, ninth,

[18] An agreement on the data to collect was established with the three housing owners, their technical administrations, and the Human Research Ethics Committee (HREC) of the École Polytechnique Fédérale de Lausanne (EPFL).

and 'not mentioned' (#7-8-9-0). We then organized the functions according to descending values of #1-2-3 and ascending values of #7-8-9-0.

Secondly, we investigated potential interrelationships between functions, push and pull factors, and residential satisfaction. The collected data were extracted, condensed and summarized. We constructed codes using English keywords from data gathered in the first group discussion, which provided the basis for qualitative tables designed for the analysis of both group discussions. The analysis and interpretation of the first discussion was then enriched with the results from the second. We used data display to draw descriptive conclusions (Miles & Huberman, 1994). More specifically, we systematically presented the data for the purpose of comparison and pattern recognition with the help of two matrices: a checklist matrix and a thematic conceptual matrix. The checklist matrix, which 'includes several components of a single, coherent variable' (Miles & Huberman, 1994, p. 105), was used to illustrate the diversity of determinants of participants' decisions to move and choose new dwellings. Based on patterns observed in the checklist matrix, we clustered the data first according to categories of tenants' residential satisfaction with the former dwelling and second according to trigger types. The resulting thematic conceptual matrix was key to drawing and displaying hypotheses on the relationship between housing functions, push and pull factors, and tenants' levels of satisfaction with the dwelling.

5.5 Findings

5.5.1 Housing functions in the housing system

5.5.2 Nine housing functions

The nine housing functions identified from the literature review integrate recurring and evolving definitions of 'what housing is for' (Gero & Kannengiesser, 2004).

As Støa & Aune (2012) elucidated, understandings of what an 'appropriate' home is have evolved throughout history. With the rise of the Modern Movement, the multi-generational sense of belonging that home conveyed in premodern agrarian society (*permanence*) was abandoned in favour of a new ideal home where the modern person 'should' live (i.e. a change in *status symbol*). From place-rooted localities to transitory stages (*impermanence*; Rérat, 2012a), dwellings have become 'disposable products' or *commodities* 'that can be moved from once [they have] lost [their] attraction' (Støa & Aune, 2012, p. 115).

Based on this overview, one could argue that the definition of home is a social construction that has varied across history. However, different meanings of home can co-exist (Sixsmith, 1986). For instance, desires for place attachment and belonging (*permanence; property*), privacy, separation, and protection (*shelter; security*) can be identified over time in the empirical categories of meaning elaborated by Sixsmith (1986), in the list resulting from the literature review of Després (1991), in the examination of the 'concept of home' by Moore (2000) and among the dominant and recurring ideas about home identified by Mallet (2004). Furthermore, regardless of culture, housing remains a means of communication and identity and a marker of ways of thinking (*self-expression*). We can in fact identify Cooper's (1974) definition of housing as 'the symbol of the self' in several investigations of the 'home for its occupants' (e.g. Després, 1991; Mallett, 2004). Scholars also frequently define home as an 'arena for activities' or a place for practices, e.g. the *production and consumption* of food, kinship, language, or religion (e.g. Lawrence, 1987b; Rakoff, 1977; Sixsmith, 1986; Støa & Aune, 2012).

Table 5.5. Definitions of the nine housing functions.

Function	Definition	SRC
Shelter	A refuge, a fortress where one can return to get rest before going back out 'into the world'; the 'homely home'.	[1-4,6,8,11-16, 19,22-23]
Security, Privacy	A private place mainly for the family's needs. Recreation preferably happens outside.	[1-6,8-9,11,13-15, 17,19,20,22-23]
Permanence	A place where a person feels they belong or are rooted in.	[5-6,8,15,20-23]
Production, Consumption	A place that enables one to perform activities (like eating, laundering, companionship).	[6,10,12,16,19]
Impermanence	A place free from tradition or memory, which reflects one’s life stage.	[13,15,19,22-23]
Commodity	A temporary place or a starting point. May be attractive for its price or location.	[6,12-13,22,24]
Status symbol	A credential for esteem, a place for exhibiting.	[1,3,5-7,10,13-14, 17-18,22-23]
Self-representation	A place for self-expression or satisfaction of aspirations.	[12,4-7,14-17, 19,22-23]
Property	A place that belongs to the occupant, s/he is entitled to do what s/he wants.	[3,6,9,12,20]

Selection of key sources illustrating the concept (SRC): 1. Belcher & Vazquez-Calcerrada (1972); 2. Blunt & Dowling (2006); 3. Coolen (2006); 4. Cooper (1975); 5. Cooper (1974); 6. Després (1991); 7. Gauvain & Altman (1982); 8. Gieseking et al. (2014); 9. Kleinhans & Elsinga (2010); 10. Koppe (1955); 11. Kuoppa et al. (2019); 12. Lawrence (1994); 13. Lawrence & Barbey (2014); 14. Lawrence (2012b); 15. Mallett (2004); 16. Rakoff (1977); 17. Rapoport (1988); 18. Rapoport (2000); 19. Sixsmith (1986); 20. Stara et al. (2017); 21. Studer & Vliet (1987); 22. Støa & Aune (2012); 23. van Ham (2012); 24. Wong (2002).

It can be observed that rather than justifying an evolution across history, the study of what home is has opened a door to different ways of defining it; the meaning of housing can be understood as something that adapts, that moves with its inhabitants and is constantly remade by them (Wise, 2000). Therefore, although housing’s predominant function in society might have changed over time, all of the functions that we identify today are sub-functions of the housing system.

The functions derived from the literature review are displayed in Table 5.5. The synthetic definition assigned to each name (i.e. shelter) is of critical importance to avoid misinterpretation.

5.5.3 Functions, behaviours and structures

It has been shown that multiple housing functions coexist in the housing realm. According to the theoretical framework illustrated in Figure 5.1, each function determines a distinct system’s behaviour, which is exhibited by and brings about a set of elements and interconnections (i.e. structure; Table 5.1).

Table 5.6 illustrates the system of each function through the application of Gero’s FBS framework (2004). The nine housing systems are arranged according to housing functions (column 1), and examples of *possible* behaviours of the material (3) and human (4) subsystems. The second column illustrates elements of the social and environmental macro-level structures influencing such behaviours. We illustrate some key results below.

Table 5.6. Nine housing systems derived from the qualitative literature review.

				SRC
What is the system for?	*What affects its behaviour?*	*What does the system bring about? (material)*	*What does the system bring about? (human)*	*Who said this?*
Shelter	Location Culture	Basic house providing shelter Detached suburban house	Dream of the homely home	[1-4,9,15]
Security, Privacy	Location Culture	Undifferentiated homes Differentiation public/private Specific room functions	Desire for privacy Recreation outside of home	[1,3,9,12,15]
Permanence	Culture	Universal archetype of house Long-lasting structures	Rigid customs, codes and regulations Attachment, identity	[9,11,14-16]
Production, Consumption	Culture Technologies	Domestic equipment substituting shared facilities	New customs, codes, regulations	[1,9]
Impermanence	Culture	Multiplication of ideal solutions for different groups and life phases	Reduced significance of place-rooted localities	[9,11,13,15]
Commodity	Market Policies Values	Prioritization of convenience (price, location) over quality	Short-term social networks	[4,15,17]
Status symbol	Socioeconomic structure Values	Facilities indoor (library, exercise rooms) Modern forms, styles, materials	Indoor social life Increasing demand on comfort and on privacy Exhibiting	[1,3,6,9,12,8]
Self-representation	Culture Life phase	Customization of housing typologies, decoration Detached suburban house	Association between the ‘self’ and the dwelling Difficulty of accepting different housing typologies	[1,3,6,9,15]
Property	Culture Location	Differentiation in housing contracts and tenure	Empowerment Less/more entitlements and obligations	[5,7,10,15]

Descriptions are structured according to (from left to right) housing functions (1), macro-level system elements (2), and the micro-level material (3) and human (4) behaviours they affect. Feedbacks between levels are not included in the table.

Sources (SRC): 1. Belcher & Vazquez-Calcerrada (1972); 2. Blunt & Dowling (2006); 3. Cooper (1974); 4. Després (1991); 5. Forrest (1983); 6. Gauvain & Altman (1982); 7. Kleinhans & Elsinga (2010); 8. Koppe (1955); 9. Lawrence (1987b); 10. Lawrence (2001); 11. Pattaroni et al. (2009); 12. Rapoport (2000); 13. Rérat (2012a); 14. Stara *et al.* (2017); 15. Støa & Aune (2012); 16. Studer & Vliet (1987); 17. Wong (2002).

A system only exists ‘if its structure and functions are adapted to [the] environment’ (Bossel, 1999, p. 24). In line with this definition, results show that dwelling forms and residential preferences vary with structural macro-level elements such as a given culture or locality (Belcher & Vazquez-Calcerrada, 1972; Coolen, 2006; Lawrence, 1987b). For instance, the geographical location and cultural context can influence the material behaviour of a dwelling that fulfils the function of *shelter*. Whilst shelter is needed from inclement weather in certain regions of the world, ‘[t]here are some homes in tropical sections of the world [whose] shelter function is little more than giving shade when the sun shines in as much as they neither keep out rain nor serve as a barrier to winds’ (Belcher & Vazquez-Calcerrada, 1972, p. 751).

In the framework of Western domesticity, this function can manifest itself in the desire for the most ‘homely home’: the detached suburban house (Blunt & Dowling, 2006; Støa & Aune, 2012), which Cooper (1974, p. 133) described as ‘a house form in which the self and family unit can be seen as separate, unique, private, and protected’.

Whether or not to adhere to the ‘universal need’ for this dwelling form also depends on the importance of housing as a symbol of the self, i.e. a place of *self-representation.* To a certain extent, the urban sprawl of many American cities is rooted in the power of the culture of the self-made man ‘clearing the land and building a cabin for himself and his family’ (Cooper, 1974, p. 133). This image plays a role in generating resistance to measures such as the provision of housing by the state (subsidized housing) or certain housing typologies such as high-rise apartments or mobile hippie houses-on-wheels (Cooper, 1974).

The desire for self-representation can engender conflicts in the definition of what the ‘self’ is and the multiple goals that a household can associate with the phases of their life course (Lawrence, 1987b). When these goals become the driving reason to choose a dwelling, the function *impermanence* prevails, bringing about a multiplication of ‘ideal solutions’ and a reduction in the significance of ‘place-rooted localities’ (Støa & Aune, 2012, p. 113).

As the dwelling acquires an increasing number of functions, households with ‘a penchant for social climbing’ add a vast number of features to their homes to reflect their *status*—libraries, exercise rooms, workshops, etc. (Belcher & Vazquez-Calcerrada, 1972, p. 752). This can result in a social life that primarily takes place indoors, where guests take part in the residents’ exhibition of their status (Koppe, 1955). What this status is and how it is reflected varies with the values and socioeconomic structure of the society.

Results from the literature also illustrate how together with macro/societal forces such as financing instruments, zoning regulations and housing policies (Després, 1991), the liberalization of housing markets and the concomitant shift in values have engendered the rise of housing as a *commodity*. In both the rental and property markets, dwellings are reduced to convenient rather than quality products (e.g. close to the current job, the cheapest possible alternative), or they may become income-generating assets (e.g. rented, sub-rented, turned into an Airbnb, used for speculative purposes; van Ham, 2012). Prioritizing housing economic and exchange value (Lawrence, 1987a), this function is shown to affect the development of social ties, which in turn impact the viability and stability of human communities (Støa & Aune, 2012).

Like the *commodity*, the *property* does not necessarily connote a private property regime; rather, this function refers to the rights conferred on both tenants and homeowners (common and private; Forrest, 1983). However, the social effects of these rights (empowerment, obligations, care or maintenance) remain under discussion (Forrest, 1983; Kleinhans & Elsinga, 2010; Støa & Aune, 2012).

5.5.4 Housing functions in Swiss tenants' residential mobility

Having identified nine housing functions, we display herein the results of our exploration of their utility for the study of Swiss households' residential mobility. More specifically, we outline four hypotheses and the data they were derived from. The hypotheses focus on the system of relationships between housing functions, residential satisfaction, and the determinants of the decisions to move and select a dwelling.

> ***Hypothesis 1***. The nine housing functions derived from the literature are credible.

During the group discussions in Lausanne and Zurich, tenants ranked each of the nine housing functions at least once among the three most important functions of their current dwellings. In Lausanne, top rankings were most frequently assigned to *property*, *shelter*, *security* and *self-representation*. The least important function, or the least mentioned, was housing as a *permanent* place. As illustrated in the theoretical framework, the Swiss population is increasingly mobile (Pattaroni, Kaufmann, et al., 2009). Furthermore, one-third of the workforce in Switzerland's labour market is comprised by international work migrants (FSO, 2018)s, many of whom do not plan to permanently settle in the country (Mulder, 2006).

In Zurich, *security* and *shelter* were again predominant; however, in contrast to Lausanne, *permanence* also featured among the three most important functions. It must be considered that the majority of the participants in the Zurich-based discussion were tenants of a housing cooperative (see Table 5.4). During the group discussion, this type of tenancy was inferred as engendering a stronger feeling of 'belonging' to a community.

In both group discussions, tenants indicated that the functions fulfilled by the chosen dwelling (i.e. 'current') corresponded to the ones desired at the time of the move (i.e. 'ideal').

> ***Hypothesis 2***. A relationship exists between tenants' level of satisfaction (LoS) with their housing consumption prior to the trigger and the trigger that prompts them to move. Triggers can be categorized into three types.

The analysis of the reasons for leaving the former dwelling shows that, when the LoS prior to the trigger was medium-to-low, tenants had predominantly moved for *opportunities*—or favourable circumstances to improve the quality of the dwelling. Examples of this trigger type are being informed of a new dwelling on the market or the opening of a noisy bar downstairs. When the LoS prior to the trigger was high, the only push factors resulting in a move were 'imposed' triggers: *radical change* and *problem-solving*. The former could correspond to a change occurring in the tenant's life course (e.g. household formation, retirement), whereas the latter could be any problem affecting the quality of life in the dwelling (e.g. expiry of the rental contract, a change in job location). Imposed triggers were found to apply to tenants with any LoS.

> ***Hypothesis 3***. Depending on the trigger, the housing function and, consequently, the elements of the housing's material structure (i.e. the dwelling's characteristics) are more—or less—prone to change. If the function remains unchanged, then the quality or type of some characteristics will be adjusted in line with the LoS and the trigger; if the function changes, the characteristics will adapt to the new function.

During the group discussions tenants did not indicate any change between the functions of the former and current dwelling, except when a radical change had triggered their move. Despite the function remaining unchanged, dwelling characteristics had sometimes been adapted: for instance, when an opportunity had engendered the means to improve the quality of a significant feature (e.g. size or a balcony) and thereby achieve a higher level of satisfaction; or following the need to solve a problematic characteristic (e.g. the distance to work).[19] On the other hand, a radical change was found to bring about a shift in function and a strong readjustment of the characteristics. Interestingly, the tenants who had moved due to this trigger type often ranked ‘self-representation’ as the most relevant function of their current dwellings, which reflects the tenant’s desire for identification with their environment. For example, when shifting from an active life to retirement, the function desired for one’s dwelling could transform from a more mundane purpose such as shelter where to find rest after work to a more symbolic or hedonic role such as a place of self-representation or a pleasant place to spend one’s remaining years and free time.

> ***Hypothesis 4***. The housing function(s) of the dwelling at the time of the move determines the tenant’s propensity to move.

We illustrate this hypothesis with two examples taken from the share of tenants for whom the functions fulfilled by their current dwellings corresponded to their former ones. First, the functions ‘shelter’ and ‘security, privacy’ were often mentioned among tenants having moved due to a low LoS or a problem to solve, which indicates that such households only left their former dwellings when certain conditions were not met. Second, the predominant functions mentioned by tenants having moved with a medium LoS were ‘commodity’ or ‘impermanence’, which by definition suggest a greater propensity to move following an opportunity—e.g. a better job in the case of ‘commodity’.

Concerning the share of tenants who moved due to a radical change, it must be considered that, since the functions of their former dwellings had changed compared to the current ones (see hypothesis 3), data on the latter could not be used to assess their propensity to move.

To summarize, the exploratory study in Switzerland shows that relationships between the elements that play a role in tenants’ residential mobility can be identified when introducing the notion of housing function (Table 5.7). More specifically, preliminary results of the analysis of the past move suggest that the tenants’ level of satisfaction with their dwelling and the function(s) they fulfil prior to the move can indicate their propensity to move following a trigger (i.e. push factors). This link becomes more apparent when introducing three types of triggers (i.e. opportunity, problem-solving and radical change). We also observe that, in their turn, the triggers can affect the function(s) for the new dwelling and/or its characteristics. For instance, this can happen following a change in tenants’ or households’ characteristics (e.g. retirement).

Table 5.7. Thematic conceptual matrix of the past move of Swiss tenants.

Trigger type	**Opportunity**	**Radical Change**	**Problem-solving**
LoS prior to the trigger	Low; medium	Low; medium; high	Low; medium; high
Function change	No	Yes	No
Characteristics change	Improvement in quality of characteristics	Change in characteristics	Improvement in problematic characteristic(s)
Functions at the time of the move	Commodity; impermanence	-	Shelter; security, privacy

Data are gleaned from two group discussions with tenants in Zurich and Lausanne. LoS: Level of satisfaction, ‘-’: data unavailable.

[19] Since the selection of a dwelling often results from compromises between the desires of different household components (Rérat et al., 2014), small improvements were also recorded in characteristics other than problematic ones.

5.6 Discussion

This paper conceptualized and operationalized housing as a system with the goal of contributing to shaping an integrative and holistic knowledge of the interactions between residential preferences and dwellings, and thus, on a larger scale, to the critical and timely research on adequate housing.

In the following subsections, we first discuss the theoretical contribution of this paper; second, we illustrate the implications of the results for practice; and finally, we acknowledge the study's limitations and suggest potential pathways for future research.

5.6.1 Theoretical contribution

In this study, we adopted a systems perspective, which implied acknowledging the role of the system's *function* as key determinant of the system's behaviour. Contrary to the mechanistic approach of 'form ever follows function' debated in the architectural field since the late 19th century (Sullivan et al., 2016, p. 408), our research focused on the sociocultural interpretation of the notion.

With this focus, the findings of the qualitative literature review showed that the housing system can fulfil multiple housing functions (Table 5.5). What housing means for individuals, societies or groups and its link to the artefact has been widely investigated, and several categorizations can be found in the literature produced in the fields of environmental psychology and people–environment studies, especially in the context of Western contemporary society (e.g. Cooper, 1975; Després, 1991; Moore, 2000; Sixsmith, 1986). However, the inductive categorization of the functions proposed in this paper differs from the approach used in similar studies inasmuch as it derives from the application of systems science lenses and thus uses explicit criteria for functions' selection—i.e., 'what is housing for?' This approach resulted in a set of functions sometimes described as separate in other studies; for instance, the meaning conferred by friends and family (e.g. 'friend and entertainment'; Sixsmith, 1986) was not defined as a function but rather as a component of other functions (e.g. security, status symbol).

Subsequently, these functions were used to understand the behaviours of the human and material subsystems, meaning households' residential preferences and dwelling forms, for given social and environmental structural elements. The way in which these two subsystems influence each other is a subject of debate among scholars, with the predominant perspective being that residential settings are contextually defined and used and no deterministic relation exist between, e.g., the geographical and physical components of spaces and their uses (Lawrence, 2014). Our conceptual framework both agrees with and challenges these findings by displaying how these 'settings' are directly and indirectly interrelated. On the one hand, we agree that the context—understood as domestic culture at the macro- and micro-level—directly influences the systems behaviour and its elements (e.g. use of space, physical housing components; Table 5.6). On the other hand, we observe that both human and material behaviours are orchestrated, and thus indirectly linked, by the housing functions.

The existence of such a link is also proposed in a study by Lawrence (2009), which introduces the federative concept of *attractiveness*. The notion simultaneously accounts for the characteristics of the building stock (building, dwelling, neighbourhood, etc.) and a variety of stakeholders' evaluations of the features' strengths and weaknesses. Strong attractiveness engenders a high level of satisfaction among households and thereby results in a relatively low rate of residential relocations (Lawrence, 2009). Our work conceptualized attractiveness by means of different lenses. Rather than focusing on the households' appreciation of dwelling features, we introduced an operational framework for the translation of the housing's material structure into the human structure and vice-versa, including their systems-hierarchical effects.

However, the purpose of our research did not differ from that of Lawrence's (2009) work, and a set of hypotheses was laid down to illustrate the role housing functions play in residential mobility. Although the literature is replete with studies on the determinants of households' decisions to move and select new dwellings, the introduction of the notion of housing functions suggested a possible path to overcome lingering gaps in the field. Introducing this concept enabled us to question the commonly-used categorizations of pull factors (e.g. dwelling, neighbourhood, relative location); as the system's functions determine its behaviour and thereby shape the structural elements enabling it (Figure 5.1), the elements of the material subsystem—i.e. dwelling features (Table 5.1)—and their categorization were found to vary with the overarching housing function. Furthermore, it addressed the limited knowledge on the interactions between triggers and levels of satisfaction (see Wong, 2002) by displaying how satisfaction with and the functions of the current dwelling influence the propensity to move following a trigger type (Table 5.7).

It can be concluded that by clearly introducing the systems terminology and exploring the potential utility of the concept of housing function in residential mobility, this paper offers a new perspective on the heterogeneous and divergent research on households and dwellings conducted until now.

5.6.2 Practical applicability

The growing gap between housing supply and demand and the insufficient effort put by the architectural practice into filling it inevitably affect the desirability of dwellings and thus the market (Franklin, 2001; Kuoppa et al., 2019; Lawrence, 2014). Further, it potentially hinders the success of strategies targeting environmentally sustainable and appropriate or adequate housing supply (i.e. if cultural or social conventions diverge from rather than align with new performant housing solutions).

It is in this context that the United Nations Human Settlements Programme (UN-HABITAT) advocates for housing policies that are 'responsive to demands and real needs' (Acioly & Horwood, 2011, p. 1). Following this recommendation is not straightforward; housing's incubation time and long-life service, as well as the multiplicity of involved actors, all contribute to hindering the maintenance of congruence between users' goal(s) and the supporting built environment (Studer & Vliet, 1987). Limited understanding of the housing system has resulted in the proliferation of short-term solutions to what are perceived as a series of 'events' (e.g. increasing vacancies, changing preferences; Meadows, 2008). Moreover, the myopic focus of practitioners, housing owners and policy-makers on the characteristics of dwellings (e.g. in the framework of zero-energy or low-emissions buildings) has resulted in their negligence of the human structure of the system and its relationships with the wider societal and environmental structures. Below, four examples illustrate how applications of the systems knowledge acquired in this research could benefit the wide spectrum of professional figures in the housing sector. Such applications go beyond the environmental and economic considerations of the housing footprint to explicitly integrate the third fundamental pillar of sustainable development—i.e. the social one (Purvis et al., 2019; World Commission on Environment and Development, 1987).

1. *Transdisciplinarity.* Use the function of housing as a transdisciplinary inclusive concept to unravel the complexity of scholarly discourse and language and thereby enable engagement in the debate by all the stakeholders who participate in producing residential space (i.e. dwelling, neighbourhood and location qualities) and who are often excluded from it (Franklin, 2001).
2. *Housing typologies.* The categories of housing characteristics or ‘typologies’ widely adopted in the building sector and by a multitude of actors only consider the material structure of the system. In order to account for the system as a *whole*, reorganize such categories according to the housing functions that they fulfil and the social and environmental context under study.
3. *Sustainability.* For each housing function, identify the environmental and sociocultural sustainability issues and opportunities that it generates (see the material and human behaviours associated with each function, Table 5.6). Conversely, apply this knowledge to investigate how changes in the macro-level structure (e.g. technical innovations) can impact the behaviour of the housing system (e.g. impact of automated stores on households’ routines).
4. *Design and architecture.* Rethink residential space to accommodate change in (i) housing functions by providing a multitude of housing functions at the dwelling, building and neighbourhood scales and (ii) context by offering the possibility for dwellers to adapt the manifestation of these functions over time (Kuoppa et al., 2019). Consider that in the proposed system, the design can provide feedback to the larger society and environment, thereby generating new meanings and functions.

5.6.3 Limitations and future research needs

It must be acknowledged that the identification of the functions and of possible behaviours of each housing subsystem derives from the reviewed literature and therefore reflects a cultural and geographical bias as well as that of the researchers. It is also of interest to highlight the consequences of innovations in communication technologies as well as the unpredictable shifts brought about by phenomena such as pandemics or climate change, which will or may subvert our relationship with housing and thus impact the identified functions (Fritz et al., 2021; Lawrence, 2014; Mallett, 2004). Therefore, rather than considering the findings as fixed, we emphasise the operational framework used to identify the system’s functions and behaviours.

Regarding the framework’s exemplification, the limits of the literature on residential mobility reviewed for the scope of this research should be taken into consideration. The paper provided a concise overview of studies on households’ decisions to move and where to move, the complexity of which requires a more thorough illustration. Additionally, it must be acknowledged that due to the small sample size and exploratory nature, the group discussions cannot be used to draw conclusions but rather only to advance hypotheses framed by contextual boundaries. In fact, as our exploration was carried out with tenants in Switzerland, the results are limited to the Swiss rental housing market and its specificities and subject to the bias of the small sample (e.g. time of move, type of owner). We also point to the fact that the formulation of such hypotheses rested on the conceptual assumption that, in the relocation process, tenants seek for the best match between their ideal and current dwelling functions. Before proceeding with further analyses, this assumption should be carefully tested, e.g., by investigating the influence of this match on households’ decisions to move and select new dwellings. Lastly, it is worth mentioning that this exploratory study was based on the past move of tenants (i.e. the so-called 'revealed preferences'; Clark & Dieleman, 1996) and did not take into account the role played by households' resources and restrictions (i.e. structural micro-level elements of the housing system) and opportunities and constraints (i.e. the macro-level ones) in the relocation process (Mulder & Hooimeijer, 1999). For instance, the very low Swiss vacancy and new building construction rates (1.66% and less than 1%, respectively; FSO, 2019b) can affect tenants' propensity to move following a trigger or the degree of change in the characteristics of the new dwelling.

As the group discussions are part of a wider research strategy, additional research is foreseen. First, to test our hypotheses, a targeted exploration of the literature on residential mobility will be conducted, which will account for the limits of the introduced concepts (i.e. 'push' and 'pull' factors, 'level of satisfaction'; Lawrence, 1987a). Second, to overcome the limits of a small sample size, a survey has recently been conducted with a larger sample of 1,000 tenants of the three housing owners introduced in this paper. The survey results will be key to clarifying the applicability of the operational framework to the residential mobility of tenants in Switzerland.

Additionally, we encourage scholars to apply the proposed operational framework in context-specific analyses. These could enrich the qualitative data collected in Table 5.6 and shed light on the diversity of each function's potential behaviours (i.e. residential preferences and dwelling forms) and their specificity to the context. Only if the collection of such behaviours reaches a significant threshold will it be possible to foresee the functions' architectural application and thereby contribute to the design of appropriate, adequate and sustainable housing (i.e. appropriate scale, affordable price, sufficient diversity of size, price and typology, suitable locations; Acioly & Horwood, 2011).

5.7 Conclusion

This paper presented an operational framework for understanding the relationship between residential preferences and dwellings. By integrating the systems terminology and concepts into the existing literature of people–environment studies, housing studies, and architecture, we introduced the notion of *function* as the key determinant of the system's behaviour. We used qualitative literature review to identify the functions of the housing system (i.e. what housing is for, e.g. shelter) and how these determine its possible human and material behaviours (i.e. residential preferences and dwellings forms) for given societal and environmental structural elements (e.g. geographical location, culture). We then conducted two small exploratory group discussions with Swiss tenants to exemplify the use of the operational framework in the context of residential mobility. The results demonstrate the potential of the housing functions concept to fill knowledge gaps concerning the determinants of households' residential relocations.

In light of the urgent imperative to provide a housing supply that is environmentally sustainable as well as culturally acceptable and desirable for its users, we propose housing functions as a transdisciplinary inclusive concept, the use of which would benefit (i) the dialogue between and inclusion of different stakeholders in the residential sector; (ii) the redefinition of holistic housing typologies; (iii) the identification of housing sustainability issues and opportunities; and (iv) the design of residential spaces capable of accommodating change at both the micro- (e.g. household's educational or occupational career) and macro-levels (e.g. innovative technologies, pandemics).

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PART III

Investigating the system's interrelationships: the determinants of residential mobility

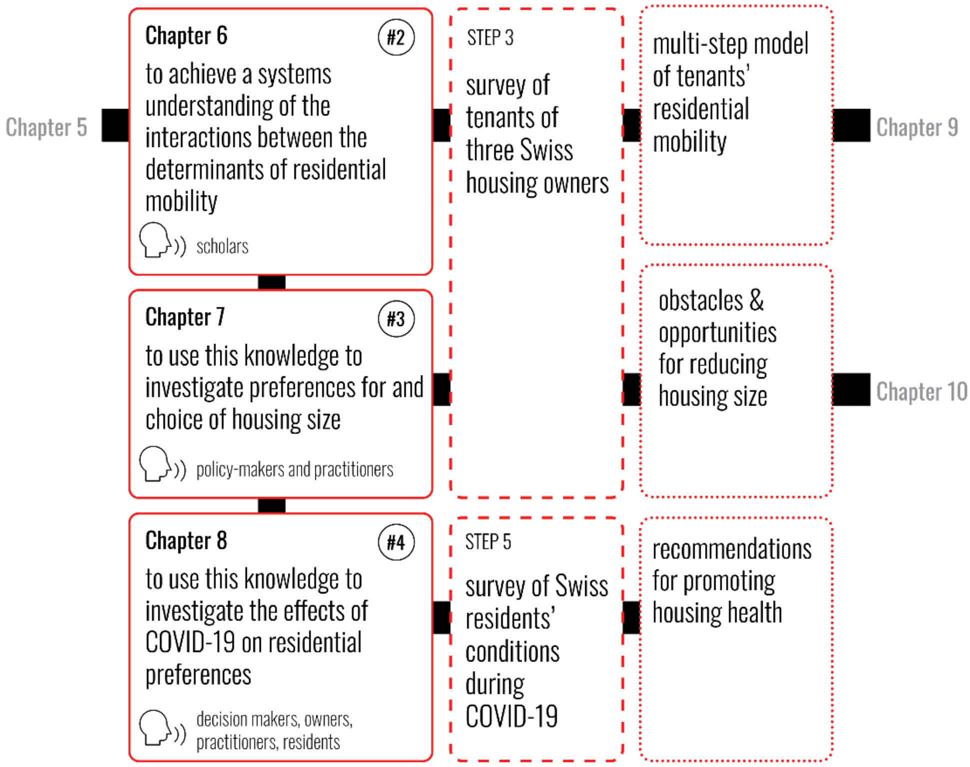

Figure III. The content of Part III. The full-lined box summarises the goal of the manuscripts (#) and the audience to whom their results are addressed. Dashed lines indicate the methods used as described in the research design. Dotted lines highlight the research outputs.

6

Tenants' residential mobility in Switzerland: the role of housing functions

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Contributions: A.P. designed the survey questionnaire, performed the statistical analyses and wrote the paper (original draft, review and editing). I.B. supported A.P. in the empirical research (questionnaire, data analysis) and revised the manuscript. C.R.B. supervised the work; she contributed to the design of the questionnaire and provided critical feedback on the manuscript.

Abstract

The interaction between residential preferences and dwellings is a complex system whose function thus far remains insufficiently explored. In this paper, we investigate housing functions as orchestrators of households' residential mobility in the context of Swiss rental housing. We propose a theoretical multi-step model and use survey data from 878 Swiss tenants to inspect the model's linkages. From the statistical analysis, we firstly observe that tenants' residential satisfaction is more likely to increase when the gap between ideal housing functions and those actually fulfilled by the current dwelling decreases. Secondly, results show that the effectiveness of an event (e.g. a job opportunity) in triggering the move is significantly related to both residential satisfaction and the functions the dwelling fulfils prior to the trigger. Thirdly, findings show that these trigger events can be grouped into three types: radical change, problem-solving and opportunity. With a medium effect size, a radical change was found to bring about the strongest change in housing functions between past and current dwellings. Lastly, in line with the hypothesis that residential preferences vary over the life course, socio-demographic characteristics and tenancy types are found to be significant explanatory variables for households' ideal housing functions. By disentangling the complexity of the housing system, the proposed multi-step model can be used to integrate households' preferences with supply-side constraints in agent-based model simulations, thereby contributing to fostering the provision of quality housing, i.e. dwellings able to meet the needs of current and future occupants.

Keywords: Housing system, residential satisfaction, triggers, residential preferences, logit models

6.1 Introduction

In Switzerland and worldwide, there is an urgent imperative to increase housing quality and adequacy in meeting the needs of current and future inhabitants (Acioly & Horwood, 2011; Lawrence, 2009). In this context, achieving a better understanding of the process by which households match their housing needs to the dwellings available to them is critical. However, the study of the residential mobility process is a complicated endeavour (Clark 2012; Dieleman 2001). It involves different geographical scales (i.e. international, national, metropolitan, households; Clark 2012), or levels (i.e. micro, macro; Mulder and Hooimeijer 1999; van Ham 2012), a multitude of disciplinary lenses (Coolen et al., 2002; Lu, 1999; Mulder, 1996; Wong, 2002), and a variety of stakeholders (i.e. the owners, the tenants, the policy-makers; Lawrence 2009). Moreover, it entails dealing with the delicate interactions of a complex human–environment system that extends beyond the material aspects of dwellings (Lawrence, 2009).

Few scholars have attempted to make sense of this complex system in the Swiss context, where questions relating to habitat remain relatively little addressed (Pattaroni, Kaufmann, et al., 2009). Among these, Lawrence (2009) introduced the federative concept of *attractiveness*, which lies at the intersection between offer and demand and accounts for both the objective characteristics of housing stock and the multiple perspectives of actors, institutions and households concerning features' strengths and weaknesses. Greater attractiveness ratings result in higher satisfaction among households and lower residential relocations and vacancy rates (Lawrence, 2009). The recent work of Pagani and Binder (2021) extended this reflection one step further with the introduction of a systems perspective to housing studies. Housing is conceptualized as a system of human and material structures whose behaviour (i.e. residential preferences; dwelling forms) is determined by the system's *function(s)* (Bossel, 1999; Hester & Adams, 2017; Meadows, 2008). Although their study illustrates a promising application of the notion of housing function to the field of residential mobility, their findings remain at the exploratory level.

With the goal to achieve an enhanced understanding of Swiss households' residential mobility and thereby contribute to fostering the provision of housing that meets current and future users' needs, this paper investigates the role of housing functions in the decisions to move and select a new dwelling based on survey data that targets the tenants of a real estate owner and of two of the largest cooperatives in Switzerland. More specifically, we address the following question and sub-questions:

What role do housing functions play in orchestrating the factors determining the moves of Swiss tenants?

- Can housing functions be used to understand residential mobility?
- To what extent do housing functions influence which determinants are effective in tenants' decision to move?
- How are the housing functions of the new dwelling influenced by this decision?
- Do socio-demographic characteristics and tenancy type have an influence on households' ideal housing functions?

To answer these questions, we proceed as follows. In Section 6.2, we explicate our theoretical framework, first reviewing the key literature on housing functions, residential mobility and previous qualitative research in Switzerland and then operationalizing the findings in a multi-step model that integrates the concept of housing functions in tenants' relocation process. Section 6.3

introduces the statistical methods used to explore the model, following which the results of the analyses are presented in Section 6.4. In Section 6.5, we discuss the relevance of the results for the wider literature along with their practical applicability, critically review the adopted methods and identify avenues for future research.

6.2 A theoretical framework for tenants' residential mobility

6.2.1 Housing functions in the housing system

A system is 'anything that is composed of system elements' (Bossel, 1999, p. 20). These elements are connected in a structure, which allows the system to perform specific *functions* in its environment. Systems can be nested within other systems (Meadows, 2008).

According to this definition, the housing system has been conceptualized as being embedded in and structured by a societal system comprising rules and resources (e.g. culture, legislation, financial capital) and an environmental system constituting the natural and technical environment (Binder, 2007; Giddens, 1984; Pagani & Binder, 2021). Encompassed within the environment and society are the human and material subsystems, which are in turn structured by e.g. households' residential biographies and dwellings' features, and manifest themselves in different residential preferences and dwelling forms, respectively (Pagani & Binder, 2021). These manifestations, also called system's behaviours, are determined by the *functions* of the housing system. For instance, for given societal and environmental structural elements (e.g. geography, culture), the material behaviour of the function *shelter* can be either a detached suburban house or a basic shelter providing shade from the sun or inclement weather; the function *commodity* can entail a prioritization of convenience (price, location) over quality.

Table 6.1 illustrates the nine housing functions identified by Pagani and Binder (2021). At the interface between residential preferences and dwelling forms, these functions are introduced by the authors as key elements in the investigation of residential mobility, the process of which is outlined in the following section.

Table 6.1. Housing functions (after Pagani & Binder, 2021).

Function	**Definition**
Shelter	A refuge, a fortress where one can return to get rest, before going back out 'into the world'; the 'homely home'.
Security, Privacy	A private place mainly for the family's needs. The recreation preferably happens outside.
Permanence	A place a person feels they belong or are rooted in.
Production, Consumption	A place that enables one to perform activities (like eating, laundering, companionship).
Impermanence	A place free from tradition or memory, which reflects one's life stage.
Commodity	A temporary place or a starting point. Maybe attractive for its price or location.
Status symbol	A credential for esteem, a place for exhibiting.
Self-representation	A place for self-expression, satisfaction of aspirations.
Property	A place that belongs to the occupant, of which s/he is entitled to do what s/he wants.

6.2.2 Residential mobility

The housing literature is replete with studies on residential mobility. Despite the variety of conceptualizations of the relocation process, many scholars have shared the assumption that an individual first decides to move and then chooses where to relocate (i.e. the two-stage choice approach; Brown & Moore, 1970; Clark & Onaka, 1983; Mulder, 1996; Mulder & Hooimeijer, 1999; Rossi, 1955). In this section, we concisely illustrate previous research on the determinants of the decisions to move and to select a dwelling, and their mediator: residential satisfaction.

Triggers are the *determinants of the decision to move*. Households 'do not relocate unless there is some trigger (or even an absolute necessity) causing the benefits of moving to outweigh its costs' (Mulder & Hooimeijer, 1999, p. 162). Brown and Moore (1970, p. 2) defined triggers as stimuli or stressors provided as continuous sources by the environment and perceived differently among households depending on their 'tolerance to stress'. In more recent studies, triggers are described as arising not only from the environment but also from the life course trajectories of housing, household, education, and work, whereby a move is caused by or timed in accordance with events related to each (Clark & Lisowski, 2017; Coulter, 2013; Dieleman, 2001; Mulder, 1996; Mulder & Hooimeijer, 1999; Rabe & Taylor, 2010). Thus, a plurality of micro- (e.g. new job location) and macro-level factors (e.g. housing market opportunities) can trigger a move.

The concept of *residential satisfaction* lies between the decision to move and that to select a dwelling. Scholars have largely cited a household's dissatisfaction with a dwelling in terms of housing attributes, neighbourhood characteristics and accessibility as a motivation for moving, while an increase in residential satisfaction has been demonstrated to be a value attached to relocation (Clark and Onaka 1983; de Groot et al. 2011; Diaz-Serrano and Stoyanova 2010; Kearns and Parkes 2003; Kim et al. 2015; Kwon and Beamish 2013; Lu 1998; Marans 1976; Mulder 1996; Mulder and Hooimeijer 1999; Speare 1974). Starting from the seminal work of Wolpert (1965), Brown & Moore (1970), Galster & Hesser (1981) and Galster (1987), residential satisfaction has been conceptualized and calculated as a function of the gap (also called mismatch, discrepancy, disequilibrium, dissonance) between how much a household needs (i.e. desires, aspirations, preferences) and how much is available (i.e. reality; Clark, 2012; Jansen, 2014b; Jiang et al., 2017, 2020; Lu, 1999; Phipps & Carter, 1984). Accordingly, the move can be seen as a process of 'adjustment' during which households seek to make the best possible match between where they live and how they 'want to live' through the exploration and evaluation of qualities of the built environment (Brown & Moore, 1970; De Jong & Fawcett, 1981; Lu, 1998; Phipps, 1989; Thomas & Pattaroni, 2012).

To assess the ways that households 'want to live' corresponds to studying the criteria they make explicit in order to evaluate vacancies—i.e. the *determinants of the decision to select* a dwelling (Marans, 1976). These factors are commonly investigated through the analysis of stated and revealed preferences, the latter of which uses information on actual moving behaviour whereas the former is more widely investigated through desires and moving intentions (Coolen et al., 2002; de Groot, Mulder, & Manting, 2011; Molin et al., 1996; Mulder, 1996; van Ham, 2012). A number of studies have asserted that residential preferences vary between individuals and over their life course (Booi & Boterman, 2019; Coolen et al., 2002; Lawrence, 2004; Mulder, 1996) and therefore change when a trigger affects it (e.g. following a divorce; Brown & Moore, 1970; Jiang et al., 2017; Kim et al., 2015; Mulder & Hooimeijer, 1999).

From the conceptualization of the decision to move and its determinants, a system of interrelationships emerges that directly and indirectly links triggers to move, residential satisfaction and preferences. This system is embedded in metropolitan (i.e. tenure composition, turnover rate), national (i.e. economic and demographic circumstances), and international scales (i.e. housing policies, wealth, tenure structures; Dieleman, 2001). Therefore, to obtain a greater understanding of the decision system of tenants in Switzerland, we introduce the geographical context of our study in the following section.

6.2.3 Residential mobility and housing functions in Switzerland

Although Switzerland's high per capita income makes it among the world's wealthiest nations, its housing market differs from what might be expected in that it is a country of tenants (Pattaroni et al. 2009; Werczberger 1997). At the end of 2017, an average of 60% of households lived in rented dwellings, with the highest proportions located in the urban cantons of Basel-Stadt (84%) and Geneva (78%; FSO, 2019h). The survival of a viable rental sector is remarkable considering that Swiss rent control legislation has been limiting landlords' ability to raise rents and evict tenants at will for the last 80 years (with the exception of new constructions or units vacated by their tenants; Werczberger, 1997).

In a country where nearly two-thirds of the population are tenants, the rules governing the tenancy of apartments and buildings permit little-to-no inhabitant participation in shaping their living environment (Rabinovich, 2009). However, housing 'quality' and 'conditions' are considered very satisfactory, except for a lower than 'natural' overall vacancy rate (2.7%), in particular in the cities of Lausanne (0.4%) and Zurich (0.1%; Werczberger, 1997; Wüest Partner, 2020; Zimmermann, 1992). Furthermore, Switzerland offers ways to simultaneously be a tenant and an owner, most notably through the housing cooperative system, in which the oldest cooperatives (also called 'large' or 'open') act as property developers with a social purpose. These cooperatives are responsible for the financing and management of the housing and its operations in order to ensure affordable rents (Rabinovich, 2009).

The Swiss context offers a promising setting for the study of the relocation process; as in most other European countries, the mobility of Swiss households has been increasing in recent decades (Pattaroni, Kaufmann, et al., 2009), and tenants, who represent the largest share of Swiss occupants, are more mobile than owners (Clark 2012; Coulter 2013; Dieleman 2001; Kwon and Beamish 2013; Rossi 1955).

Pagani and Binder's (2021) research on housing functions and residential mobility is framed in the above-described context. Based on two exploratory group discussions with tenants in the Swiss cities of Lausanne and Zurich, the authors advanced a set of hypotheses regarding the determinants of the decisions to move and select a dwelling. Concerning the former, they inductively formulated three categories of triggers comprising events emerging from the micro- and macro-context: 'opportunity' (e.g. construction of a new building in front of the current one); 'problem-solving' (e.g. change in job location); 'radical change' (e.g. leaving the parental home). Problems to solve and a radical changes are imposed triggers, which were observed to happen and become effective no matter how large the satisfaction of a household with its dwelling was; in contrast, an opportunity was found to be effective only when the household displayed a medium-to-low level of satisfaction. Additionally, the authors observed that these trigger types were more—or less—effective depending on the *function* fulfilled by tenants' dwellings; for instance, an opportunity was more likely to be identified when the dwelling was perceived as a 'commodity' or an 'impermanent' place.

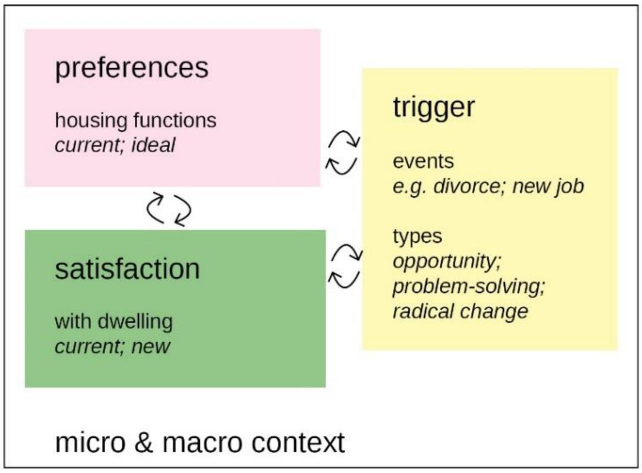

Figure 6.1. A conceptual framework for the residential mobility of Swiss tenants. Arrows indicate the recursive interactions between triggers to move, households' residential preferences and their residential satisfaction.

Concerning criteria for selection of the new dwelling, tenants indicated that the functions fulfilled by the dwelling they were living in at the time of the group discussion (i.e. *current* functions) corresponded to the functions they desired when selecting it (i.e. *ideal* functions). Changes between the functions of the former and current dwelling (i.e. revealed preferences) were reported only following radical changes in tenants' life course, such as leaving the parental home; conversely, catching an opportunity or solving a problem was not observed to affect the housing function(s) of the dwelling to which tenants moved, but rather to improve the quality of or resolve the issues related to a significant feature (e.g. dwelling size; distance to work).

To summarize, households' residential mobility can be described as a process consisting of the decisions to move and where to move. Two types of determinants play a role in the process: triggers events (i.e. determinants to move) and households' residential preferences (i.e. determinants to select a dwelling). The former can be categorized into three types (opportunity, radical change and problem-solving), whereas the latter can be classified into two types (the ideal and current housing functions). These determinants affect each other, even as they influence and are influenced by the household's level of satisfaction with its current dwelling and that it considers selecting. The introduced variables are embedded in and shaped by contextual factors at the micro- and macro-levels (e.g. tenants' life courses, housing market; Figure 6.1).

6.2.4 Hypotheses and model

Based on the literature reviewed in Section 6.2.3, we propose a set of hypotheses (H) for the residential mobility of tenants in Switzerland. The hypotheses are first operationalized (O) and then summarized in a multi-step model (Figure 6.2). Considering the residential tenure under study, the term 'household' is used as a synonym of 'tenant'.

H1 Housing functions can be used as proxies for residential attributes (housing, neighbourhood, location) to understand the gap between a household's preferences and reality, i.e. satisfaction with its dwelling. As residential satisfaction plays a key role in both the decision to move and the formulation of households' preferences, housing functions are relevant for unravelling both processes.

***O1** The gap between the housing functions of the ideal and current dwelling is a significant predictor of households' residential satisfaction.*

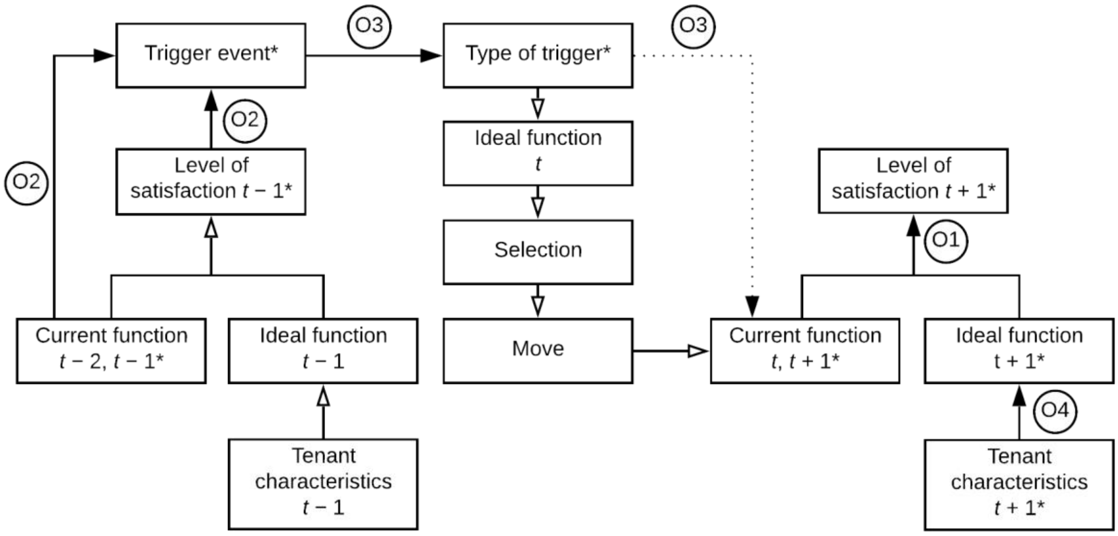

Figure 6.2. Multi-step model of tenants' residential mobility. $t - 2$ indicates the time of the past move; $t - 1$ indicates the time prior to the decision to move at time t; t denotes the time of the decision and relocation; $t + 1$ represents the time following the move. The symbol '*' indicates the measured variables: full arrows show the analysed relationships; dotted lines indicate the proxies used for the analysis; 'O' refers to the operational hypotheses tested in this study.

H2 Housing functions directly and indirectly influence the triggers leading to the move.

O2 *The effectiveness of a trigger is significantly related to (i) the residential satisfaction prior to the trigger (which is itself determined by the gap between current and ideal functions) and (ii) the function(s) the dwelling fulfils.*

H3 Trigger events can be categorized into trigger types, depending on which households readjust their preferences for the new dwelling. More specifically, a change in housing functions occurs only when tenants move in response to the trigger type 'radical change'.

O3 *Trigger events determine trigger types. Changes between the housing functions of past and current dwellings significantly differ across trigger types.*

H4 As residential preferences vary over the life course, there is a relationship between households' characteristics and their ideal housing functions.

O4 *Tenants' characteristics (socio-demographics, tenancy types) are significant predictors of their ideal housing functions.*

Below, based on the above-advanced hypotheses and their operationalization, we describe the steps of the relocation process explored in this study and illustrated in Figure 6.2:

1. At $t - 1$, the size of the gap between a tenant's ideal housing function and the extent to which such a function is fulfilled by the current dwelling (chosen at $t - 2$) determines the tenant's residential satisfaction.
2. The level of satisfaction with the dwelling at time $t - 1$ indicates whether a trigger event is effective for the move.[a]
3. The function of the current dwelling at $t - 1$ also indicates the extent to which a trigger event is effective for the move.

4. The trigger events determine which trigger type will lead to the move.
5. Following the trigger and according to its type, the ideal function is updated (time *t*).
6. At time *t*, the tenant selects and moves to a new (current) dwelling, which minimizes the gap between preferences and reality in terms of housing functions.
7. At $t + 1$, the size of the gap between the ideal and current housing functions (chosen at step *t*) determines the tenants' residential satisfaction.
8. The ideal function at any time step is influenced by the tenant's characteristics.

[a]Because imposed triggers can occur regardless of households' satisfaction, we choose the trigger event prior to its categorization into types as the scale of observation.

6.3 Materials and methods

6.3.1 Survey procedure

To explore the relationships displayed in Figure 6.2, we conducted a survey of the tenants of three housing owners: the insurance company and property owner Swiss Mobiliar (Schweizer Mobiliar Asset Management AG), with dwellings all around Switzerland and the housing cooperatives ABZ (Allgemeine Baugenossenschaft Zürich) in the canton of Zurich and SCHL (Société Coopérative d'Habitation Lausanne) in the canton of Vaud. The diversity of housing owners made it possible to consider different types of tenancy and linguistic regions. A draft questionnaire was translated into French and German and reviewed by three laboratories at the Swiss Federal Institute of Technology in Lausanne (EPFL) as well as the housing owners (ABZ, SCHL and Swiss Mobiliar). Following the approval by the Human Research Ethics Committee of EPFL (HREC), the survey was pre-tested by members of the EPFL's Faculty of the Built Environment (ENAC) and the three housing owners.

The survey was conducted between the 16th of September and the 28th of November 2019. The survey institute LINK collected the data via an online questionnaire addressed to one of the adults in the household who actively influenced the decision to move to her/his current dwelling. Tenants accessed the questionnaire with a personal code shipped by post to 2,500 households: those who lacked internet access were given the possibility to participate by phone. The sample was designed based on data provided by the owners and stratified according to four groups: the two cooperatives ABZ and SCHL and the two language regions where Mobiliar dwellings are predominantly located (i.e. French, German). As the initial response rate did not meet our objective, 500 additional tenants were contacted. The final response rate was 32% for a total sample of 968 tenants.

Data were cleaned by inspecting variables (i.e. setting missing values for outliers) and cases (i.e. suppressing cases when answers had a standard deviation of 0 across a block, e.g., tenants who always replied 'neither, nor'), thereby resulting in a final sample of 878 cases. Statistical analyses were performed using IBM SPSS Statistics 26.[20]

[20] IBM SPSS Statistics 26. https://www.ibm.com/analytics/spss-statistics-software.

6.3.2 Survey content

This section delineates the blocks used for the analysis of tenants' past choices to move to their current dwellings. Tenant profiles are summarized in the "Appendix" (Table 6.7, Table 6.8, Table 6.9, and Table 6.10).

1. *Household composition*, including the socio-demographic characteristics of tenants and their tenancy types. Each respondent's age, family status (e.g. children at home) and marital status (e.g. divorced) were combined to create household types. Tenants had the option not to answer questions regarding employment, salary and education.
2. *Housing functions*, including tenants' ideal housing functions at the time of the survey and the functions fulfilled by their past and current dwellings. To avoid misinterpretation, tenants had to evaluate whether each function's definition described their dwellings independently of its label (5-point Likert scale; 1 = strongly disagree; 5 = strongly agree; see Table 6.1).
3. *Trigger*, including the trigger event that led to the move and the trigger type associated with the event. A list of trigger events was proposed to the tenants based on (i) a literature review and (ii) the results of two previous group discussions during which tenants listed the reasons that pushed them to leave their previous dwelling. In the survey, tenants were given the option to add another answer if none of the proposed corresponded to their choice. The free-form responses were recoded into four new trigger events for a total of 20 events. Tenants directly attributed the chosen events to one of the three trigger types.
4. *Residential satisfaction*, including the tenants' level of satisfaction with their current and previous dwellings, measured on a 5-point Likert scale (1 = strongly dissatisfied; 5 = strongly satisfied). Satisfaction with the past dwelling was defined as the tenants' level of satisfaction prior to the trigger event determining the move.

Questions were formulated at the level of the individual in order to capture his/her preferences and understanding of the housing function. However, we acknowledged that because partners in a household attempt to overcome differences between their views, answers could reflect preferences at the scale of the household (Booi & Boterman, 2019).

6.3.3 Statistical methods

Data analysis

To analyse the data, we first performed a descriptive analysis and explored the variables under study. Depending on the variable type, we then ran binary, ordinal and multinomial logistic regression analyses. When the ordinal logistic regression model violated the proportional odds assumption, the multinomial logistic regression was used instead. This was the case for O1 (see Table 6.2), when tenants' satisfaction (measured on an ordinal scale) was inputted into the model as categorical variable, meaning that the independent variable measuring the difference between ideal and current housing functions (i.e. 'gap') was considered as influencing each category of satisfaction without taking their order into account.[21]

[21] This choice was supported by the assumption that the distance between categories of satisfaction (e.g. 'strongly dissatisfied' and 'dissatisfied') is not always equal.

Table 6.2. Operational hypotheses (O), steps of the model, variables and methods.

O	**Step of the model**		**Variable**		**Method**
	#	Description	Dependent	Independent	
O1	1 6 7	Gap between ideal and current functions is a predictor of satisfaction	Level of satisfaction $(t + 1)$ [a]	Gap $(t + 1)$ [b]	Multinomial logistic regression
O2	2	Trigger effectiveness is related to tenants' residential satisfaction	Trigger event [c]	Level of satisfaction $(t - 1)$[a]	Multinomial logistic regression
O2	3	Trigger effectiveness is related to the functions of the current dwelling	Trigger event [c]	Current functions $(t - 1)$ [a]	Multinomial logistic regression
O3	4	Trigger events determine trigger types	Trigger type [d]	Trigger event [c]	Binary logistic regression
O3	5	Change between past and current functions differs between trigger types	Δfunctions $(t, t - 1)$ [b]	Trigger type [d]	One-way ANOVA
O4	8	Tenants' characteristics are predictors of ideal functions	Ideal function $(t + 1)$ [a]	Socio-demographic characteristics, tenancy type [c]	Ordinal logistic regression

[a] Ordinal variable
[b] Continuous variable, see "Data transformation"
[c] Categorical variable
[d] Three dummy variables for three trigger types (0 = no, 1 = yes), see "Data transformation"

Furthermore, we used one-way analysis of variance (ANOVA) to compare mean differences of continuous variables between groups defined by a categorical variable (see Step 5 in Table 6.2).

Table 6.2 illustrates the variables and methods, the steps of the model to which they refer, and the operational hypotheses they test. The transformations needed to perform the analyses are listed in the following subsection.

Data transformation

Data transformation was required to perform the analyses outlined in Table 6.2. In particular, three new variables were computed:

1. Gap $(t + 1)$ (O1; Step 7)

   For each of the nine housing functions, we computed the variable 'gap' as the difference between current and ideal functions at time $t + 1$ (Step 7, proxy for Step 1 and 6). When reality exceeded tenants' preferences and aspirations (i.e. when the current housing function scored higher than the ideal one), the gap was assigned a value of 0 (i.e. no gap). We formulated it as follows:

$$\text{If } IF_{ij,t+1} \geq CF_{ij,t+1} \text{ then } GF_{ij,t+1} = \left|CF_{ij,t+1} - IF_{ij,t+1}\right|, \text{ else } GF_{ij,t+1} = 0 \qquad (6.1)$$

where $IF_{ij,t+1}$ and $CF_{ij,t+1}$ measure the extent to which a function j describes the ideal and current dwelling of a tenant i at time $t + 1$ [1 = strongly disagree; 5 = strongly agree], respectively, and $GF_{ij,t+1}$ measures the gap between residential preferences and reality [0 = perfect match; 4 = largest gap].[22]

2. Trigger type (O3; Step 4)

   From the categorical variable 'trigger type' [1 = opportunity, 2 = problem-solving, 3 = radical change], we generated three dummy variables: opportunity [0, 1], problem-solving [0, 1] and radical change [0, 1].

3. Δfunctions (t, t – 1) (O3; Step 5)

   To explore the extent to which trigger types adjust the determinants of the decision to select a dwelling, we looked at changes in tenants' *revealed* preferences. The variable Δfunctions (t, t – 1) was calculated as the average absolute difference between the nine current functions at t and $t - 1$ (i.e. current and past, respectively):

$$\Delta F_{t,t-1} = \bar{x}\left|CF_{ij,t} - CF_{ij,t-1}\right| \tag{6.2}$$

   where $CF_{ij,t}$ and $CF_{ij,t-1}$ measure whether a function j describes the current dwelling of a tenant j at time t and t – 1 [1 = strongly disagree; 5 = strongly agree], respectively, and $\Delta F_{t,t-1}$ measures the change in revealed preferences [min = 0, max = 4].

6.4 Results

6.4.1 Descriptive analysis

The descriptive statistics for the blocks introduced in the previous section are illustrated in Table 6.7, Table 6.8, Table 6.9, and Table 6.10.

The final sample consists of a higher share of cooperative tenants (33.5% from ABZ, 39.5% from SCHL) compared with households renting from the private owner (27% from Mobiliar).[23] German-speaking tenants (approx. 46%) are similarly but less represented than the French-speaking ones (approx. 54%). Females comprise approximatively 54% of respondents compared with the male proportion of 46%. When grouped into household types, middle-aged couples with children at home constitute the major share of respondents in the cooperatives (24% in ABZ and approx. 18% in SCHL), whereas young couples without children comprise the largest group of tenants renting from Swiss Mobiliar (16.5%). Respondents' ages range from 22 to 89 years with an average of 51 years (SD = 15.5). Many of the surveyed tenants have a university degree (40% of respondents with a bachelors or masters, plus 5% with PhDs) and are employed either full- or part-time (approximately 71% of respondents).[24]

[22] In order to perform the transformations illustrated in point 1 and point 3, the distance between adjacent answer categories (i.e. ratings on each housing function) was assumed to be equal.

[23] We can attribute this to two elements: first, cooperative systems often request tenants' participation in surveys; second, the invitation letter to the cooperatives included the signature of the cooperatives' directors, which was not present in those from Swiss Mobiliar. In fact, the presence of its logo could have biased the responses, as (i) Mobiliar is an insurance company and (ii) the tenants rent through technical administrations and are often unaware of their dwelling owner's identity.

[24] The percentages are 'valid percentages', which exclude the missing values (or those tenants who did not answer the question) from the total.

With regard to residential mobility, the vast majority of the households (95%) has moved in the last 30 years. The most frequently cited reasons for moving are the opportunity to rent another dwelling, an increasing lack of comfort, and household growth (e.g. a new child). Approximately 80% of tenants claim to be satisfied or strongly satisfied with their current dwelling.

Regarding housing functions, housing as a place for 'production, consumption' scores the highest for the past (mean = 4.02, SD = 0.82), present (mean = 4.29, SD = 0.69) and ideal dwellings (mean = 4.55, SD = 0.61). Housing as a 'permanent' place evinces the greatest increase in importance between past and present dwellings (mean = 0.42, SD = 1.28), while 'commodity' exhibits the largest absolute change (increase and decrease; mean = 0.91, SD = 1.02). The greatest difference between current and ideal dwellings is for the function 'property' (mean = -0.92, SD = 1.40), which remains the case when applying the gap formula (mean = 1.02, SD = 1.28; Eq. 6.1).

6.4.2 Housing functions in the relocation process: tenants' satisfaction (O1)

This section examines the applicability of housing functions to understanding households' residential satisfaction with the goal to determine whether functions play a role in the relocation process (H1; O1).

Table 6.3 shows the results of the multinomial regression model, whereby the difference between each of the nine current and ideal housing functions at $t + 1$—i.e. the variable 'gap'—was used as explanatory variable for tenants' residential satisfaction. The model considers each category of satisfaction against the highest level ('strongly satisfied'). Its explanatory power is modest (Nagelkerke $R^2 = .160$) but not unusual (de Groot, Mulder, & Manting, 2011).

As hypothesized, we observe that for five of the nine functions, the greater the gap between reality and preferences, the greater the odds of not being strongly satisfied with the current residential condition. More specifically, the more tenants imagine their ideal dwelling as a place where they belong (i.e. 'permanence') or as a place for the 'self' (i.e. 'status symbol' and 'self-representation'), the more likely they are to be dissatisfied or even strongly dissatisfied when their current dwelling doesn't fulfil that function. However, the findings also show that gap variables are not consistently significant across categories of residential satisfaction; for instance, a one-unit increase in gap for the function 'self-representation' does not discriminate between 'strongly satisfied' and 'satisfied'.

Two predictors evince unexpected results: 'property' and 'production, consumption'. Regarding the first, as opposed to the other regression coefficients, results show that the greater the difference between ideal and current functions, the lower the chances of being strongly dissatisfied (OR = 0.74; 10% sig. level). Regarding the second, it can be observed that for a one-unit increase in the gap between reality and preferences, the odds of being satisfied rather than strongly satisfied increase by 55%. Considering that a place for 'production, consumption' refers to the performance of daily activities (e.g. eating, laundering), the function is expected to be determinant in discriminating a lower level of satisfaction from a higher one rather than a high level from the highest.

Table 6.3. Multinomial logistic regression of tenants' residential satisfaction with their dwellings when the gap between each current and ideal housing function increases by one point

	Strongly dissatisfied	Dissatisfied	Neither, nor	Satisfied
Satisfaction with current dwelling (ref. cat. 'strongly satisfied')				
Intercept	-2.05*** (0.212)	-2.51*** (0.216)	-3.02*** (0.252)	-0.54*** (0.116)
Property	-0.3* (0.156) [0.74]	0.00 (0.127) [1.00]	0.12 (0.133) [1.12]	0.13* (0.071) [1.14]
Production, Consumption	-0.17 (0.319) [0.85]	0.44* (0.232) [1.56]	0.33 (0.253) [1.40]	0.44*** (0.149) [1.55]
Impermanence	0.09 (0.201) [1.09]	-0.11 (0.208) [0.89]	0.00 (0.207) [1.00]	-0.05 (0.116) [0.95]
Status symbol	-0.17 (0.375) [0.84]	0.48** (0.243) [1.62]	0.73*** (0.234) [2.07]	0.41** (0.166) [1.5]
Security	0.25 (0.302) [1.28]	0.12 (0.266) [1.13]	-0.64 (0.394) [0.52]	-0.14 (0.181) [0.87]
Commodity	-0.21 (0.318) [0.81]	-0.47 (0.319 [0.63]	-0.10 (0.276) [0.90]	-0.25 (0.162) [0.78]
Self-representation	0.3 (0.226) [1.35]	0.52*** (0.187) [1.68]	0.56*** (0.191) [1.76]	0.04 (0.129) [1.04]
Shelter	0.38 (0.265) [1.46]	0.36 (0.239) [1.43]	0.23 (0.255 [1.26]	0.22 (0.158) [1.24]
Permanence	0.48** (0.232) [1.62]	0.4* (0.208) [1.49]	0.62*** (0.213) [1.86]	0.41*** (0.135) [1.51]
N	878			
Initial -2LL	1473			
Model -2LL	1334			
Improvement (Chi^2)	Chi^2 = 139.358, df = 36, p < .001***			
Nagelkerke R^2	0.160			

Beta coefficients; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (Standard Error); [Odds ratio]

6.4.3 The influence of housing functions on the determinants of the decision to move (O2)

Having clarified the link between housing functions and residential satisfaction, this section examines their relationship with the determinants of the decision to move: the triggers. Triggers can generate from gradual changes (e.g. decrease in comfort, increase in stress), or sudden ones (e.g. a divorce); they can arise from the tenant's life course trajectory (e.g. new job location), or they can be caused by the management and dynamics of the housing stock (e.g. a demolition).

Table 6.11 in the "Appendix" displays the results of the multinomial logistic regression model, which estimates the effects of the level of satisfaction and the nine housing functions on the effectiveness of a trigger event. The explanatory power of the logistic regression model with all predictors (Nagelkerke R^2 = .306) is improved compared to the model limiting its predictors to the level of satisfaction (Nagelkerke R^2 = .057) or to the functions (Nagelkerke R^2 = .281).[25] The model considers each event against the trigger 'increasing lack of comfort'.

Trigger events and residential satisfaction

Table 6.11 shows that, overall, the more tenants are satisfied with their dwelling, the less likely they are to move due to the reference category 'lack of comfort'. Our interest is focused more specifically on ranking the odds, which shows the power of each trigger event against the level of satisfaction (Table 6.4).

The higher the level of satisfaction, the more likely it is that the trigger events resulting in a move are problems generated either by the housing stock (e.g. a forced move, a rental contract expiration) or the tenant's educational or occupational career; for instance, tenants are nearly four times more likely to move because of a change in life-location than a lack of comfort when the level of satisfaction increases by one point (OR = 3.72). Changes in household career—such as an explicit need for radical change, a move with the partner or the shrinking and growing of the household—are also found to be from 32% to 55% more likely to be effective with a higher residential satisfaction.

Compared to a lack of comfort, the opportunity to rent another dwelling or be accepted in a cooperative displays the lowest odds of moving with a satisfaction increase of one point (OR = 1.29). To consider and catch an opportunity, the tenant is indeed expected to have a lower level of satisfaction.

Table 6.4. Ranked overview of odds ratios of significant predictors from the multinomial logistic regression analysis of moving due to a trigger event when the level of satisfaction increases by one point.

Trigger event	
Change in life-location	3.72**
Forced to move	1.88***
Rental contract expiration	1.57*
New job location	1.56***
Need for a radical change	1.55**
Move with partner	1.44***
Rent too high	1.43**
Dwelling too small	1.42**
Children leaving home	1.40**
Need for autonomy	1.39*
Household growth	1.34**
Divorce, separation, loss of partner	1.32**
Opportunity to rent	1.29**

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[25] To check the criterion of parsimony in the model, we computed the Akaike information criterion (AIC). Results show that the AIC is lower in the partial models (satisfaction: 467; function: 4750) than in the full one (4797), meaning that the full model performs less well than the partial one. However, the goal of our analysis in this case was *exploratory* rather than predictive.

Trigger events and housing functions

Table 6.11 indicates that the trigger event leading to the move significantly depends on the function fulfilled by the dwelling.

When the dwelling is considered a place to belong (i.e. permanence), households are more likely to move due to relevant changes in their life-course (e.g. leaving the parent(s)' home, OR = 8.35; children leaving home, OR = 2.20) or the imposed circumstances (i.e. forced to move, OR = 2.32; dwelling too small, OR = 1.52) rather than a decrease in comfort. The same is the case when the dwelling meets the needs of a specific life phase (i.e. impermanence); for instance, when this function is perceived as 1-point stronger in one's dwelling, the odds of moving due to retirement increase by a factor of 2.11. Similarly, tenants who consider their dwelling a place for 'self-representation' or a 'status symbol' are overall more reticent to move unless an event such a divorce (which supposedly imposes a change in status and the self) impels it (self-representation OR = 1.52; status symbol OR = 1.32, 10% sig. level). Lastly, results show that the 'homely home' or 'shelter' is more likely to be left due to a move with the partner rather than a decrease in comfort (i.e. rebuilding a shared shelter; OR = 1.47).

Compared to these results, dwellings labelled as 'properties', places for 'production, consumption' or 'commodities' evince the opposite regression coefficients; tenants living in such dwellings are more likely to move due to a lack of comfort than other trigger events. Among these, only the function 'commodity' indicates an exception; when the dwelling is considered a temporary or convenient place, a raise in salary can be the perfect opportunity for change (OR = 2.24, 10% sig. level).

6.4.4 Change in preferences following a trigger (O3)

The findings of the previous section confirmed the hypothesis that for most of the functions, the level of satisfaction with the dwelling where tenants reside and the housing functions that it fulfils indicate the extent to which a trigger event is effective. This section tests the hypothesis that these triggers can be categorized into types with varying impacts on adjusting tenants' preferences for the new dwelling (H3; O3).

From trigger events to trigger types

To organize the variety of determinants to move, the survey asked tenants to assign the event that impelled them to move to one of the three proposed types: opportunity, problem-solving, or radical change. Table 6.5 displays an overview of the significant predictors of each trigger type resulting from three binary logistic regressions (for the full table, see Table 6.12 in the "Appendix").

Firstly, results show that whether a trigger is perceived as a problem is more likely to depend on events that are 'external' to the household. The most important problem to solve is the rental contract expiration (OR = 40.22), followed by interpersonal problems with neighbours or flatmates (OR = 19.80). Additional predictors include issues related to the rented dwelling (e.g. a rent too high, OR = 13.29; lack of accessibility, OR = 6.88) and educational or occupational career events (e.g. the 'family'—meaning for instance the need to move closer to locations relevant for children's education, OR = 9.90; a change in life-location, OR = 12.38; a new job location, OR = 2.78, 10% sig. level).

Table 6.5. Ranked overview of odds ratios of significant trigger events predicting each type of trigger leading to the move.

Opportunity [a]		**Problem-solving** [b]		**Radical change** [c]	
Raise in salary	7.00**	Rental contract expiration	40.22***	Leaving parent(s)' home	67.50***
Opportunity to rent	6.76***	Interpersonal problems	19.80***	Divorce, separation, loss of partner	20.53***
Divorce, separation, loss of partner	0.05***	Rent too high	13.29***	Need for a radical change	16.07***
Rental contract expiration	0.23*	Change in life-location	12.38***	Move with partner	13.59***
New job location	0.39**	Lack of space	9.72***	New job location	12.92***
		Family (ageing, children)	9.90***	Need for autonomy	10.91***
		Forced move	8.57***	New child or household growth	9.03***
		Increasing lack of comfort	7.46***	Children leaving home	6.30**
		Accessibility	6.88***	Retirement	5.36*
		Divorce, separation, loss of partner	3.90***		
		New job location	2.78**		

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
[a] The reference category is 'Forced move'
[b] The reference category is 'Opportunity to rent'
[c] The reference category is 'Rental contract expiration'

Secondly, changes exclusively related to life course trajectories are relevant predictors of 'radical change': along with the explicit need for a radical change (OR = 16.07), a divorce (OR = 20.53), a move with a partner (OR = 13.59), a new job location (OR = 12.92) and households' growth (OR = 9.03) are significantly related to this typology. The strongest predictor is leaving the parent(s)' home, which when compared to the reference category 'rental contract expiration' increases the odds of considering the move as a radical change by a factor of 67.

Lastly, we can observe that the odds to move for an opportunity decrease between 95% and 61% when the trigger pushing the move is a divorce, a rental contract expiration or a new job location. This finding indicates a clear distinction between opportunity and the two other triggers; however, there is a less stark difference between problem-solving and radical change, which can encompass both the loss of the partner or a new job location (although the odds are significantly higher for the third trigger type).

Change in housing functions with trigger types

The results of the one-way ANOVA for the full sample of respondents indicate that the trigger type significantly influences the extent to which housing functions change between the former dwelling (i.e. current at time $t-1$) and the current residence at time t (ΔFunctions; Table 6.6).

Table 6.6. One-way ANOVAs between trigger types on the mean change in functions between current dwellings at *t* and *t* – 1 for the full sample and the 'strongly satisfied' subsample.

	N	Mean	SD		SS	df	MS	*F*	Sig.	η_p^2
Full sample										
OP	323	0.62	0.45	Between Groups	3.11	2	1.556	6.317	0.002***	0.014
PS	217	0.71	0.53							
RC	338	0.76	0.52	Within Groups	215.56	875	0.246			
Tot	878	0.70	0.50	Tot	218.67	877				
Subsample 'strongly satisfied'										
OP	55	0.46	0.36	Between Groups	4.77	2	2.386	9.079	0.000***	0.088
PS	51	0.79	0.61							
RC	86	0.82	0.53	Within Groups	49.67	189	0.263			
Tot	192	0.71	0.53	Tot	54.45	191				

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Full sample $R^2 = 0.014$; Adjusted $R^2 = 0.012$;
Subsample $R^2 = 0.088$; Adjusted $R^2 = 0.078$
SS Sum of Squares; MS Mean of Squares; Tot Total; OP Opportunity; PS Problem-solving; RC Radical change

However, the trigger type explains only 1.2% of the spread of this change around the overall mean (adjusted R^2), and the effect size is rather weak ($f = 0.1$; Cohen, 1992).

Additionally, post-hoc tests with Bonferroni correction reveal that the change in functions following the trigger type 'problem-solving' does not significantly differ from the two other types, whereas 'opportunity' and 'radical change' do (mean difference 0.14; $p < 0.01$; Table 6.13 in the Appendix). This result indicates that contrarily to H3, a problem to solve can lead to both a strong and a weak change in housing functions. However, it also confirms that tenants who moved due to a radical change in their lives rather than an opportunity chose dwellings with significantly different functions than those of their previous residence.

To further investigate changes in preferences in relation to trigger types, Table 6.6 also displays the results of the one-way ANOVA for those respondents with the highest level of satisfaction prior to the trigger (5 points over 5). For this population, the gap between current and ideal housing functions before the move is supposed to be minimum, and no adjustment in housing functions for the new dwelling is therefore expected following the occurrence of an opportunity or a problem to solve.

Compared with the full sample, results for this subset show a moderate improvement—adjusted $R^2 = 0.078$, medium effect size ($f = 0.31$; Cohen, 1992). As was the case for the full sample, post-hoc tests with Bonferroni correction indicate that ΔFunctions following an opportunity significantly differs from ΔFunctions following a radical change with a mean difference of 0.36 points ($p < 0.01$). However, contrarily to the hypothesis (H3), the category 'problem-solving' also elicits a significantly greater change in function compared with 'opportunity' (+0.33 points, $p < 0.01$).

6.4.5 Tenants' characteristics and ideal housing functions (O4)

A variety of household characteristics play a role in the decision to move and where to move. Table 6.14 in the "Appendix" displays the result of the ordinal logistic regressions, whereby household type, employment status, salary, education level and tenancy type (i.e. housing owner) are used as explanatory variables of tenants' preference for each housing function—i.e. ideal function at $t + 1$. According to the test of parallel lines, or the proportional odds assumption, five of the nine models are equal across outcome levels (chi-square > 0.05) and are therefore included in the table. To facilitate their presentation, we illustrate the results of the models in four subsections.

Property

The first model displays the largest range of significant predictors.

We firstly observe that singles (18–64 years) and young couples (18–34 years) are between two to almost six times more likely to aspire to have a place that 'belongs' to them compared with middle-aged tenants with children. The relative probability of considering such a place as ideal decreases by nearly 60% for couples above retirement age (10% sig. level; Table 6.14). Secondly, compared with a university degree, holding a high school diploma also indicates a lower likelihood to wish for a 'property' (OR = 0.49). Lastly, this likelihood is 51% greater for households renting from the private sector (i.e. Swiss Mobiliar) compared with those in the SCHL cooperative.

Employment rate and salary are also significant explanatory variables of the function 'property'. On the one hand, being unemployed decreases the likelihood of desiring this function for one's dwelling (OR = 0.49); on the other hand, and surprisingly, the second lowest category of salary decreases it compared to the first (OR = 0.60). It must be considered that the variable 'salary' accounts for the sum of the salaries of all household members, which is expected to be lower for one-person households—this is particularly pertinent given that the category 'single' is a significant predictor of this function.

To summarize, the profile of tenants considering the housing function 'property' as ideal can be outlined as renters having just started their housing and household careers: single or young couples, tenants with lower salaries, a higher level of education, working full-time, and renting from a private owner rather than being part of a cooperative system.

Status symbol

Young singles and full-time workers are also attracted by the function 'status symbol'. Results show that the likelihood of considering housing as a credential for esteem most strongly increases when the tenant is a young single (18–34 years, OR = 2.08), and working full time (working part-time decreases the odds of considering the status symbol 1-point more 'ideal' by 78%). Interestingly, significant predictors include renting from ABZ (OR = 1.58) and Mobiliar (OR = 1.40), whose dwellings are predominantly located in the Swiss-German part of Switzerland.

However, it must be noted that the explanatory power of this model is weak ($R^2 = 0.083$), which is also the case for the next model: impermanence ($R^2 = 0.085$).

Impermanence and shelter

A dwelling 'free from tradition or memory' (i.e. impermanent) is the ideal place for 'lonely', middle-aged tenants who are divorced or widowed and do not have children (OR = 2.42). In addition, Table 6.14 shows that renting from a private owner rather than a cooperative increases the likelihood of desiring a place that merely reflects current needs by 51%.

Single (OR = 1.46) or divorced middle-aged tenants (OR = 2.48) are also in search of a 'shelter'; however, this function is most strongly desired by young couples (with children, OR = 3.81; without children OR = 3.90). In addition, when growing old (i.e. middle age), couples are approx. 60% less likely to desire the 'shelter' function when their children are gone than when they are still living in the dwelling. In summary, 'shelter' fits well to a broad range of tenants, such as young couples, families of mid- and younger age, and lonely tenants. Again, the predominant location in the Swiss-German part of Switzerland (i.e. ABZ, OR = 2.47; Mobiliar, OR = 1.44, 10% sig. level) is a significant predictor of this function.

Permanence

In addition to 'property' and 'shelter', young couples without children also long for 'permanence' (OR = 2.18), or a place to feel rooted, which is consistent with considering this household type as just starting its housing career and therefore imagining the dwelling as its own stable and cosy place. As is the case for 'shelter', the likelihood of considering such place as ideal decreases when the children leave the nest (OR = 0.37).

Moreover, we point to the finding that employment is another significant explanatory variable for this model. More specifically, the odds of considering the ideal dwelling as a permanent place increase by a factor of 3.31 when the tenant spends more time at home, i.e. is a housewife or househusband.

6.5 Discussion

In this paper, we investigated the role played by housing functions in the residential mobility of the tenants of a real estate owner and two of the largest cooperatives in Switzerland. Based on prior qualitative research, we introduced a multi-step theoretical model of tenants' decision to relocate (Figure 6.2) and then explored its linkages by means of empirical analyses of survey data.

In the following subsections, we discuss the results of this study along four lines: first, we present a synthesis of the findings and their theoretical contribution; second, we illustrate potential implications for practice; third, we discuss the study's limitations; lastly, we identify promising avenues for future research.

6.5.1 Research findings in perspective: disentangling systems complexity

The first hypothesis scrutinized in this study was that housing functions can be used as proxies for residential attributes (housing, neighbourhood, location) to understand households' satisfaction with their dwellings and thus are relevant for unravelling the decision to move and the selection process (H1).

Results have shown that, in most cases, residential satisfaction is more likely to increase with a decreasing gap between the housing functions of the ideal and current dwelling. However, we also observed that these findings are not consistently significant across categories of satisfaction. More specifically, the fulfilment of a housing function was found to make large or little-to-no difference to tenants' residential satisfaction—e.g., for certain functions the gap was a significant predictor of the jump between a strong dissatisfaction to a strong satisfaction or vice-versa, for others of the jump between 'neither nor' to 'strongly satisfied' or vice-versa. In agreement with recent studies that have disproved the commonly explored existence of a linear relation between satisfaction and gap (see e.g. Jiang et al., 2020), our choice of a multinomial regression model pointed to the different influences that housing functions can have on rather than across categories of satisfaction. Also, our findings contribute to the research of the many scholars who, since the seminal work of Rossi (1955), have attempted to disentangle the complex links between residential satisfaction and the determinants of residential mobility (see, for instance, the conceptual model proposed by Marans 1976). In particular, the existence of a *direct* or *'mechanistic'* relationship between the residential environment and household satisfaction has often been questioned (Lawrence, 1987a; Michelson, 1980), arguing that the latter can vary within and between households who subjectively interpret and assess the objective characteristics of the former (i.e. (dis)amenities), depending on a variety of factors (expectations, reference groups, subjective beliefs; Cook & Bruin, 1994; Diaz-Serrano & Stoyanova, 2010; Galster, 1987; Galster & Hesser, 1981; Jansen, 2014b; Jiang et al., 2020; Marans, 1976). By introducing the functions as mediators between the human and material subsystems and thereby accounting for both tenants' preferences and dwelling forms, this study does not advocate for the existence of a *direct* relationship between satisfaction and dwelling but rather an *indirect* and systemic one. This conceptualization makes it possible to overcome the limitations encountered in other authors' empirical analyses, and in particular the aforementioned subjective ways but also the complex combinations in which dwellings features affect residential satisfaction—i.e. the correlations between and within categories of residential attributes (dwelling, neighbourhood, location) or the different effects that each of these categories has been found to exert on residential satisfaction (Jiang et al., 2017; Molin et al., 1996; Wong, 2002). In other words, our results demonstrated that the notion of housing function can offer a shortcut to link residential satisfaction to the objective and subjective characteristics of the environment and of its residents while accounting for the system's complexity.

The findings of H1 are of relevance given that residential satisfaction plays a role in the decision to move and the formulation of preferences for the new dwelling. When looking at the former, we found that housing functions both directly and indirectly influence the extent to which tenants are likely to move following an event (e.g. a new child; H2). More specifically, we observed that the level of residential satisfaction (which itself is influenced by the size of the gap between ideal and current functions) and the function that the dwelling fulfils are significant explanatory variables of the event triggering the move. Building on the seminal work of Speare (1974), most scholars have examined the direct and indirect relations between households' mobility, residential satisfaction, housing features and socio-demographic characteristics (for an overview, see Jiang et al., 2017). Our findings contribute to this body of literature by focusing on the effects that satisfaction and housing functions (and therefore housing and residents' characteristics) have on the *triggers* of the relocation process, rather than on the intention and actual behaviour.

Similar research was undertaken by Wong (2002), whose results showed that the triggers to move have 'unequal correlations' with households' level of satisfaction (p. 227). By grouping triggers into types (i.e. opportunities, problems to solve, and radical changes), our model extends her results one step further. More specifically, when comparing Table 6.4 with Table 6.5 and confirming former exploratory findings (Pagani & Binder, 2021), we observe that the trigger events that are the most effective with an increasing level of satisfaction are often the predictors of the imposed triggers or 'forced' moves (Clark and Onaka 1983), i.e. 'radical change' and 'problem-solving'.

When looking at the formulation of residential preferences and by further exploring the systems interrelations between housing functions and triggers, our findings demonstrate that trigger types differently arbitrate the change in function for the new dwelling (H3). More specifically, despite the weak-to-medium effect size, a radical change was found to most strongly affect tenants' preferences in terms of housing functions. This finding first supports the argument that relocations are instrumental to goals, which can change during the household's life course (Coolen et al., 2002; Mulder & Hooimeijer, 1999); second, it corroborates H1 by showing that housing functions are a constituent element of these 'goals'.

Based on this observation and on the body of literature introduced in this paper, households' characteristics were expected to influence housing functions in multiple ways (H4). Our regression models confirm that household type (marital status, age and children) is a significant explanatory variable for five of the nine ideal housing functions. The findings also illustrate the diversity of ideal dwellings resulting from combinations of different *careers* (e.g. educational, occupational; Mulder & Hooimeijer, 1999), including the type of tenancy.

As outlined in this section, our findings contribute to the body of literature on residential mobility by illustrating the potential of introducing the notion of housing functions for disentangling the complexity of the human–environment system under study. More specifically, our results suggest that the functions orchestrate the factors leading to the moves of Swiss tenants (i.e. triggers, satisfaction and preferences).

6.5.2 Relevance for practice

In agreement with several scholars, this study argued that a better understanding of the relocation process and its determinants can play a key role in fostering the provision of adequate, appropriate, and quality housing—i.e. dwellings that support and meet the culture, values and needs of households for which those are intended (see for instance Clark et al., 2006; Franklin, 2001; Kahlmeier et al., 2001; Lawrence, 2004; Molin et al., 1996; Rapoport, 1977). Due to the housing system's complexity, disagreement between housing providers (i.e. owners, practitioners, policy makers) and users (i.e. residents) on what constitutes residential quality persists (Diaz-Serrano & Stoyanova, 2010; Franklin, 2001; Jansen, 2014b; Lawrence, 2009, 2021d; Marans, 1976), which can have several implications. For instance, the difficulty in understanding the links between objective and subjective assessments of the residential environment can undermine the success of housing developments or neighbourhoods—when the housing situation is dissatisfactory, the residents consider housing alternatives (Cook & Bruin, 1994; Kwon & Beamish, 2013; Lawrence, 2009); also, dissatisfaction has been demonstrated to have repercussions beyond households' relocation, and especially to impact residents' health and well-being (Clark and Kearns 2012; Jansen 2014; Kahlmeier et al. 2001; Rolfe et al. 2020).

For these reasons, it has long been argued that plans and programs related to providing or improving housing quality must include final users in the discussion (Lawrence, 2021d). However, participatory approaches might be insufficient if tools to disentangle the system's complexity and foster the integration of the multiple stakeholders' perspectives are not available. Therefore, based on the results presented in our study, practitioners should consider the added value of adopting a systems perspective and using the notion of housing functions for accounting for the relative value that different residents' groups attach to specific dwelling, neighbourhood and location features while ensuring a comprehensive assessment and provision of the many 'interrelated purposes that impinge upon the quality of the [residential] environment' (Lawrence, 1995, p. 1663).

6.5.3 Limitations

While the multi-step model proposed in this study offers a new take on the conceptualization of the residential mobility process, several limitations must be acknowledged. Mainly, the results of the analyses were not consistently significant for the nine housing functions: on the one hand, they were sensitive to the chosen regression models (i.e. ordinal, multinomial; e.g. Table 6.14); on the other hand, they were influenced by the choice of the variable to investigate. Below, we discuss the effects of models and variables on our results.

Gap and satisfaction

Looking at the data of Table 6.3, four of the nine functions are not significant in the regression model. When comparing it with Table 6.8, it can be observed that 'commodity', 'impermanence' and 'security' are on average fulfilled more than tenants desire (see variable ΔCurrent-Ideal). This result shows the limitation of the formula chosen to compute the gap between reality and preferences, which considers only the *lack* of a dwelling function as a predictor of residential satisfaction, regardless of its *abundance*. Rather, more complex models have assumed the existence of an ideal point, whereby satisfaction decreases if reality deviates from aspirations in both directions (see e.g. Jiang et al., 2017, 2020); in other words, a function might also be perceived as *undesirable* or conflictual and thereby negatively affect tenants' level of satisfaction (e.g. a dwelling 'free from tradition and memory' *versus* the need for a place 'where I feel rooted'). In addition, to account for residents' different sensitivities to under- and outperformance of a preference, Jiang and colleagues (2020) proposed non-linear asymmetric gap models which consider that the same gap might not always lead to the same level of dissatisfaction. Also, beside the generally used difference formulation, the authors computed the size of the gap as a relative difference, i.e. dependent on how great the level of aspiration is.

Aside from the way variables were computed, the predominance of moderately and totally satisfied tenants in the sample of respondents is a relevant limitation (see Table 6.10); this bias or dissonance is common in other studies, and derive from a tendency of evaluating a past decision positively (Jansen, 2014b; Kahlmeier et al., 2001; Marans, 1976).

In sum, residential satisfaction is a complex notion that has been conceptualized, measured, and calculated in manifold ways and is subjected to several biases. In this study, the way the dependent and independent variables were computed revealed several limitations which could be overcome by more methodologically advanced gap models.

Trigger types

Asking tenants to assign the trigger events to one of the three proposed types aimed at validating the typology of triggers proposed in the Pagani and Binder's (2021) qualitative study. However, while observing the richness of events that can be categorized as problems to solve or radical changes, we also faced the issue of having the same event categorized in both types.

More specifically, a closer examination of Table 6.5 and Table 6.11 shows that the links between functions, trigger events and trigger types remain unclear. For instance, the function 'property' was found on the one hand to increase the likelihood of moving due to trigger events categorized as 'radical changes' or 'problems to solve' and on the other hand to decrease the likelihood of moving due to a 'decrease in comfort', which tenants also classified as a problem to solve. Another example is Table 6.6, where an update in housing functions—which was only expected for the category 'radical change'—was observed following the trigger 'problem-solving', a result that could also be explained by the above-mentioned overlapping of types per event.

These unclear relationships potentially suggest the existence of sub-categories of the three trigger types depending on the triggering 'power' of each event in the type, meaning the level of satisfaction at which they are effective.

ΔFunctions and trigger types

The choice to compare changes in current housing functions (i.e. between past and present dwelling) to observe the effects of triggers on residential preferences should also be discussed. One could argue that this approach is correct only if the current housing function (i.e. revealed preferences) corresponds to the ideal one (i.e. stated preferences). If not, the tenant would take advantage of any trigger type to choose a dwelling that better matches its ideal functions (Pagani & Binder, 2021). At time *t*, the result of the move would evince an update in current functions, which would not correspond to an update in the ideal ones.

In agreement with this argument, results for the subsample who moved with a high level of satisfaction (i.e. with current and ideal functions matching; see H1) showed improved results compared with the full sample (Table 6.6). However, contrary to H3, the trigger 'problem-solving' brought about an unexpected and significantly greater change than the trigger 'opportunity'. Possible explanations for this result emerge when considering the context, as illustrated in the next subsection.

Beyond variables: the relevance of the context

The extraordinarily low vacancy rate in Switzerland cannot be overlooked when investigating tenants' residential choices. Although encompassed by the trigger events, the influence of micro- and macro-level contexts was not thoroughly accounted for in the variables chosen for our analysis of preferences. In fact, analysing the stated and revealed preferences through ideal and current housing functions did not account for the adjustments of the criteria to *what is possible* (Timmermans et al., 1994; van Ham, 2012); elements such as income or the availability of dwellings on the market can make preferences and final selections deviate from ideal housing functions. This is clear in Section 6.4.5, where salary and education were found in most cases not to be good predictors of ideal housing functions. This argument is also key for our interpretation of Section 6.4.4, whereby the trigger 'problem-solving' was found to bring about an unexpected change in function; considering time constraints (i.e. contract expiration), a compromise between the dwellings available on the market and the ideal one is often needed, thereby potentially resulting in a change in function. Further, the results presented in Section 6.4.2 show that fulfilment of the function 'production, consumption'—which encompasses basic activities such as laundering or social activities such as companionship—is relevant but not sufficiently critical to discriminate a low from a high level of satisfaction; this finding should be further investigated in relation to the Swiss economic and sociocultural context (e.g. wealth, interpersonal relationships).

Previous studies have accounted for resources and restrictions (e.g. household salary), and opportunities and constraints (e.g. vacant dwellings) when investigating the decision process by adopting the so-called 'three-stages approach' (Mulder, 1996; Mulder & Hooimeijer, 1999). Following this approach, a new function could be introduced: the *desired* function. As the *ideal* function is only dependent on a household's trajectories, the *desired* function would correspond to the adaptation of the ideal one to resources and restrictions, and the *current* function to the adaptation of the desired one to opportunities and constraints. These three types of functions would more specifically account for the trade-off between the multiple determinants that arise from, for example, lifestyle and individual resources (Thomas and Pattaroni 2012) and the re-evaluation of preferences in the search process (Brown & Moore, 1970).

6.5.4 Future research

Based on the limitations illustrated above, it becomes clear that further research is needed. Firstly, the role of housing functions in the selection process should be more closely considered by (i) focusing on the readjustment of the ideal housing function(s) to the desired one(s) following a trigger and of the latter to the current one(s) for the final selection; (ii) critically analysing the contribution of the three types of functions to households' satisfaction with and selection of a dwelling; and (iii) exploring the potential to use previously-identified explanatory variables for tenants such as age, size of household and rent as predictors of the desired function (Clark and Dieleman 1996). In particular, further studies of the relationship between housing functions and resident satisfaction could benefit from the substantial methodological advances in the field, e.g. the use of non-linear models (Jiang et al., 2020).

Secondly, while our study investigated tenants' past move—where the intention to move corresponds to actual residential mobility—new insights could be gained by examining unsuccessful relocations (Coulter, 2013); in this context, the factors preventing relocation identified in the large amount of research based on the stress-resistance models could be explored in relationship to housing function and trigger types (i.e. the monetary and non-monetary costs of moving; see Brown & Moore, 1970; Clark & Onaka, 1983; Goodman, 1976; Mulder, 1996; Phipps, 1989; Phipps & Carter, 1984; Wolpert, 1965).

Thirdly, this paper presented the results of quantitative research conducted in the framework of the Swiss rental market which are country- and tenure-specific; considering the relevance of the context for the present and future studies, the *tenancy* type and the influence it has on tenants' decisions could also benefit from further research (e.g. due to occupancy rules, a reduction in household size can result in a 'forced move' for cooperative tenants). Furthermore, while the notion of housing functions allowed us to consider and have a better understanding of the interrelationships at play in the housing system (i.e. objective and subjective assessments of housing quality, changes in residential preferences, residential satisfaction, etc.), additional qualitative and quantitative research could be conducted to explore the functions' potential material manifestations in the Swiss context for different inhabitants' groups.

Lastly, for our results to appeal to decision-makers and practitioners, and thereby reduce the so-called 'applicability gap' (Lawrence, 2021b), the proposed model of residential mobility should be explicitly integrated with context dynamics, i.e. opportunities and constraints generated by the housing market. Since a systems perspective was adopted, an agent-based model (ABM) can be utilized for this purpose. The goal of an ABM is to observe the parallel actions of components and their interaction, thereby discovering emergent properties from a bottom-up perspective (Nikolic & Ghorbani, 2011). Implementing an ABM would make it possible to simulate the system outlined in this paper (i.e. tenants' residential relocation process) and integrate it with housing stock dynamics (i.e. construction, demolition, renovation). By accounting for the material components of housing and stakeholders' goals, priorities and values, the model would contribute to a greater understanding of the behaviour of such a complex human–environment system and thereby make it possible to observe otherwise-unpredictable reciprocal effects between residential preferences and dwellings.

6.6 Conclusion

This study investigated the role of housing functions as orchestrators of tenants' residential mobility in Switzerland. We operationalized previous qualitative work in a multi-step model and explored it by means of survey data. The survey targeted the tenants of a Swiss real estate owner and of two of the country's largest cooperatives.

Our analyses showed that tenants' residential satisfaction is more likely to increase when the gap between ideal housing functions and those actually fulfilled by the current dwelling decreases. As residential satisfaction is relevant both in the decision to move and the formulation of preferences, there is a potential to use housing functions to understand the relocation process. Secondly, we found that these functions both directly and indirectly influence the likelihood of an event triggering a move; the effectiveness of such triggers was observed to depend on the satisfaction prior to the event (e.g. a rental contract expiration is more powerful than an opportunity to rent a dwelling elsewhere) and the function fulfilled by the dwelling (e.g. a place for 'self-representation' being left for events such as a divorce). Additionally, we found that trigger events can be grouped into types (i.e. opportunities, problems to solve and radical changes), which were found to influence the change in housing function(s) before and after the move to a certain degree. This change is further explained by the significance of socio-demographic data and tenancy type as predictors of *ideal* functions, as these data are updated after radical changes (e.g. leaving the parent(s)' home).

Finally, the use of current and ideal functions was found to be key for depicting Swiss tenants' residential preferences. However, this paper discussed several limitations in the models and variables chosen for the analysis and highlighted the need for a better integration of micro- and macro-contextual elements in the analysis of preferences. In this framework, our study could benefit from the integration of a new variable: the *desired* function. This variable would account for the adjustment of the ideal functions to tenants' resources and restrictions and then be further adapted to the available housing supply, thereby resulting in the selection of the most satisfactory current function.

Having a greater understanding of the complex human–environment interactions in the housing system is key for research and practice that targets the supply of adequate and quality housing, and thereby residents' health and well-being. With this purpose, the findings of this study could be simulated by means of an ABM that integrates the proposed model with supply-side constraints and opportunities.

Appendix

See Table 6.7, Table 6.8, Table 6.9, Table 6.10, Table 6.11, Table 6.12, Table 6.13, and Table 6.14.

Table 6.7. Respondent profiles for block 1: Household composition

Variable [0, 1]	Full sample		ABZ		SCHL		Mobiliar	
	N	%	N	%	N	%	N	%
Sex	877	100	294	100	346	100	237	100
Female	472	53.8	171	58.2	187	54	114	48.1
Male	405	46.2	123	41.8	159	46	123	51.9
Household type	870	100	292	100	344	100	234	100
Young single	43	4.9	8	2.7	17	4.9	18	7.7
Young couples without children	73	8.4	10	3.4	24	7.0	39	16.7
Young couples with children	26	3.0	9	3.1	8	2.3	9	3.8
Middle-aged single	88	10.1	24	8.2	37	10.8	27	11.5
Middle-aged couples without children	66	7.6	18	6.2	20	5.8	28	12.0
Middle-aged alone without children	59	6.8	23	7.9	27	7.8	9	3.8
Middle-aged couple with children living at home	163	18.7	70	24.0	61	17.7	32	13.7
Middle-aged couple with children not living at home	46	5.3	19	6.5	20	5.8	7	3.0
Middle-aged alone with children living at home	50	5.7	20	6.8	18	5.2	12	5.1
Middle-aged alone with children not living at home	38	4.4	17	5.8	16	4.7	5	2.1
Other middle-aged couples	19	2.2	6	2.1	7	2.0	6	2.6
Older couple	95	10.9	28	9.6	43	12.5	24	10.3
Older alone	104	12.0	40	13.7	46	13.4	18	7.7
Employment	848	100	286	100	330	100	232	100
Full-time 80-100%	430	50.7	121	42.3	153	46.4	156	67.2
Part-time <80%	171	20.2	86	30.1	61	18.5	24	10.3
Housewife / Househusband	17	2.0	6	2.1	6	1.8	5	2.2
Student or apprenticeship	8	0.9	4	1.4	1	0.3	3	1.3
Unemployed	18	2.1	1	0.3	14	4.2	3	1.3
Retired	204	24.1	68	23.8	95	28.8	41	17.7

Variable [0, 1]	Full sample		ABZ		SCHL		Mobiliar	
	N	%	N	%	N	%	N	%
Salary	701	100	235	100	280	100	186	100
Less than 60,000 CHF/year	229	32.7	90	38.3	111	39.6	28	15.1
60.0001–88,000 CHF/year	211	30.1	79	33.6	89	31.8	43	23.1
88,001–120,000 CHF/year	149	21.3	42	17.9	48	17.1	59	31.7
120,001–164,999 CHF/year	67	9.6	14	6.0	20	7.1	33	17.7
More than 165,000 CHF/year	45	6.4	10	4.3	12	4.3	23	12.4
Education	811	100	274	100	313	100	224	100
Unfinished mandatory school	4	0.5	1	0.4	3	1.0	0	0
Mandatory school	72	8.9	13	4.7	47	15.0	12	5.4
Professional school	319	39.3	109	39.8	136	43.5	74	33.0
High school	53	6.5	21	7.7	21	6.7	11	4.9
University (BA / MA)	326	40.2	110	40.1	102	32.6	114	50.9
PhD	37	4.6	20	7.3	4	1.3	13	5.8
Language	878	100	294	100	347	100	237	100
German	401	45.7	294	100	0	0	107	45.1
French	477	54.3	0	0	347	100	130	54.9
Total	878	100	294	33.5	347	39.5	237	27.0

N.B. 'Couples' include married and unmarried tenants; 'alone' includes divorced, widowed or separated tenants.

Table 6.8. Respondent profiles for block 2: Housing functions.

Variable	N	Current ($t-1$)		Current ($t+1$) [a]		Ideal ($t+1$)		ΔCurrent ($t, t-1$)		ΔCurrent-Ideal ($t+1$)		Δfunctions ($t, t-1$) [b]		Gap ($t+1$) [b]	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Property	878	2.65	1.234	2.71	1.211	3.63	1.164	0.06	1.056	-0.92	1.402	0.58	0.886	1.02	1.284
Production, Consumption	878	4.02	0.828	4.29	0.686	4.55	0.609	0.27	0.859	-0.26	0.750	0.48	0.762	0.35	0.613
Impermanence	878	3.04	1.136	3.03	1.131	3.02	1.135	-0.01	1.230	0.00	1.150	0.80	0.937	0.36	0.708
Status symbol	878	2.09	1.043	2.07	0.988	2.10	1.007	-0.02	0.973	-0.03	0.815	0.53	0.817	0.24	0.564
Security	878	3.48	1.041	3.61	0.947	3.47	0.988	0.14	1.034	0.14	0.850	0.62	0.840	0.18	0.482
Commodity	878	3.35	1.158	3.10	1.218	2.69	1.175	-0.24	1.345	0.42	1.127	0.91	1.022	0.17	0.501
Self-representation	878	3.06	1.082	3.36	0.984	3.59	0.965	0.30	1.181	-0.24	1.074	0.79	0.923	0.45	0.827
Shelter	878	3.58	1.045	3.95	0.909	4.17	0.923	0.37	1.029	-0.22	0.800	0.67	0.865	0.34	0.627
Permanence	878	3.02	1.194	3.44	1.069	3.78	0.991	0.42	1.277	-0.34	0.950	0.89	1.003	0.47	0.787

[a] Equivalent to current function at time t.
[b] The variable 'gap' measures the absolute difference at $t + 1$ between tenants' current and ideal functions when the latter exceeds the former (Eq. 6.1); 'Δfunctions' measures the absolute difference between tenants' current functions at t and $t - 1$, whose average is used for running the ANOVA (Eq. 6.2; Table 6.6).

Table 6.9. Respondent profiles for block 3: Trigger.

Variable [0, 1]	Full sample		Opportunity		Problem-solving		Radical change	
	N	%	N	%	N	%	N	%
Total	875	100	323	100	216	100	336	100
Raise in salary	10	1.1	8	2.5	0	0	2	0.6
Retirement	12	1.4	5	1.5	2	0.9	5	1.5
Opportunity to rent [a]	107	12.2	85	26.3	8	3.7	14	4.2
Accessibility	14	1.6	7	2.2	5	2.3	2	0.6
New job location	49	5.6	9	2.8	9	4.2	31	9.2
Rental contract expiration	17	1.9	2	0.6	13	6.0	2	0.6
Interpersonal problems	13	1.5	3	0.9	8	3.7	2	0.6
Increasing lack of comfort	101	11.5	49	15.2	38	17.6	14	4.2
Divorce, separation, loss of partner	71	8.1	2	0.6	17	7.9	52	15.5
Move with partner	90	10.3	27	8.4	5	2.3	58	17.3
New child or household growth	97	11.1	30	9.3	14	6.5	53	15.8
Need for autonomy	27	3.1	7	2.2	4	1.9	16	4.8
Need for a radical change	22	2.5	5	1.5	2	0.9	15	4.5
Rent too high	56	6.4	13	4.0	29	13.4	14	4.2
Children leaving home	46	5.3	20	6.2	5	2.3	21	6.3
Leaving parent(s)' home	10	1.1	1	0.3	0	0	9	2.7
Forced move [b]	66	7.5	24	7.4	27	12.5	15	4.5
Lack of space	50	5.7	23	7.1	22	10.2	5	1.5
Family (ageing, children) [c]	9	1.0	2	0.6	4	1.9	3	0.9
Change in life-location [d]	8	0.9	1	0.3	4	1.9	3	0.9

[a] Opportunity to rent another dwelling or acceptance from the cooperative
[b] Demolition, renovation
[c] Moves related to a change in household career (e.g. closer to the family when ageing, closer to schools for children)
[d] For example, moving to Switzerland

Table 6.10. Respondent profiles for block 4: Residential satisfaction.

Variable [1, 5]	Full sample			Strongly dissatisfied		Dissatisfied		Neither, nor		Satisfied		Strongly satisfied	
	N	Median	IQR	N	%	N	%	N	%	N	%	N	%
Satisfaction $t-1$	878	4	1	55	6.3	62	7.1	52	5.9	347	39.5	362	41.2
Satisfaction t	878	4	1	78	8.9	130	14.8	150	17.1	328	37.4	192	21.9

Table 6.11. Multinomial logistic regression of moving for a trigger event compared to the reference category 'increasing lack of comfort' when the level of satisfaction prior to the trigger increases by one point.

Trigger events (ref. cat. 'Decreasing comfort')	RAS	RET	OPP	ACC	NJL	RCE	ITP	DIV	MOP	HOG	NFA	NRC	RTH	CLH	LPH	FM	DTS	FAM	CLL
Int.	-4.34*	-4.3**	-1.08	-1.42	-1.84	-6.56***	-2.68	-1.42	-3.28***	-1.4	-1.89	-4.7***	-0.75	-4.53***	-8.75***	-5.5***	-2.6**	-6.58**	-10.98***
	(2.444)	(2.159)	(0.955)	(1.866)	(1.217)	(2.154)	(2.166)	(1.081)	(1.052)	(0.984)	(1.427)	(1.838)	(1.124)	(1.318)	(3.037)	(1.236)	(1.223)	(2.834)	(3.807)
SAT	0.02	0.43	0.26**	0.08	0.44***	0.45*	0.38	0.28**	0.37***	0.29**	0.33*	0.44**	0.36**	0.33**	0.39	0.63***	0.35**	0.34	1.31**
	(0.282)	(0.267)	(0.115)	(0.225)	(0.152)	(0.233)	(0.262)	(0.129)	(0.123)	(0.119)	(0.183)	(0.206)	(0.143)	(0.149)	(0.311)	(0.149)	(0.147)	(0.301)	(0.527)
	[1.02]	[1.53]	[1.29]	[1.09]	[1.56]	[1.57]	[1.46]	[1.32]	[1.44]	[1.34]	[1.39]	[1.55]	[1.43]	[1.4]	[1.48]	[1.88]	[1.42]	[1.4]	[3.72]
PRO	-0.12	-0.18	-0.17	0.11	-0.08	-0.47*	-0.24	-0.19	-0.2	-0.43***	-0.15	0.11	-0.4**	-0.33*	-0.39	-0.23	-0.29*	0.27	-0.67*
	(0.31)	(0.299)	(0.134)	(0.275)	(0.168)	(0.249)	(0.293)	(0.15)	(0.141)	(0.142)	(0.211)	(0.22)	(0.165)	(0.173)	(0.322)	(0.157)	(0.172)	(0.312)	(0.371)
	[0.89]	[0.84]	[0.84]	[1.11]	[0.92]	[0.62]	[0.78]	[0.83]	[0.82]	[0.65]	[0.86]	[1.12]	[0.67]	[0.72]	[0.68]	[0.79]	[0.75]	[1.31]	[0.51]
PC	-0.65*	0.32	0.06	-0.2	0.07	0.05	0.1	0.16	0.06	-0.07	-0.05	0.44	-0.06	-0.18	-0.39	0 (0.24)	0.08	0.65	-0.05
	(0.373)	(0.448)	(0.187)	(0.392)	(0.24)	(0.416)	(0.372)	(0.218)	(0.204)	(0.192)	(0.271)	(0.365)	(0.23)	(0.259)	(0.427)	[1]	(0.234)	(0.522)	(0.565)
	[0.52]	[1.38]	[1.07]	[0.82]	[1.07]	[1.05]	[1.1]	[1.17]	[1.07]	[0.93]	[0.95]	[1.55]	[0.94]	[0.84]	[0.68]		[1.08]	[1.92]	[0.95]
IMP	0.08	0.75**	-0.03	-0.18	-0.11	0.24	0.25	-0.09	0.02	0.09	-0.37*	-0.14	0.1	0.16	-0.58	0.1	-0.03	0.14	0.72*
	(0.311)	(0.315)	(0.134)	(0.279)	(0.168)	(0.253)	(0.276)	(0.154)	(0.145)	(0.141)	(0.22)	(0.223)	(0.167)	(0.179)	(0.405)	(0.16)	(0.168)	(0.346)	(0.373)
	[1.09]	[2.11]	[0.97]	[0.83]	[0.89]	[1.28]	[1.28]	[0.91]	[1.02]	[1.1]	[0.69]	[0.87]	[1.1]	[1.17]	[0.56]	[1.11]	[0.97]	[1.15]	[2.05]
SS	-0.24	0.26	-0.14	0.03	-0.19	0.01	-0.52	0.28*	0.15	0.02	0.24	0.04	0.08	-0.12	-0.03	-0.06	-0.09	0.34	0.6
	(0.395)	(0.327)	(0.157)	(0.297)	(0.199)	(0.262)	(0.437)	(0.165)	(0.158)	(0.159)	(0.241)	(0.245)	(0.181)	(0.192)	(0.346)	(0.173)	(0.199)	(0.371)	(0.37)
	[0.78]	[1.29]	[0.87]	[1.03]	[0.83]	[1.01]	[0.6]	[1.32]	[1.16]	[1.02]	[1.28]	[1.04]	[1.08]	[0.89]	[0.97]	[0.94]	[0.91]	[1.41]	[1.83]
SEC	-0.26	-0.04	0.05	0.28	0.14	0.18	-0.22	0.05	-0.12	0.2	0.33	-0.05	-0.05	0.19	0.02	0.13	0.18	-0.23	0.62
	(0.326)	(0.313)	(0.146)	(0.319)	(0.187)	(0.289)	(0.285)	(0.167)	(0.152)	(0.157)	(0.244)	(0.236)	(0.178)	(0.199)	(0.322)	(0.175)	(0.188)	(0.336)	(0.459)
	[0.77]	[0.96]	[1.05]	[1.32]	[1.15]	[1.19]	[0.8]	[1.06]	[0.89]	[1.22]	[1.39]	[0.95]	[0.95]	[1.21]	[1.02]	[1.14]	[1.2]	[0.8]	[1.86]
COM	0.81*	-0.95***	-0.14	-0.52*	-0.24	-0.39	0.2	-0.37**	-0.03	-0.24*	-0.17	-0.26	-0.46***	-0.08	0.08	-0.08	0.03	0.15	-0.75**
	(0.449)	(0.283)	(0.138)	(0.27)	(0.169)	(0.247)	(0.337)	(0.153)	(0.148)	(0.143)	(0.207)	(0.222)	(0.165)	(0.179)	(0.308)	(0.161)	(0.177)	(0.375)	(0.346)
	[2.24]	[0.39]	[0.87]	[0.59]	[0.79]	[0.68]	[1.22]	[0.69]	[0.97]	[0.79]	[0.84]	[0.77]	[0.63]	[0.92]	[1.09]	[0.92]	[1.03]	[1.17]	[0.47]
SER	-0.02	-0.8**	0.16	0.44	0.15	0.27	0.14	0.42**	-0.03	0.15	-0.4	0.11	0.54**	0.2	-0.58	0.04	-0.1	-0.63	0.12
	(0.432)	(0.389)	(0.183)	(0.391)	(0.228)	(0.354)	(0.387)	(0.211)	(0.191)	(0.191)	(0.277)	(0.301)	(0.227)	(0.238)	(0.381)	(0.21)	(0.225)	(0.43)	(0.541)
	[0.98]	[0.45]	[1.18]	[1.55]	[1.16]	[1.3]	[1.15]	[1.52]	[0.97]	[1.16]	[0.67]	[1.12]	[1.71]	[1.23]	[0.56]	[1.04]	[0.91]	[0.53]	[1.13]
SH	0.29	0.27	0.16	-0.07	0.04	0.46	0.02	-0.04	0.38**	0.13	-0.03	0.31	-0.03	0.15	0.7	0.1	-0.04	0.06	0.29
	(0.394)	(0.369)	(0.164)	(0.332)	(0.203)	(0.379)	(0.31)	(0.184)	(0.185)	(0.171)	(0.252)	(0.295)	(0.197)	(0.23)	(0.528)	(0.206)	(0.202)	(0.395)	(0.533)
	[1.33]	[1.31]	[1.17]	[0.93]	[1.04]	[1.59]	[1.02]	[0.96]	[1.47]	[1.14]	[0.97]	[1.37]	[0.97]	[1.17]	[2.02]	[1.1]	[0.96]	[1.06]	[1.34]
PER	0.58	0.45	0.08	-0.07	0.04	0.54*	-0.34	-0.1	0.39**	0.26	0.46*	-0.16	-0.01	0.79***	2.12***	0.84***	0.42**	0.05	0.07
	(0.365)	(0.344)	(0.161)	(0.331)	(0.202)	(0.32)	(0.379)	(0.181)	(0.17)	(0.168)	(0.246)	(0.257)	(0.197)	(0.217)	(0.569)	(0.198)	(0.201)	(0.378)	(0.459)
	[1.79]	[1.57]	[1.08]	[0.93]	[1.04]	[1.71]	[0.71]	[0.9]	[1.48]	[1.3]	[1.58]	[0.85]	[0.99]	[2.2]	[8.35]	[2.32]	[1.52]	[1.05]	[1.07]
N	875																		
-2LL[a]	4698																		
-2LL[b]	4379																		
Chi^2	$Chi^2 = 319.695$, df = 190, $p < .001$***																		
R^2	0.306																		

Beta coefficients; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (Standard Error); [Odds ratio]
Dependent variables: RAS raise in salary; RET retirement; OPP opportunity to rent; ACC accessibility; NJL new job location; RCE rental contract expiration; ITP interpersonal problems with neighbours, flatmates; DIV divorce, separation, loss of partner; MOP move with partner; HOG household growth; NFA need for autonomy; NRC need for a radical change; RTH rent too high; CLH children leaving home; LPH leaving parent(s)' home; FM forced move; DTS dwelling too small; FAM family (ageing, children); CLL change in life-location. *Predictors:* Int Intercept; SAT Level of satisfaction at time $t - 1$; PRO property; PC production, consumption; IMP impermanence; SS status symbol; SEC security; COM commodity; SER self-representation; SH shelter; PER permanence; -2LL[a] Initial -1 Log Likelihood; -2LL[b] Model -2 Log Likelihood; Nagelkerke R^2

Table 6.12. Overview of three binary logistic regressions of moving for a trigger type, depending on the event triggering the move.

Trigger event	**Opportunity**	**Problem solving**	**Radical change**
Raise in salary	1.95** (0.831) [7.00]	-18.69 (12710.133) [0.00]	0.63 (1.092) [1.87]
Retirement	0.22 (0.639) [1.25]	0.91 (0.857) [2.48]	1.68* (0.954) [5.36]
Opportunity to rent	1.91*** (0.35) [6.76]	*ref*	0.12 (0.806) [1.13]
Accessibility	0.56 (0.593) [1.75]	1.93*** (0.668) [6.88]	0.22 (1.072) [1.25]
New job location	-0.93** (0.449) [0.39]	1.02** (0.521) [2.78]	2.56*** (0.809) [12.92]
Rental contract expiration	-1.46* (0.795) [0.23]	3.69*** (0.68) [40.22]	*ref*
Interpersonal problems	-0.64 (0.706) [0.53]	2.99*** (0.678) [19.8]	0.31 (1.076) [1.36]
Increasing lack of comfort	0.50 (0.324) [1.65]	2.01*** (0.421) [7.46]	0.19 (0.806) [1.21]
Divorce, separation, loss of partner	-2.98*** (0.762) [0.05]	1.36*** (0.461) [3.9]	3.02*** (0.799) [20.53]
Move with partner	-0.29 (0.344) [0.75]	-0.32 (0.589) [0.73]	2.61*** (0.784) [13.59]
New child or household growth	-0.24 (0.337) [0.78]	0.74 (0.468) [2.09]	2.2*** (0.78) [9.03]
Need for autonomy	-0.49 (0.508) [0.61]	0.77 (0.655) [2.15]	2.39*** (0.849) [10.91]
Need for radical change in life	-0.66 (0.569) [0.51]	0.21 (0.828) [1.24]	2.78*** (0.881) [16.07]
Rent too high	-0.64 (0.407) [0.53]	2.59*** (0.455) [13.29]	0.92 (0.814) [2.5]
Children leaving home	0.3 (0.392) [1.35]	0.41 (0.600) [1.51]	1.84** (0.809) [6.3]
Leaving parent's home	-1.64 (1.085) [0.19]	-18.69 (12710.133) [0.00]	4.21*** (1.295) [67.5]
Forced move	*ref*	2.15*** (0.445) [8.57]	0.79 (0.808) [2.21]
Lack of space	0.40 (0.382) [1.49]	2.27*** (0.465) [9.72]	-0.18 (0.888) [0.83]

Trigger event	**Opportunity**	**Problem solving**	**Radical change**
Family (ageing, children)	-0.69 (0.842) [0.50]	2.29*** (0.765) [9.90]	1.32 (1.033) [3.75]
Change in life-location	-1.39 (1.099) [0.25]	2.52*** (0.797) [12.38]	1.5 (1.049) [4.5]
Constant	-0.56** (0.256) [0.57]	-2.52*** (0.368) [0.08]	-2.01*** (0.753) [0.13]
N	878	878	878
-LL2	971	826	946
Improvement (Chi^2)	Chi^2 = 180.990, df = 19, *p* < .001***	Chi^2 = 152.231 , df = 19, *p* < .001***	Chi^2 = 219.965, df = 19, *p* < .001***
Nagelkerke R^2	0.255	0.237	0.302
Hosmer & Lemeshow test	p = 1	p = 1	p = 1
Classification accuracy	71.0%	76.9%	73.3%

Beta coefficients; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (Standard Error); [Odds ratio]

Table 6.13. Bonferroni adjusted pairwise comparisons of mean change in function between current dwellings at t and $t - 1$ per trigger type.

(I) trigger type	**(J) trigger type**	**ΔMean (I-J)**	**S.E.**	**Sig.**	**95% C.I.**	
Full sample					L.B.	U.B.
Opportunity	Problem-solving	-0.09	0.04	0.119	-0.19	0.01
	Radical change	-0.14	0.04	0.001***	-0.23	-0.04
Problem-solving	Opportunity	0.09	0.04	0.119	-0.01	0.19
	Radical change	-0.05	0.04	0.861	-0.15	0.06
Radical change	Opportunity	0.14	0.04	0.001***	0.04	0.23
	Problem-solving	0.05	0.04	0.861	-0.06	0.15
Subsample 'strongly satisfied'						
Opportunity	Problem-solving	-0.33	0.10	0.004***	-0.57	-0.09
	Radical change	-0.36	0.09	0.000***	-0.57	-0.15
Problem-solving	Opportunity	0.33	0.10	0.004***	0.09	0.57
	Radical change	-0.03	0.09	1.000	-0.25	0.19
Radical change	Opportunity	0.36	0.09	0.000***	0.15	0.57
	Problem-solving	0.03	0.09	1.000	-0.19	0.25

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Based on observed means. The error term is Mean Square (Error) = .246 (full sample), Mean Square (Error) = .263 (subsample). L.B. Lower Bound; U.B. Upper Bound

Table 6.14. Ordinal logistic regression models of tenants' agreement with the *ideal* housing functions according to changing socio-demographic characteristics and tenancy type.

	Property	**Impermanence**	**Status symbol**	**Shelter**	**Permanence**
Threshold = 1	-3.46*** (0.364) [0.03]	-1.77*** (0.318) [0.17]	-0.81*** (0.314) [0.45]	-3.03*** (0.409) [0.05]	-3.58*** (0.417) [0.03]
Threshold = 2	-1.73*** (0.319) [0.18]	-0.26 (0.306) [0.77]	0.78** (0.314) [2.18]	-1.81*** (0.346) [0.16]	-1.61*** (0.323) [0.2]
Threshold = 3	-0.6* (0.311) [0.55]	1.03*** (0.309) [2.8]	2.27*** (0.332) [9.67]	-0.83** (0.328) [0.43]	-0.11 (0.312) [0.9]
Threshold = 4	0.99*** (0.313) [2.69]	2.8*** (0.33) [16.42]	4.27*** (0.453) [71.7]	1.38*** (0.331) [3.98]	1.74*** (0.321) [5.7]
Household type (ref. cat. Middle-aged couple with children living at home)					
Young single	1.75*** (0.387) [5.73]	0.34 (0.354) [1.41]	0.73** (0.358) [2.08]	0.54 (0.378) [1.71]	0.03 (0.36) [1.03]
Young couples without children	0.91*** (0.31) [2.49]	0.15 (0.3) [1.17]	0.45 (0.304) [1.57]	1.36*** (0.338) [3.9]	0.78** (0.309) [2.18]
Young couples with children	0.87** (0.411) [2.39]	0.27 (0.398) [1.31]	0.36 (0.403) [1.44]	1.34*** (0.468) [3.81]	0.4 (0.41) [1.5]
Middle-aged single	0.85*** (0.296) [2.34]	-0.07 (0.288) [0.94]	-0.37 (0.297) [0.69]	0.67** (0.31) [1.96]	0.1 (0.294) [1.11]
Middle-aged couples without children	0.46 (0.33) [1.59]	0.46 (0.324) [1.59]	-0.34 (0.333) [0.71]	0.07 (0.343) [1.07]	-0.14 (0.33) [0.87]
Middle-aged alone without children	0.03 (0.344) [1.03]	0.88*** (0.345) [2.42]	0.29 (0.349) [1.33]	0.05 (0.363) [1.06]	-0.31 (0.349) [0.73]
Middle-aged couple with children not living at home	-0.3 (0.376) [0.74]	0.44 (0.375) [1.55]	-0.6 (0.395) [0.55]	-0.93** (0.393) [0.39]	-1*** (0.382) [0.37]
Middle-aged alone with children living at home	0.17 (0.339) [1.18]	0.47 (0.336) [1.59]	-0.56 (0.351) [0.57]	0.18 (0.357) [1.19]	-0.29 (0.342) [0.74]
Middle-aged alone with children not living at home	0.63 (0.409) [1.88]	0.69* (0.403) [1.98]	-0.58 (0.418) [0.56]	0.91** (0.444) [2.48]	0.49 (0.417) [1.63]
Other middle-aged couples	0.33 (0.6) [1.39]	0.25 (0.593) [1.29]	0.56 (0.602) [1.75]	0.46 (0.634) [1.58]	1.11* (0.63) [3.03]
Older couple	-0.78* (0.418) [0.46]	0.25 (0.417) [1.29]	-0.2 (0.429) [0.82]	-0.22 (0.439) [0.8]	-0.06 (0.425) [0.94]
Older alone	-0.21 (0.431) [0.81]	0.6 (0.431) [1.82]	-0.03 (0.442) [0.97]	0.46 (0.457) [1.59]	0.04 (0.44) [1.04]
Employment (ref. cat. Full-time 80-100%)					

	Property	**Impermanence**	**Status symbol**	**Shelter**	**Permanence**
Part-time <80%	-0.23 (0.214) [0.79]	0.05 (0.211) [1.05]	-0.7*** (0.22) [0.5]	0.37 (0.229) [1.45]	0.3 (0.217) [1.35]
Housewife / Househusband	-0.08 (0.552) [0.92]	0.16 (0.547) [1.17]	0.05 (0.557) [1.05]	1.23 (0.631) [3.43]	1.2** (0.574) [3.31]
Student or apprenticeship	-0.98 (0.719) [0.38]	-0.16 (0.71) [0.85]	0.07 (0.715) [1.07]	0.15 (0.814) [1.16]	-0.58 (0.725) [0.56]
Unemployed	-1.28** (0.518) [0.28]	0.97* (0.519) [2.64]	0.31 (0.524) [1.36]	0.14 (0.55) [1.15]	-0.44 (0.523) [0.65]
Retired	-0.02 (0.374) [0.98]	0.43 (0.373) [1.54]	-0.22 (0.384) [0.8]	-0.11 (0.393) [0.9]	0.44 (0.381) [1.55]
Salary (ref. cat. Less than 60,000 CHF/year)					
60,000–88,000 CHF/year	-0.51** (0.208) [0.6]	-0.23 (0.204) [0.79]	-0.24 (0.211) [0.79]	0.21 (0.22) [1.23]	0.01 (0.21) [1.01]
88,001-120,000 CHF/year	-0.22 (0.242) [0.8]	-0.2 (0.238) [0.82]	-0.03 (0.243) [0.97]	0.1 (0.256) [1.11]	-0.16 (0.244) [0.85]
120,001-164,999 CHF/year	-0.51 (0.312) [0.6]	0.2 (0.307) [1.23]	-0.08 (0.313) [0.92]	-0.18 (0.326) [0.84]	-0.26 (0.313) [0.77]
> 165,000 CHF/year	0.28 (0.383) [1.33]	0.28 (0.37) [1.33]	0.36 (0.375) [1.43]	0.13 (0.396) [1.14]	-0.42 (0.377) [0.66]
Education (ref. cat. University (BA / MA)					
Unfinished school	-1.49 (0.937) [0.23]	-0.42 (0.934) [0.66]	0.04 (0.95) [1.04]	-1.6* (0.949) [0.2]	0.21 (0.961) [1.24]
Mandatory school	-0.37 (0.304) [0.69]	0.06 (0.302) [1.06]	0.14 (0.309) [1.14]	0.61* (0.328) [1.84]	0.07 (0.308) [1.07]
Professional school	-0.14 (0.174) [0.87]	0.13 (0.171) [1.14]	-0.14 (0.175) [0.87]	0.26 (0.184) [1.3]	-0.01 (0.175) [0.99]
High school	-0.72** (0.312) [0.49]	-0.24 (0.308) [0.79]	-0.33 (0.317) [0.72]	0.14 (0.328) [1.15]	0.38 (0.317) [1.46]
PhD	0.09 (0.357) [1.09]	-0.83** (0.352) [0.44]	-0.39 (0.36) [0.68]	-0.31 (0.372) [0.74]	0.18 (0.359) [1.19]
Owner (ref. cat. SCHL)					
ABZ	0.11 (0.175) [1.12]	-0.21 (0.173) [0.81]	0.46*** (0.179) [1.58]	0.9*** (0.189) [2.47]	1.06*** (0.182) [2.89]
Mobiliar	0.41** (0.194) [1.51]	0.41** (0.191) [1.51]	0.34* (0.194) [1.4]	0.37* (0.203) [1.44]	0.24 (0.193) [1.28]
N (valid)	651	651	651	651	651
Initial -2 Log Likelihood	1512	1550	1346	1189	1384

	Property	**Impermanence**	**Status symbol**	**Shelter**	**Permanence**
Model -2 Log Likelihood	1402	1495	1294	1106	1306
Improvement (Chi^2)	$Chi^2 = 109.951$, df = 28, $p < .001$***	$Chi^2 = 55.278$, df = 28, $p < .01$***	$Chi^2 = 52.127$, df = 28, $p < .01$***	$Chi^2 = 83.123$, df = 28, $p < .001$***	$Chi^2 = 77.172$, df = 28, $p < .001$***
Nagelkerke R^2	0.164	0.085	0.083	0.133	0.120
Test of parallel lines	$Chi^2 = 73.910$, df = 84, $p = .776$	$Chi^2 = 82.645$, df = 84, $p = .521$	$Chi^2 = 94.739$, df = 84, $p = .199$	$Chi^2 = 101.058$, df = 84, $p = .099$	$Chi^2 = 105.963$, df = 84, $p = .052$

Beta coefficients; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (Standard Error); [Odds ratio]

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Data availability

The datasets analysed during the current study will be made available in a public repository upon completion of the research project 'Shrinking Housing's Environmental Footprint (SHEF)'.

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

Ethical approval

The survey which provided the data analysed in this study was approved by the École Polytechnique Fédérale de Lausanne (EPFL) Human Research Ethics Committee in the 'Request for opinion on ethical acceptability of projects undertaken by researchers at EPFL'.

Informed consent

We confirm that this manuscript is an original submission: it has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with its submission to the *Journal of Housing and the Built Environment.*

7

Obstacles and opportunities for reducing dwelling size to shrink the environmental footprint of housing: tenants' residential preferences and housing choice

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Abstract

The environmental footprint of housing is greatly influenced by the size of a dwelling. Housing size is the result of households' dwelling selections; accordingly, it is critical to consider residential preferences and choices to inform efforts towards housing sustainability. This study aimed to understand tenants' preferences for and choices of housing size as one amongst several dwelling characteristics and identify obstacles and opportunities for reducing size in the light of promoting sustainable housing. We employed logistic regression models to analyse a survey with 878 Swiss tenants, and our results identify preference for large dwellings as a major obstacle for reducing dwelling size among affluent tenants. Conversely, tenants with lower income might be forced to move to a smaller dwelling due to financial constraints or attribute higher importance to the financial benefit of lower rents. However, financial disincentives along with substantial non-monetary costs of moving, such as the disruption of local bonds and the difficulty of finding a satisfactory dwelling, can outweigh the benefits of moving to a smaller dwelling. To overcome such obstacles, we suggest offering incentives and other facilitating measures for downsizing moves as well as ensuring an adequate supply of smaller dwellings capable of providing high living quality. We highlight the potential of studying housing functions to conceptualize dwellings fulfilling these requirements.

Keywords: Space consumption, housing preferences, residential mobility, sustainability, Switzerland

7.1 Introduction

Housing contributes substantially to the human environmental footprint on a global scale (GlobalABC, IEA and UN 2019). The consumption of land, energy, materials and water as well as the production of waste and emissions by the residential sector impose manifold impacts on the natural environment (Lavagna et al., 2018; Williams, 2007).

The size of dwellings is a key factor in determining the consumption of resources and energy in housing (Heeren & Hellweg, 2018b; Huebner et al., 2015; Lavagna et al., 2018; Saner et al., 2013; Williams, 2007). Several studies suggest that the per capita environmental footprint of housing increases with rising per capita floor space (Clune et al. 2012; Ellsworth-Krebs 2020; Huebner et al. 2015; Huebner and Shipworth 2017; Lorek and Spangenberg 2019). To sustain the additional floor area, more resources are required in the construction and use phases, which dominate the environmental impact of a building during its life cycle. In the construction phase, additional dwelling space leads to a higher demand for land, materials and energy, while during the use phase, more energy is consumed, namely for space heating (Heeren & Hellweg, 2018b; Lavagna et al., 2018; Saner et al., 2013; Williams, 2007).

In Switzerland, as well as globally, a significant increase in per capita living area has been observed in the last decades, which has been associated with an increase in the size of dwellings and a growing number of one- or two-person households, which requires more separate dwelling units (Bradbury et al. 2014; Williams 2007). The unrestricted growth in per capita space consumption—from 34m^2 in 1980 to 46m^2 in 2019 (Delbiaggio et al., 2018; FSO, 2019b)—has partly undermined the efforts to reduce the substantial share of Swiss final energy use attributed to buildings (Infras et al., 2019; Prognos AG, 2019), and is likely to do even more so in the future.

Hence, there is a need for planning and policy instruments that target a relative reduction of energy consumption (i.e. increasing energy efficiency) as well as an absolute reduction of domestic consumption by restricting further growth in or even reducing per capita floor space. Concerning the latter, scholars have stressed that policy interventions should begin with the sociocultural dimension of housing space consumption (Dowling & Power, 2012; Ellsworth-Krebs, 2020; Ellsworth-Krebs et al., 2021); on the one hand, household practices and visions of an ideal home can determine the materiality (i.e. the size) of the chosen dwelling; on the other hand, the supply of dwellings on the market as well as policy and institutional regulations can influence households' dwelling choices (Pagani, Laurenti, et al., 2020). The interplay of these factors has been the subject of a vast body of residential mobility literature describing how households adjust their housing consumption to meet changing needs (Rossi, 1955). However, research on residential relocation processes has thus far hardly addressed questions in the context of environmental sustainability, in particular regarding households' space consumption.

With this paper, we aim to gain an understanding of households' preferences for and choices of dwelling size and thereby identify obstacles and opportunities for reducing the latter. Such insights are crucial for reconciling a reduction of the housing environmental footprint with households' preferences and needs.

On the basis of a survey with Swiss tenants, we first seek to understand what has led households to move to smaller or larger dwellings in the past and secondly analyse tenants' stated willingness to move to a smaller dwelling in response to a shrinking household size. Our analysis addresses the following research question and sub-questions:

What determinants of households' relocation decisions present opportunities or obstacles for reducing housing size?

- *What determinants have led households to reduce or augment their dwelling size during the last relocation?*
- *What are the determinants of tenants' willingness to move to a smaller dwelling if their household were to shrink in size?*

To answer these questions, we proceed as follows. In the next section, we review relevant concepts in previous residential mobility literature in order to establish a theoretical framework and formulate hypotheses for our study. In the third section, we describe the methods used to analyse the tenant survey, the results of which we present in the fourth section. Before concluding, we discuss the theoretical and practical implications of our results in the fifth section and present the limitations of our study along with potential future research toward the goal of improving housing sustainability.

7.2 Theory and background

7.2.1 Residential mobility

Residential mobility describes the process whereby a household reacts to shifting housing needs and preferences and adjusts its residential situation through relocation (Mulder & Hooimeijer, 1999; Rossi, 1955). This process is influenced by an interplay of micro- and macro-level factors (Mulder & Hooimeijer, 1999; van Ham, 2012).

The relocation process is initiated by a *trigger* that induces a household's desire to move (Mulder, 1996; Mulder & Hooimeijer, 1999). Triggers can arise from the micro- or macro-context. The micro-context represents the household or the individual, whose life-course is constituted of sequences of life events within different domains—such as education, labour, leisure, family and housing—termed trajectories or careers. As the trajectories of different life domains and household members evolve in parallel to each other, an event in one trajectory can induce a change in a household's situation (Clark et al., 1984; Clark & Lisowski, 2017; Clark & Onaka, 1983; Dieleman & Schouw, 1989; Kan, 1999), which in turn can result in a shift in housing needs and preferences in order to accommodate the new situation (Mulder & Hooimeijer, 1999; van Ham, 2012). Furthermore, triggers for relocation can arise from the macro-context, which represents the 'external' environment that cannot be influenced by the household, such as the housing market and institutional situation (Brown & Moore, 1970; Clark & Onaka, 1983; Mulder & Hooimeijer, 1999). Such triggers include the expiration of a rental contract or the availability of a specific offer on the market.

In order to adjust to an altered situation, the household considers moving to a new dwelling. It can also decide to improve the current dwelling situation by restructuring its environment (e.g. purchasing a car to reduce the distance to work; Brown & Moore, 1970; Dieleman, 2001); however, this is not always an option. If the household has developed a desire to move, it will evaluate available vacancies on the market according to its preferences and choose the dwelling that best satisfies them (Brown & Moore, 1970). Numerous scholars have investigated preferences for certain types of housing in terms of dwelling, neighbourhood and location characteristics (Dieleman, 2001; Molin et al., 1996; van Ham, 2012; Wong, 2002).

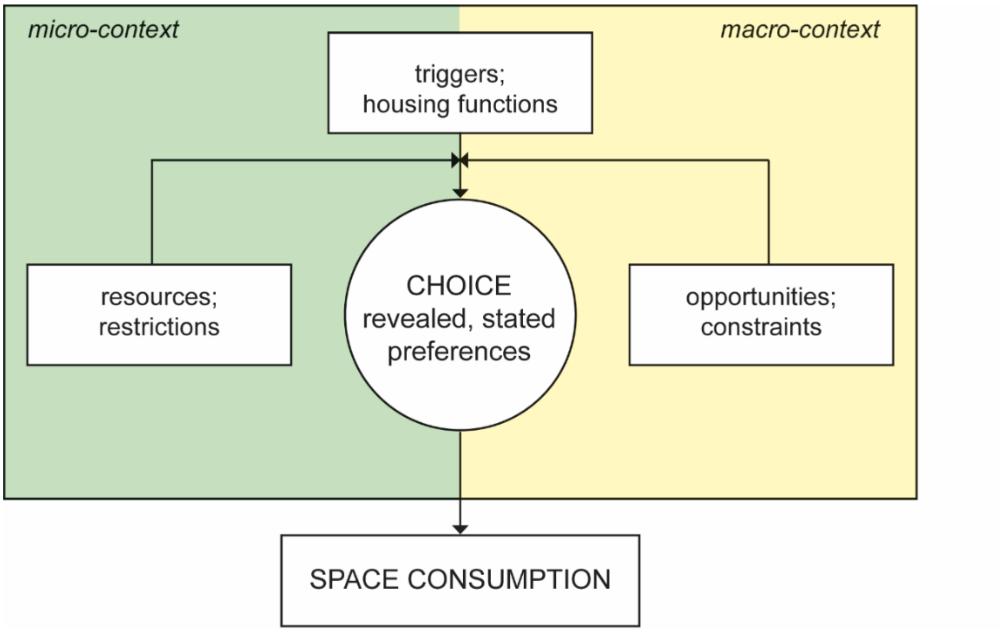

Figure 7.1. Theoretical framework employed in this study. The decision to move and the choice of a new dwelling are shown as a result of an interplay between triggers for moving and the ideal and current housing functions, resources and restrictions and opportunities and constraints. The latter arise from the micro- and from the macro-context, respectively, whereas triggers and housing functions are shaped by, both, the micro- and macro-context. The space consumption in housing constitutes the result of the residential choice.

In their recent exploration of residential mobility in the Swiss context, Pagani et al. (2021) and Pagani and Binder (2021) introduced the notion of housing *function* (e.g. 'shelter'; c.f. Table 7.6 in the Appendix for all functions) as a mediator between residential preferences (e.g. dream of the homely home) and housing form (e.g. detached suburban house). Residential preferences are determined by households' life-course trajectories or residential biography, whereas the housing form includes a bundle of characteristics, one of them being dwelling size.

Some scholars regard the chosen dwelling as revealing the household's preferences for dwelling type and environment (i.e. *revealed* preferences or *current* housing functions). However, due to the high cost of moving and limited availability of dwellings on the market, or a lack of knowledge thereof, there can be a discrepancy between *revealed* and *stated* (i.e. *ideal* housing functions) preferences (de Groot, Mulder, & Manting, 2011; Hooimeijer & Oskamp, 1996; Mulder, 1996; Pagani, Baur, et al., 2021; van Ham, 2012). In fact, whether a desire to move is translated into action and what dwelling will be chosen depends on enabling and inhibiting factors arising from the micro- and macro-contexts. The enabling aspects of the macro-context are termed *opportunities* and refer to the offers available on the housing market. Inhibiting factors are denoted *constraints* and can emerge through conditions such as the accessibility of a certain location or eligibility criteria for subsidized housing. The set of available dwellings for a household is further influenced by *resources* and *restrictions* of the micro-context, i.e. the characteristics of a household that derive from the state of its parallel life-course trajectories (Mulder, 1996; Mulder & Hooimeijer, 1999; van Ham, 2012). More specifically, previous studies have investigated the role of characteristics such as income (Clark & Lisowski, 2017; de Groot, Mulder, Das, et al., 2011; Lu, 1998; Wanner, 2017), employment (Kan, 1999; van Ham, 2012), and age (Clark & Lisowski, 2017; Clark & Onaka, 1983; de Groot, Mulder, & Manting, 2011; Fiori et al., 2019; Lu, 1998) in the formation and realization of moving intentions. Furthermore, the functions fulfilled by the dwelling at the time of the move have been found to influence a tenant's propensity to move (Pagani, Baur, et al., 2021).

Depending on a combination of such enabling and hindering factors, moving entails substantial monetary and non-monetary costs, which is why relocation is only considered when a sufficiently strong trigger is present and the expected improvement of the situation outweighs the costs (Mulder, 1996; Mulder & Hooimeijer, 1999). The household's *level of residential satisfaction* has been found to critically influence the probability to form a wish to move. The higher the household's residential satisfaction relative to its dissatisfaction threshold, the less likely the household is to develop a wish to move, and the greater the cost of moving, the higher the dissatisfaction threshold (Speare, 1974). In other words, whether or not a certain trigger effectively induces an intention to move depends on the household's level of satisfaction (Pagani, Baur, et al., 2021).

In this study, we adopt a model in which a combination of factors from the micro- and macro-contexts simultaneously determines a mobility outcome. Our model corresponds to the 'risk approach' elucidated in Mulder (1996), which is a 'mainstream type of research' (p. 216) to investigate determinants of the 'risk' to move using surveys that do not contain separate information on intentions to move and actual moves. Figure 7.1 depicts the theoretical framework used in this study. A trigger for moving deriving from the micro- or macro-context can represent a change in the housing function desired for the new dwelling (i.e. ideal function), which is itself simultaneously shaped by life-course trajectories and factors such as the housing market. In addition, enabling and hindering factors from the micro- and macro-contexts influence the translation of a moving intention into action and the choice of a new dwelling. Space consumption, which is associated with an environmental impact, is shown as the result of the decision to move and the choice of dwelling. The framework only includes the relationships relevant for the present empirical study, with no claim to completeness.[26]

7.2.2 The Swiss housing context

Despite its economic strength, Switzerland features a comparatively high share of tenants (60% in 2017; FSO, 2019b, 2019g, 2019i; Werczberger, 1997). A specific quality of the Swiss rental market is rent control, which restricts rental owners' ability to raise the rent in existing tenure contracts at will (Bourassa et al., 2010; Sager, 2018; Werczberger, 1997). Although this legislation protects tenants from excessive rents, it has led to substantial differences between existing rents and those negotiated in new contracts (i.e. 'rent-gap'), the consequences of which include reduced residential mobility and a higher probability to live in a too large or too small dwelling (Sager, 2018). Another feature of the Swiss housing market is the low vacancy rates (Bourassa et al. 2010), which amounted to 1.72% across the country in 2020, with values below one per cent in urban cantons (Zürich, Genève, Basel-Stadt; FSO, 2019b). Although the vacancy rate has been rising for more than ten years (FSO, 2019b), the Swiss housing market is still characterized by a shortage of supply, in particular for affordable housing (Balmer & Gerber, 2018; Tranda-Pittion, 2009). One instrument counteracting this issue is housing cooperatives, which are partly supported by the state (Balmer & Gerber, 2018). Housing cooperatives aim to withdraw real estate objects from the speculative market and offer dwellings for cost rent. Furthermore, they often follow a social purpose, promoting participation, neighbourhood

[26] For instance, the framework does not depict the concept of residential satisfaction, which influences and is influenced by both triggers and housing functions (Pagani, Baur, et al., 2021).

relations and social mixing among inhabitants. The admission of inhabitants is regulated to a variable extent in different cooperatives.[27] Furthermore, certain cooperatives establish occupancy rules that oblige tenants to relocate when occupancy decreases below a certain threshold. In such cases, tenants are commonly given the opportunity to move to a smaller dwelling within the cooperative.[28] The national market share of housing cooperatives is 8.4%; the share is higher in urban regions—including 16% in the canton of Zurich (FSO, 2019b).

Per capita dwelling space in Switzerland has substantially increased in the past few decades to reach an overall average of 46 m^2 per person in 2019 (41m^2 for renters and of 53m^2 for homeowners; FSO, 2019b). Potential reasons for the growth in per capita dwelling space are, firstly, that households do not reduce their dwelling size when their size decreases, as empirical studies have shown (NZZ / Wüest Partner AG, 2018, 2020; Rey, 2015). The failure to downsize in case of reduced space requirements can have structural reasons, but also may be the result of a generalized preference for large dwellings (Clark et al., 1984; Delbiaggio et al., 2018; NZZ / Wüest Partner AG, 2018), which constitutes a second reason for high per capita space consumption in Switzerland. Thirdly, the number of one- or two-person households has been growing in the past several decades; whereas 12% of the population was living in one-person households in 1980, the share in 2018 had increased to 16% of the population, corresponding to 36% of all households. This proportion is projected to continue to rise in the future (FSO, 2019g). An increased number of small households leads to a higher demand for separate dwelling units and less sharing of space among household members. Therefore, the dwelling area per person in Switzerland is on average larger in one-person households than in households with two or more people (FSO 2019a).

7.2.3 Hypotheses

Based on our review of previous literature, we lay down a set of hypotheses for the tenant survey analysis. In line with the two research sub-questions, the first two hypotheses address the housing choice made with the past move (i.e. revealed preferences of housing size), and the remaining two hypotheses concern the willingness to move in response to a shrinking household (i.e. stated preferences).

> **H1** There is an overall trend of moving to larger dwellings, regardless of the change in household size.
>
> **H2** Whether dwelling size was augmented or reduced can be explained by a combination of the trigger event and changes in household size and housing functions.
>
> **H3** A minority of the tenants would be willing to move if their household size decreased.
>
> **H4** The willingness to move can be explained by the simultaneous effects of current housing functions, households' sociodemographic characteristics, current dwelling size and dwelling owner and residential satisfaction.

[27] Two of the largest housing cooperatives in Switzerland are the *Allgemeine Baugenossenschaft Zürich* (ABZ; https://www.abz.ch/genossenschaft/portrait/; accessed 27.10.20) and the *Société Coopérative d'Habitation Lausanne* (SCHL; https://www.schl.ch/; accessed 27.10.20), which are partners in this research.
[28] This is practiced in ABZ.

7.3 Methods

7.3.1 Data collection

The data used in this study was obtained from a quantitative survey with tenants in Switzerland. This survey is part of the research project ‘Shrinking Housing’s Environmental Footprint (SHEF)’, supported by the Swiss National Science Foundation (SNSF) within the framework of the National Research Programme ‘Sustainable Economy: resource-friendly, future-oriented, innovative’ (NRP 73) under Grant [number 407340_172435]. Three real estate owners, namely Allgemeine Baugenossenschaft Zürich (ABZ), Société Coopérative d’Habitation Lausanne (SCHL) and Schweizer Mobiliar Asset Management AG (SM) are partners in the research. The survey was approved by the HREC (Human Research Ethics Committee) of EPFL and carried out by the LINK institute for market and social research in Switzerland, which selected a random sample of 3020 tenants of the three project partners covering the German and French language regions. The survey was conducted from September to November 2019 and was online based with a limited amount of CATI (Computer Assisted Telephone Interview) available for the elderly or people lacking internet access. The response rate was 32% for a total sample of 968 responses. The data were cleaned by inspecting cases and variables. Regarding the former, cases were deleted when answers to nominal and ordinal variables had a standard deviation of 0 across a block, e.g. respondents always checked the first answer option (straightliners), which resulted in deletion of 90 cases. To clean variables, we focused on the variables capturing current and previous household and dwelling size. Whilst data on the current dwelling size had been provided by the dwelling owners and associated to the ID of each survey participant prior to anonymization, the current household size was provided by the survey respondents and three outliers were set as missing, where consistency with other variables was not given. As for the previous dwelling, data on both, the dwelling and household size, were provided by the respondents, we proceeded as follows to detect outliers: we calculated the dwelling area per capita (m^2/cap), its third quartile (Q_3) and the interquartile range (IQR). We coded the variables previous dwelling size, previous household size as well as previous dwelling area per capita as missing in case the following condition was true: $m^2/cap > Q_3 + 3 * IQR$. This led to 14 missing cases. Data cleaning resulted in a final sample of 878 cases. All treatment and analysis of the data was conducted with the software IBM SPSS Statistics for Windows, V26 (IBM Corp., Armonk, N.Y., USA).

7.3.2 Structure, content and measures of the study

Our analysis of the tenant survey proceeded in two steps (c.f. Table 7.1). Firstly, we analysed the housing choices of the tenants’ past moves. We considered change in dwelling size as the variable of interest and related it to a set of independent variables.

Secondly, we considered the tenants’ stated residential preference by assessing their willingness to move to a smaller dwelling if their household were to shrink and their reasons for not being willing to move. We aimed to explain willingness to move with reference to a set of independent variables.

Variables

Three categories of information from the survey were used as variables in this study.

1. ***Housing functions*** of the previous and current dwellings (c.f. Table 7.6 in the Appendix). Respondents were asked to evaluate the importance of each function according to their

description (and not the label) on a 5-point Likert scale. Housing functions were considered as interval variables in the statistical analysis.

2. ***Household and dwelling characteristics*,** which included

- the sociodemographic characteristics of the household at the time of the survey and, for household size, at the time before moving (nominal variables, except for household size (interval variable));[29]
- the size of the current and previous dwelling (interval variable);
- the dwelling owner (nominal variable); and
- the level of residential satisfaction with the current dwelling (ordinal variable evaluated on a 5-point Likert scale).

3. ***Housing choices***, captured with the

- trigger motivating the past relocation (nominal variable: a list of 20 events; see Pagani et al. 2021)
- prospect of moving within the next five years (nominal variable: 1 = *yes, 2 = maybe, 3 = no*);
- willingness to move to a smaller dwelling in case of a shrinking household (only for households counting more than one person; ordinal variable evaluated on a 5-point Likert scale); and
- reasons for not being willing to move and reasons potentially preventing those who were in principle willing to move from actually moving (open answers; two possible each).

Data transformation

A transformation of the survey data was performed, and the following additional variables were computed for the analysis:

- change in household (HH) size: a categorical variable was computed (*1= HH size decreased, 2= HH size increased, 3 = HH size did not change*)
- change in dwelling size: a binary variable was computed (*1 = the household reduced dwelling size, 0 = the household did not reduce (i.e. augment) dwelling size*)
- residential satisfaction: five levels were aggregated to three categories (1 = *satisfied, 2 = neutral, 3 = unsatisfied*)
- change in housing functions: a categorical variable for each function was computed (*1 = increase* (in the importance of the function)*, 2 = decrease, 3 = no change*)
- prospect of moving within the next five years: a binary variable was computed (*1 = yes/maybe*; *0 = no*)
- willingness to move in case of a shrinking household: five categories were aggregated into three (1 = *not willing, 2 = neutral, 3 = willing*)
- reasons for not being willing to move and reasons potentially preventing those willing to move in principle from actually moving: open answers were grouped, recoded and evaluated as multiple response sets

[29] We did not consider education and employment status in the regression because these applied only to the person completing the survey, whereas the relocation decision concerned the entire household.

Table 7.1. Structure of the study, including the analysed dependent and independent variables and the employed methods. The independent variables are classified according to their provenance from the micro- or macro-context of the residential mobility process (c.f. Figure 7.1).

Section	Dependent variable	Independent variables	Micro- / macro-context	Method
Previous move				
	Change in dwelling size	change in HH size	Micro	Binary logistic regression
		change in housing functions	Micro / Macro	
		triggers	Micro / Macro	
Reducing dwelling size when the HH shrinks				
	Willingness to move	Reasons for unwillingness	Micro / Macro	Descriptive
		Current housing functions	Micro / Macro	Multinomial logistic regression
		Household characteristics	Micro	
		Current dwelling size	Micro	
		Level of satisfaction	Micro	
		Dwelling owner	Micro	

HH = household

7.3.3 Statistical analysis

Descriptive analysis of the dataset included computing the frequency of each nominal variable category and calculating the mean and standard deviation for metric variables.

To assess bivariate relations between nominal variables, we used the Pearson chi^2 test. In cases of degrees of freedom (*df*) equal to one, we applied the Yates correction for a more conservative test statistic (Backhaus et al., 2018). To analyse relations between metric and nominal variables, we employed the Kruskal-Wallis test. We chose this non-parametric test because the metric variables did not follow a normal distribution.

To evaluate the combined effect of the independent variables on the dependent variables, we employed multiple regression models (c.f. Table 7.1 for the structure of the analysis).

Firstly, we conducted a binary logistic regression to explain the dichotomous dependent variable ‘the household reduced dwelling size with the previous relocation’. The independent variables used in the analysis comprised the changes in housing functions that occurred with the relocation as well as the trigger inducing the move. Since the relation between the trigger to move and the change in household size upon the move was not consistent (e.g. moving in with the partner did not always result in an increase in the household size; c.f. Table 7.8 in the Appendix), we considered change in household size as a separate independent variable in addition to the triggers. We computed different models incorporating different combinations of the predictor variables: 1) change in household size and change in housing functions; 2) change in household size and the triggers; and 3) all three groups of predictors. The change in household size was used in every model, as we assumed it to have the strongest effect on changes in dwelling size. Housing functions and triggers were simultaneously used in the last model. Although a link between triggers and housing functions exists (Pagani, Baur, et al., 2021; Pagani & Binder, 2021), the two variables contain different facets of information such that one cannot be used in place of the other (e.g. not all triggers lead to a change in housing function). To avoid overfitting, not all variables and categories were included in the model. To select which changes in housing functions to include, we used the SPSS ‘forward stepwise’ algorithm (based on the significance of the conditional statistic) for inclusion of variables. Furthermore, we did not include triggers for which the number of observations was smaller than 25.

Secondly, we conducted a multinomial logistic regression to explain the tenants' 'willingness to move in case their household shrunk'. An ordinal logistic regression could not be performed because the assumption of parallel lines was not met by the data.[30] Independent variables covered current housing functions, household- and dwelling-related micro-context variables and dwelling owner as a macro-context variable. We computed four different models of increasing complexity by adding the different variable blocks one by one.

We verified the following prerequisites of the data for both analyses. For each category of independent variables, the number of observations was equal or higher than 25. Further, we checked multicollinearity between independent variables by looking at the variance inflation factors (VIF), using the test implemented for linear regression in SPSS. All the VIFs were below a value of 10, which ensured sufficiently small multicollinearity (Backhaus et al., 2018).

7.4 Results

7.4.1 Sample characteristics

A description of the sociodemographic characteristics of the sample as well as the affiliation of the tenants with the three different dwelling owners and their space consumption is presented in Table 7.7 in the Appendix. Approximately half of the sample was constituted by women (54%) and men (46%), respectively, which is representative of the Swiss average (FSO, 2019g). The age categories 34–49 years and 50–64 years have the strongest representation in the sample (33% and 29%, respectively), followed by the categories of 65 years and older (21%) and 33 years and younger (17%). The slight overrepresentation of middle-aged and old people compared to the Swiss population is coherent with the fact that only adult tenants were surveyed (FSO, 2019g). Half of the respondents were married or living in a couple and roughly a quarter each were single or separated, divorced or widowed. Less than a third (28%) of the households had children. Households with one (33%) or two persons (35%) were most common, followed by those with three to four persons (27%) and a minority of households with five or more members (5%), which also coincides with national statistics (FSO, 2019g). Most respondents held either a professional school (39%) or a university degree (40%). A third of the households earned an annual income below CHF 60K, 30% between CHF 60K and 88K and 21% between CHF 88K and 120K. The higher income categories are less frequently represented, with 10% and 6% earning CHF 120K–165K and more than CHF 165K, respectively. Since the income categories in the survey were chosen differently from those in national statistics (FSO, 2019i), the values cannot directly be compared, but lower income categories are likely to be represented slightly more frequently than in national statistics. This is likely due to the high percentage of tenants from cooperatives in the sample who tend to have a lower income than those in the private rental market (see e.g. Allgemeine Baugenossenschaft Zürich, 2019). The three dwelling owners were represented by approximately a third of the respondents each (33.5%, 39.5% and 27% of the tenants renting from ABZ, SCHL and SM, respectively). The mean per capita floor space in the sample amounts to

[30] The test of parallel lines, or proportional odds assumption, verifies whether the regression parameters are the same between all categories of the dependent variable. For more details, see https://www.ibm.com/support/knowledgecenter/en/SSLVMB_23.0.0/spss/tutorials/plum_germcr_parallel.html#plum_germcr_parallel (accessed 16.12.2020).

46m^2. This value is equal to the Swiss average but higher than the average among Swiss renters of 41m^2 per person (c.f. Section 7.2.2). This might be because the sample represents only three different dwelling owners.

7.4.2 Revealed preferences: Past housing choice

Change in space consumption (H1)

Table 7.2 shows the change in space consumption and change in household size resulting from the households' last relocation.

In line with H1, although only 16% of the households grew, more than half of the relocations resulted in an increase in dwelling space (unit size as well as space per person). The majority (82%) of the households that grew moved to larger dwellings, as did 70% of the households that did not change in size and nearly 40% of the households whose size decreased.

We also observe that although 60% of the households that shrunk reduced the size of their dwelling, most of them (90%) increased their per capita space consumption. In smaller households, rooms such as kitchens or living rooms are shared among fewer people, which is why per capita space consumption can increase even if the overall dwelling size decreases (Williams, 2007).

Table 7.2. Change in space consumption with the previous move and its relation to the change in household size.

			Change in m^2			Change in m^2/cap		
	n	%	% reduced	% augmented	Sign.	% reduced	% augmented	Sign.
Full sample	864 / 862	100.0	40.0	60.0		29.0	71.0	
by *change in HH size*								
decreased	337	39.1	60.2	39.8	***	9.8	90.2	***
increased	137	15.9	18.2	81.8	***	74.5	25.5	***
no change	388	45.0	30.2	69.8	***	30.2	69.8	-

*** Indicates the 1% significance level

Predictors of change in space consumption (H2)

Having found that more than half of the previous relocations in our sample resulted in an increase in dwelling space, we hereafter investigate the combined effect of changes in household size, changes in housing functions and triggers on the dichotomous variable 'the household reduced dwelling size'. Table 7.3 displays the odds ratios (OR) of the significant regression parameters in the binary logistic regression model, which are ranked by the strength of their effect.

The results firstly show that triggers associated with a change in household size are key in explaining changes in dwelling size. The strongest effect on the dependent variable is exerted by the 'birth of a child', which implies the growth of the household and significantly reduces the likelihood of moving to a smaller dwelling (OR=0.10). Triggers related to a shrinking household size—i.e. 'children leaving home', 'divorce, separation or loss of partner' and 'need for autonomy'—significantly augment the probability of reducing dwelling size by factors 6, 4 and 3, respectively. Accordingly, a 'decrease in household size' with the past move also significantly increases the probability of moving to a smaller dwelling (OR=2.3).

Table 7.3. Ranked odds ratios of the significant parameters in the binary logistic regression model for predicting the likelihood of having reduced dwelling size with the last relocation.

Variable	OR (sign.)	95 % confidence interval	
		Lower value	Upper value
Children leaving home	5.706***	2.149	15.156
Divorce, separation, loss of partner	4.274***	1.927	9.481
Need for autonomy	2.666*	0.983	7.225
Decrease in HH size	2.275***	1.578	3.280
Rent too high	1.886*	0.934	3.809
Status symbol -	1.849***	1.185	2.886
New child	0.104***	0.040	0.269
Lack of space	0.122***	0.040	0.373
Opportunity to rent	0.395***	0.210	0.744
Status symbol +	0.623**	0.399	0.973
Privacy +	0.658**	0.445	0.973

***, ** and * indicate the 1%, 5% and 10% significance levels, respectively; HH = household; the plus or minus sign after a housing function indicates the increase or decrease, respectively, of the importance of that function for the household with the past relocation

Secondly, we observe that a strong effect applies to 'lack of space', which diminishes the probability of a reduction of dwelling size without necessarily implying a growth in household size (c.f. Table 7.8 in the Appendix). Two additional triggers not related to a change in household size have a slightly weaker effect on the dependent variable; tenants moving for an 'opportunity to rent' were less likely to reduce the size of their dwelling (OR=0.4), whereas a 'too high rent' shows the opposite effect (OR=1.9).

Finally, the functions 'status symbol' and 'privacy' both exhibit a significant influence on the dependent variable. A decrease in the importance of a place for 'exhibiting' (i.e. 'status symbol') increases the likelihood of reducing dwelling size (OR=1.9), and the opposite holds for an increase in the importance of this function (OR=0.6). The same effect applies for a place fulfilling the 'family's needs' (i.e. 'privacy'; OR=0.7).

In addition, Table 7.11 in the Appendix compares the described model (i.e. model 3) with two models using subsets of the independent variables: the change in household size and change in housing functions (model 1) and the change in household size and triggers (model 2). Model 3, which includes all three blocks of independent variables, shows the highest explanatory power (Nagelkerke pseudo R2=0.38) and the lowest AIC (Akaike Information Criterion) value, which implies that all the included independent variables add to the explanatory power of the model without the latter being offset by the increasing complexity of the model.

7.4.3 Stated preferences: Reducing dwelling size when the household shrinks

Willingness to move (H3)

Having looked at the tendency to move to smaller or larger dwellings with the past move, in this section, we verify the hypothesis that the sample would exhibit a small propensity to move due to a shrinking household (H3). Table 7.4 shows the percentage of tenants in the sample that would be 'not willing', 'neutral' and 'willing' to move. In line with H3, 25% of the respondents were willing to move in case their household shrunk, 36% were undecided and 39% were not willing to move.

Table 7.4. Frequencies of categories of willingness to move to a smaller dwelling in response to a shrinking household.

	Total	**Not willing**	**Neutral**	**Willing**
n	570	220	206	143
%	100	38.6	36.3	25.1

Figure 7.2 presents the various answer categories to the questions ‘Why would you not be willing to move in case your HH shrunk?’ and ‘If you were willing, what could prevent you from moving?’ derived from the text answers. The predominant reason for not being willing to move was satisfaction with the current dwelling situation, including location and neighbourhood, which together were mentioned by 57.4% of the respondents. In other words, the perceived necessity to move in case of excessive dwelling space is small, such that giving up a satisfactory housing situation is not worthwhile (H3). Furthermore, the liberation of space in case of a shrinking household is not necessarily perceived as a deterioration of the housing situation, i.e. the respondent would not prefer less space. Rather, a decrease in household size can lead from a suboptimal condition to a more desirable state in case more space is preferred. This is evident from the tenants who stated that their current dwelling was already small and/or they would welcome more available space, which represents the second most frequent reason for not being willing to move (29.4% of the respondents). In this case, no necessity to move is perceived at all. Satisfaction with the current dwelling situation is also among the more frequent reasons that could prevent tenants who are in principle willing to move from actually moving. Preponderant here is the importance of dwelling location, such that a change in location could prevent tenants from moving.

The financial aspects of relocation appeared to be important in the decision to move. Moving to a smaller dwelling intuitively implies a reduction in rent. Nevertheless, 7.4% of the respondents mentioned an inexpensive current rent (i.e. financial limitations) as a reason for not being willing to move, and 23.1% indicated a higher rent in the new dwelling as a reason potentially preventing them from moving. On the other hand, a small fraction (4.4%) of the respondents explicitly stated that they could afford their dwelling on their own if the household were to be reduced; in other words, for this subsample, reduction of the rent would not be an incentive to move.

The difficulty of finding a suitable new dwelling was mentioned by only 2% of the respondents as a reason for not being willing to move (least frequent reason) but is the second most frequently cited reason potentially preventing tenants who are in principle willing to move from actually moving (25.6%). Furthermore, the burden of the moving process was named with similar frequencies in both questions (6.4% and 5%), standing among the less frequently mentioned reasons. Also potentially referring to the burden of moving, some tenants stated their age, retirement or health as a factor (potentially) preventing them from moving (3.9% and 2.5%, respectively). The last category of reasons potentially preventing tenants from moving is life events (e.g. the loss of employment), which was mentioned by 2.5% of the respondents.

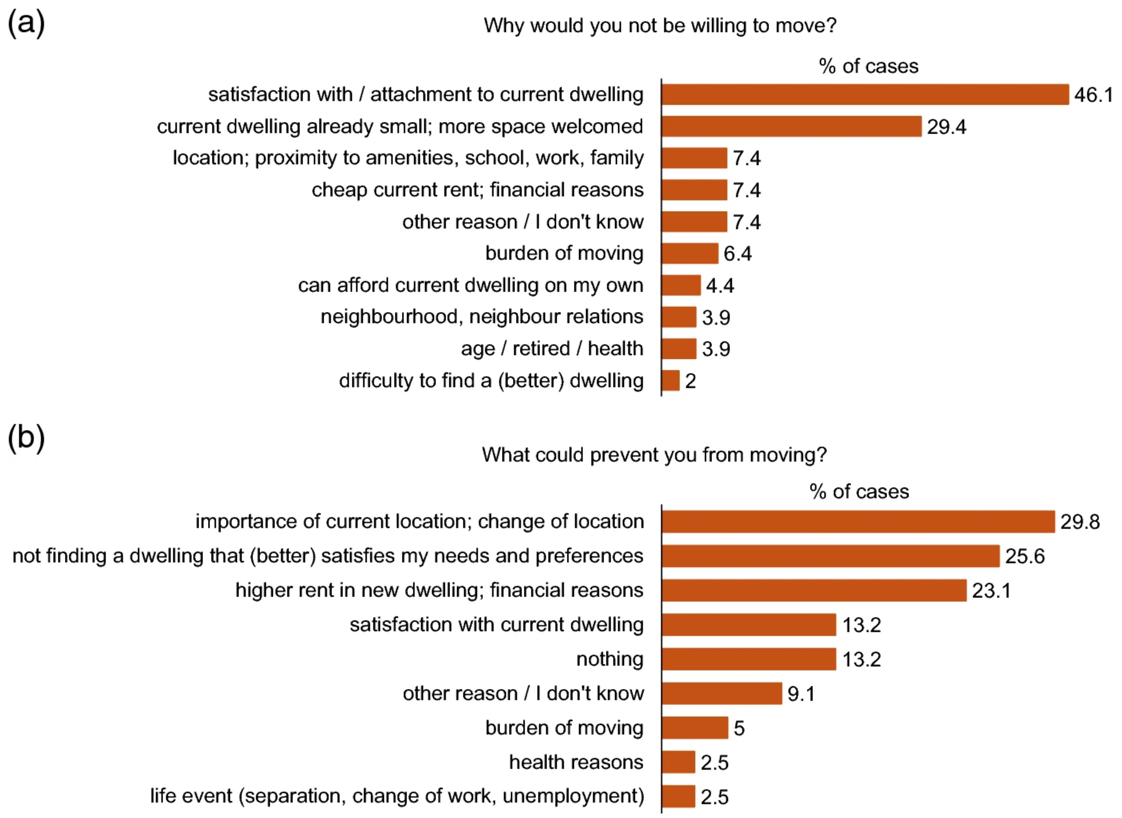

Figure 7.2. Multiple response frequencies of text answers to the questions a) Why would you not be willing to move in case your HH size decreased? (n=204) and b) In case you were willing, what could prevent you from moving? (n=121).

Predictors of the willingness to move (H4)

Knowing that only a quarter of the respondents would be willing to move if their household were to shrink, we hereafter explain the willingness to move with current housing functions, household and dwelling-related micro-context variables and the dwelling owner as a macro-context variable (c.f. Table 7.1). Table 7.5 presents the odds ratios of the significant parameters in the multinomial logistic regression model ranked by the strength of their effect on the probability of being willing to move (i.e. 'willing' against 'not willing to move'). Willingness to move is most strongly predicted by the household income and the dwelling owner. Compared with those in the second lowest income category (60K – 88K CHF/y), tenants in higher income categories were less likely to be willing to move, with the inhibiting effect increasing in correlation with income (odds ratios between 0.5 and 0.1). The bivariate analysis shows a congruent result (c.f. Table 7.12 in the Appendix). Concerning the dwelling owner, the probability of ABZ tenants being willing to move was approximately a third as high as that of SCHL tenants, and SM tenants were approximately half as likely to be willing to move as ABZ tenants. The bivariate analysis reveals the same tendency (c.f. Table 7.12). Lastly, several housing functions show a significant relation with not being willing to move. More specifically, a higher importance of the functions 'status symbol' and 'permanence' led to a lower probability of the tenant to be willing to move in case of a shrinking household (OR=0.6 and OR=0.7, respectively). However, we also observe that a higher importance of the functions 'production-consumption' and 'self-representation' increased the likelihood of being willing to move (OR=1.9 and OR=1.5, respectively).

The 'prospect of moving within the next five years' shows the strongest enhancing effect on the probability of being willing to move. Tenants foreseeing a move were approximately twice as likely to be willing to move than those who did not expect a relocation. Even if a move is planned for another reason than a shrinking household, the idea of relocating might already be more familiar for these tenants, resulting in a higher willingness to move in case of a shrinking household. Finally, a larger area of the current dwelling positively influences the willingness to move, with an odds ratio close to 1 (OR=1.03).[31]

Contrary to previous studies, the tenants' age did not emerge as a significant predictor of the category 'willing to move'. Age only shows a significant effect between the categories 'not willing' and 'neutral' (c.f. Table 7.13 in the Appendix), thereby indicating that even if they were not clearly willing to move, tenants aged 50–64 years seemed to show a less strong aversion to the idea of relocation than tenants aged 34–49, which may be because the former age group constitutes the period when children leave the parental home and parents might newly orient themselves. The presence of children only shows a significant effect on the category 'neutral'. Households without children were more likely to be 'neutral' than 'not willing' compared with those with children (c.f. Table 7.13 in the Appendix). Since children can present an additional burden to moving (Mulder & Hooimeijer, 1999), their absence appears to reduce the aversion to moving but does not significantly enhance the willingness to move. Marital status appears to have no significant effect on the willingness to move. Even though satisfaction with the current dwelling was cited as an important reason for not being willing to move (c.f. Section "Willingness to move (H3)"), the level of satisfaction with the current dwelling does not appear as a significant predictor of the willingness to move in either the bivariate or multivariate analysis. It must also be noted that 80% of the respondents were rather or absolutely satisfied with their current dwelling (c.f. Table 7.12 in the Appendix).

Compared with the three additional models computed with subsets of the independent variables, the full model exhibits the highest explanatory power (Nagelkerke pseudo R^2 of 0.27) and the lowest AIC (c.f. Table 7.13 in the Appendix). Furthermore, the significance and strength of the predictors in the chosen model ('not willing' vs. 'willing') display more significant and stronger effects than for the model including the category ('not willing' vs. 'neutral').

Table 7.5. Ranked odds ratios of the significant parameters of the multinomial regression for predicting the category 'willing to move' with reference to the category 'not willing to move'.

Variable	**OR (sign.)**	**95% confidence interval**	
		Lower value	Upper value
Prospect of moving within the coming 5 years	2.068**	1.125	3.800
Production-consumption	1.858***	1.184	2.916
Self-representation	1.456**	1.055	2.009
Area of dwelling [m^2]	1.025***	1.008	1.042
Annual income above 165K CHF	0.095***	0.027	0.337
Owner SCHL	0.296***	0.150	0.582
Annual income 120K – 165K CHF	0.331**	0.134	0.818
Owner SM	0.414**	0.191	0.895
Annual income 88K – 120K CHF	0.534*	0.257	1.108
Permanence	0.555***	0.402	0.767
Status symbol	0.710**	0.526	0.958

***, ** and * indicate the 1%, 5% and 10% significance levels, respectively

[31] However, it must be noted that the dwelling area as well as the housing functions are interval variables and that their effects increase with larger variable variation.

7.5 Discussion

Based on the premise that a reduction of housing size contributes to diminishing the environmental footprint of housing, the goal of this paper is to understand tenants' preferences and choices regarding housing size and to identify obstacles and opportunities to reduce space consumption. In this section, we first discuss the findings from the tenant survey showing how different factors influence the decision to move and the choice of dwelling size. Secondly, we synthesize obstacles and opportunities for a reduction of housing size in the context of the Swiss rental market before we acknowledge the limitations of our analysis and illustrate possible paths for future research.

7.5.1 Exploring tenants' preferences of housing size

The choice of housing size in perspective

In the first part of the analysis, we investigated tenants' revealed preferences for housing size. We found that more than half of the reported relocations resulted in an increase in dwelling space, which is in accordance with findings in previous studies (e.g. Clark et al., 1984) and validates our first hypothesis (H1).

The fact that a substantial proportion (40%) of the households that had decreased in size and the majority of those that had not changed size moved to larger dwellings implies a general preference for larger dwellings (c.f. Table 7.2). The likelihood of downsizing was related to several independent variables. Whereas triggers associated with a change in household size accordingly influenced the likelihood of reducing dwelling size (i.e. a shrinking household led to an increase of the probability to reduce space consumption and vice-versa), an opportunity to rent significantly decreased the probability of moving to a smaller dwelling, and the opposite was the case for relocations due to a too high rent (H2; c.f. Table 7.3). Moving for an opportunity presumably only happens when dwelling characteristics can be improved (Clark & Onaka, 1983), whereas moving due to excessively high rent implies the need to solve a problem whereby the household is financially limited in its choice of dwelling (Pagani, Baur, et al., 2021). This corroborates the hypothesis of a preference for larger dwellings when an opportunity is available and implies that moving to a smaller dwelling is the result of a constraint.

Changes in two of the nine housing functions showed a significant effect on the odds of moving to a smaller dwelling (c.f. Table 7.3). This is in line with previous research indicating that housing functions determine the material behaviour of housing (i.e. housing characteristics such as size; Pagani & Binder, 2021). More specifically, results indicate that an increase in the importance of a dwelling as a 'credential for esteem' or a place for 'family's needs' lowers the likelihood of reducing its size. The first case reflects the 'status symbol' as a place for comfort, manifesting itself with features such as a growing amount of indoor facilities (e.g. library, exercise rooms; Pagani & Binder, 2021) and with the potential to prove sophistication or classiness and respectability toward strangers (Dowling & Power, 2012). However, the second case is more controversial. A private place is defined as a place for the 'family's needs' where 'recreation preferably happens outside' (c.f. Table 7.6 in the Appendix). On the one hand, saving space for leisure activities could suggest a reduction in housing size; on the other hand, an increase in the relevance of meeting a *family's needs* might entail more spacious homes to satisfy the requirements of all family members and reconcile feelings of independence *and* familial togetherness within the home (e.g., one room per child; see Table 5.6 in Pagani & Binder, 2021; Dowling and Power 2012; Ellsworth-Krebs et al. 2021).

The willingness to move in perspective

In the second part of the analysis, we assessed tenants' stated willingness to move to a smaller dwelling if the size of their household were to shrink and explored the determinants that influenced the latter.

We considered reduction in household size as an event in the household trajectory constituting a potential micro-context trigger for the formation of an intention to move. The survey results demonstrated that for almost 40% of the respondents, this trigger would not be sufficiently important to outweigh the expected cost of moving or was not regarded a trigger at all (H3; c.f. Table 7.4). This result is in accordance with the findings of a recent study on residential mobility in Switzerland in which only 5% of the respondents mentioned an excessively large dwelling as a reason for moving (NZZ / Wüest Partner AG, 2018). Nevertheless, our analysis showed some potential for reducing dwelling size, as 25% of the questioned tenants would be willing to move if their household were to shrink.

Based on our review of the literature, responses to the trigger event of a shrinking household were hypothesised to be determined by the function(s) fulfilled by the dwelling as well as enabling or hindering factors arising from the micro- and macro-context (H4).

In agreement with previous research, housing functions were found to influence the effectiveness of such a trigger in different ways (Pagani, Baur, et al., 2021; c.f. Table 7.5). More specifically, the likelihood of being willing to downsize in response to a shrinking household was significantly higher for tenants attributing a stronger importance to 'production-consumption' and 'self-representation' of their dwelling but significantly lower for those giving higher values to 'status symbol' and 'permanence'. The results are coherent with the definition of 'production-consumption' as a place for basic activities (i.e. eating, laundering), which require less space for a smaller household. For the function 'status symbol', the results agree with the interpretation given in the first part of our analysis and thereby indicate that the relevance of this function for a tenant has an influence both on its residential preferences and housing choice. Comparing the results to the findings of Pagani and colleagues (2021) can offer keys for interpretation of the effects of the other two functions. On the one hand, and in agreement with our findings, their research showed that tenants who attributed more importance to the function 'self-representation' had moved predominantly after a divorce or in response to excessively high rent, both of which imply a reduction in household size (see also previous section). On the other hand, and controversially, the authors indicate that the past moves of tenants who considered their dwelling a permanent place was triggered by a 'dwelling too small', a forced move (e.g., demolition), and most strongly a shrinking household (i.e. leaving the parents or having the children leaving the nest). These results highlight the relevance of a household's *residential biography*, thereby indicating that tenants who had already adjusted their dwelling size in their previous move might be more reluctant to move again (and reduce their dwelling size).

Three main restrictions to downsizing moves were revealed in the micro-context. Firstly, we ascertained that satisfaction with and attachment to the current dwelling situation, including its location and neighbourhood, could prevent tenants from moving (c.f. Figure 7.2). As elaborated in Mulder (1996) and Mulder and Hooimeijer (1999), the sentimental value of a dwelling and local bonds formed within the daily activity space can discourage households from moving. Secondly, we found increased household income to significantly lower the probability of being willing to move (c.f. Table 7.5). The strong influence of this predictor was not expected, as opposing qualitative effects of income have been suggested in the literature (de Groot, Mulder, Das, et al., 2011; Lu, 1998; Wanner, 2017). Our results suggest that less affluent households may have less freedom to cope with a reduction of the number of household members who financially contribute to the rent and may be forced to move to a smaller—thus cheaper—dwelling, as was also suggested by Clark and Lisowski (2017). For tenants in higher categories of household income, the latter did not appear to be a factor promoting moves but rather for remaining in the current dwelling. Thirdly, retirement and old age were mentioned as reasons for not being willing to move or potentially preventing a move (c.f. Figure 7.2). Obstacles for old people previously mentioned in literature include the rupture with a familiar environment, such as access to services and the social network, an uneasiness with change, and financial limitations (Delbiaggio et al., 2018; Neuhaus et al., 2016). Such findings illustrate the non-monetary cost of moving and are in line with other studies that found that the propensity to move was lower with higher age (Clark & Lisowski, 2017; de Groot, Mulder, & Manting, 2011; Lu, 1998). However, it must also be noted that age was not a significant predictor of the willingness to move in our regression model (c.f. Table 7.13 in the Appendix). Considering that tenants might have a higher propensity to move shortly after retirement than due to older age (Fiori et al., 2019), this finding could have resulted from an excessively broad definition of the older age category for the analysis (i.e. 64 years and older).

In the macro-context, a constraint for leaving a satisfactory dwelling in case of household reduction was the difficulty of finding a new dwelling with equal or better characteristics, which represents an additional important cost of moving (c.f. Figure 7.2). Further, the preoccupation of having to pay a higher or equal rent in a smaller dwelling—a potential consequence of the Swiss rent control legislation—was found to constrain tenants from moving. In addition, the dwelling owner appeared to significantly influence the willingness to move in a manner representing both constraints and opportunities (c.f. Table 7.5). Occupancy rules for tenants benefiting from cost rent oblige them to move to a smaller dwelling when the household shrinks, whereas the absence of such rules favours remaining in the current dwelling, as might be the case for tenants of SCHL. The results also suggest that the practice of assisting tenants in finding a new dwelling within the cooperative positively influences the willingness to move, as reflected in the case of tenants of ABZ (c.f. Table 7.5 and Table 7.13 in the Appendix).

7.5.2 Obstacles and opportunities for reducing housing size

Based on our findings, we put forward several obstacles and opportunities for reducing housing size in the Swiss rental context to serve as inspiration for "invisible energy policies" (Royston et al., 2018), meaning policies that go beyond the sole enhancement of energy efficiency and aim at an absolute reduction of resource consumption by limiting housing space consumption. An overview of the identified aspects is presented in Figure 7.3.

Reshaping preferences

A major obstacle for reducing housing size is the preference for large dwellings exhibited by a large proportion of respondents. In combination with sufficient financial resources and the freedom to choose one's dwelling, such preference leads to a low propensity to move to a smaller dwelling. Tenants who tend to adhere to this logic have higher income and can be characterised, according to an additional analysis shown in Table 7.14 in the Appendix, as young or middle-aged, living as couples or married, and renting from the private market (i.e. SM) or living in a cooperative without occupancy rules (i.e. SCHL). For these tenants, we assume it would be difficult to present incentives (financial or other) to reduce their space consumption so long as reduced dwelling space is equated with a loss of dwelling quality and thus quality of living. Therefore, we articulate the need to overcome current housing standards and develop solutions that fulfil households' preferences and needs while efficiently using space such that living in a smaller dwelling would no longer be the result of a constraint but rather a choice even for more affluent households.

The ascertained relationship between housing functions and stated or revealed dwelling size preferences corroborates the existence of a link between practices and values and resource use (Dowling & Power, 2012). Understanding which housing aspirations require more space to be satisfied can support the conception of dwellings fulfilling the same functions with a reduced consumption of space. Our findings identified the high importance of the functions 'privacy', 'status symbol' and 'permanence' to be an obstacle for reducing housing size, which could be tackled as follows:

- *Privacy*: To enable households to have separate rooms for separate uses while reducing their personal space, residential buildings could provide shared rooms and facilities (e.g. a workshop room or a music room; Ellsworth-Krebs, 2020; Huebner & Shipworth, 2017; Pattaroni & Marmy, 2016). Such rooms could still preserve households' privacy, such as via a room-rental system. Furthermore, architectural solutions and sound-proofing could be employed to provide senses of privacy for individual family members (Dowling & Power, 2012; Ellsworth-Krebs, 2020; Ellsworth-Krebs et al., 2021).
- *Status symbol*: Shrinking the size of a 'status symbol' requires acting on the culture and society in which this function is rooted. Media, architects and designers can play a powerful role in forming expectations of an ideal home (Ellsworth-Krebs, 2020; Ellsworth-Krebs et al., 2019, 2021) and thereby shape a new 'sustainable' status symbol through the advertisement of dwellings of small size *and* a high quality of living.
- *Permanence*: Attachment to a dwelling and the neighbourhood play key roles in defining what housing is. A dwelling with a flexible layout capable of adapting to the evolution of the household could enable a reduction of space consumption while also relieving the burden of moving. In case of a shrinking household, excess space could be placed at the disposal of additional users (e.g. Beyeler, 2017; Ellsworth-Krebs, 2020), which might be especially beneficial for the elderly.

Mitigating the cost of moving

An opportunity for reducing housing size is evinced in the minority of tenants who would be willing to move if their households shrunk either because the financial incentive of paying less rent outweighs other preferences or because they see an advantage in having a smaller dwelling. In the first case, these are generally tenants with limited financial means living in a cooperative with occupancy rules (i.e. ABZ), thus having less freedom to choose their dwelling, such as older tenants and those living alone (c.f. Table 7.14 in the Appendix). In the second case, these are tenants who tend to change their dwelling in order to adapt to their current life-stage or aspirations (function 'self-representation') or those who regard their dwelling as a place that serves mostly for the basic needs of the household (function 'production-consumption'). However, these tenants can be deterred from relocating due to the high monetary and non-monetary costs of moving; the elderly may be particularly affected by such costs.

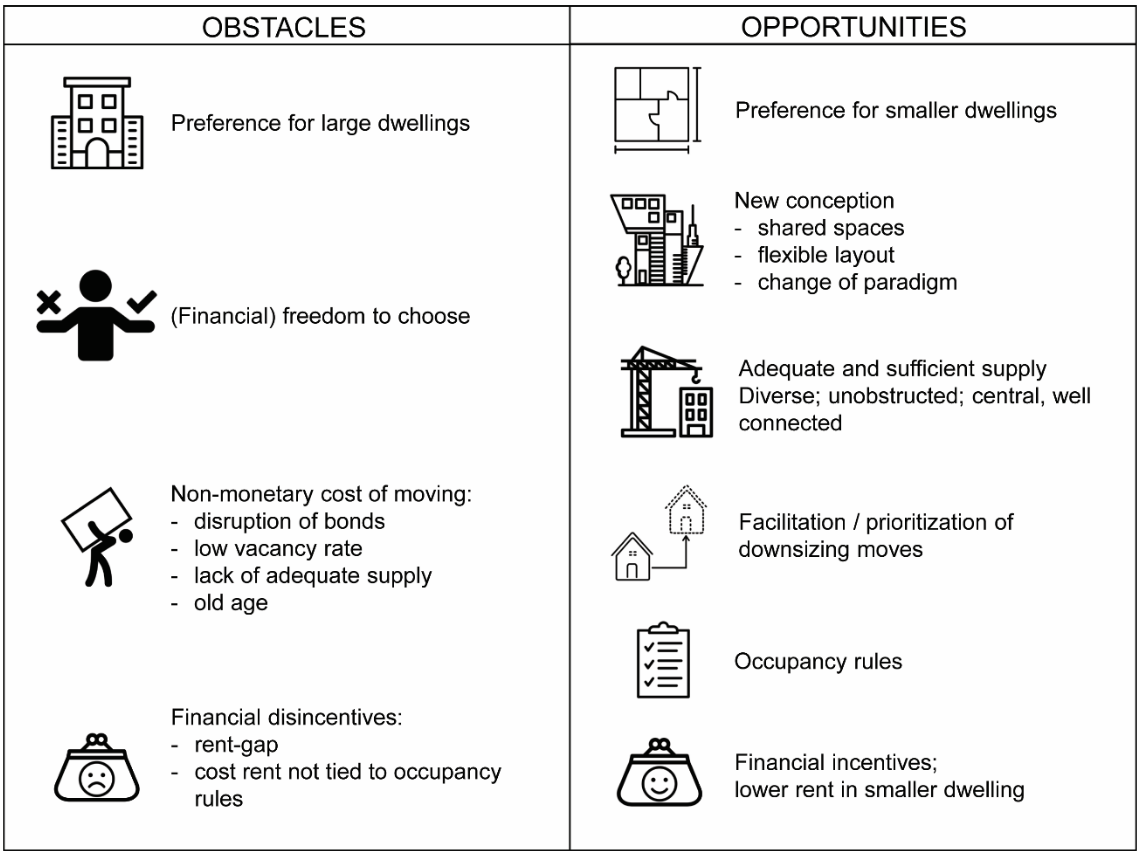

Figure 7.3. Overview of obstacles and opportunities for reducing housing size as synthesised from the results of the survey analysis.

An important non-monetary cost of moving in the micro-context is the disruption of household members' sentimental attachment to the current dwelling and bonds formed within the daily activity space (c.f. Figure 7.2). Arising from the macro-context, a second non-monetary cost is the difficulty of finding a suitable dwelling, which is likely a result of the low vacancy rates in Switzerland, especially in urban areas, but potentially is also due to an inadequate supply of small dwellings for the growing number of single- and two-person households of both young and elderly tenants (ETH Wohnforum - ETH CASE, 2016; Neuhaus et al., 2016). The lack of enough and adequate supply of small dwellings has previously been mentioned as a barrier to downsizing for the cases of the UK and Germany (Huebner and Shipworth 2017; Lorek and Spangenberg 2019) and likely represents an obstacle for downsizing also in Switzerland.

To relieve the non-monetary costs of moving, a basic requirement would be an appropriate and sufficient supply of small dwellings that fulfil the needs of diverse life-designs and household sizes (i.e. singles, patchwork families, elderlies with special requirements, etc.). Furthermore, the aspiration across age groups for living centrally, well connected and in proximity to daily activity spaces and social networks stood out in this research and was also put forward in other articles (e.g. Birrer & Glaser, 2017; Neuhaus et al., 2016)). In light of the already limited space in (urban) centres, this finding implies a need for denser, area sparing construction or the formation of new liveable centres with diverse utilization. To promote this, corresponding incentives and rules for investors could be established (for more details, see Ellsworth-Krebs, 2020; Huebner & Shipworth, 2017; Institut für Wirtschaftsstudien Basel, 2016), which would lead to a reduction of resource consumption and at the same time enable more people to live in desired areas. To minimize the disruption of local bonds, a mix of dwellings of different sizes would be needed in a building project, such that relocating to a smaller dwelling within the same complex would be possible in case of household shrinkage (Institut für Wirtschaftsstudien Basel, 2016). To further facilitate relocation, rules for prioritizing moves to smaller dwellings and/or a minimum occupancy are imaginable not only in housing cooperatives but also more widely. In addition, counselling for moves could be provided from an institutional side, which could be especially beneficial for the elderly (Institut für Wirtschaftsstudien Basel, 2016).

Finally, monetary costs of moving also present obstacles for reducing dwelling size. The rent-gap engendered by the rent control legislation in Switzerland (c.f. Section 7.2.2) presents a financial disincentive or even restriction for moving. A recent empirical study about the effect of the rent-gap on residential mobility in Switzerland did not find the former to be a significant predictor of living in a too-large dwelling (Sager et al., 2018); however, it emerged as an important reason for not being willing to move in our survey and should therefore not be neglected. A second financial disincentive exists for tenants of cooperatives lacking clear occupancy rules (i.e. SCHL), which could be eliminated by imperatively linking cost rents to occupancy rules and rigorously enforcing them.

7.5.3 Limitations

Several limitations to our conceptual approach, the survey analysis and the generalizability of the study should be noted.

Firstly, in our model of past moves, we assumed that observed changes in dwelling size were the result of a household's *choice* of dwelling size. However, housing choice is 'a choice under constraints' and involves a trade-off between different dwelling characteristics (Rérat 2020, pp. 225–226). As the choice between different options might have been very limited, aspects other than size might have been preponderant in the selection of the dwelling. Secondly, due to data availability, we have employed the risk approach, whereas other scholars modelled the residential mobility process with a two-stage approach (e.g. Clark & Lisowski, 2017; de Groot, Mulder, & Manting, 2011; de Groot, Mulder, Das, et al., 2011; Mulder, 1996). Although the risk approach is widely used, it does not enable discernment between intentions to move and actual moving behaviour. However, we enriched the study of actual moving behaviour in the first part of the study with an analysis of stated preferences in the second part. Furthermore, the advantage of the two-stage approach has been relativized through previous findings that the formation of the intention to move and the choice of a new dwelling may well take place simultaneously (e.g. Mulder, 1996). Thirdly, the expressed willingness to move due to a shrinking household was only hypothetical; therefore, the stated answers might differ from the behaviour tenants would show in a real-life situation, which is a common drawback of stated preference approaches. Lastly, this study is restricted to Swiss tenants of three different owners in mainly urban regions and did not aim for generalizability. Due to the substantial complexity of the formation of residential preferences and choices and their dependence on cultural, spatial and temporal contexts, opportunities and constraints for reducing housing size may vary between different contexts and between dwelling owners both within and outside of Switzerland.

7.5.4 Future research: The environmental footprint of housing

As part of the overarching goal of this paper, we investigated the potential of reducing housing size as a means to increase housing sustainability by also considering its sociocultural dimension. Although research has confirmed that the per capita environmental impact of housing increases with growing space consumption, this relation is not linear. Depending on the type of dwelling, its energy standard and its construction materials, the relevance of dwelling size in its overall environmental impact varies. To further reduce the environmental footprint of housing, other aspects such as occupant behaviour, mobility, energy efficiency or the decarbonisation of heating systems should be taken into account (Dürrenberger et al., 2001; Guerra Santin et al., 2009; Perkins et al., 2009; Randolph, 2008; Saner et al., 2013). Furthermore, aside from the size of a dwelling unit, the number of occupants of the unit is also crucial. The per capita consumption of space and energy in housing usually decreases with increasing household size as space, infrastructure, goods and services are shared among more people (Dürrenberger et al., 2001; Ellsworth-Krebs, 2020; FSO, 2019b; Underwood & Zahran, 2015; c.f Table 7.2). In consequence, future research should not only focus on studying how to reduce the size of individual dwelling units but also on possibilities for and social acceptance of more condensed building and living and sharing of resources among residents (as was also mentioned in Section "Mitigating the cost of moving"). Doing so will be crucial to counteracting the increasing emergence of separate dwelling units as a consequence of the growing number of single and two-person households in Switzerland. In addition, future research should more deeply investigate the relationship between housing functions and the choice of dwelling size and use the resulting insights to develop dwelling concepts that fulfil diverse functions while also using space efficiently. Finally, to contribute to the global effort toward reducing housing's environmental footprint, we invite researchers to explore the findings of this paper in different geographical and cultural contexts.

7.6 Conclusion

In this study, we directed residential mobility research towards the broader question of how to reconcile environmentally sustainable housing with households' needs and preferences. By means of a survey with tenants of two large cooperatives and of a private real estate owner in Switzerland, we investigated obstacles and opportunities for reducing housing size.

We revealed that a major obstacle for reducing dwelling size is the preference for large dwellings, particularly to fulfil the functions of 'privacy', 'status symbol' and 'permanence', in combination with the (financial) freedom to choose one's dwelling. In addition, substantial non-monetary and monetary costs of moving can impede relocation. An opportunity for downsizing is seen in some tenants prioritizing the financial benefit of a lower rent as well as those who prefer smaller dwellings to fulfil the functions of 'self-representation' and 'production-consumption'.

Accordingly, this paper underpins previous calls for invisible energy policies and offers sources of inspiration for such. More specifically, we argue for incentives for and facilitation of downsizing moves, as is currently practiced in cooperatives, in particular for tenants in the private rental market. An additional requirement is a sufficient supply of small dwellings that are centrally located and well-connected and fulfil diverse needs. For this purpose, denser building and living might be necessary, which would simultaneously increase the environmental sustainability of housing and allow more people to live in desired areas. Finally, we underline the need to rethink current housing standards to provide resource-efficient dwellings that also ensure a high quality of living and attract affluent households.

Future research should make use of the housing functions concept to elaborate housing forms that can meet diverse preferences while also using space efficiently, and investigate in how to counteract the environmental consequences of the growing number of single households with increased sharing of space and resources.

Appendix

Table 7.6. The nine housing functions and their definitions: after Pagani & Binder (2021).

Function label	**Definition**
Property	A place that belongs to the occupant, of which s/he is entitled to do what s/he wants.
Poduction-consumption	A place that enables one to perform activities (like eating, laundering, companionship).
Impermanence	A place free from tradition or memory, which reflects one’s life stage.
Status symbol	A credential for esteem, a place for exhibiting.
Privacy	A private place mainly for the family's needs. The recreation preferably happens outside.
Commodity	A temporary place or a starting point. Maybe attractive for its price or location.
Self-representation	A place for self-expression, satisfaction of aspirations.
Shelter	A refuge, a fortress where one can return to get rest, before going back out 'into the world'; the 'homely home'.
Permanence	A place a person feels they belong or are rooted in.

Table 7.7. Sample description: Household sociodemographic characteristics, affiliation with dwelling owners and space consumption per person.

Variable [0,1]	**Frequency**	
	n	% or mean (S.D.)
Gender	877	100.0
Female	472	53.8
Male	405	46.2
Age	878	100.0
33 and younger	147	16.7
34-49	289	32.9
50-64	258	29.4
65 and older	184	21.0
Marital status	874	100.0
Single	201	23.3
Married/couple	438	50.1
Divorced/separated/alone/widow	232	26.5
Presence of children	870	100.0
HH with children	239	27.5
HH without children	631	72.5
Household size	809	100.0
1 pers.	269	33.3
2 pers.	285	35.2
3 - 4 pers.	216	26.7
5 + pers.	39	4.8
Annual income of household	701	100.0
Below 60K CHF	229	32.7
60K – 88K CHF	211	30.1
88K – 120K CHF	149	21.3
120K – 165K CHF	67	9.6
above 165K CHF	45	6.4
Level of education	811	100.0
Mandatory school not completed	4	0.5
Mandatory school	72	8.9
Professional/commercial school	319	39.3
High school (Matura)	53	6.5
University (Bachelor/Master)	326	40.2
PhD	37	4.6
Dwelling owner	878	100.0
ABZ	294	33.5
SCHL	347	39.5
SM	237	27.0
Space consumption [m^2/cap]	875	45.8 (20.9)

Table 7.8. Change in household size after the previous move in relation to the trigger inducing the move.

	Change in HH size				
	n	% reduced	% augmented	% no change	Sign.
Full sample	862	39.1	15.9	45.0	
By trigger					
Raise in salary	10	30.0	0.0	70.0	
Retirement	10	20.0	10.0	70.0	
Opportunity to rent	104	32.7	10.6	56.7	**
Accessibility	13	15.4	0.0	84.6	**
New job location	49	30.6	20.4	49.0	
Rental contract expiration	17	47.1	5.9	47.1	
Interpersonal problems	12	33.3	8.3	58.3	
Increasing lack of comfort	100	31.0	10.0	59.0	***
Need for radical change in life	22	22.7	27.3	50.0	
Rent too high	54	38.9	9.3	51.9	
Forced move	64	31.3	6.3	62.5	***
Lack of space	50	24.0	16.0	60.0	*
Family (ageing, children)	10	30.0	0.0	70.0	
Divorce, separation, loss of partner	70	91.4	1.4	7.1	***
Moving in with partner	89	29.2	38.2	32.6	***
New child	95	21.1	43.2	35.8	***
Children leaving home	44	77.3	2.3	20.5	***
Leaving parents' home	9	100.0	0.0	0.0	***
Need for autonomy	27	77.8	3.7	18.5	***

***, **, * indicate the 1%, 5% and 10% significance levels, respectively;
HH = household

Table 7.9. Change in dwelling size in relation to change in housing functions during the last move. Only cases in which the household size did not change are considered.

				Change in m²		
		n	%	Increase (%)	Decrease (%)	Sign.
Total		388		69.8	30.2	
By change in housing functions						
Property						
	+	74	19.1	78.4	21.6	
	-	54	13.9	55.6	44.4	**
	=	260	67.0	70.4	29.6	
Production-consumption						
	+	107	27.6	78.5	21.5	**
	-	33	8.5	57.6	42.4	
	=	248	63.9	67.7	32.3	
Impermanence						
	+	90	23.2	71.1	28.9	
	-	112	28.9	72.3	27.7	
	=	186	47.9	67.7	32.3	
Status symbol						
	+	78	20.1	84.6	15.4	***
	-	65	16.8	60.0	40.0	*
	=	245	63.1	67.8	32.2	
Privacy						
	+	101	26.0	78.2	21.8	**
	-	51	13.1	68.6	31.4	
	=	236	60.8	66.5	33.5	*
Commodity						
	+	70	18.0	67.1	32.9	
	-	140	36.1	75.0	25.0	
	=	178	45.9	66.9	33.1	
Self-representation						
	+	140	36.1	78.6	21.4	***
	-	67	17.3	68.7	31.3	
	=	181	46.6	63.5	36.5	**
Shelter						
	+	134	34.5	75.4	24.6	
	-	39	10.1	61.5	38.5	
	=	215	55.4	67.9	32.1	
Permanence						
	+	149	38.4	73.8	26.2	
	-	58	14.9	62.1	37.9	
	=	181	46.6	69.1	30.9	

**, ** and ** indicate the 1%, 5% and 10% significance levels

Table 7.10. Change in dwelling size in relation to the trigger inducing the move.

	Change in m^2				
	n	%	% reduced	% augmented	Sign.
Full sample	864	100.0	40.0	60.0	
By trigger					
Raise in salary	10	1.2	10.0	90.0	
Retirement	10	1.2	70.0	30.0	
Opportunity to rent	104	12.0	22.1	77.9	***
Accessibility	13	1.5	23.1	76.9	
New job location	49	5.7	53.1	46.9	*
Rental contract expiration	17	2.0	52.9	47.1	
Interpersonal problems	12	1.4	33.3	66.7	
Increasing lack of comfort	100	11.6	31.0	69.0	*
Need for radical change in life	22	2.5	45.5	54.5	
Rent too high	55	6.4	58.2	41.8	***
Forced move	65	7.5	38.5	61.5	
Lack of space	50	5.8	8.0	92.0	***
Family (ageing, children)	10	1.2	20.0	80.0	
Divorce, separation, loss of partner	70	8.1	84.3	15.7	***
Moving in with partner	89	10.3	34.8	65.2	
New child	95	11.0	6.3	93.7	***
Children leaving home	44	5.1	86.4	13.6	***
Leaving parents' home	9	1.0	100.0	0.0	***
Need for autonomy	27	3.1	74.1	25.9	***

***, **, * indicate the 1%, 5% and 10% significance levels, respectively

Table 7.11. Binary logistic regression models with the dependent variable 'household reduced dwelling size upon the last relocation'.

	Model 1			Model 2			Model 3		
Variable	B	S.E.	exp(B)	B	S.E.	exp(B)	B	S.E.	exp(B)
CHANGE IN HOUSEHOLD SIZE (ref. cat. no change)									
Increase	-0.712***	0.257	0.491***	-0.461	0.281	0.631	-0.445	0.286	0.641
Decrease	1.245***	0.162	3.473***	0.829***	0.183	2.291***	0.822***	0.187	2.275***
CHANGE IN HOUSING FUNCTIONS									
Impermanence +	0.385**	0.178	1.470**				0.202	0.197	1.224
Status symbol +	-0.486**	0.211	0.615**				-0.473**	0.227	0.623**
Status symbol -	0.587***	0.205	1.799***				0.615***	0.227	1.849***
Privacy +	-0.484***	0.181	0.616***				-0.418**	0.200	0.658**
Shelter -	0.465*	0.242	1.593*				0.26	0.263	1.297
TRIGGERS									
Opportunity to rent				-1.022***	0.315	0.360***	-0.929***	0.323	0.395***
New job location				0.487	0.359	1.627	0.537	0.367	1.711
Increasing lack of comfort				-0.532*	0.3	0.588*	-0.461	0.308	0.631
Rent too high				0.629*	0.349	1.875*	0.634*	0.359	1.886*
Lack of space				-2.135***	0.564	0.118***	-2.100***	0.568	0.122***
Forced move				-0.247	0.333	0.781	-0.335	0.345	0.715
Divorce, separation, loss of partner				1.465***	0.398	4.329***	1.453***	0.406	4.274***
Moving in with partner				-0.217	0.314	0.805	-0.267	0.321	0.765
New child				-2.270***	0.475	0.103***	-2.260***	0.483	0.104***
Children leaving home				1.782***	0.491	5.943***	1.742***	0.498	5.706***
Need for autonomy				0.968*	0.495	2.632*	0.980*	0.509	2.666*
Constant	-0.893***	0.139	0.410***	-0.513**	0.217	0.599**	-0.528**	0.246	0.590**
n	849			849			849		
df	7			13			18		
Chi^2	138.324***			258.267***			282.020***		
-LL2	1004			884.02			860.27		
Nagelkerke pseudo R^2	0.203			0.355			0.382		
AIC	1020			912.02			898.27		

***, ** and * indicate the 1%, 5% and 10% significance levels

Table 7.12. Descriptive statistics of categories of willingness to move and bivariate relations between categories of willingness to move and independent variables.

		n	% *or* mean (S.D.) in sample	% *or* mean (S.D.) in subsample			Sign.
Willingness to move		570	100.0	not willing	neutral	willing	
	Not willing	220	38.6				
	Neutral	207	36.3				
	Willing	143	25.1				
CURRENT HOUSING FUNCTIONS		570					
	Property		2.66 (1.18)	2.64 (1.19)	2.73 (1.179)	2.57 (1.17)	
	Production-consumption		4.31 (0.68)	4.27 (0.70)	4.25 (0.69)	4.45 (0.61)	** (n-w, nw-w)
	Impermanence		3.02 (1.10)	3.04 (1.11)	3.02 (1.03)	2.99 (1.20)	
	Status symbol		2.06 (0.99)	2.13 (0.96)	2.14 (1.08)	1.84 (0.85)	** (nw-w)
	Privacy		3.67 (0.88)	3.67 (0.88)	3.70 (0.87)	3.65 (1.00)	
	Commodity		3.08 (1.20)	3.10 (1.23)	3.09 (1.12)	3.06 (1.25)	
	Self-representation		3.32 (0.99)	3.28 (1.01)	3.33 (1.00)	3.35 (1.02)	
	Shelter		3.93 (0.92)	3.98 (0.87)	3.87 (0.95)	3.94 (0.93)	
	Permanence		3.47 (1.08)	3.57 (1.08)	3.43 (1.07)	3.37 (1.09)	
MICRO CONTEXT (household)							
Gender		570	100.0				
	Female	294	51.6	55.0	45.4	55.2	*
	Male	276	48.4	45.0	54.6	44.8	*
Age		570	100.0				
	33 and younger	94	16.5	17.3	15.9	16.1	
	34-49	213	37.4	41.4	31.4	39.9	*
	50-64	176	30.9	22.7	36.7	35.0	***
	65 and older	87	15.3	18.6	15.9	9.1	**
Marital status		567	100.0				
	Single	62	10.9	12.4	9.2	11.3	

		n	% *or* mean (S.D.) in sample	% *or* mean (S.D.) in subsample			Sign.
	Married or couple	408	72.0	69.7	74.4	71.8	
	Divorced, separated, alone or widowed	97	17.1	17.9	16.4	16.9	
Presence of children		565	100.0				
	HH with children	237	41.9	41.7	36.4	50.3	**
	HH without children	328	58.1	58.3	63.6	49.7	**
No. of persons in HH		567	100.0				
	1[a]	0	0.0				
	2	282	49.7	53.2	50.5	43.4	
	3-4	241	42.5	40.4	41.3	47.6	
	5+	42	7.4	6.4	7.3	9.1	
Annual income of household		448	100.0				
	below 60K CHF	97	21.7	20.3	23.5	21.2	
	60K – 88K CHF	141	31.5	26.6	34.0	35.6	
	88K – 120K CHF	114	25.4	24.3	25.5	27.1	
	120K – 165K CHF	57	12.7	16.4	9.2	11.9	
	above 165K CHF	39	8.7	12.4	7.8	4.2	**
Prospect of moving within the next 5 years		551	100.0				
	yes/maybe	236	42.8	42.3	38.1	50.4	*
	no	315	57.2	57.7	61.9	49.6	*
MICRO CONTEXT (dwelling)							
Area of dwelling		570	90 (20)	88 (19)	91 (18)	94 (23)	*** (nw-w)
m^2 per person		567	35 (10)	34 (10)	35 (10)	34 (11)	
Level of satisfaction		570	100.0				
	Unsatisfied	81	14.2	12.3	16.4	14.0	
	Neutral	29	5.1	5.5	6.3	2.8	

		n	% *or* mean (S.D.) in sample	% *or* mean (S.D.) in subsample			Sign.
	Satisfied	460	80.7	82.3	77.3	83.2	
MACRO CONTEXT (market)							
Owner		570	100.0				
	ABZ	213	37.4	32.3	35.3	48.3	***
	SCHL	202	35.4	42.3	32.9	28.7	**
	SM	155	27.2	25.5	31.9	23.1	

[a]The willingness to move in case of a shrinking household was only assessed for those households with more than one person;
***, ** and * indicate the 1%, 5% and 10% significance levels, respectively; categories of willingness to move between which the independent variable differed significantly, are indicated in brackets; nw = not willing; n = neutral; w = willing.

Table 7.13. Multinomial logistic regression models with willingness to move in case the household size decreased as the dependent variable and the reference category 'not willing to move'. The regression parameters, standard errors and odds ratios of four different models are shown; for each model, a set of parameters for the regression between the reference category and the other respective category is given. The bottom section shows the number of observations included in the analysis (N), the model statistics and measures of model fit.

	Model 1		**Model 2**		**Model 3**		**Model 4**	
Variable	Neutral	Willing	Neutral	Willing	Neutral	Willing	Neutral	Willing
CURRENT HOUSING FUNCTIONS								
Property	0.212*	0.114	0.212*	0.065	0.195	0.065	0.158	-0.024
	(0.111)	(0.117)	(0.118)	(0.124)	(0.12)	(0.127)	(0.123)	(0.133)
	[1.236*]	[1.121]	[1.236*]	[1.068]	[1.215]	[1.067]	[1.172]	[0.976]
Production-consumption	-0.022	0.526**	0.023	0.632***	0.007	0.603***	-0.037	0.620***
	(0.177)	(0.213)	(0.186)	(0.221)	(0.189)	(0.224)	(0.193)	(0.23)
	[0.978]	[1.691**]	[1.023]	[1.882***]	[1.007]	[1.827***]	[0.963]	[1.858***]
Impermanence	0.113	0.014	0.117	0.043	0.124	0.039	0.116	0.035
	(0.111)	(0.118)	(0.115)	(0.122)	(0.117)	(0.125)	(0.118)	(0.127)
	[1.12]	[1.014]	[1.125]	[1.044]	[1.133]	[1.04]	[1.123]	[1.036]
Status symbol	0.021	-0.394***	0.099	-0.352**	0.108	-0.360**	0.105	-0.343**
	(0.122)	(0.143)	(0.129)	(0.147)	(0.131)	(0.149)	(0.133)	(0.153)
	[1.021]	[0.675***]	[1.105]	[0.704**]	[1.114]	[0.698**]	[1.111]	[0.710**]
Privacy	0.101	-0.061	0.104	-0.093	0.138	-0.065	0.197	0.007
	(0.135)	(0.138)	(0.139)	(0.144)	(0.139)	(0.148)	(0.143)	(0.152)
	[1.106]	[0.94]	[1.109]	[0.911]	[1.148]	[0.937]	[1.217]	[1.007]
Commodity	-0.05	-0.078	-0.042	-0.136	-0.043	-0.106	-0.056	-0.171
	(0.105)	(0.112)	(0.11)	(0.118)	(0.112)	(0.121)	(0.115)	(0.125)
	[0.952]	[0.925]	[0.959]	[0.873]	[0.958]	[0.899]	[0.945]	[0.843]
Self-representation	0.157	0.309**	0.112	0.355**	0.106	0.325**	0.138	0.376**
	(0.138)	(0.149)	(0.147)	(0.158)	(0.149)	(0.161)	(0.15)	(0.164)
	[1.17]	[1.362**]	[1.118]	[1.426**]	[1.111]	[1.383**]	[1.148]	[1.456**]
Shelter	-0.264*	-0.007	-0.217	0.02	-0.256	-0.04	-0.270*	-0.122
	(0.147)	(0.161)	(0.156)	(0.168)	(0.16)	(0.172)	(0.16)	(0.174)
	[0.768*]	[0.993]	[0.805]	[1.02]	[0.774]	[0.961]	[0.764*]	[0.886]
Permanence	-0.136	-0.385***	-0.217	-0.441***	-0.193	-0.460***	-0.231	-0.589***
	(0.133)	(0.142)	(0.141)	(0.153)	(0.144)	(0.156)	(0.151)	(0.165)
	[0.873]	[0.680***]	[0.805]	[0.643***]	[0.825]	[0.632***]	[0.794]	[0.555***]
MICRO CONTEXT (household)								

	Model 1		Model 2		Model 3		Model 4	
Variable	Neutral	Willing	Neutral	Willing	Neutral	Willing	Neutral	Willing
Age (ref. cat. 34-49)								
33 and younger			0.044 (0.391) [1.045]	-0.466 (0.417) [0.627]	0.191 (0.398) [1.21]	-0.361 (0.429) [0.697]	0.238 (0.403) [1.269]	-0.191 (0.445) [0.826]
50-64			0.787** (0.319) [2.197**]	0.334 (0.34) [1.396]	0.794** (0.322) [2.213**]	0.287 (0.347) [1.332]	0.806** (0.323) [2.238**]	0.286 (0.353) [1.331]
65 and older			0.139 (0.419) [1.149]	-0.566 (0.494) [0.568]	0.211 (0.424) [1.235]	-0.495 (0.503) [0.609]	0.265 (0.427) [1.304]	-0.429 (0.511) [0.651]
HH with children (ref. cat. without children)			-0.403 (0.285) [0.669]	0.052 (0.308) [1.053]	-0.613** (0.299) [0.542**]	-0.155 (0.324) [0.856]	-0.593** (0.301) [0.553**]	-0.189 (0.332) [0.828]
Marital status (ref. cat. married or couple)								
Single			0.024 (0.441) [1.024]	0.022 (0.455) [1.023]	0.182 (0.451) [1.199]	0.252 (0.468) [1.287]	0.091 (0.453) [1.095]	0.2 (0.482) [1.221]
Divorced, separated, alone or widowed			0.083 (0.347) [1.086]	-0.435 (0.39) [0.647]	0.091 (0.35) [1.095]	-0.407 (0.395) [0.666]	0.098 (0.352) [1.103]	-0.412 (0.4) [0.662]
Annual income of household (ref. cat. 60K - 88K CHF)								
Below 60K CHF			-0.075 (0.35) [0.928]	-0.076 (0.385) [0.927]	0.098 (0.361) [1.103]	0.093 (0.396) [1.098]	0.097 (0.362) [1.101]	0.071 (0.405) [1.073]
88K – 120K CHF			-0.174 (0.323) [0.84]	-0.416 (0.346) [0.66]	-0.272 (0.337) [0.762]	-0.659* (0.362) [0.518*]	-0.293 (0.34) [0.746]	-0.628* (0.373) [0.534*]
120K – 165K CHF			-0.782* (0.414) [0.457*]	-0.836** (0.423) [0.433**]	-1.029** (0.433) [0.357**]	-1.244*** (0.449) [0.288***]	-1.075** (0.441) [0.341**]	-1.107** (0.462) [0.331**]
Above 165K CHF			-0.656 (0.452) [0.519]	-1.914*** (0.591) [0.147***]	-1.037** (0.486) [0.355**]	-2.427*** (0.631) [0.088***]	-1.085** (0.496) [0.338**]	-2.354*** (0.646) [0.095***]

Variable	Model 1 Neutral	Model 1 Willing	Model 2 Neutral	Model 2 Willing	Model 3 Neutral	Model 3 Willing	Model 4 Neutral	Model 4 Willing
Prospect of moving within the next 5 years			-0.185 (0.276) [0.831]	0.524* (0.296) [1.688*]	-0.109 (0.284) [0.897]	0.700** (0.305) [2.014**]	-0.11 (0.286) [0.896]	0.726** (0.31) [2.068**]
MICRO CONTEXT (dwelling)								
Area of dwelling [m^2]					0.020*** (0.008) [1.020***]	0.025*** (0.008) [1.025***]	0.018** (0.008) [1.019**]	0.024*** (0.008) [1.025***]
Level of satisfaction (ref. cat. satisfied)								
Unsatisfied					0.382 (0.351) [1.465]	0.021 (0.396) [1.021]	0.253 (0.358) [1.288]	-0.194 (0.409) [0.824]
Neutral					0.768 (0.574) [2.156]	-1.193 (0.873) [0.303]	0.778 (0.57) [2.176]	-1.07 (0.875) [0.343]
MACRO CONTEXT (market)								
Owner (ref. cat. ABZ)								
SCHL							-0.565* (0.315) [0.569*]	-1.218*** (0.346) [0.296***]
SM							-0.034 (0.36) [0.967]	-0.883** (0.394) [0.414**]
Intercept	-0.18 (0.926) [0.8350]	-1.412 (1.103) [0.2440]	-0.139 (1.004) [0.870]	-1.446 (1.186) [0.2360]	-1.893 (1.193) [0.151]	-3.214** (1.373) [0.040**]	-1.316 (1.246) [0.268]	-1.844 (1.436) [0.158]
n	430		430		430		430	
df	18		40		46		50	
Chi^2	40.746***		82.444***		102.048***		117.545	
-2LL	891.646		852.721		833.117		817.62	
Nagelkerke pseudo R^2	0.102		0.197		0.238		0.270	
AIC	931.646		936.721		929.117		921.62	

***, ** and * indicate the 1%, 5% and 10% significance levels, respectively; HH = household; (Standard Error); [odds ratio]

Table 7.14. Relations between income categories and household characteristics and the dwelling owner.

		Below 60K CHF	60K – 88K CHF	88K – 120K CHF	120K – 165K CHF	Above 165K CHF	Frequency in sample (%)
	Frequency in sample (%)	21.7	31.5	25.4	12.7	8.7	
Frequency in income category (%)	*Age*	(n=448)					
	33 and younger	13.4	13.5	21.9	24.6	20.5	17.6
	34-49	34	34.8	35.1	38.6	59	37.3
	50-64	33	26.2	31.6	33.3	20.5	29.5
	65 and older	19.6	25.5	11.4	3.5	0.0	15.6
	Ssign.		***		**	***	
	Marital status	(n=445)					
	single	14.7	8.5	13.3	10.5	12.8	11.7
	married or couple	48.4	77.3	72.6	82.5	84.6	71.2
	divorced, separated, alone or widowed	36.8	14.2	14.2	7.0	2.6	17.1
	Sign.	***			*	**	
	Presence of children	(n=443)					
	HH with children	38.3	39.3	51.3	50.9	53.8	44.9
	HH without children	61.7	60.7	48.7	49.1	46.2	55.1
	Sign.						
	Owner	(n=448)					
	ABZ	50.5	43.3	30.7	22.8	23.1	37.3
	SCHL	37.1	39.	35.1	31.6	30.8	35.9
	SM	12.4	17.7	34.2	45.6	46.2	26.8
	sign.	***	**	*	***	**	

***, ** and * indicate the 1%, 5% and 10% significance levels, respectively;
HH = household

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Declarations

Conflicts of interest/Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics approval

The survey which provided the data analysed in this study was approved by the École Polytechnique Fédérale de Lausanne (EPFL) Human Research Ethics Committee in the 'Request for opinion on ethical acceptability of projects undertaken by researchers at EPFL'.

Consent

We confirm that this manuscript is an original submission: it has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with its submission to the *Journal of Housing and the Built Environment.*

Availability of data and material

The datasets analysed during the current study together with the codes used for the analysis will be made available in a public repository upon completion of the research project 'Shrinking Housing's Environmental Footprint (SHEF)' (see 'Funding').

8

How the first wave of COVID-19 in Switzerland affected residential preferences

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Contributions: A.P. introduced a set of questions on the ideal housing functions in the survey designed by L.F. and colleagues. She was in charge of conducting the statistical analyses and writing the paper. L.F. and R.H. supported A.P. in the conceptualisation of the investigation, the data analyses, and the manuscript preparation. V.K. and C.R.B. took part in the research project design and critically revised the manuscript.

Abstract

During the first wave of COVID-19, residents' health and well-being were challenged as residential environments suddenly had to accommodate most of the functions of an urban system. Although scholars and practitioners have proposed reconsidering dwelling requirements, their top-down approach overlooks the agency of residents whose preferences might have changed during the confinement. This paper investigates the effects of the first wave of COVID-19 on residential preferences in Switzerland. Adopting a systems perspective, we use an online survey of residents (N = 5378) to explore the extent to which the *functions* assigned to ideal dwellings have changed during the pandemic and relate these shifts to socio-demographic characteristics, changes in leisure activities, and respondents' environment conditions. Results indicate that at least one ideal function changed in importance for 60% of the respondents. The desire for a place for self-representation increased, whereas a place for meeting basic needs evinced the largest loss in importance. Our regression models enable us to identify two profiles of residents who responded differently to residential stress. We argue that housing owners, practitioners and policy-makers should empower inhabitants to respond to current and future challenges by acting on and changing their residential environment for their health and well-being.

Keywords: System science, housing functions, residential health and well-being, logit models, residents' agency

8.1 Introduction

A healthy urban system enables people to perform all the functions of life and develop to their maximum potential (Gatzweiler et al., 2017; Hancock, 1993; Hancock & Duhl, 1986). During the first wave of the spread of COVID-19 in Switzerland, most of these functions were condensed into a single subsystem: housing. As of 16th March 2020, the Swiss Federal Council issued declarations urging the population to reduce social contacts and remain at home until further notice (Giachino et al., 2020; Hansmann et al., 2021; Swiss Federal Office of Public Health (SFOPH), 2020). In addition, measures were put in place that included the closing of all 'non-essential' services and work places, with the exception of companies where a physical presence was needed and social distancing was possible (Der Schweizerische Bundesrat, 2020b, 2020a). As a consequence, most of the Swiss population found itself spending a considerable amount of time at home, which suddenly had to satisfy a large range of needs (Gwiazdzinski et al., 2020; Kaufmann, 2021).

Previous studies have expressed concern for occupants' health—understood as physical, mental and social well-being (World Health Organization (WHO), 1946)—when activities typically situated outside the residential environment are transferred into it (Hartig & Lawrence, 2003; Hartig et al., 2007). The confinement due to COVID-19 reinforced this concern by evincing that the lack of adequate space for work, study, exercise, and personal privacy at home can engender higher stress levels and eventually impact on residents' well-being (Amerio et al., 2020; Clair, 2020; Hansmann et al., 2021; Tinson & Clair, 2020). In response, practitioners and scholars have proposed to reconsider the requirements of residential buildings by predominantly focusing on dwelling features (e.g. room layouts, indoor air quality) that could solve the deficiencies revealed during the COVID-19 experience, e.g. lack of comfort, virus propagation, or increased energy usage (see Tokazhanov et al., 2020 for an overview). However, this linear top-down approach overlooks the complexity of the housing system and its dynamics, as it does not consider potential changes in residents' preferences during the confinement. Long advocated in the 'residential context of health' (Hartig & Lawrence, 2003; Lawrence, 2006, 2021g), and more recently in the context of the COVID-19 pandemic (Gatzweiler et al., 2020; Lawrence, 2020; Rippon et al., 2020), a systems perspective recognizes people as agents of change *for* their health and well-being (Gatzweiler et al., 2017; Lawrence, 2004; Mitchell, 2003; Stokols, 1992). As such, the study of the effects of COVID-19 on the housing system must account for its occupants' needs and desires (Grigoriadou, 2020; Pineo et al., 2018).

Our paper aims to provide insights into the extent to which the first wave of COVID-19 affected residential preferences in Switzerland as a means to identify the 'adaptive' and 'life-enhancing' resources that must be made available in order to establish and maintain healthy residential environments (Stokols, 1992). We adopt a systems perspective whereby the *function* of a system (i.e. what it is for) determines how the system behaves or manifests itself (i.e. what it does; Gero & Kannengiesser, 2004; Meadows, 2008). Previous work has demonstrated the co-existence of multiple *housing functions* in the housing realm, each of which shapes various human behaviours (i.e. residential preferences) and material behaviours (i.e. dwelling forms; e.g. 'suburban detached house'; Pagani & Binder, 2021). Therefore, studying housing functions enables us to observe changes at a higher systems level and simultaneously account for trade-offs between and changes in dwelling, neighborhood or location features regardless of the societal and environmental supersystems influencing them (e.g. culture, geography; Pagani, Ballestrazzi, et al., 2021; Rapoport, 2000). Based on this framework, we analyze data from a survey of Swiss residents (N = 5378) and explore the relationships between shifts in the housing functions assigned to ideal dwellings and socio-demographic characteristics, changes in leisure activities, and the conditions of respondents' environments (physical, social, legal, economic).

The next section contextualises this research by providing a succinct overview of the specificities of the Swiss housing and health systems. The methods used for this study are then detailed, followed by the results of the statistical analyses. Before concluding, we put our findings in perspective, acknowledge their limitations and discuss their contributions to housing health research and practice, thereby paving the way for future investigations.

8.2 Housing and health in Switzerland

There is evidence that the interrelations between housing and health are shaped by several factors (e.g. meaning of housing, autonomy, tenure security, social policies), which vary between populations and across geopolitical levels (Hartig & Lawrence, 2003; Lawrence, 2012a, 2021g). The Swiss housing and health systems present some unique features, the understanding of which is crucial when investigating the housing-related effects of the confinement due to COVID-19.

First and foremost, Switzerland exhibits the highest share of tenants among OECD countries (more than 60% against less than 28%; OECD, 2019a), a proportion that reaches above three fourth of the population in the urban cantons of Basel-Stadt (84%) and Geneva (78%; FSO, 2019b). The rental housing market is dominated by the private sector, whereby the rules governing the tenancy of apartments most often permit little-to-no inhabitant participation in designing their residential environment (Rabinovich, 2009). In addition, considering that a third of the population lives in buildings constructed before 1960, dwellings often mismatch with the requirements of increasingly diverse households (FSO, 2019b; Hugentobler, 2017; Lawrence, 2021d). Finding appropriate housing where to relocate can be a challenging task, given that the Swiss housing market exhibits a lower than 'natural' vacancy rate (from a national average of 1.72% down to 0.63% in the agglomeration of Geneva; FSO, 2019b; Zimmermann, 1992). This housing shortage is exacerbated by high housing costs, which in 2009 potentially affected 25% of Swiss households in their ability to meet basic needs (Hugentobler, 2017).

Despite these figures, the share of Swiss residents reporting satisfaction with the availability of 'good, affordable housing in their city or the area where they live' is higher than the average for OECD countries (55% versus 48%; OECD, 2019a; Werczberger, 1997); more generally, life satisfaction in Switzerland scores 7.5 out of 10 points, which contributes to the country's high performance in the Better Life Index (2021). In fact, people in Switzerland have a high life expectancy, supported by a high level of economic development and a responsive health system (OECD/WHO, 2011, p. 11). The latter, however, comes at a price for its citizens; 'an exception to the norm in Europe', Switzerland does not offer neither a public health insurance scheme nor a national health service, but a regulated privatised system (Bonoli & Kato, 2004, p. 218). Radically reformed in 1994, the system consists of health insurance funds (called *Krankenkassen* in German, or *caisses maladie* in French) which provide coverage for their members; all persons residing in

Switzerland are compulsorily insured under the basic insurance scheme. The premiums are independent of the individuals' income, which can imply a disproportionate contribution from low and middle income people, reaching up to 20% of the available household income in certain cantons (Sax, 2020). These disparities reveal the lack of a comprehensive and coherent national health policy, whereby the cantons have considerable room for manoeuvre in applying the federal legislation (Rossini, 2020). Furthermore, the commitment of the Swiss Confederation and the cantons to social goals is intended to *complement* individual responsibility and private initiative, thereby giving important responsibility to the individual when it comes to social risk (Studer, 2020). This understanding of subsidiarity as '*Eigenverantwortung*' or '*responsabilité individuelle*' applies also to the housing sector (Glaser, 2020), whereby a lack of a national or cantonal policy for the provision of social housing leaves the search for dwellings mostly to the people, depending on local programmes and options in the city (Hugentobler, 2017).

The importance given to individual responsibility can also partly explain the large compliance of the Swiss population with the measures adopted during the first wave of COVID-19. While the Swiss consociational system was 'profoundly' altered to allow the Federal Council to overrule cantonal responsibilities and form immediate responses, the federal measures and recommendations strongly relied on national 'common sense' and voluntary adhesion. As a result, a compromise between lockdown and freedom was reached in form of a 'semi-confinement', with recommendations and measures aimed at limiting non-essential movements without obliging households to stay at home (Clément et al., 2021; Sager & Mavrot, 2020).

Against this socio-political context, this article investigates whether, during the first 'lockdown light' in Switzerland, a change in residential preferences occurred. Considering the important role of socio-demographic variables in shaping the interrelationships between housing and health, potential changes are first explored in relation to the characteristics of the study participants. Subsequently, we examine these changes with regards to variations in leisure activities during the lockdown, which gives us the opportunity to explore the effects of and compliance with the Swiss Federal Council's measures and recommendations. Although the latter aimed to preserve citizens' agency, several structural factors may have hindered residents' ability to adapt housing in response to residential stress (e.g. tenure type, age of the building); we therefore consider the conditions of residents' environment during the pandemic (e.g. economic resources, housing comfort) as additional explanatory factors for the change in the kind of dwelling they considered as ideal.

8.3 Methods

8.3.1 Survey implementation

The survey was implemented with the goal to investigate the material and emotional experience of the lockdown as part of 'Swiss Corona Citizen Science', a transformative mixed methods study carried out by the École Polytechnique Fédérale de Lausanne (EPFL), University of Lausanne (UNIL), and the Idiap research institute.[32] Survey administration began three weeks after the introduction of measures (8th April 2020) and ended the day before most of the measures were terminated (10th May 2020; i.e. Phase 2 of re-opening; Giachino et al., 2020). The questionnaire was available online in the three official languages of Switzerland (German, French, Italian) and English, and was disseminated via several channels (e.g. university websites, social media, press release).

8.3.2 Questionnaire and study measures

The survey started with questions on the respondents' socio-demographic characteristics shortly before the confinement, including gender, age, professional status, household type, education level and tenure type.

To measure changes in residential preferences, participants were first asked about the kind of dwelling they considered as ideal before the COVID-19 pandemic, and then about the type they would choose if they were to move after the 'crisis' (i.e. post-pandemic). As possible answers, respondents were given the definitions of nine housing functions identified in previous research and asked to select a maximum of three (Table 8.1).

In addition, residents were asked which leisure activities they most enjoyed prior to the pandemic and which they have done since the beginning of the confinement; their choices encompassed 18 multiple answer options—for example, going to shows or movies. A set of 13 consecutive items was used to assess the conditions of respondents' environments (physical, social, legal, economic) during the confinement as measured via agreement with a set of statements (e.g. 'my accommodation lacks comfort', 'I lack economic resources') on a scale ranging from 1= strongly disagree to 5 = strongly agree (0 = not concerned; set as missing).

Table 8.1. Definitions of ideal housing functions provided to the respondents. Adapted from Pagani and Binder (2021).

Function	**Definition**
Security, privacy	A safe, intimate place
Self-representation	A place for expression, for satisfaction of aspirations
Status symbol	A 'showcase' of my status
Permanence	A place where I feel rooted
Commodity	A temporary place
Impermanence	A place that responds to my current needs
Production, consumption	A place that facilitates the performance of essential activities i.e. sleeping, eating, working
Property	A place that belongs to me
Shelter	My 'homely home'

[32] The mixed methods design is described in Fritz and colleagues (2021); a detailed description of the survey implementation is given in Hansmann and colleagues (2021).
The project can be found at: https://www.coronacitizenscience.ch/

8.3.3 Analysis

Statistical analyses were conducted using IBM SPSS Version 26. As the questionnaire asked for the selection of a minimum of 1 and maximum of 3 ideal functions, we filtered out cases in which zero or more than three options were selected, which resulted in a sample of N = 5378 out of the N = 5932 original respondents. We then computed descriptive statistics of the residents' socio-demographic characteristics, changes in their ideal functions and leisure activities during the confinement, and the conditions of their physical, social, economic and legal environments at the time of the survey.

To measure changes in each of the nine ideal functions i, we computed the variable $IF_{c,i}$ [-1 = loss in importance, 0 = unchanged, 1= gain in importance]:

$$IF_{c,i} = IF_{p,i} - IF_{b,i} \tag{8.1}$$

where $IF_{p,i}$ and $IF_{b,i}$ indicate whether the function i describes the ideal dwelling post-pandemic and the one before the pandemic, respectively.

To observe the number of changes—i.e. loss or gain in importance—in the max. 3 selected ideal functions we computed IF_a [range: min. 0 to max. 6]:

$$IF_a = \sum_{i=1}^{9} |IF_{c,i}| \tag{8.2}$$

To explore concomitant changes in each leisure activity i, we computed $LA_{c,i}$ [-1 = loss in importance, 0 = unchanged, 1 = gain in importance]:

$$LA_{c,i} = LA_{p,i} - LA_{b,i} \tag{8.3}$$

where $LA_{b,i}$ indicates whether activity i was among the most enjoyable before the pandemic and $LA_{p,i}$ denotes whether activity i was actually performed during the confinement phase.

We used a McNemar's test on paired dichotomous data to assess whether changes in ideal functions and leisure activities were significant (i.e. $IF_{p,i}$ and $IF_{b,i}$; $LA_{p,i}$ and $LA_{b,i}$). The two ideal functions exhibiting the most relevant gain and loss in importance were selected to run binary logistic regressions. The ideal function for a post-pandemic dwelling $IF_{p,i}$ was set as a dependent variable, and four blocks of predictors were entered consecutively: (i) the ideal function before the pandemic $IF_{b,i}$ (1 item); (ii) the respondents' socio-demographic characteristics (6 items); (iii) changes in leisure activities $LA_{c,i}$ (18 items); and (iv) the assessment of respondents' environment conditions (13 items). Due to the lack of empirical evidence or theories about the most important explanatory variables for our model, we reduced the number of independent variables by using the Wald forward selection method (Bortz, 1999), whereby entry and removal testing were based on the significance of the score statistic (p < 0.05) and the probability of the Wald statistic (p < 0.1), respectively.

8.4 Results

8.4.1 Respondents' characteristics

Table 8.2 displays the sociodemographic distribution of the respondents (N = 5378). Due to the channels used for participant recruitment, the sample is not representative of the Swiss population, as it exhibits a predominance of French-speaking respondents (90%) over the German-speakers (approx. 5%) compared with 23% and 62%, respectively, in national statistics (FSO, 2019d; Hansmann et al., 2021). Female residents constituted the largest share of respondents (65%; about 15% more compared to Swiss population; FSO, 2019e). Residents aged 25–54 years were overrepresented (68.3%) to the detriment of the 65+ age group (about 15% less than official figures; FSO, 2019e). This distribution is reflected in the large proportion of employed (75.6%) and highly educated (i.e. tertiary education; 54.5%) respondents, whose frequency was at least 10% greater than in the Swiss population (FSO, 2019e).

Table 8.2. Selected socio-demographic characteristics of the sample (N = 5378).

Category	**Variable**	***N***	**%**
Gender	Male	1872	35.1
	Female	3458	64.9
	Total	5330	100
Age	18-24	501	9.4
	25-34	1218	22.8
	35-44	1314	24.5
	45-54	1126	21.0
	55-64	738	13.8
	65-74	368	6.9
	75+	88	1.6
	Total	5353	100
Professional status	Employed	3902	75.6
	Student	413	8.0
	Unemployed	847	16.4
	Total	5162	100
Education level	Non-academic	2312	45.5
	Academic	2774	54.5
	Total	5086	100
Household type	Flatshare	260	5.3
	Couple with children	1877	38.5
	Couple without children	1311	26.9
	Monoparental family	281	5.8
	One-person household	1142	23.4
	Total	4871	100
Tenure type	Owner	1970	36.7
	With parents	27	0.5
	Other	148	2.8
	Tenant	3222	60.0
	Total	5367	100

In addition, most households were couples with (38.5%) and without children (26.9%) rather than one-person households (23.4%)—the most frequent household type in Switzerland (36%; FSO, 2019a). However, the larger share of tenants (60%) over homeowners (36.7%) roughly reflects the distribution of tenure types in the Swiss housing market (FSO, 2019b).

8.4.2 Change in ideal functions

Overall, approx. 40% of the residents did not report any change in their ideal housing functions IF_a, whereas 60% of respondents indicated that at least one ideal function gained or lost in importance during the pandemic. Approximately one-third of the respondents reported two changes, i.e. substituted one ideal function with another, and about 13% noted three or four. Twenty respondents (0.4% of the sample), reported six changes, thereby identifying a totally new set of ideal functions.

Figure 8.1 shows the descriptives for the variables $IF_{c,i}$, where the functions, 'property', 'shelter' and 'impermanence' exhibit the largest oscillation in importance and therefore a certain stability with regard to their relevance for the overall sample. The functions 'property' (+13.5%), 'impermanence' (+7%), and 'self-representation' (+9.2%) evince the greatest gains in importance. In particular, the latter displays very small observed losses in importance (-3.3%), thereby resulting in the highest absolute gain (approx. 6%). Conversely, 'production, consumption' shows a relevant loss (-8%) and the smallest gain in importance (+4%).

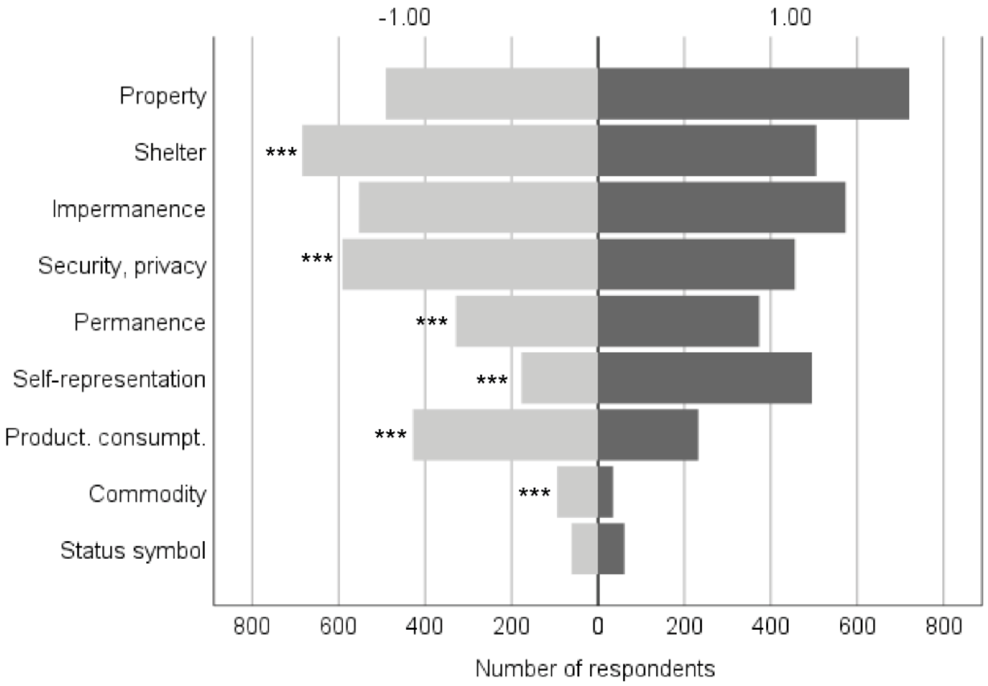

Figure 8.1. Housing functions considered to be ideal for a post-pandemic dwelling but not before (1.00) versus ideal before but not post-pandemic (-1.00) for the share of respondents for whom at least one function changed (n = 3142). Product. consumpt. = production, consumption. McNemar's test comparing ideal housing functions before and during the pandemic: *** $p < 0.001$

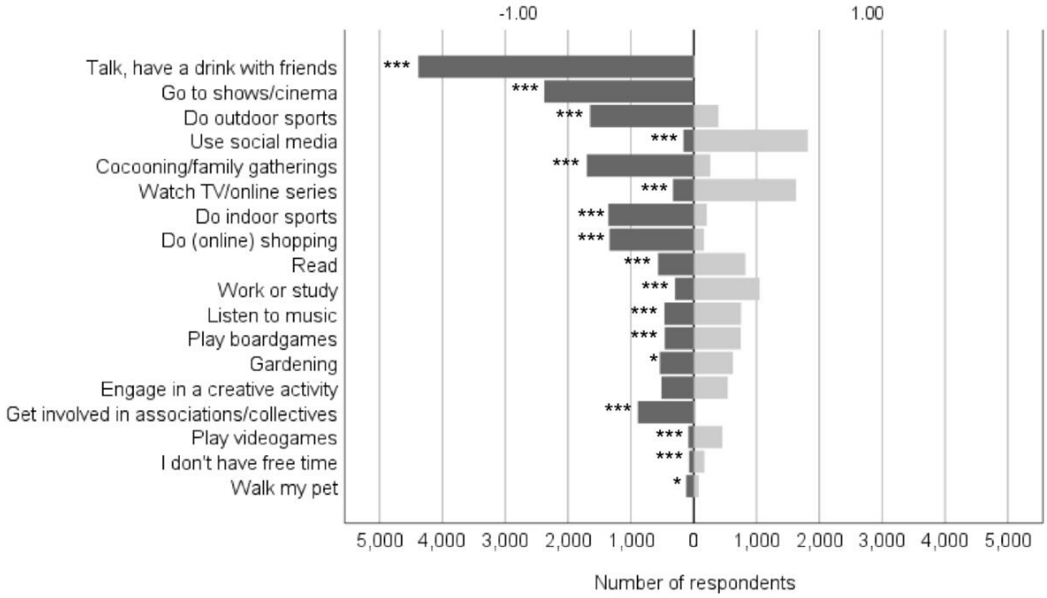

Figure 8.2. Leisure activities most performed during but not selected as preferred before the confinement (1.00) and most enjoyed prior to but not engaged in during the confinement (-1.00). Only the share of responses denoting that change occurred is displayed (n = 4118). McNemar's test comparing leisure activities before and during the confinement: *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results of the McNemar's test indicate that there is a statistically significant difference in the functions considered to be ideal before the pandemic $IF_{b,i}$, and those reported as desirable for the post-pandemic $IF_{p,i}$, with the exception of 'status symbol', 'permanence' and 'impermanence', which evince similar gains and losses of importance (Figure 8.1).

8.4.3 Change in leisure activities

The descriptive analysis of variable $LA_{c,i}$ shows that during the first wave of COVID-19, residents predominantly gave up activities such as talking or having a drink with friends (70%) and going to shows (37%). Although not particularly favored prior to the pandemic, social media use (29%) and watching TV or online series (26%) were reported as the most performed activities since the beginning of the confinement. All differences in leisure activities are statistically significant except for 'engage in a creative activity', which was equally enjoyed before and performed during the confinement (Figure 8.2; McNemar's test).

8.4.4 Conditions of respondents' environments

Figure 8.3 illustrates the extent to which respondents agreed with a set of statements concerning the conditions of their physical, social, legal, and economic environments during the first wave of COVID-19. The predominant feeling was 'I miss my loved ones' (54% of respondents), followed by 'I lack interactions (virtual, face-to-face, etc.) and physical contacts' (38%). Also notable are boredom, excessive workload, and fear for one's health, with which around 20% of respondents rather or strongly agreed.

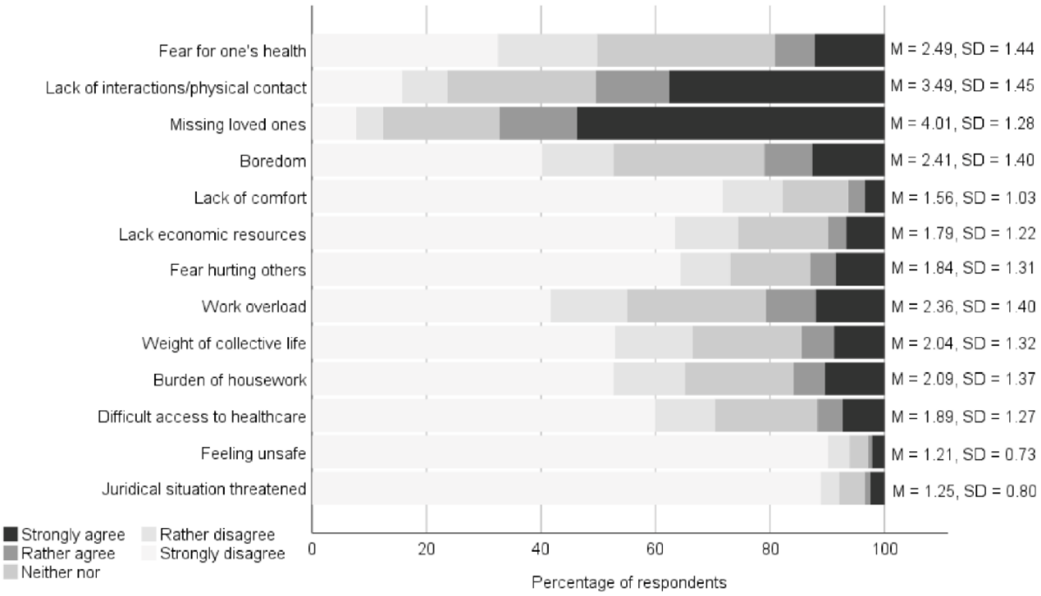

Figure 8.3. Assessment of respondents' environment conditions during the first wave of COVID-19. Share of respondents to whom a condition applies: n min = 3708, n max = 5056

8.4.5 Regression analyses: 'self-representation' and 'production, consumption'

Table 8.3 and Table 8.4 present the results of two binary logistic regressions in which the dependent variable is the function (i.e. 'self-representation' and 'production, consumption') selected (= 1) or not selected (= 0) as ideal for a post-pandemic dwelling.

The strongest determinant of the selection of 'self-representation' as ideal function for a post-pandemic dwelling was whether it was selected to describe the ideal dwelling before the confinement (OR =23.91, CI = 17.26–33.13). Table 8.3 additionally indicates that male respondents were 27% less likely than females to consider such a place as their ideal dwelling to which to move after the pandemic (OR = 0.73, CI = 0.55–0.97). The same is true for residents without an academic degree compared with those with tertiary education (OR = 0.71, CI = 0.53–0.94). Residents who liked to go to the cinema or shows during their leisure time—and have not been able to do so since the confinement began—appear to be 31% more likely to desire a place for 'self-representation' for their post-pandemic dwelling, as increase in this activity exhibits the strongest negative association with selecting such a function (OR = 0.69, CI = 0.53–0.89). Among respondents' environment conditions, residing in an uncomfortable dwelling (OR = 1.28, CI = 1.14–1.44) increased the likelihood of considering this function to be ideal by a factor of 1.28; having to take on too much domestic or care work (e.g. children or other relatives; OR = 1.17, CI = 1.06–1.29) was also positively but less strongly associated with this desire, whilst missing the loved ones (OR = 0.89, CI = 0.81–0.99) evinced the opposite regression coefficient.

Table 8.4 indicates that the strongest determinant of the selection of 'production, consumption' as the ideal function for a post-pandemic dwelling was whether it was selected to describe the ideal dwelling before the confinement (OR = 29.42, CI = 21.95–39.44). Furthermore, male respondents were 45% more likely to consider such a place the ideal dwelling to which to move after the pandemic (OR = 1.45, CI = 1.08–1.93). Residents living in a shared flat (OR = 0.50, CI = 0.27–0.92), in a couple without children (OR =

0.60, CI = 0.39–0.94), or in a monoparental family (OR = 0.45, CI = 0.22–0.92) were significantly less likely to have or develop this desire compared with one-person households. Tenure type exhibits the second strongest effect, as the odds of preferring such a function post-pandemic were more than five times greater for residents living in 'other' living situations (i.e. temporary residence, e.g. hotels, hostels, hosted by someone) than for tenants (OR = 5.54, CI = 1.68–18.21). Lacking free time for leisure activities since the beginning of the confinement also increased the likelihood to prefer a place that 'facilitates the performance of essential activities' (i.e. production, consumption) by a factor of 2 (OR = 2.07, CI = 1.05–4.08; Table 8.1). On the opposite, respondents who reported lacking interactions and physical contact were less likely to consider such a place to be ideal (OR = 0.86, CI = 0.78–0.95).

Table 8.3. Binary logistic regression analysis of predictors of deeming a place for 'self-representation' the ideal dwelling to which to move after the pandemic.

	B	**SE**	**Wald**	**df**	***p***	**OR**	**95% CI**
Ideal function before the pandemic							
Self-representation	3.17	0.166	364.27	1	0.000***	23.91	17.26–33.13
Socio-demographic characteristics							
Gender (*ref. cat.* Female)	-0.31	0.146	4.62	1	0.032*	0.73	0.55–0.97
Household type (*ref. cat.* One-person household)			14.60	4	0.006**		
Flatshare	-0.06	0.318	0.04	1	0.848	0.94	0.50–1.76
Couple with children	-0.37	0.208	3.18	1	0.074	0.69	0.46–1.04
Couple without children	0.26	0.206	1.62	1	0.203	1.30	0.87–1.95
Monoparental family	-0.16	0.306	0.26	1	0.612	0.86	0.47–1.56
Education level (*ref. cat.* academic)	-0.35	0.143	5.86	1	0.016*	0.71	0.53–0.94
Change in leisure activities							
Go to shows / cinema	-0.38	0.134	7.86	1	0.005**	0.69	0.53–0.89
Assessment of environment conditions							
Lack of comfort	0.24	0.060	16.92	1	0.000***	1.28	1.14–1.44
Burden of housework	0.16	0.051	9.63	1	0.002**	1.17	1.06–1.29
Missing loved ones	-0.11	0.051	4.92	1	0.027*	0.89	0.81–0.99
Constant	-2.30	0.297	59.63	1	0.000***	0.10	
N	2282						
-2 Log likelihood	1587						
Improvement	Chi^2 = 499.705, df = 11, *p* = 0.000***						
Nagelkerke R^2	0.328						
Cox & Snell R^2	0.197						
Classification accuracy	87.7%						

* *p* < 0.05, ** *p* < 0.01, *** *p* < 0.001; B Beta coefficients; SE Standard Error; OR Odds ratios; CI Confidence Interval for OR.

Table 8.4. Binary logistic regression of predictors of deeming place for 'production, consumption' the ideal dwelling to which to move after the pandemic.

	B	SE	Wald	df	*p*	OR	95% CI
Ideal function before the pandemic							
Production, consumption	3.38	0.150	511.63	1	0.000***	29.42	21.95–39.44
Socio-demographic characteristics							
Gender (*ref. cat.* Female)	0.37	0.148	6.23	1	0.013**	1.45	1.08–1.93
Household type (*ref. cat.* One-person household)			9.82	4	0.044*		
Flatshare	-0.70	0.316	4.88	1	0.027*	0.50	0.27–0.92
Couple with children	-0.24	0.206	1.36	1	0.243	0.79	0.53–1.18
Couple without children	-0.51	0.224	5.09	1	0.024*	0.60	0.39–0.94
Monoparental family	-0.79	0.361	4.83	1	0.028*	0.45	0.22–0.92
Tenure type (*ref. cat.* Tenant)			11.30	3	0.010**		
Owner	-0.24	0.161	2.29	1	0.130	0.78	0.57–1.07
With parents	0.95	1.834	0.27	1	0.605	2.58	0.07–93.95
Other	1.71	0.607	7.94	1	0.005**	5.54	1.68–18.21
Change in leisure activities							
Cocooning / family gatherings	0.25	0.143	3.00	1	0.083	1.28	0.97–1.69
I don't have free time	0.73	0.346	4.44	1	0.035*	2.07	1.05–4.08
Assessment of environment conditions							
Lack of interaction / physical contact	-0.15	0.050	8.62	1	0.003**	0.86	0.78–0.95
Constant	-2.19	0.255	74.14	1	0.000***	0.11	
N	2282						
-2 Log likelihood	1321						
Improvement	$Chi^2 = 727.618$, df = 12, $p = 0.000^{***}$						
Nagelkerke R^2	0.461						
Cox & Snell R^2	0.273						
Classification accuracy	87.9%						

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; B Beta coefficients; SE Standard Error; OR Odds ratios; CI Confidence Interval for OR.

8.5 Discussion

This paper investigated how the first wave of COVID-19 in Switzerland affected residential preferences. We adopted a systems perspective whereby we considered changes in the housing system's *functions* as proxies for its human and material behaviours—i.e. occupants' preferences and their material manifestation in terms of dwelling form, respectively. In the following sections, we put our results in perspective, discuss the study's limitations and contribution to research and practice, and outline potential pathways for future research.

8.5.1 Results in perspective

Descriptive analyses indicated that the housing functions attributed to an ideal pre- and post-pandemic dwelling did not differ for 40% of the respondents. This result suggests a certain stability of preferences, which might derive from a perception of the first wave as a temporary and 'exceptional' event and the expectation of a relatively speedy return to 'normal life' (Preece et al., 2020), but also from the 'light' lockdown measures, which allowed Swiss residents to leave their homes at any time for any activity (Clément et al., 2021). However, the same analysis revealed that social and outdoor activities, although not forbidden, were drastically reduced to comply with the recommendations of the Swiss Federal Council. In this exceptional setting, we observe that a change in ideal housing functions had occurred for the majority of the sample (60%), thereby corroborating previous studies that have shown how certain 'triggers'—e.g. a divorce, the birth of a child—can bring about a change in residential preferences (Brown & Moore, 1970; Mulder & Hooimeijer, 1999; Pagani, Baur, et al., 2021; Pagani & Binder, 2021).

The most relevant change in ideal functions concerned the desire for a place of 'self-representation' and 'production, consumption'. These two functions can be associated with fundamentally different human needs, the former reflecting higher needs (i.e. self-actualization or fulfilment), whilst the latter relates to lower, physiological requirements (e.g. sleep, food; see Maslow, 1948). The respective increase and decrease in the importance of these functions and needs can be explained as a manifestation of measures and recommendations to prevent the spread of COVID-19, whereby residential environments were tasked with simultaneously providing manifold services and functions of urban systems—i.e. to fulfill substantially more than basic needs. The observed dichotomy between the gain and loss in importance of higher and lower needs, respectively, is further accentuated by the results of the regression analyses, which evinced two distinct profiles of residents who responded differently to residential stress; on the one hand, a group that could be denoted as the 'trapped' showed a greater propensity to develop a desire for a place of 'self-expression' during the confinement. This group comprised predominantly female respondents, reporting a higher education degree, who enjoyed cultural activities prior to the first wave, and have been particularly negatively affected by the confinement (i.e. burden of housework, lack of comfort) but were less likely to miss their loved ones (unlike a large part of the survey respondents; Figure 8.3). This profile exacerbates the widely-reported conditions of women in Switzerland, who are daily confronted with reconciling work and family life (Bonoli & Kato, 2004; FSO, 2021; Martin, 2020). On the other hand, the 'pragmatic' group encompassed predominantly male respondents, living alone, in temporary housing situations (e.g. hotels, hosted by someone), lacking free time (i.e. working, studying) and not signalling a lack of interactions or physical contact (again, unlike a large share of the surveyed residents; Figure 8.3); this group displayed a greater likelihood of developing a desire for a place fulfilling the basic housing function of 'production, consumption'.

8.5.2 Limitations

Some limitations to this research must be acknowledged. Firstly, the descriptive analyses showed that the sample was not representative—e.g. of older adults, whose preferences differ from less vulnerable residents and are critical to addressing the impact COVID-19 had on well-being (Brüchert et al., 2021; Hartt, 2020), but also of differences across cantons, which have been shown to play a key role in the definition of housing and health policies (Glaser, 2020; Rossini, 2020). Moreover, the observed decrease in the desire for a place for 'sleeping, eating, working' evinces that in contrast to other studies (Benfer et al., 2021; Cole et al., 2020; Jones & Grigsby-Toussaint, 2020; Tinson & Clair, 2020), the survey did not exhaustively capture the effects of the pandemic for situations of homelessness, overcrowding, and poor quality or insecure housing. Secondly, the survey depicts preferences during a clearly delimited time frame; on the one hand, the observed changes might look different at the present time—one year into the pandemic, on the other hand, independent measurement of pre-pandemic preferences are not available for comparison. Lastly, we point to the fact that our identification of the two profiles reflects an unintended polarization (men–women; pragmatic–trapped) and insufficiently depicts the plurality of respondents' lifeworlds.

8.5.3 Contributions to and recommendations for housing health

Scholars have long demonstrated that the relevance of housing for health extends far beyond having or not having housing (Hartig & Lawrence, 2003; Hoisington et al., 2019; Kahlmeier et al., 2001; Marans, 1976; Shaw, 2004). Maintaining healthy environments during a confinement, when the values generated and functions provided by the city are condensed into our homes, means redefining the notion of basic need so as to provide access to more than four walls and a roof (UN-Habitat, 2012b). It requires reflecting upon what 'adaptive' and 'life-enhancing' resources are needed for occupants to respond to residential stress stemming from the lack of space for sleeping, eating and working to an increasingly relevant mismatch between the dwelling and one's image of the self (Peters & Halleran, 2021; Hartig & Lawrence, 2003); it also means responding to the strongly perceived lack of interactions and nostalgia for the loved ones (Figure 8.3), the desire to meet friends and go to shows or the cinema (Figure 8.2), i.e. sociocultural needs for which our dwellings are unprepared to provide alternatives.

In sum, during a confinement, healthy housing is expected to exhibit the same qualities as a healthy city, i.e. to be compatible with and enhance access to a wide variety of experiences, resources, contacts and interactions while also addressing the urgency to contain the virus spread (Gwiazdzinski et al., 2020; Kahlmeier et al., 2001; Lawrence, 2021g; Marans, 1976). Given that in the Swiss context several factors may prevent inhabitants from adapting their dwelling to environmental stresses (e.g. tenure type), it is the responsibility of architects, housing providers and policy makers to ensure that dwellings' design promotes and preserves the autonomy of households and individuals, i.e. their freedom to use residential space independently and to adjust it to mitigate change (Blunt & Dowling, 2006; Lawrence, 2012a; Turner, 1976). In practice, this task could be translated into the provision of shared but personal spaces in residential buildings, which, if made accessible via a room-rental system, would benefit both the 'trapped' (e.g. music rooms, libraries) and the 'pragmatic' resident profiles (e.g. extra room for teleworking, which tripled during the first wave in Europe; Kaufmann, 2021). Promoting the adaptability of spaces to different spatio-temporal needs at the building scale would also be beneficial for the mitigation of conflicts that arise between the functions each household member desires for their dwelling (be they basic, e.g. adults' work, children's schooling, or self-expressive, e.g. leisure). In addition, designing private but visually interconnected external spaces such as balconies could address the need for safe interactions with the surrounding community (visual, auditory, e.g. from balcony to balcony, from street to balcony), while functioning as public stage for 'social expression' (see Grigoriadou, 2020); ensuring access to this kind of supportive environment would be of paramount importance for the health and well-being of elderly people who live alone and are at risk of spatial and social isolation (Lawrence, 2021g). Such propositions are in line with scenarios for the future of housing developed during the first wave of COVID-19 in Switzerland within the framework of two Citizen Think Tanks that involved a share of the survey residents (see Pagani et al. 2020, Fritz et al. 2021).

It becomes clear that, as has been argued since the 1970s, healthy cities—and residential environments—should allow for a high degree of public participation and control over the decisions affecting health and well-being (Lawrence, 2021g; Marans, 1976); in other words, if residents are asked by the Federal Constitution to be *responsible* for their residential conditions, they should be *empowered* to act upon and change their residential environment during any stage of its life cycle (e.g. design, operation; Arroyo et al., 2021). Such empowerment would be in line with the call for proactive rather than corrective approaches for the promotion of health and well-being (Gatzweiler et al., 2020; Lawrence, 2004, 2019, 2021g). Furthermore, in light of the increasing attractiveness of the suburbs due to the failure of urban housing to meet residents' preferences during the confinement (Gwiazdzinski et al., 2020; Jones & Grigsby-Toussaint, 2020; Kaufmann, 2021), enhancing housing resilience could potentially counteract the negative consequences for climate and the environment entailed by the acceleration of urban sprawl.

8.5.4 Future research

From now on, homes will increasingly be expected to provide more than just the residential functions of urban systems (Jefferies et al., 2020; Kaufmann, 2021; Tokazhanov et al., 2020); inhabitants will need to cope not only with the progression of the pandemic, but also with other complex societal challenges (e.g. the imminent threats of climate change) requiring coordinated system thinking and actions (Lawrence, 2020). To support the formulation of a holistic response to these issues, we encourage scholars to build on the results of this study to consider other effects of the COVID-19 pandemic on the housing and urban systems. For instance, a parallel study found the lack of housing comfort, together with sociodemographic variables such as sex, civil status, and professional status to be significant predictors of subjective psychological strain deriving from the confinement in Switzerland (Hansmann et al., 2021); investigating the link between subjective or objective health status and changes in preferences could lead to a clearer picture of which types of stress induce adaptations of residents' needs and desires and vice versa. To further explore the stability of residential preferences, another survey could aim at capturing the change in ideal functions during subsequent waves of COVID-19. Lastly, the approach adopted in this study could be used to investigate inhabitants' perceived shifts in urban systems' functions during the pandemic and thereby contribute to a better understanding of their changes (i.e. redistribution) in the housing subsystem.

8.6 Conclusion

This study illuminated that investigations of the pandemic effects on housing can benefit from a systems perspective whereby changes in residential preferences can be observed in relation to several elements of the housing system (i.e. occupants' characteristics, leisure activities, conditions of their environments). Our results contribute to ongoing reflections on ways to provide housing that guarantees inhabitants' health, understood as physical, mental and social well-being. We urge practitioners, housing owners and policy-makers to acknowledge the increasing need for housing as a place for self-representation and consider the added value of empowering inhabitants to respond to this design challenge.

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Disclosure statement

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PART IV

Simulating residential mobility: an agent-based model for navigating complexity

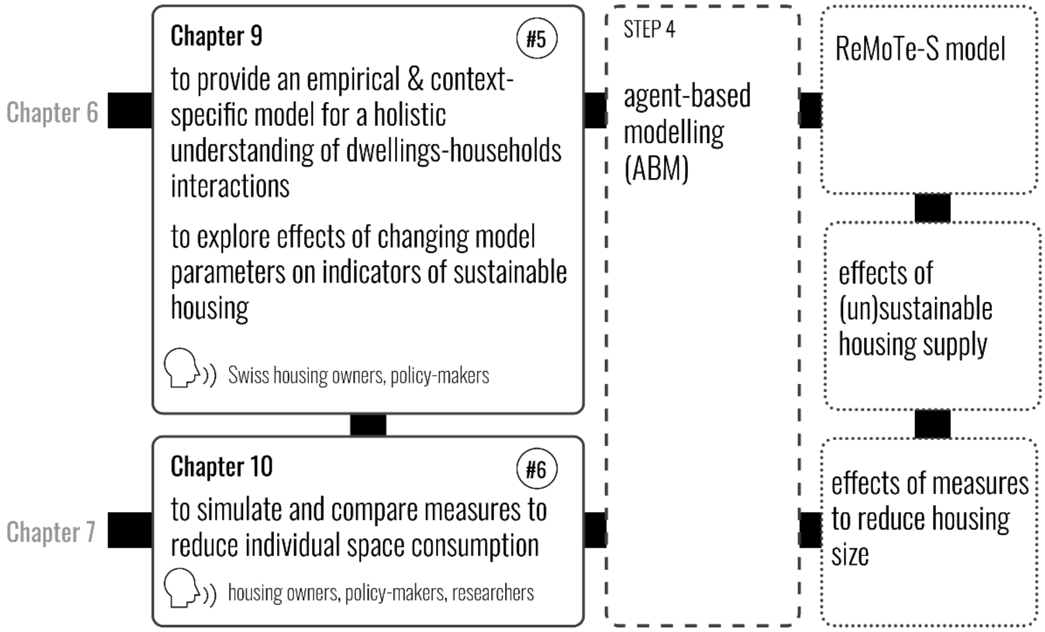

Figure IV. The content of Part IV. The full-lined box summarises the goal of the manuscripts (#) and the audience to whom their results are addressed. Dashed lines indicate the methods used as described in the research design. Dotted lines highlight the research outputs.

9

ReMoTe-S. Residential Mobility of Tenants in Switzerland: an agent-based model

Authors: Pagani, A., Ballestrazzi, F., Massaro, E., & Binder, C. R.

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Version: Pre-print (2021), revised version.

Contributions: A.P. was responsible for designing the structure of the ABM, running the simulations, interpreting the results, producing the figures and writing the manuscript. F.B. coded the ABM in Python. E.M. provided supervision to A.P. and F.B. on the modelling side. C.R.B. supervised the work and the choice of experiments. All authors critically revised the manuscript.

Abstract

Sustainable housing is a key priority for Switzerland. To provide both environmentally and socio-culturally sustainable housing, Swiss property owners need to navigate the complex and context-specific system that articulates the match between households' preferences and the dwellings available to them—i.e. residential mobility. In response to this need, this paper outlines ReMoTe-S, an agent-based model of tenants' residential mobility in Switzerland. The model design is based on empirical research conducted with the tenants of three multifamily housing providers. It accounts for the life course of dwellings and households, during which the latter attempt to maximise their satisfaction, which is calculated as the correspondence between their desired *housing functions* (e.g. a status symbol) and the functions of dwellings. To illustrate the model's potential uses, we explore the sensitivity of its outputs to changes in dwellings' and buildings' qualitative and quantitative features by looking at two key indicators of housing sustainability: floor space per capita and vacancy rate. We firstly observe that a supply dominated by medium-to-large dwellings and the application of less strict occupancy rules can result in housing underoccupancy. Secondly, it emerges that certain combinations of housing features engender a lower vacancy rate inasmuch as they more successfully generate housing functions. We conclude that by enabling housing providers to explore the complex human-environment interactions of the housing system, ReMoTe-S can be used to inform a sustainable management of housing stock.

Keywords: Household mobility, household relocation, housing, human-environment systems, sustainability, agent-based modelling

9.1 Introduction

Accounting for approximately a fourth of the CO_2 emissions and total energy consumption in Switzerland (IEA, 2018a, 2018b), housing plays a crucial role in the transition of urban systems towards sustainability (Binder, Wyss, et al., 2020). While measures to reduce the environmental footprint of the residential sector are urgently needed, housing supply must also be congruent with the cultural and social conventions of the present and future households (Chiu, 2004; Prochorskaite et al., 2016). Providing sustainable housing therefore requires a holistic understanding of the complex interplay between households' needs (i.e. demand) and their environment (i.e. supply; Lawrence, 2009; Pagani, Laurenti, et al., 2020). This interplay is made explicit in the relocation process, wherein households match their housing requirements to the dwellings available to them (Clark, 2012). Such process is commonly investigated as an object of study in itself, whereby microlevel data are collected and used for empirical analyses (Mulder, 1996; Rérat, 2020). However, dynamic models are needed to investigate the macrolevel outcome of all households' simultaneous choices over time (Benenson, 2004; Mulder, 1996).

Agent-based models (ABM) are particularly suitable for the exploration of real-world systems dynamics emerging from the interaction of agents and their individual preferences (Friege et al., 2016; Nikolic & Ghorbani, 2011). Several theory-based and empirical ABMs of urban residential choice exist. However, despite their apparent comprehensiveness, these models are not applicable to all urban realms because cultural, political, economic and social contexts have a remarkable influence on residential settings and preferences (Booi & Boterman, 2020; Lawrence & Barbey, 2014). In particular, Swiss housing strongly differs from housing in other OECD countries. In Switzerland, nearly two-thirds of the population are tenants whose rights are protected by a rent control legislation limiting landlords' ability to raise rents and evict them at will (FSO, 2017b). A share of rental housing is populated by housing cooperatives, whose management of tenants differs from that of private landlords or asset managers. Furthermore, although housing quality and conditions are reported as being very satisfactory (Rabinovich 2009), finding a dwelling is not an easy endeavour considering the lower than 'natural' vacancy rate (2.7% in 2019)—in particular for the cities of Lausanne (0.4%) and Zurich (0.1%; Werczberger, 1997; Wüest Partner, 2020; Zimmermann, 1992).

To provide housing that is both environmentally and socio-culturally sustainable, Swiss property owners need to navigate the above-described complexity—i.e. to account for the effects of households' housing-related preferences and decisions as well as the tenure- and context-specific factors affecting them. In response to this need, we outline ReMoTe-S, an agent-based model of the residential mobility of tenants in Switzerland. The model is based on assumptions derived from empirical qualitative and quantitative research conducted with the tenants of three multifamily housing providers. Its goal is to foster a holistic understanding of the reciprocal influence between households and dwellings and thereby inform a sustainable management of the simulated housing stock.

This paper is organised as follows. Section 9.2 contextualises and illustrates the theoretical framework and assumptions underlying the model design. Section 9.3 introduces the ABM, including a description of its agents, the model initialisation and its sub-models. Section 9.4 concisely describes the model's calibration and verification. Section 9.5 exemplifies potential model's uses; it presents the setup and results of two 'what-if' experiments, where the concepts of housing environmental and socio-cultural sustainability are operationalised in quantitative and qualitative terms. More specifically, the first experiment consists in varying the size of the dwellings supplied to observe effects on average floor area per capita—a crucial indicator of resources and energy consumption in housing (Ellsworth-Krebs, 2020; Karlen et al., 2021; Lorek & Spangenberg, 2019; Pagani, Laurenti, et al., 2020). The second experiment explores and compares the outcomes of the supply of dwellings with 'sustainable' qualitative features (e.g. closeness to public transports) and 'unsustainable' ones (e.g. parking places). Here, the average vacancy rate of dwellings in the model is used as indicator to assess their correspondence with households' preferences and needs (Haase et al., 2010). Finally, Section 9.6 discusses the theoretical contributions, validity and limitations of ReMoTe-S. The paper concludes with recommendations for the three housing providers and future research pathways towards a sustainable management of their residential building stock.

9.2 Theoretical framework and previous work

Most of the literature on residential mobility describes it as the process by which a household decides to move and to choose a new dwelling (Dieleman et al., 2000). This process is commonly divided into two stages: in the first, a stressor or *trigger* arises for the household to decide to seek a new residence; in the second, the household searches, evaluates and selects a housing vacancy based on its residential *preferences* with the goal of increasing its *satisfaction* (Brown & Moore, 1970; Lu, 1998; Mulder, 1996; Mulder & Hooimeijer, 1999).

Several attempts to model the interactions between triggers, residential preferences and residential satisfaction can be found among existing ABMs (see Huang et al., 2014; Klabunde & Willekens, 2016 for an overview). For instance, the HI-LIFE model uses qualitative and quantitative data to simulate household agents' (HA) residential mobility in relation to changes in their lifecycle stages (Fontaine & Rounsevell, 2009). Following a trigger (e.g. couple formation), the HA's preferred features are updated according to the HA type, thereby influencing the search for vacancies and their ranking (i.e. via potential attractiveness).

Similarly, other models of residential mobility increasingly distinguish between agent types based on 'stages' of a household's lifecycle (e.g. RESMOBcity by Haase et al., 2010; HRRM by Ma et al., 2013). However, the concept of the 'lifecycle stage' has been gradually replaced by the 'life course' notion (van Ham, 2012), which models individual life histories from a succession of micro- and macro-level events linked to a household's family, education, work, or residential careers (for theory, see Clark & Dieleman, 1996; Clark & Lisowski, 2017; Mulder & Hooimeijer, 1999; Rérat, 2020; for examples of computer models, see Klabunde & Willekens, 2016; Torrens, 2007). These life events can variously affect the preferences of a household for its dwelling (see Devisch et al. 2009; Ettema 2011), which are most often modelled as depending on a feature of interest (e.g. agents' religious identity; Benenson et al., 2002) and derived from a bundle of dwelling or location attributes (e.g. neighbourhood identity).

In light of these complex interrelationships, our earlier work conceptualised, explored and operationalised the relocation process by means of a systems perspective (Pagani, Baur, et al., 2021; Pagani & Binder, 2021). To account for the specificities of Swiss housing, we conducted two group discussions and a survey involving 968 tenants of three multifamily housing owners, namely the insurance company and institutional property owner Swiss Mobiliar (Schweizer Mobiliar Asset Management AG), and two of the country's largest housing cooperatives: ABZ

(Allgemeine Baugenossenschaft Zürich) and SCHL (Société Coopérative d'Habitation Lausanne).[33]

Results showed that triggering events resulting from the progression in a households' life course career can be categorised into opportunities, problems to solve, and radical changes, whereby depending on its satisfaction with the current location, a household either considers moving or is forced or induced to do so, respectively (Clark & Onaka, 1983; Ma et al., 2013). Radical changes were observed to most strongly alter households' preferences for the new dwelling. Residential preferences were investigated via the notion of *housing functions*, i.e. what the housing system is for (Gero & Kannengiesser 2004; Meadows 2008). Ranging from 'status symbol', to 'permanence', or 'commodity', nine functions of the housing system were identified in the literature and explored empirically. Revealed preferences were studied by looking at the current functions of the dwellings in which households lived and the associated dwelling's features (e.g. balcony); stated preferences were defined as the functions desired for a dwelling and found to depend on households' sociodemographic characteristics.[34] A decreasing gap between the two types of functions was shown to increase residential satisfaction with the dwelling, which is relevant for both the decision to move and the selection process. In fact, when searching for a new dwelling, the household seeks to make the best possible match between where to live and how it wants to live (Thomas & Pattaroni, 2012). This match might be suboptimal, as the selection of a dwelling depends on households' preferences within a *choice set*, which will be widened or narrowed by micro-level resources and restrictions (e.g. financial resources) as well as macro-level opportunities and constraints (e.g. availability of housing and prices, job opportunities; Rérat, 2020; van Ham, 2012; Figure 9.1).

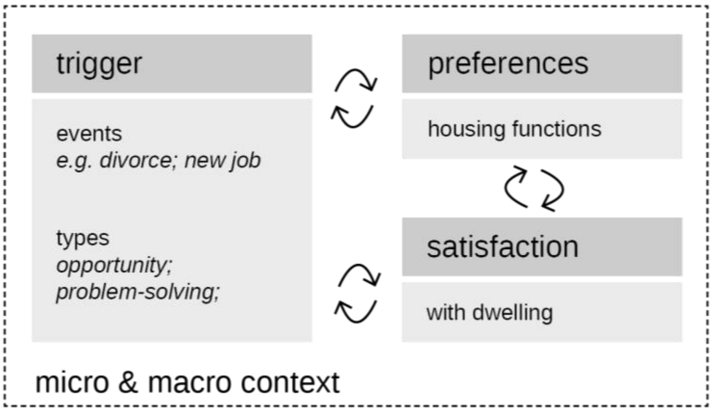

Figure 9.1. A conceptual framework for the residential mobility of Swiss tenants. Arrows indicate the recursive interactions between system elements, which are embedded in and shaped by contextual factors (e.g. family career; housing supply; after Pagani, Baur, et al., 2021).

[33] Collectively, these owners manage approximatively 10,000 dwellings. The final sample used for analyses was N = 878.

[34] Our previous work introduced the concept of 'desired' function as an adaptation of the 'ideal' function to micro-level resources and restrictions (e.g. a household's income), whereas the 'current' function is described as an adaptation of the desired function to macro-level opportunities and constraints (e.g. available dwellings; Pagani, Baur, et al., 2021). As agent-based modelling permits us to account for the interaction between micro- and macro-level factors, this paper focuses on the simulation of 'desired' functions and 'current' functions—here simply defined as 'dwelling' functions. To do so, we applied the empirical knowledge gained on the notion of ideal functions to that of desired functions assuming a linear effect of the gap between aspirations and reality on households' satisfaction (Eq. 9.1)

9.3 Agent-based model

Having introduced the goal of ReMoTe-S (Section 9.1) as well as the conceptual system and empirical explorations on which its assumptions are based (Section 9.2), in this section, we provide an overview of the most important model design decisions structured according to the Overview, Design concepts and Details (ODD) protocol (Grimm et al. 2010; for the full protocol, see 'Model documentation').

9.3.1 Entities and state variables

ReMoTe-S introduces four classes of multidimensional agents: tenants, households, dwellings and buildings. The tenant belongs to a household, who lives in a dwelling contained in a building. Each agent disposes of a unique id number and of state variables that control its behaviour (Table 9.1; see the ODD protocol for full list).

Building: This agent class is composed of a certain number of dwelling agents that are managed by the three different Swiss multifamily housing owners ABZ, SCHL and Mobiliar. Buildings are characterised by a postcode depending on the geographical location of the owners' building stock and by qualitative features such as closeness to 'places of interest' (e.g. public transport) and 'neighbourhood' qualities (e.g. safe).

Table 9.1. Classes of agents and their most relevant state variables.

	State variable	**Type**	**Range**	**Description**
Building	dwellings_num	integer	[2,121]	number of dwellings in the building
	owners_type	string	{ABZ, SCHL, Mobiliar}	multifamily housing owner
	postcode	integer	[1000, 9000]	postcode where the building is located
	neighbourhood	set	{safe, sociocultural mix, accessible by car}	
	places_of_interest	set	{work, public transports, city centre}	
Dwelling	rooms	integer	[1, 7]	number of rooms in the dwelling
	size	integer	f(rooms)	dwelling size depending on rooms
	rent_price	integer	f(size)	yearly rent price based on dwelling size
	characteristics	set of strings	{bright, with balcony, with green spaces, with parking place}	
	functions	set of integers	e.g. {1, 5, 9}	set of functions of the dwelling
Household	mover	boolean	[0, 1]	if True, then agent is searching for a dwelling
	trigger	string	e.g. 'divorce'	trigger to move (see Table 9.2)
	months_waited_since_mover	integer	[0, ∞)	count of months searching for a dwelling
	TYPE	integer	[1, 13]	household type
	desired_functions	set of integers	e.g. {1, 5, 9}	set of household's desired functions
	satisfaction	float	[1, 5]	residential satisfaction with the dwelling
Tenant	age	integer	[0, 99]	age of the tenant
	member_type	string	{minor, adult}	under or over 18 years old
	salary	float	f(age)	monthly salary depending on age category

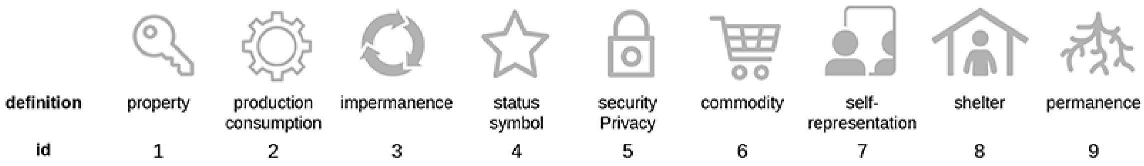

Figure 9.2. Definitions and ids of nine functions (F) and desired functions (DF) after Pagani & Binder (2021). Example of a set of DF or F: {1, 3, 5, 8}.

Dwelling: Each dwelling agent comprises a single household agent. Dwellings are characterised by quantitative state variables, e.g. the number of rooms, size, and rent price, and qualitative ones, i.e. 'characteristics' (e.g. balcony). Most important for the relocation process is the set of functions (F) that the dwelling fulfils (e.g. status symbol, shelter, property; see Figure 9.2).

Household: This class is composed of one or more members i.e. tenant agents. A household agent is characterised by its type (T), which results from the combination of the average age, number, and type of its members (adults, minors; e.g. T8 = middle-aged couple with children living at home). The agent holds the most relevant state variables for the relocation process, including residential preferences (i.e. its set of desired functions DF; Figure 9.2) , residential satisfaction (min = 1, max = 5), and other variables useful to control its moving behaviour, e.g. the trigger that pushed it to move, the amount of time it spent searching for a dwelling.

Tenant: A household member, i.e. tenant agent, is characterised by its age and its member type, which determine its monthly salary.

9.3.2 Process overview and scheduling

The process is simulated on a step-wise monthly basis wherein one step represents one month. The initialisation of the model (time-step t_0) is followed by the two sub-models 'to move' (t_1) and 'to select' (t_2) which are executed successively at each global time step (Figure 9.3).

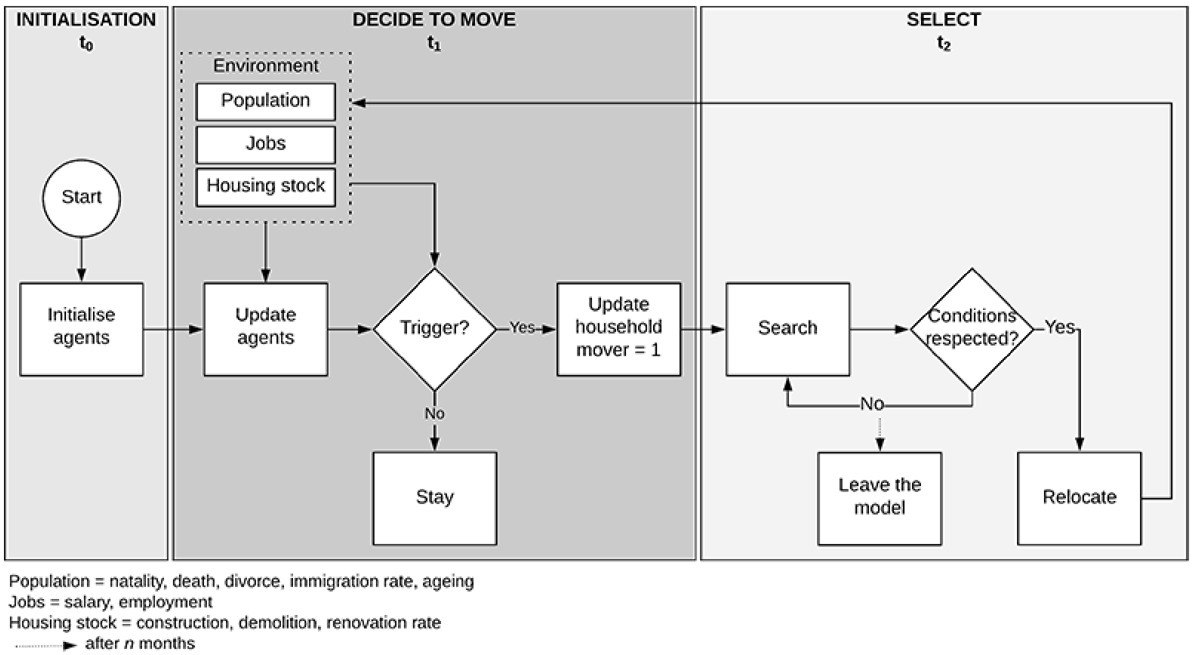

Figure 9.3. Overview of the process, including initialisation (t_0 = 0) and two sub-models: decide to move (t_1) and select (t_2).

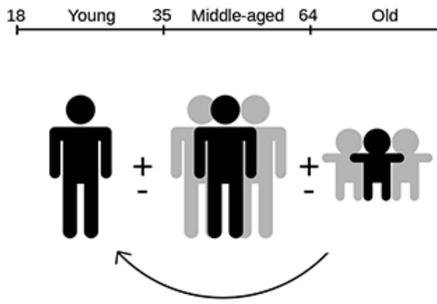

Figure 9.4. Evolution of household type depending on the passage of time and other events. The '+' and '–' indicate the addition and subtraction of an adult or minor to the household (divorce; new child; leaving flatshare). Minors become independent adults at the age of 19 years. Example of a type: T10 = middle-aged alone with children living at home.

Progress in the family, work and/or residential life course careers can result in a trigger, whereby households are synchronously updated as movers (t_1) and sequentially activated to engage in the search of a new dwelling (t_2). At the end of t_2, the movers have either found a dwelling or continue the search. If a suitable vacancy is not found after n time-steps, we assume that agents out-migrate, i.e. move to dwellings belonging to housing providers other than the three simulated in ReMoTe-S. Higher-level processes are used to simulate agent dynamics according to global parameters:

Population: While progressing in age, agents are born, become independent adults, form and dissolve groups (couple, flatshare), have children and die following rules and events compatible with their type (Figure 9.4). At every time-step, new agents enter the model to search for a vacancy. These processes are regulated by the passing of time (ageing every 12 time-steps), mortality, natality, divorce, and immigration rates. In addition, we assume that households' residential satisfaction falls by 0.1% with every additional time-step spent in their dwelling (see Friege et al., 2016).

Jobs: The salary and employment status of the tenant agent evolve over time. More specifically, salaries are subjected to a yearly increase of 0.9% unless the tenant is fired and given a subsidy by the state for a maximum of two years (FSO 2019b; SECO 2020).

Housing stock: Dwellings and buildings are affected by construction, demolition and renovation rates. Dwellings can undergo renovation and be unavailable for a fixed amount of time, following which the rent price is adjusted. We assume that buildings are demolished depending on their age and the amount of time their dwellings have been vacant.

9.3.3 Design concepts

This subsection concisely describes four of the design concepts proposed by Grimm (2010), which are relevant for understanding how ReMoTe-S works.

Objectives: Based on the theoretical framework introduced in Section 9.2, we assume that household agents' final goal is to find a dwelling that maximises residential satisfaction under supply constraints and households' restrictions. Our empirical explorations revealed that the gap between residential aspirations and reality is a predictor of residential satisfaction (Pagani, Baur, et al., 2021). Therefore, we calculate the level of satisfaction of a household agent i with a dwelling j at time t ($los_{ij}(t)$) based on the correspondence of its set of desired functions to the set of functions of the selected dwelling:

$$los_{ij}(t) = 4\left(\frac{len\left(DF_i \,\&\, F_j\right)}{len(DF_i\ )}\right) + 1 \qquad (9.1)$$

where DF_i is the set of desired functions of a household i, F_j is the set of functions of the selected dwelling j, len returns the number of items and $los_{ij}(t)\ min = 1,\ los_{ij}(t)\ max = 5$.

For instance, if at time t $DF_i = \{1, 3, 5, 8\}$ and $F_j = \{1, 3, 7\}$, the resulting satisfaction is:

$$los_{ij}(t) = \ 4\left(\frac{2}{4}\right) + 1 = 3 \qquad (9.2)$$

<u>Interaction</u>: In the moving process, agents directly and indirectly interact within and across classes. Examples of direct interactions include: a tenant's loss of job, which affects the salary of its collective (*tenant-household*); the merging of two households, e.g. via couple formation (*household-household*); or more simply renting or leaving a flat (*household-dwelling*). Occupying a dwelling can also have indirect effects by preventing similar agents from finding a vacancy that satisfies them and eventually pushing them to leave the model (i.e. competition).

<u>Stochasticity</u>: Stochasticity is used to simulate the random component for which an agent would decide to move in a particular period, i.e. to cause model events to occur and trigger residents' relocation following empirically-based probabilities (e.g. a change in job location; see 'Decide to move'). Stochasticity also serves to reproduce variability in processes whose cause is irrelevant (e.g. the sample of dwellings that an agent 'sees' when searching; Grimm et al. 2010).

<u>Observation</u>: The desired information is collected at every time step and saved in a .csv file at the end of the simulation. The output data are then sampled and used for testing, understanding and analysing the model's behaviour, as illustrated in the following sections.

9.3.4 Model initialisation and input data

The model is populated with the tenants' survey dataset (N = 878). The dataset contains information on households' socio-demographic characteristics (including e.g., types, salary), their revealed and stated preferences (i.e. desired/current housing functions, housing features), the triggers that pushed them to relocate, and their residential satisfaction. When needed, statistics from the Federal Statistical Office (FSO) are used instead. The initialisation process does not vary among simulations; however, stochastic variables vary with every iteration.

Agents are initialised via three procedures. A desired number of buildings is first generated (N = 30). The buildings' owner type corresponds to the share of survey respondents per owner (ABZ = 33.5%, SCHL = 39.5%, Mobiliar = 27%), based on which the postcode is assigned. Buildings are randomly attributed at least one qualitative feature among 'neighbourhood' and 'places of interest'.

Secondly, dwellings are created and distributed among available buildings. The distribution of the number of rooms per dwelling is based on survey data (M = 3.5, SD = 1) and is used to determine the dwelling's size (sqm/room) and rent price (CHF/sqm). Dwellings are stochastically attributed a minimum of one 'characteristic'. The set of functions (F) of a dwelling agent is established with probabilities that depend on dwellings' and buildings' features in the survey (see Table 9.7 in Appendix).

Finally, households are generated (N = 1000). Their type (T) follows the distribution of survey respondents and is used to set the ranges of several tenant agents' state variables (e.g. age, salary). The set of desired functions (DF) is sampled from their frequencies per household type in the survey (see Table 9.8 in Appendix).

The initialisation process works similarly to the process 'select' (t_2) and consists of matching households to available dwellings depending on a set of conditions. The process is completed when all dwellings are occupied. A fixed number of vacant dwellings is then randomly generated in existing buildings in order to comply with the rental housing vacancy rate of different Swiss cantons (0.4% for postcode 1000, 0.1% for postcode 8000, 2.7% for all others; Wüest Partner, 2020).

9.3.5 Decide to move

This subsection illustrates the first sub-model of ReMoTe-S, at the end of which household agents decide to move (Figure 9.3 and Figure 9.5).

We consider 17 triggers organised in the three types identified in our previous qualitative and quantitative exploratory work (Pagani, Baur, et al., 2021; Pagani & Binder, 2021): opportunities, which are effective under the condition of a medium level of satisfaction (i.e. < 5); problems to solve; and radical changes (Table 9.2).

Triggers are discrete events caused by either the environment (i.e. exogenous) or a sequence of events in the model (i.e. endogenous). The probabilities of exogenous triggers to occur are based on the survey dataset and official statistics. Endogenous triggers depend instead on parallel events (e.g. loss of a job can render the rent unaffordable). Certain requirements must be met for an event to trigger a household's move; for instance, the expiration of rental contract does not apply to cooperative tenants, whereas underoccupancy checks do not apply to non-cooperative housing.[35]

Synchronously with radical changes and changes in household's type, the household agent is attributed a new set of desired functions (i.e. update in residential preferences).

Table 9.2. Triggers overview.

Opportunity	**Problem-solving**	**Radical change**
1. Salary increase	3. Expire contract	11. Change job location
2. New building[a]	4. Demolition	12. Need for change
	5. Renovation / transformation	13. Create couple
	6. Interpersonal problems	14. New child
	7. Rent too high	15. Separate / divorce
	8. Underoccupancy	16. Children leaving
	9. Growing old, retirement	17. Leaving the flatshare
	10. Family[b]	

[a] The trigger 'New building' works as an advertisement whereby a signal is sent to all tenants residing in the building's postcode with a medium level of satisfaction. All notified tenants apply for a dwelling in the new building. If they do not obtain it after the first trial, then their status reverts to mover = 0.
[b] E.g. moving closer to the family when ageing, closer to schools for children.

[35] This trigger consists of an annual check of the cooperatives' (i.e. ABZ, SCHL) compliance rules with the goal to prevent inefficient use of space. This rule only applies to the cooperative dwellings with $RO_j(t) \geq 4$ and if $S_i(t) < RO_j(t) - 2$, where $RO_j(t)$ is the number of rooms for a dwelling j at time t, and $S_i(t)$ is the number of members of a household i at time t.

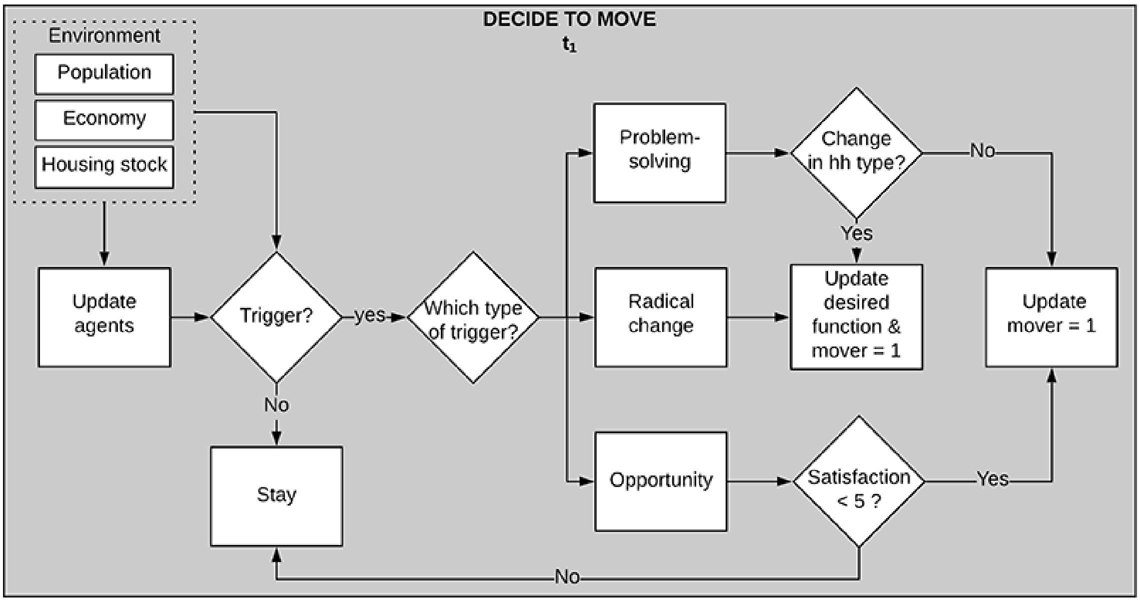

Figure 9.5. Submodel 1: the decision to move. 'mover = 1' indicates that the agent will engage in the search.

9.3.6 Select

Following the process 'decide to move', agent-movers are sequentially activated to search for either joinable groups or vacant dwellings (Figure 9.6). Values are updated as soon as they are calculated by the process (i.e. asynchronous updating) so that the dwellings that have been occupied first are not available for the next searching agent.

We assume that the household (i) filters the dwellings it 'sees' depending on a set of 'conditions' (Table 9.3), (ii) gathers them in a list, (iii) ranks them according to the satisfaction they potential generate, and eventually (iv) moves to the first one on the list. If two alternatives have the same score, then the dwelling is randomly selected; if no dwelling is found in *n* time-steps, then the household out-migrates.

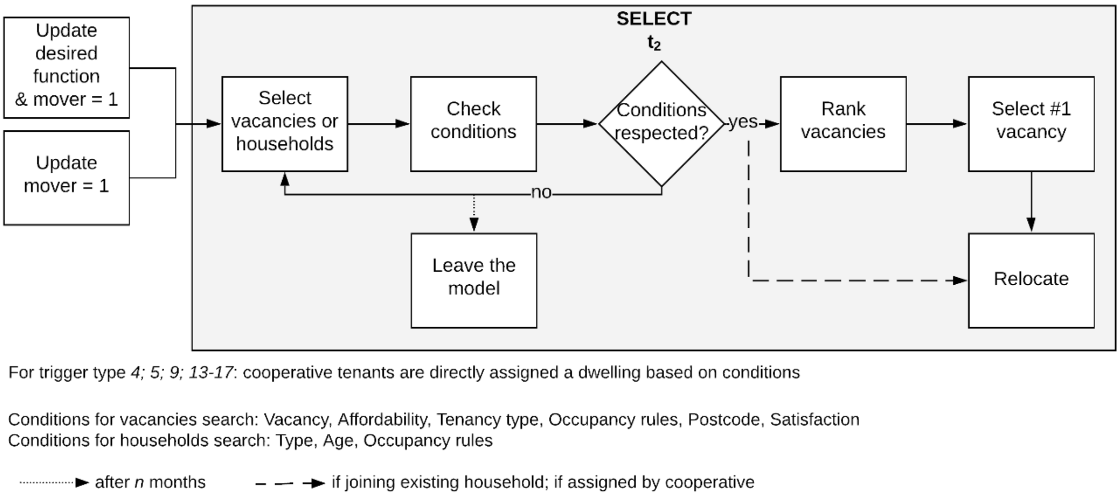

Figure 9.6. Submodel 2: the selection of the dwelling.

Table 9.3. Conditions for the selection of a dwelling. Considering that the search for a dwelling happens at both t_0 and t_2, we display the applicable process for each condition.

Condition	Description	Process
Vacancy	The dwelling is empty.	t_0, t_2
	The dwelling is different from that where the household resides. It is not under renovation, and will neither be demolished nor renovated in the following year.	t_2
Affordability	$SA_i(t) \geq 1/3\ R_j(t)$ where $SA_i(t)$ is the sum of the annual salary of each member comprising the household i and $R_j(t)$ is the annual rent of the selected dwelling j.	t_0, t_2
Tenancy type	For SCHL and ABZ: The selected dwelling belongs to the same owner as the current one.	t_2
Occupancy rules	Mobiliar: $S_i(t) - 1 \leq RO_j(t) \leq S_i(t) + 2$	
	SCHL and ABZ: $S_i(t) - 1 \leq RO_j(t) \leq S_i(t) + 1$ where $S_i(t)$ is number of members of the household i, and $RO_j(t)$ is the number of rooms of the selected dwelling j at time t.	t_0, t_2[a]
Postcode	It must be equal to the postcode of the current dwelling, except in case of a change in job location (trigger 11) or the need to move closer to the family (10).	t_2
Satisfaction	$los_{ij}(t) \geq los_{ik}(t)$ where $los_{ik}(t)$ is the level of satisfaction of a household i with its current dwelling k at time t, and $los_{ij}(t)$ is the level of satisfaction with the selected dwelling j (see Eq. 9.1).	t_0, t_2

[a] To initialise the model and after a certain number of attempts, only the lower condition applies, i.e. $S_i(t) - 1 \leq RO_j(t)$.

If a single partner is found, then the newly-formed couple will look for a new dwelling to which to move; if a flatshare is found, then the tenant will be directly integrated in their dwelling; if the tenant has not found a compatible household to join after a fixed number of attempts, then s/he will create a one-person household and search for a vacancy for 1-time step.

9.4 Model calibration and verification

The model's calibration and verification are part of a circular process (Boero & Squazzoni, 2005), which we synthetize in two steps. First, we set the baseline scenario by adjusting one key parameter to produce a desirable output value (Fontaine & Rounsevell, 2009; Friege et al., 2016; Palmer et al., 2015; Schulze et al., 2017). Second, we follow a household agent over its life course to verify whether the model performs as expected.

We account for the stochastic variation of parameter values by evaluating the outputs of 100 simulation runs via averages and confidence intervals (Huang et al., 2014). To estimate the model's long-term behaviour, the time span is set to 30 years (i.e. 360 time-steps; see Hatna & Benenson 2015).

9.4.1 Setting the baseline scenario

A key characteristic of the Swiss housing market is its remarkably low vacancy rate (Thalmann, 2012; Werczberger, 1997). Considering that ReMoTe-S simulates households' in- and out-migration, this rate is greatly influenced by the number of agents who try to enter the model monthly. Therefore, the parameter 'immigration rate' is calibrated by varying its value between 0% and 10% and selecting the best fit of the output to the average Swiss dwelling vacancy rate (2.7% in 2019; Wüest Partner 2020). After filtering out the effects of the model 'warm up' (23 time-steps; Figure 9.7), a final value of 4% of monthly immigration rate is retained as the closest to real-world data.

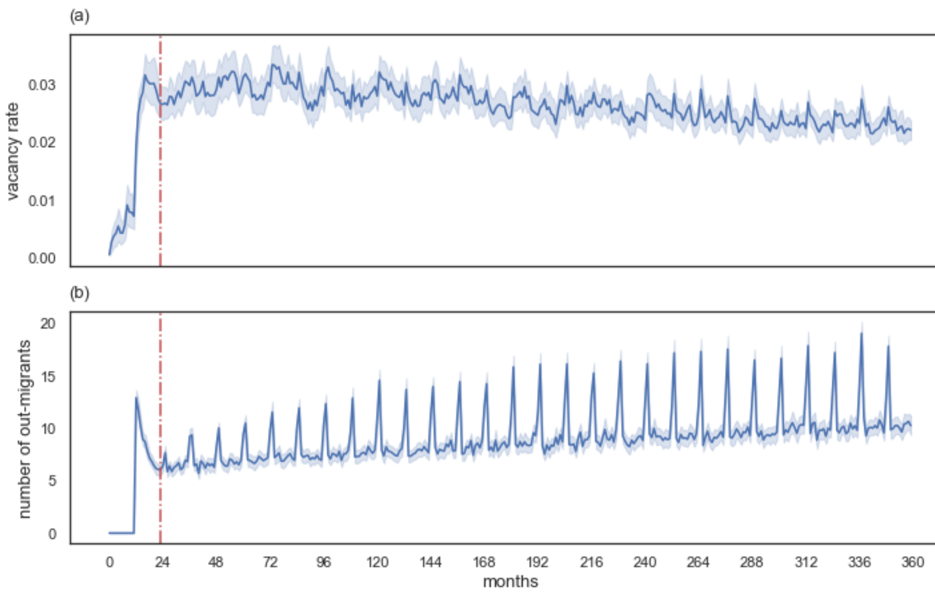

Figure 9.7. Model warm-up. Variations in a) vacancy rate and b) number of out-migrants over time. Average over 100 runs.

9.4.2 Following a household over its life course

Although ABMs enable the investigation of both micro- and macro-level outcomes, the model verification and validation rarely include individual-level observations (Huang et al., 2014). Figure 9.8 schematically synthetises the .csv output of one of 100 model runs, whereby selected metrics are recorded over 30 years of simulation to observe a household's job, family and housing careers and eventually its out-migration.

Following a separation, one of the two household's members remains in the dwelling and engages in the search for a new one (for a maximum of 12 time-steps), whereas the other former partner immediately leaves the shared accommodation to search for potential joinable groups. This event, which corresponds to a radical change, updates the household's preferences, meaning that a new set of desired functions is computed based on its new type (i.e. divorced). After approximately five years, a change in job location triggers the search for a dwelling in a different postcode than the current one (i.e. 3000). Three years later, the agent receives the trigger 'create couple', meaning that its state variables have aligned with the constraints of another tenant in search of a joinable group. Towards the end of the simulation, the household is notified of the upcoming demolition of the building it inhabits. An unsuccessful search pushes it to out-migrate. Over its time in ReMoTe-S, new buildings are generated in the same postcode where the agent resides; because its attempts to obtain a new dwelling have failed (i.e. another agent occupied it first), the household does not relocate.

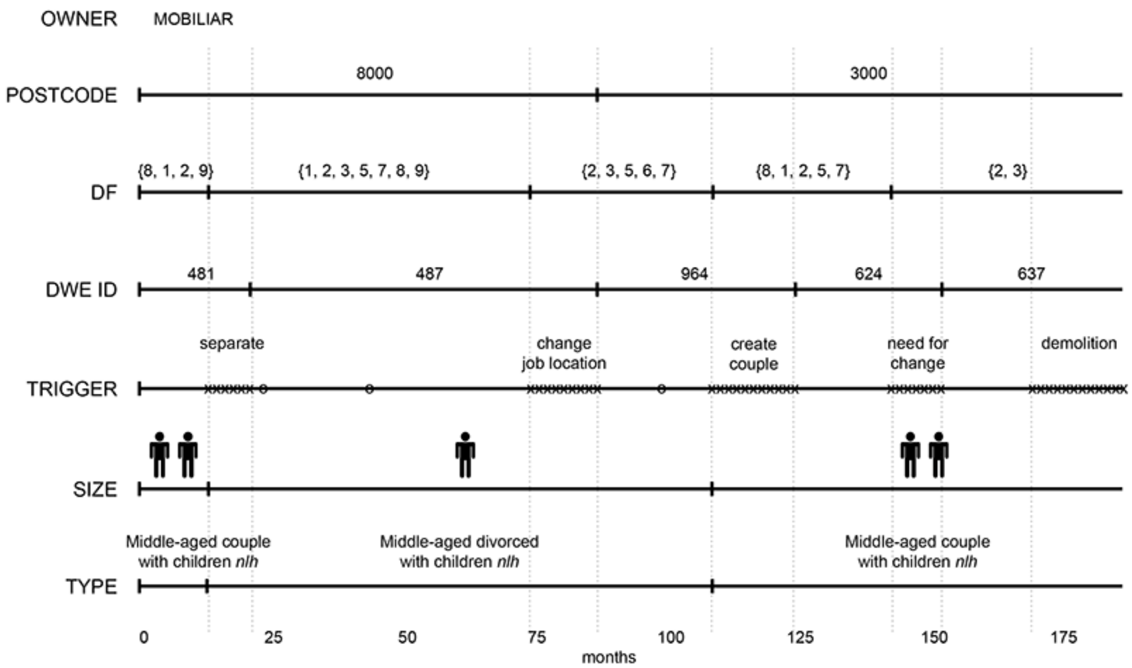

Figure 9.8. Residential mobility patterns of of an arbitrarily-chosen household agent. DF: set of desired functions; size, i.e. number of household's members; *nlh* = not living at home. The 'o' indicates when a new dwelling is added to the housing stock and triggers the household's desire to move without forcing its move. The 'x' indicates the time of the search.

9.5 Simulation experiments and scenario comparison

Following the model's calibration, simulation experiments are run under the assumption that households' behaviours and demographic trends continue as they are today. The purpose of the experiments is to observe the sensitivity of model outputs to changes in dwellings' qualitative and quantitative features. The impacts of these variations are monitored via two key indicators of housing sustainability: (i) average floor space per capita, which is the largest determinant of domestic energy consumption and (ii) average vacancy rate, which provides information on whether dwelling features exhaustively fulfil households' preferences (Table 9.4).

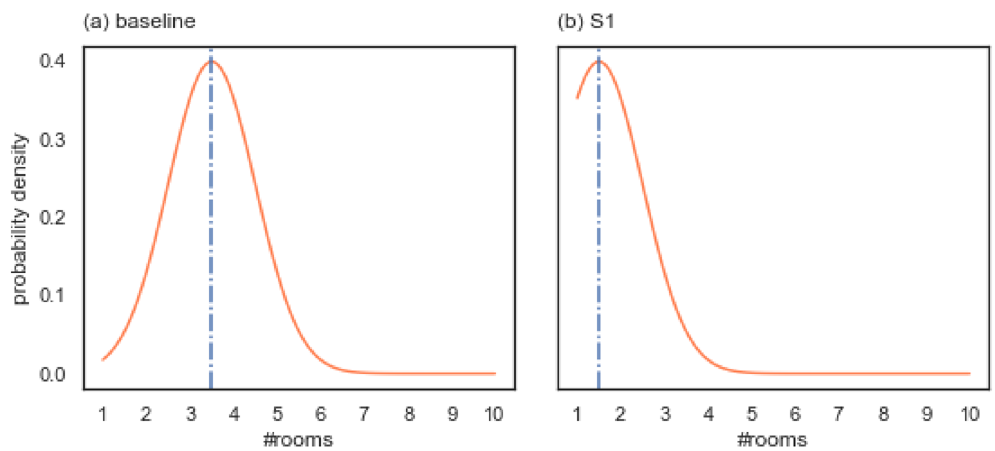

Figure 9.9. Probability density function of the dwellings generated in the model to be characterised by a certain number of rooms in (a) the baseline scenario, privileging medium-size dwellings (M = 3.5 rooms), and (b) the scenario S1, privileging small-size dwellings (M = 1.5 rooms).

The first experiment explores the impact of changes in average dwelling size on how efficiently dwellings are occupied. A one-factor-at-a-time sensitivity analysis (OFAT) is run on the parameter 'rooms mean' (M),[36] which controls the average number of rooms per dwelling (initialised and newly built) in the housing stock. We then specifically focus on two scenarios with a larger number of medium- (baseline; Figure 9.9a) and small-size dwellings (S1; Figure 9.9b).

The second experiment explores and compares the effects of the provision of new housing with 'sustainable' and 'unsustainable' features on the average dwellings' vacancy rate, which is assumed to depend on households' satisfaction and therefore on the number of housing functions per dwelling (Eq. 9.1). For this purpose, we reduce the palette of 'characteristics', 'neighbourhood' and 'places of interest' that can be randomly attributed to dwelling and building agents when newly built (i.e. not at initialisation; minimum one feature per agent class).

Table 9.4. Description of simulation experiments (exp). Rooms: number of rooms per dwelling (initialised and newly built). Features: 'characteristics', 'neighbourhood' and 'places of interest' that can be randomly attributed to newly built dwelling and building agents (minimum one per agent class). PT: public transports.

Exp	Scenario	Rooms	Features	Indicators
		Parameters varied	*Parameters varied*	
1[a]	Baseline	M = 3.5 SD = 1.0 min = 1, max = 10	min = 2, max = 10 Full palette	sqm/tenant #tenants in three rooms #one-person household
	S1	M = 1.5 SD = 1.0 min = 1, max = 10	*baseline*	
2[b]	A3	*baseline*	min = 2, max = 3 With green spaces Close to PT Sociocultural mix	vacancy rate (new dwellings, all dwellings) #dwelling functions level of satisfaction
	B7	*baseline*	min = 2, max = 7 Bright, with balcony, with parking place Close to work, close to city-centre Safe, accessible by car	
	B3	*baseline*	min = 2, max = 3 With parking place Close to work Accessible by car	
	A7	*baseline*	min = 2, max = 7 Bright, with balcony, with green spaces Close to PT, close to city-centre Safe, sociocultural mix	

[a] The number of rooms per dwelling follows a truncated normal distribution
[b] Complementary scenarios: A3 – B7; B3 – A7

[36] OFAT entails selecting 'a base parameter setting […] and varying one parameter at a time while keeping all other parameters fixed' (ten Broeke et al., 2016, p. 3).

Scenarios A3 and B3 can be characterised by a maximum of three ‘sustainable’ and ‘unsustainable’ features, respectively; the complementary scenarios B7 and A7 can generate dwellings with all features except the three ‘sustainable’ and ‘unsustainable’ ones, respectively (Table 9.4). Finally, we check the sensitivity of the scenarios’ results to changes in construction rate (set to 0.69%). The model warm-up is fixed at 47 months, the time span during which the output ‘new dwellings available rate’ shows the largest fluctuation.

9.5.1 Experiment 1: The impact of dwellings’ size on floor area per capita

Figure 9.10a illustrates the sensitivity of the output ‘sqm/tenant’ to changes in the parameter ‘rooms mean’. We observe that the area per capita increases as the average number of rooms per dwelling increases up to 3.5 rooms on average, beyond which it is relatively stable. This result indicates a positive correlation between the number of small dwellings in the housing stock and the efficiency of space usage.

If we compare the provision of medium-size (baseline) with that of small-size dwellings (S1, Figure 9.10b), we observe that the difference in floor area per capita is particularly accentuated in three-room apartments. Considering that this size represents the largest majority of dwellings in our sample (baseline; Figure 9.9a), the overall efficiency of space use appears to predominantly depend on how well three-room apartments are occupied.

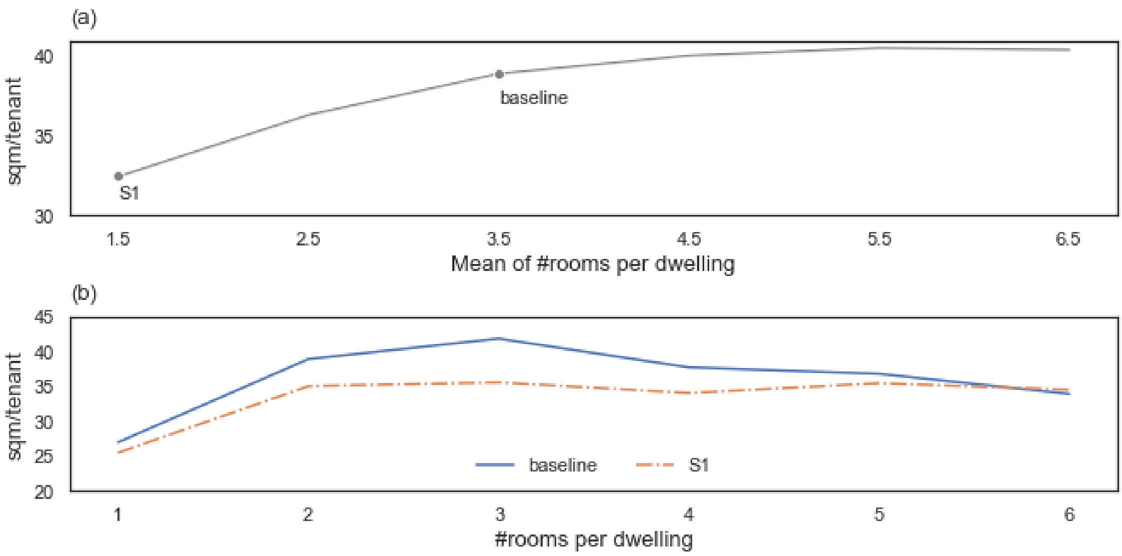

Figure 9.10. (a) Sensitivity of the average floor space per capita to varying average number of rooms per dwelling in the model. Grey dots identify the scenarios ‘baseline’ and ‘S1’. (b) Average floor space per capita per dwellings’ size (i.e. number of rooms) in the model. Results are shown for the two selected scenarios. Average over 100 runs and 337 time-steps.

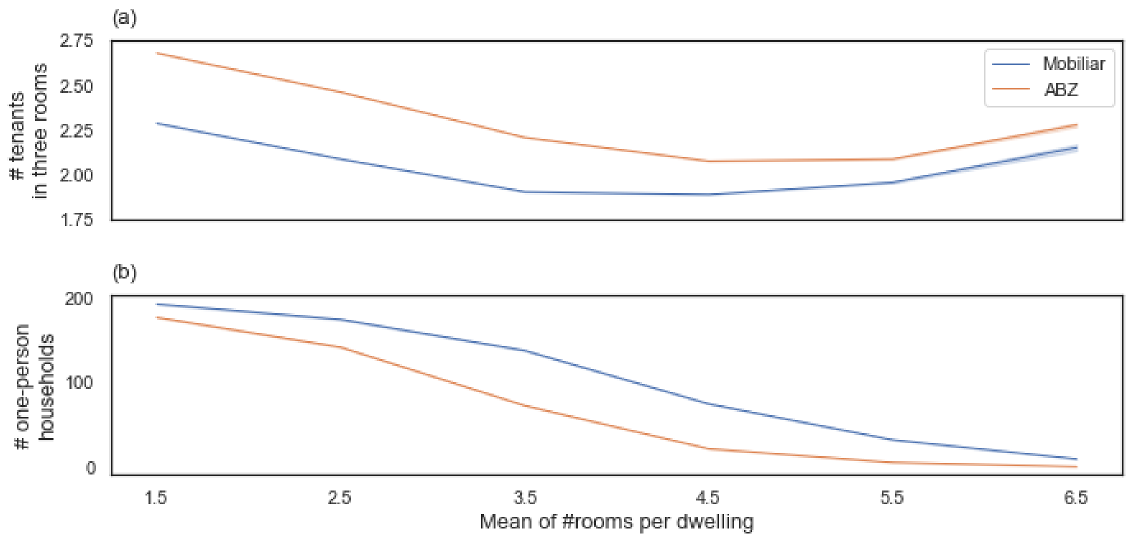

Figure 9.11. Sensitivity of (a) the number of occupants of three-rooms dwellings and (b) the number of one-person households in the model to the average number of rooms per dwelling. Average over 100 runs and 337 time-steps. N.B. As the results for ABZ and SCHL are similar, only the former is displayed.

Figure 9.11a illustrates the occupation of these dwellings for two housing providers: the cooperative ABZ and the asset manager Mobiliar. We observe that when the average size is centred between 3.5–5.5 rooms, the number of tenants occupying a three-room apartment is overall the lowest. It therefore appears that when the offer of smaller dwellings is reduced, tenants tend to under-occupy medium-to-large dwellings.

This hypothesis is enriched by Figure 9.11b, which compares the number of one-person households renting from the two housing owners. In the case of the cooperative, we observe that the number of single households in the model decreases with a decreasing supply of smaller dwellings (i.e. with a greater average number of rooms). In contrast, we observe that for the asset manager, there is little-to-no difference between the number of one-person households in a scenario with smaller (mean = 1.5; S1) and those with average-size dwellings (mean = 3.5; baseline).

Figure 9.12 provides additional information on the indicator ‘sqm/tenant’ for ABZ and Mobiliar, whereby as per occupancy rules, the latter exhibits the most space-consuming tenants (baseline; Table 9.3). Notably, a provision of smaller dwellings has the largest effect on the occupancy of its dwellings (baseline M = 46.6, SD = 1.63; S1 M = 34.1, SD = 1.28), which becomes comparable to the one of the cooperative ABZ (baseline M = 35.5, SD = 1.32; S1 M = 31.8, SD = 1.22). This result can be explained by the occupancy rules set for the households of Mobiliar, which allow a relocating tenant to occupy a three-room dwelling alone (versus two rooms for the cooperatives). This behaviour is also supported by the relative affluence of ReMoTe-S tenants, who can afford larger dwellings on their own.

In summary, results indicate that a reduced supply of small-size dwellings and a greater flexibility in occupancy rules result in an increase of floor area per capita.

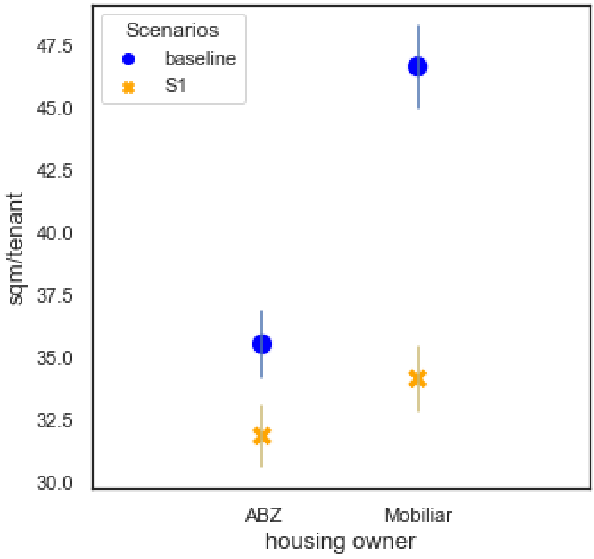

Figure 9.12. Floor space per capita per multifamily housing owner for the two scenarios. Average over 100 runs and 337 time-steps. N.B. As the results for ABZ and SCHL are similar, only the former is displayed.

9.5.2 Experiment 2: The success of 'sustainable' housing features

Figure 9.13 displays the dwellings' average vacancy rate for the five scenarios described in Table 9.4.

When comparing the two subfigures, we observe a positive correlation between the number of functions fulfilled by a dwelling and the household population's level of satisfaction. When comparing the scenarios with three features (A3, B3) and seven features (A7, B7), we also observe thata larger number of possible features entails on average a larger number of dwelling functions.

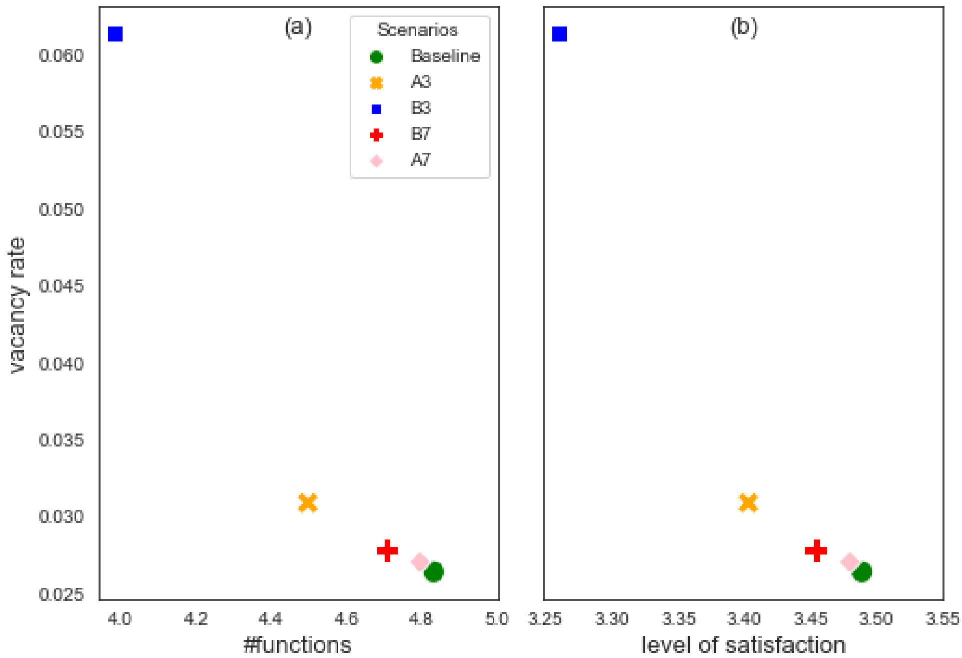

Figure 9.13. Average vacancy rate of dwellings and its relationship with (a) the average number of functions per dwelling and (b) average level of satisfaction of household agents in the model (right) for five different scenarios. Average over 100 runs and 313 time-steps.

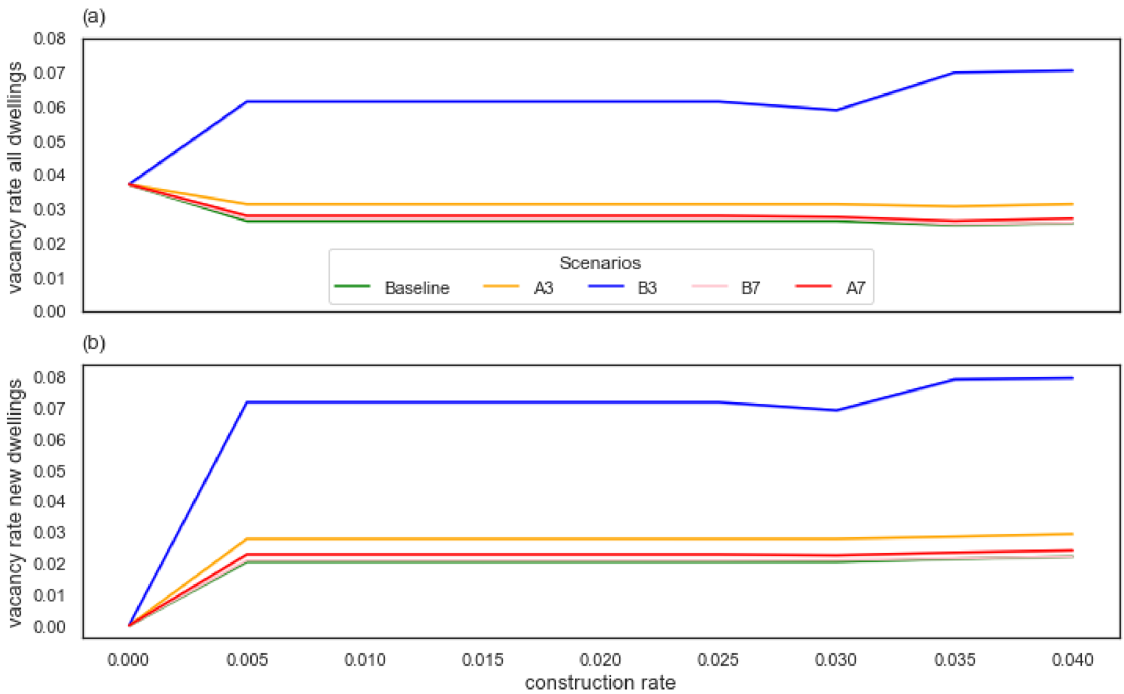

Figure 9.14. Sensitivity of the vacancy rate of (a) all dwellings in the model and (b) the newly-built dwellings to different construction rates for five different scenarios. Average over 100 runs and 337 time-steps.

These results are coherent with model rules, whereby satisfaction depends on the match between the functions of the desired and selected dwellings, the latter of which is computed based on their characteristics, proximity to places of interests and neighbourhood qualities. However, the difference between the two ‘sustainable’ housing scenarios A3 and A7 in all indicators is negligible compared with the difference between the ‘unsustainable’ scenario B3 and all others. If we also consider that the vacancy rate for scenario A3 (with only three features) is very close to that for B7 (with seven features), then the results seem to suggest that scenario A3 includes characteristics that are comparably more relevant for generating functions, and thus satisfaction.

To investigate whether the results are sensitive to the number of new dwellings generated during the simulation, Figure 9.14 shows the results of the OFAT on the construction rate parameter for the five scenarios. Overall, the plots corroborate the aforementioned observations, in that the relative difference in vacancy rates does not vary with an increase of new dwellings. Furthermore, we observe that from a 0.5% construction rate onwards, the vacancy rate of all dwellings (Figure 9.14a) and new dwellings (Figure 9.14b) is relatively small and stable for most scenarios. This result indicates that the larger the number of attractive dwellings, the larger the number of households (in the model and in-migrating) that find a suitable vacancy in the housing stock. Conversely, the scenario B3 exhibits a considerably large vacancy rate, which increases with greater construction rates. This finding confirms that the dwellings provided in B3 mismatch with the desired functions of the majority of the simulated households. It also suggests that, from a construction rate of 3%, the number of newly-constructed dwellings exceeds the (small) share of households with matching preferences and requirements.

9.6 Discussion and conclusion

This paper addressed the need of Swiss property owners to navigate the complexity of the housing system to provide both environmentally and socio-culturally sustainable dwellings. We outlined an approach for modelling the recursive effects between households and dwellings, which are made explicit in residential mobility. We based our agent-based model on explicit assumptions derived from a survey of tenants of three Swiss housing providers and illustrated its utility through two applications. While accounting for context-specific factors that are determinant to the relocation process, the model responds to the need for more empirically-based and context-specific ABMs (Boero & Squazzoni, 2005; Knoeri et al., 2011).

Below, we first put the results of the simulations in perspective and discuss the validity and limitations of the ABM. We then conclude with practical recommendations for the three housing providers, based on which we propose avenues for future research.

9.6.1 Results in perspective

To outline potential uses of the model, we focused on two relevant aspects of housing sustainability: (i) housing size (monitored via sqm/tenant) and (ii) preferences for and success of certain housing features (via vacancy rate, satisfaction). This exploration entailed simultaneously considering households' preferences, satisfaction and triggers to move as well as opportunities and constraints (e.g. dwellings available) and resources and restrictions (e.g. household salary), all of which ReMoTe-S was designed to include.

The goal of Experiment 1 was to explore the effects of variations in dwellings' average size on individual space consumption. It emerged that a supply that prioritises medium-to-large size dwellings in combination with a less strict application of occupancy rules can result in an increase in average floor area per capita. This finding is in agreement with other studies (Ellsworth-Krebs, 2020; Huebner & Shipworth, 2017) and in particular with the statistical analyses of Karlen et al. (2021), which were conducted with the same survey dataset used in this article. Karlen et al. (2021) highlighted the lack of an adequate supply of small dwellings for the increasing number of one- and two-person households as well as the absence of occupancy rules or rigor in enforcing them as obstacles to reducing space consumption. Furthermore, and also in line with our results, a preference for larger dwellings was found to especially concern tenants with sufficient financial resources.

Experiment 2 aimed at achieving a better understanding of the effect of changing dwelling, neighbourhood and location features on dwelling vacancy rates by observing variations in the functions they fulfil and households' residential satisfaction. Our findings are key in the research on residential mobility more generally as well as more specifically on the discrepancy and reciprocal influence between stated and revealed preferences (Clark & Dieleman, 1996; Clark & Lisowski, 2017; Dieleman, 2001; Mulder & Hooimeijer, 1999). In fact, we demonstrated that dwelling and building features only determine whether a dwelling fulfils one or more housing functions to a certain extent and with interesting combinations. As previously argued by the authors (Pagani, Baur, et al., 2021), and in line with other scholars (Lawrence, 1987a; Michelson, 1980), residential satisfaction is not based on the mechanistic correspondence between the set of desired and current characteristics of the settlement (e.g. balcony, public transports). On the contrary, a perfect match between households' desired functions and those fulfilled by the dwelling can result in an imperfect alignment of its qualitative features. Therefore, simulating the mediating effects of housing functions makes it possible to account for the *trade-offs* in the relative value attached to specific dwelling, neighbourhood and location features (Rapoport, 2000).

9.6.2 Model validity

Before discussing its validity, the purpose of a model and its level of complicatedness need to be stated (Edmonds et al., 2019; Sun et al., 2016). Considering the seven categories proposed by Edmonds and colleagues (2019), ReMoTe-S was developed for a descriptive purpose; it represents 'what is important' in the relocation process of a subpopulation of Swiss tenants renting from three housing owners. In line with this objective, the ABM lies on a spectrum between a toy model and a 'complicated' model with a higher degree of structural realism (Schulze et al., 2017; Sun et al., 2016). A minority of ABMs of residential dynamics make the validation process explicit by demonstrating the plausibility of the assumptions underlying the model (i.e. conceptual validation; Knoeri et al., 2011), or its initial conditions (see Fontaine & Rounsevell 2009; Friege et al. 2016; Torrens 2007). On these premises, we discuss model validity as follows.

Concerning conceptual validation, the implementation of ReMoTe-S is the outcome of a structured transdisciplinary research path that entailed the formulation of an interdisciplinary conceptual model, its qualitative exploration in group discussions, and its quantification in a survey with the tenants of three multifamily housing owners. Its operating rules, boundaries and input data can be considered reasonable because they were based on and agreed upon by the decision-makers it simulates (Janssen & Ostrom, 2006).

Concerning the plausibility of the model outputs, the households' average salary, satisfaction, number of desired functions and triggers to move were checked for their correspondence to survey results across all modelling stages (i.e. implementation, initialisation; for more information, see the ODD protocol). In addition, the plausibility of micro-level outputs was verified by collecting and analysing 100 different residential mobility patterns of one targeted agent over its life course. Lastly, the sensitivity analyses presented in this paper enabled us to explore extreme model conditions (e.g. 0% of immigration rate) as well as discuss and interpret the emergent effects of our manipulations.

9.6.3 Limitations

The most relevant limitations of ReMoTe-S concern the assumptions on which the model is built as well as the dataset, methods, and choice of experiments.

The emphasis on tenants' residential mobility and the associated dataset required us to formulate assumptions on the dynamics of the housing stock, i.e. construction, demolition, renovation. Although the difference between cooperative and non-cooperative housing was accounted for, heterogeneity in e.g. cantonal regulations were levelled out by using data at the scale of the confederation. Furthermore, the occupancy rules matching households to dwellings require further investigation, as their real-world application may sometimes be less strict than was simulated in the ABM (Karlen et al., 2021).[37]

The survey dataset also evinces some limitations. In particular, the data used to attribute functions to dwellings shows relatively small differences across features' frequencies for a given dwelling

[37] The average floor area per capita in the model is smaller than in our empirical sample. However, the difference between cooperative and non-cooperative housing is well captured, which is why the model setup can be used to compare them (for more details on this limitation, see Section 7.1 of the ODD protocol).

function (see Table 9.7 in Appendix). However, the choice not to vary this distribution was consciously taken in line with the goal to account for preferences in the closest alignment with the reality depicted by the survey.

Concerning the methods, our choice of an OFAT sensitivity analysis enabled our interdisciplinary research team to have equal control and understanding over the varied parameters and the emergent system responses. However, its simplicity and attractiveness exposes its limitations, which could be overcome by exploring other approaches (see Lee et al., 2015; ten Broeke et al., 2016).

Regarding the choice of experiments, the selection of building and dwelling features to include and exclude in Experiment 2 was based on an artificial dichotomy drawn between 'sustainable' and 'unsustainable' dwellings. It should be acknowledged that depending on contextual and normative factors, the characteristics of the 'unsustainable' scenarios might well be perceived as sustainable (e.g. a parking place can be essential for a family with children attending school in another neighbourhood). Furthermore, Experiment 1 should also be considered as an exploration of artificial conditions in that the dwellings of scenario S1 cannot accommodate households comprising more than five members.

It is also worth mentioning that the relatively high degree of realism of ReMoTe-S and its context dependency inevitably bring about less generality (Knoeri et al., 2011), and the results therefore need to be contextualised and carefully discussed.

9.6.4 Recommendations and future research

Bearing these limitations in mind, we propose recommendations for the three housing providers simulated by ReMoTe-S, based on which we outline future research pathways targeting a sustainable management of the residential building stock.

To reduce per capita floor space, the projected increase in the number of one-person households in Switzerland (FSO, 2019g) should be counteracted by the supply of a greater number of small dwellings and the adoption of occupancy rules by all housing providers. This measure is especially relevant considering that the majority of the Swiss housing stock was composed of three- or four-room apartments in 2019, whereas one-room apartments represented only 6% (FSO, 2019b). In the same vein, additional measures could be explored in future experiments. For instance, to prevent tenants from forming one-person households as a consequence of an unsuccessful search for a joinable flatshare, age limits for the formation of groups could be varied, such as by permitting young students to mix with elderly tenants in intergenerational dwellings. Furthermore, variations in the standard deviation of the number of rooms per dwelling (fixed to 1; Table 9.4) could enable the investigation of the effects of a more diversified housing supply capable of accommodating any household size.

The provision of sustainable housing understood in all its dimensions must also account for the potential discrepancy between the dwellings' objectively-measurable qualities and inhabitants' subjective perception of them. In particular, we encourage housing providers to consider that a design based on a perfect correspondence between stated and revealed preferences for housing features (e.g. preference for parking places = design of more parking places) underestimates the complexity of trade-offs aimed at fulfilling needs at a higher systemic level, which ReMoTe-S can help to address. Applications of this knowledge should be supported by more research on the association between functions and dwelling, neighbourhood and location features in different socio-cultural contexts.

To conclude, we invite scholars to focus on one or more aspects of ReMoTe-S to address new research questions. In addition, the model could be integrated with an ABM simulating the housing market (e.g. rent evolution), to provide a more accurate instrument to identify and promote practical measures for a sustainable management of the residential building stock.

Model documentation

ReMoTe-S is implemented in the open-source software Python 3.9. The code and the ODD protocol linked to this paper are available from CoMSES OpenABM at this link:
https://www.comses.net/codebase-release/45117bff-8627-4ab9-a4e4-bb26e79a662e/

Appendix

This section provides additional information on the dataset used for the model parametrisation.

Table 9.5. Household types (T) and their frequency (%) in the survey. Age = average age of the household's members; Size (S) = number of members (types: adults A; minors M).

T	Description	Age	Size	%
1	young single[a]	18-35	S1 = 1A to 10A	5
2	young couple[b] without children	18-35	S2 = 2A	8.5
3	young couple with children	18-35	S3 = 2A + 1M to 8M	3
4	young alone[c] with children	18-35	S4 = S3 -1A	0.6
5	middle-aged single[a]	36-64	S5 = 1A to 10A	10.3
6	middle-aged couple without children	36-64	S6= 2A	7.7
7	middle-aged alone without children	36-64	S7 = 1A	6.9
8	middle-aged couple with children living at home	36-64	S8 = 2A + 1M to 8M	19
9	middle-aged couple with children not living at home	36-64	S9 = 2A	5.4
10	middle-aged alone with children living at home	36-64	S10 = S8 -1A	5.8
11	middle-aged alone with children not living at home	36-64	S11 = 1A	4.4
12	older couple (with/without children)	65-99	S12 = 2A + 1M to 8M	11.1
13	older alone[c] (with/without children)	65-99	S13 = 1A to 10A or S12-1A	12.1
			TOT	100

[a] Types 1, 5 and 13 can constitute a flatshare; the maximum size of a household is controlled by a parameter set to 10
[b] Couple: in a relationship, married
[c] Alone: single, divorced, widow

Table 9.6. Initialisation of key state variables and data source.

	Parameter	N	State variable		Source
Buildings	*num_ buildings*	30			assumption
			dwellings (#)	random	assumption
			owner_type		survey
			ABZ	33.5%	
			SCHL	39.5%	
			Mobiliar	27%	
			postcode	SCHL = 1000, ABZ = 8000, Mobiliar = random	survey
			age	[0-40]	assumption
			neighbourhood[a]	random	assumption
			places of interest[a]	random	assumption
Dwellings	*num_ dwellings*	1000			survey
			rooms	M = 3.5, SD = 1.0, min = 1, max = 10	survey
			size	f(rooms)	FSO[b]
			rent_price	f(size)	FSO[b]
			characteristics[a]	random	assumption
			function	see Table 9.7	survey
Households	*num_ households*	1000			survey
			TYPE	see Table 9.5	survey
			members		
			#children	M = 1.67, SD = 0.76, min = 1, max = 5	survey
			#adults in flatshare	Type = 1: M = 1.49, SD = 1, min = 1, max = 6 Type = 5: M = 1.17, SD = 0.57, min = 1, max = 4 Type = 13: M = 1.12, SD = 0.48, min = 1, max = 5	survey
			desired functions	see Table 9.8	survey
			satisfaction	3	assumption[b]
Tenants			age	f(TYPE)	FSO[b]
			salary	f(age)	FSO[b]

[a] The qualitative features of building and dwelling agents were chosen based on the ones the most frequently used by tenants to describe their residential environment in the survey.
[b] The equations used to compute these variables are detailed in the ODD protocol.

Table 9.7. Frequencies of the functions F and the features of the dwelling in which households were living at the time of the survey. The frequencies are used for the attribution of F to dwellings in the model.

Dwelling and building features		**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
		%	%	%	%	%	%	%	%	%
dwelling	bright	24	24	27	21	21	24	26	24	25
	with balcony	38	39	34	33	36	38	38	39	39
	with green spaces	26	29	28	29	30	26	30	29	30
	with parking place	16	19	17	20	20	19	17	17	13
places of interest	work	33	33	27	27	32	31	29	32	28
close to…	public transports	49	53	52	37	54	55	52	52	53
	city-centre	31	33	35	38	33	33	35	33	35
neighbourhood	safe	39	31	31	33	31	31	31	32	32
	sociocultural mix	24	23	21	16	22	25	22	25	23
	accessible by car	17	24	24	20	24	26	22	23	18

Table 9.8. Frequencies of the desired functions DF by household type T in the survey. The frequencies are used for the attribution of DF to households at initialisation.

	DF1	**DF2**	**DF3**	**DF4**	**DF5**	**DF6**	**DF7**	**DF8**	**DF9**
	%	%	%	%	%	%	%	%	%
T1	94	94	50	22	28	44	67	83	50
T2	77	97	41	13	41	26	62	97	74
T3	89	100	56	33	67	22	78	100	67
T4	100	100	100	0	100	100	100	100	0
T5	85	100	30	11	56	26	70	85	67
T6	71	96	46	14	54	18	61	82	61
T7	67	100	56	11	78	33	67	100	44
T8	63	100	25	19	53	13	66	97	72
T9	57	100	43	0	43	29	29	57	57
T10	67	100	50	0	58	42	58	67	33
T11	60	100	100	0	80	60	100	80	80
T12	58	100	54	4	67	29	38	79	67
T13	50	94	61	6	56	33	50	83	61

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Shrinking housing's size: Using agent-based modelling to explore measures for a reduction of floor area per capita

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Contributions: A.P. was responsible for designing the structure of the ABM, designing the experiments, running the simulations, producing the figures and writing the manuscript. F.B. coded the ABM in Python. C.R.B. supervised the work. All authors revised the manuscript.

Abstract

To shrink the environmental footprint of housing, reducing dwellings' size is key. There is agreement among scholars on the measures that should be taken to achieve this goal, however their effectiveness and effects have not been sufficiently investigated. In this paper, we explore and compare the outcomes of measures for reducing housing size. We use ReMoTe-S, an empirical agent-based model that simulates the residential mobility of Swiss tenants. Results show that an increase in floor area per capita is predominantly the consequence of a discrepancy between housing demand and supply. On the demand-side, findings indicate that enabling the formation of multigenerational households is the most successful measure, while helping relocating tenants to more easily find groups to join is the least effective. On the supply-side, we observe that increasing the diversity of dwellings' sizes leads to an important reduction in sqm/tenant where rules restrict the minimum number of occupants per dwelling the most. With regard to these rules, findings display a moderate reduction of individual space consumption when preventing households whose children have moved out from under-occupying their dwelling. We conclude that efforts from both the housing demand- and supply-side are needed to achieve a reduction in housing size.

Keywords: Housing size, Switzerland, empirical agent-based modelling, sustainability

10.1 Introduction

House size is the largest determinant of domestic energy consumption. A greater floor space entails a larger need of energy for heating and cooling, ventilation, and lighting, and allows for the operation of more and potentially bigger appliances (Lorek & Spangenberg, 2019). As dwelling size is on the rise, the number of members composing a household is decreasing globally, which results in an increase in floor area per capita (Ellsworth-Krebs, 2020).

In response to this trend, recent studies have identified and agreed upon measures and recommendations to promote 'sufficiency' in housing via financing strategies, public policies, and the engagement with the many different housing stakeholders (planners and architects, housing providers, residents, etc.; Ellsworth-Krebs, 2020; Huebner & Shipworth, 2017; Karlen et al., 2021; Lorek & Spangenberg, 2019). Although first examples of successful implementation of the proposed approaches can be found in the literature (e.g. Lorek & Spangenberg, 2019), their effectiveness and effects over time remain mostly unexplored.

By supplementing traditional scientific methods, dynamic models can play a key role in this context (Filatova et al., 2009); in particular, agent-based models (ABM) have largely been used to test hypotheses and undertake experiments with the goal to explore emergent patterns at the macro level (e.g. average space consumption) due to interactions at the micro level (e.g. between households' preferences, i.e. demand, and the dwellings available to them, i.e. supply; Sun et al., 2016).

This paper investigates which measures are the most successful in reducing floor space per capita and thereby mitigating one of the major drivers of energy consumption in housing. For this purpose, we simulate, explore and compare several scenarios using ReMoTe-S, an agent-based model of the residential mobility of Swiss tenants. Based on empirical research on the tenants of three Swiss multifamily housing owners, the model allows us to account for the reciprocal effects between households' preferences and dwellings.

The remainder of this paper is structured as follows. In the next two subsections, we present previous research findings on obstacles to shrinking housing size in the context of Swiss rental housing (10.1.1), based on which we outline the set of measures investigated in this study (10.1.2). Section 10.2 illustrates the ABM and the construction of the simulated scenarios, the results of which are shown in Section 10.3. We conclude with a discussion of the results, recommendations for the three housing providers and suggestions for future research (Section 10.4).

10.1.1 Previous research in Switzerland

This paper builds upon the results of a survey of tenants renting from two housing cooperatives and one insurance company and asset manager in Switzerland (N = 968), the analysis of which led to the identification of several obstacles for a reduction in housing size (Karlen et al., 2021).

Relevant to mention is, firstly, the preference for larger dwellings, which predominantly concerned the households renting from the private asset manager with sufficient financial resources at their disposal. In fact, contrary to the latter, housing cooperatives control the floor space per capita via occupancy rules, which regulate the number of occupants per bedroom and whose compliance is regularly checked.

Secondly, research has shown that another major obstacle to downsizing is the difficulty of finding suitable dwellings to relocate to. This issue encompasses several interconnected structural and logistical barriers (Huebner & Shipworth, 2017), which include but are not limited to the very low vacancy rate in Switzerland (2.7%; Wüest Partner, 2020), and the inadequate supply of housing of different sizes. In particular, the current housing stock does not efficiently accommodate the growing number of one- and two-person households (Lorek & Spangenberg, 2019)—resulting from, among other reasons, the reduced availability of kin to cohabit with (Bradbury et al., 2014; Ellsworth-Krebs, 2020).

Lastly, a reduction of housing size was found to be hindered by other non-monetary costs associated with moving, among which the fear of disrupting bonds when relocating (especially if the lack of supply pushes households to move to another neighbourhood, or when attachment and memories are associated with the years spent in a home; Huebner & Shipworth, 2017; Karlen et al., 2021). When no occupancy rules are in place, these costs can lead to underoccupancy, e.g. for those households whose children have left the nest.

A first corroboration of these findings was made using ReMoTe-S (Pagani, Ballestrazzi, et al., 2021), an empirical agent-based model of Swiss tenants' residential mobility. Based on the same dataset of Karlen and colleagues (2021), the ABM was used to explore the reciprocal effects between housing supply and demand via simulation experiments targeting relevant aspects of housing sustainability, among which housing size. In particular, one of the experiments aimed to investigate the effects of changes in the size of dwellings supplied in the model on individual space consumption. Two scenarios were simulated, where the average number of rooms per dwelling was set to 3.5 (medium-to-large dwellings) and 1.5 (small dwellings). It emerged that a supply that prioritizes medium-to-large size dwellings in combination with less strict occupancy rules and the relative affluence of the tenant agents can result in (i) a greater average floor area per capita and (ii) a number of one-person households comparable to a scenario offering small dwellings only. These preliminary results revealed the potential of using ReMoTe-S to study strategies to shrink housing's size.

10.1.2 Measures to reduce floor area per capita

In light of the findings illustrated in Section 10.1.1, this paper uses ReMoTe-S to simulate and compare a set of measures to reduce floor area per capita:

1. Regarding the dwellings (i.e. supply): to provide a more diversified offer of housing, able to accommodate different household sizes and potentially allowing tenants to relocate in the same building. This measure can be explored by varying the standard deviation of the number of rooms per dwelling;
2. Regarding the occupants (i.e. demand): to prevent tenants from forming one-person households as a consequence of an unsuccessful search for people to cohabit with. This strategy can be explored by facilitating the formation of larger households via (i) multigenerational housing and (ii) the provision of more information to tenants about available dwellings.
3. Regarding occupancy rules: to prevent the underoccupancy of shrinking households. This measure can be explored by applying stricter occupancy rules, i.e. forcing households to relocate once all the children have left the nest.

10.2 Methods

10.2.1 Agent-based model

ReMoTe-S is an agent-based model of the residential mobility of Swiss tenants. Its goal is to provide a holistic understanding of the reciprocal influence between households and dwellings, and thereby inform a sustainable management of the housing stock it simulates. Based on explicit assumptions of a survey of residents renting from three housing providers, the model lies in a spectrum between a toy and a ‘complicated’ model (Schulze et al., 2017; Sun et al., 2016). A detailed description of the model can be found in Pagani, Ballestrazzi, et al. (2021; under review).[38]

Agents and their dynamics.

The model comprises four classes of agents characterised by several state variables (Figure 10.1). Each tenant belongs to a household, which lives in a dwelling contained in a building. Agent dynamics are simulated using global parameters and according to the passage of time: for instance, while progressing in age, agents are born, die, and in-migrate in the model following rates and rules that depend on the household type; households’ residential satisfaction decreases of 0.1% with every additional time-step spent in the dwelling; a tenant’s (and therefore household’s) salary increases yearly and can be disrupted by a job loss; dwellings and buildings are built, demolished and renovated depending on fixed rates.

Process overview.

The relocation process is simulated on a step-wise monthly basis, where the initialisation of the model (t_0) is followed by the first submodel ‘decide to move’ (t_1) and the second submodel ‘select’ (t_2; Figure 10.2).

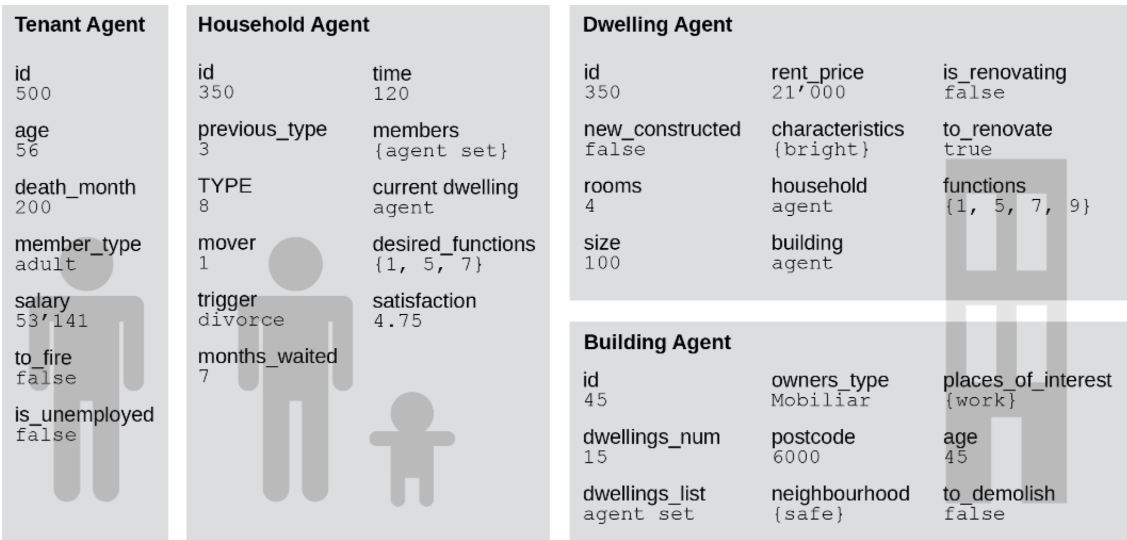

Figure 10.1. Example of a tenant agent, the household it belongs to, the dwelling it inhabits and the building where the latter is located. The household’s attribute ‘desired functions’ represents the preferences of a household for a dwelling, which is attributed a set of ‘functions’. Num: number.

[38] For more details, the ODD and code can be retrieved at the following link:
https://www.comses.net/codebase-release/45117bff-8627-4ab9-a4e4-bb26e79a662e/

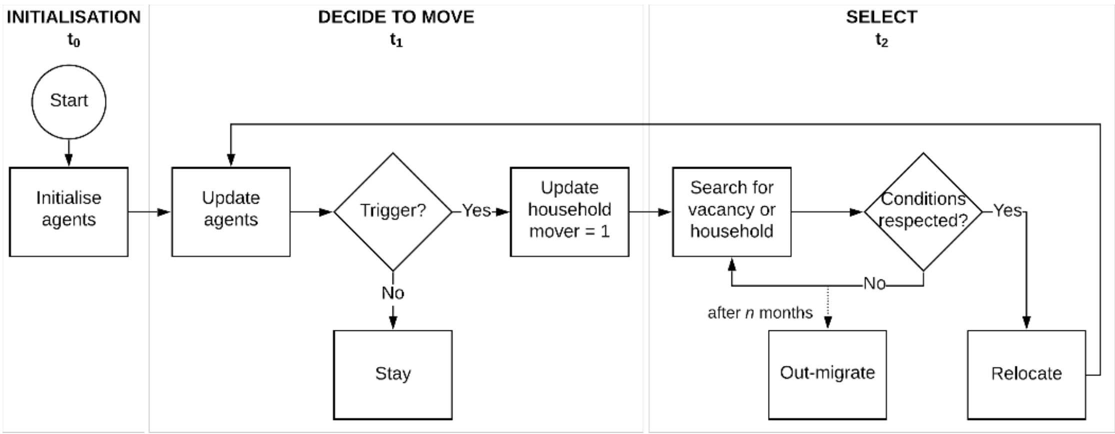

Figure 10.2. Overview of the process, including initialisation (t_2) and two submodels: decide to move (t_1) and select (t_2).

At t_0, the model is populated with heterogeneous dwelling and household agents; the distribution of their attributes is based on the survey dataset, official statistics, or, when necessary, set stochastically (see footnote 38). The simulation starts after all households are matched with the dwellings available (for a total of 1000). The progress of households in their family, work, and/or residential life course career is intertwined with endogenous and exogenous triggers, which generate a desire to move at a random time step following pre-defined frequencies (e.g. children leaving, leaving the flatshare, divorce). Triggered agents are synchronously updated as movers (t_1), and are sequentially activated to search for either vacant dwellings or joinable groups (t_2). As agents are updated asynchronously, the dwellings that have been occupied first are not available for the next searching agent (i.e. 'first comes first served').

In most cases, the household engages in the search for a new dwelling for a duration of max. 12 months, after which it is forced to out-migrate. We assume that at every time step the agent 'visits' and filters a number of randomly-selected vacancies according to a set of 'conditions' (e.g. affordability), puts the filtered dwellings in a list, and ranks them according to the satisfaction they potentially generate, which is calculated based on the match between a household's set of desired functions (i.e. preferences) and the set of functions of the selected dwelling (e.g. 4: status symbol; 8: shelter; Fig. 1). Eventually, the household moves to the first dwelling on the list. For cooperative members and following specific triggers (i.e. a renovation), the owner facilitates the households' move by directly assigning them a vacancy that meets the aforementioned conditions.

The search for a joinable group occurs in case of a divorce, when leaving a flatshare, or when leaving the parental home. When looking into a pre-defined number of randomly-selected households, a moving tenant applies the following selection criteria:

1. Singleness: the household is not in a couple;
2. Compatible age: one of its members (randomly-chosen) is maximum 10 years older/younger than the searching tenant;
3. Occupancy: There must be room for a new tenant (only for flatshares) according to occupancy rules. More specifically, tenants renting from the asset manager can occupy dwellings with a maximum of two rooms more than the number of household members; for cooperatives, this rule is restricted to a maximum of one room.

When a one-person household is found, the newly-formed couple looks for a dwelling to move to using the same criteria described above; when an existing flatshare is found, the searching tenant is directly integrated in their dwelling. If the tenant has not found a compatible household to join, s/he will then create a one-person household and search for a vacancy for 1-time step.

Calibration, verification and validation.

These steps, illustrated in Pagani, Ballestrazzi et al. (2021), consisted in (i) adjusting the number of households that in-migrate in the model (i.e. parameter 'immigration rate') to reproduce the very low vacancy rate that characterizes the Swiss housing rental market, (ii) checking whether the agents behaved as expected by following a household over its life course, and (iii) checking the plausibility of the model's assumptions and outputs across all modelling stages (Boero & Squazzoni, 2005).

10.2.2 Simulations

To explore the measures presented in Section 10.1.2, we simulated four scenarios under the assumption of unchanged agents' behaviours and demographic trends. The scenarios were selected based on the results of a one-factor-at-a-time sensitivity analysis (OFAT) over four parameters of interest (Table 10.1), whose performance was assessed by looking at the metric 'sqm/tenant', i.e. the average floor space per capita. As the two housing cooperatives showed similar results, we selected only one of them for comparison with the asset manager. To account for the stochastic variation of parameter values and to estimate the model's long-term behaviours we used averages of 50 simulations runs over 30 years; the effects of the model 'warm up' were filtered out, corresponding to 23 time-steps.

The scenario 'diversified offer' consisted in providing a similar offer of small to large dwellings. In the model, the size of a dwelling (measured in sqm) is computed based on the number of rooms, whose distribution is controlled by a parameter set according to survey results (min = 1, max = 10, M = 3.5, SD = 1.0). To vary the offer of dwelling sizes, we changed the standard deviation of the number of rooms per dwelling. The scenarios 'multigenerational' and 'larger network' were designed to facilitate tenants' search for joinable households by increasing (i) the compatible difference in age between members of a group and (ii) the number of groups a tenant 'visits' at every time-step during the search. Finally, the scenario 'shrinking household' was designed to trigger the relocation of shrinking households when the last child moves out (i.e. turns 19 y/o). This was done by varying the frequency (i.e. probability) of the trigger 'children leaving'.

Table 10.1 Scenarios simulated. HH: household; P: probability, '-': baseline

Experiment	**Parameter varied**			
	SD #rooms	Compatible age	HH visited	P(relocate)
Baseline	*1.0*	*+/- 10 years*	*50*	*0.127*
Diversified offer	6.0	-	-	-
Multigenerational	-	+/- 30 years	-	-
Larger network	-	-	950	-
Shrinking HH	-	-	-	1.0

10.3 Results

Figure 10.3 shows the results of the OFAT over the four parameters of Table 10.1.

Overall, we observe that all measures lead to a decrease in floor space per capita, except for 'larger network', where an increase in the number of households a searching tenant visits doesn't show any effect on how well occupied the dwellings are.

The measure 'multigenerational' yields the largest effect. Compared to the baseline (M = 38.8, SD = 1.20), when the compatible difference in age for couples and flatshares is increased to 30 y/o (i.e. when a tenant of 50 can join another of 20 or 80 y/o), we observe a reduction of more than 4 sqm/tenant on average (M = 34.5, SD = 1.23).

The second largest effect is for the strategy 'diversified offer'. Increasing the standard deviation of the number of rooms per dwelling exhibits a sharp decline in the average floor area per capita in the sample up to a value of 3 (-2.40 sqm/tenant; M = 36.3, SD = 1.22), and a light decrease up to a value of 6 (M = 36.1, SD = 1.30).

Lastly, increasing the probability of a household to relocate after the last child has moved out (i.e. scenario 'shrinking household') shows a moderate effect on the reduction of individual space consumption. If all households were to relocate after the trigger (P = 1.0), the latter would decrease by about 1.8 sqm/tenant (M = 37.0, SD = 0.90).

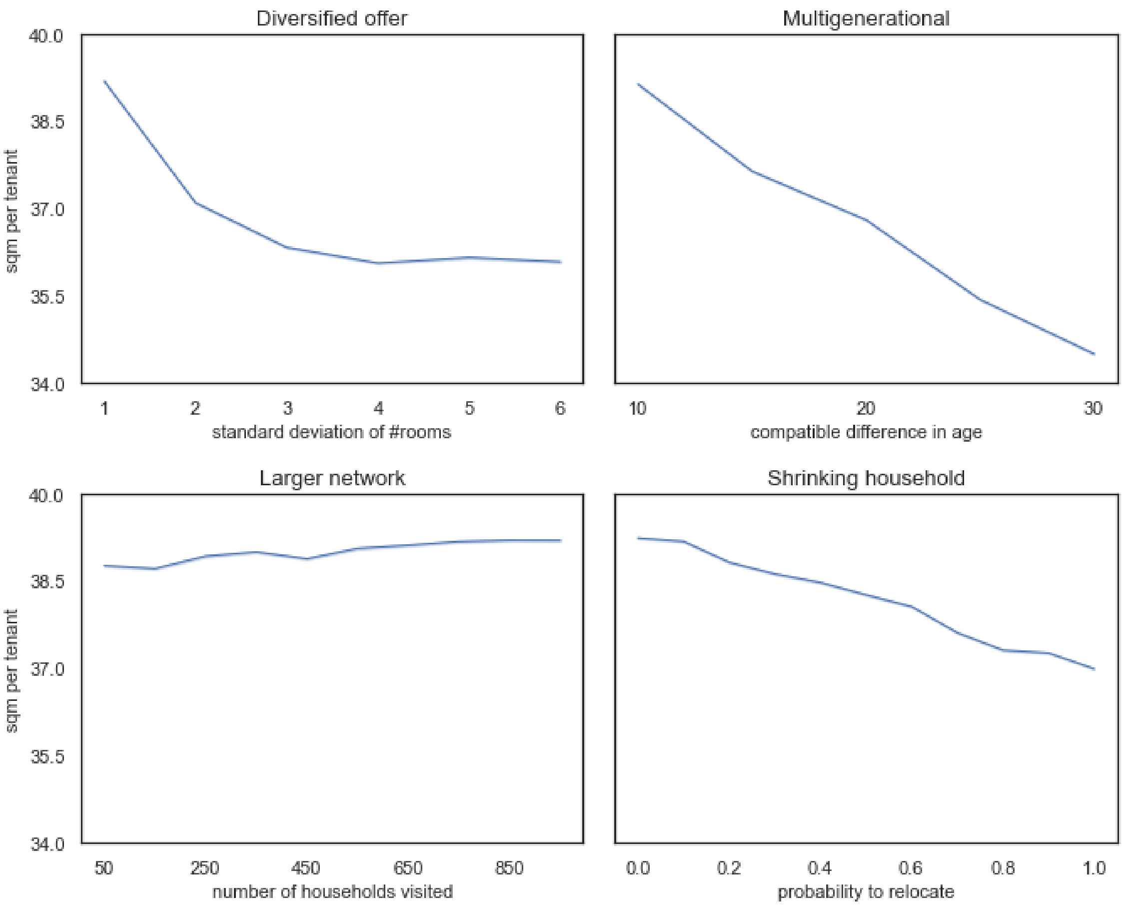

Figure 10.3. Sensitivity analysis of the floor space per capita to the variation of four parameters. Average over 50 runs and 337 time-steps.

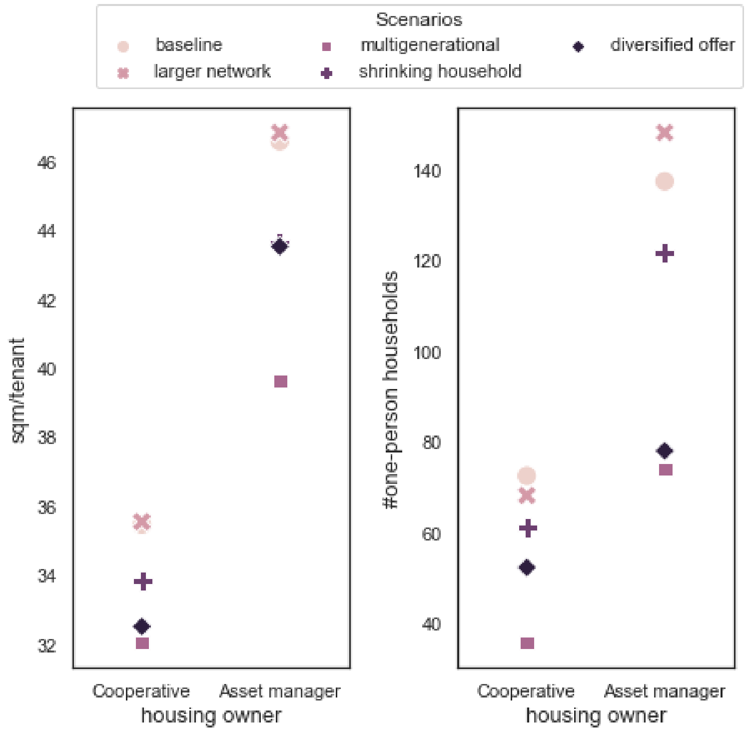

Figure 10.4. Floor space per capita (left) and number of one-person households (right) per housing owner for the baseline and other four scenarios. Average over 50 runs and 337 time-steps.

Figure 10.4 allows us to look closer at extreme parameter values for each scenario and compare them in terms of sqm/tenant and the number of one-person households in the model.

Concerning the cooperative, we observe that enabling the formation of multigenerational groups (i.e. compatible age =+/-30 years) and increasing the diversity of dwelling sizes (i.e. SD = 6; Table 10.1) lead to the strongest decrease in sqm/tenant. In other words, a better adaptation of households' size to the offer of dwellings simulated in the model (i.e. via an increase of larger and consequent reduction of smaller households) yields the same effect as a better adaptation of the offer to the size of households initialized and in-migrating in the model (i.e. via an increase in the SD of the number of rooms per dwelling). This is not the case for the asset manager, for which the two measures show different outcomes.

More specifically, the multigenerational scenario exhibits the strongest decrease in sqm/tenant, which results in a space consumption close to the baseline scenario of the cooperative. This finding is of interest considering that the asset manager does not apply strict occupancy rules, and thereby displays the most space-consuming households. The adjustment of supply to demand, instead, has a smaller effect than that observed for the cooperative owner. On the one hand, a greater diversity in housing size brings about a reduction of one-person households—which were predominantly under-occupying 3-rooms apartments; on the other hand, a larger SD implies a greater number of large dwellings, which, as per occupancy rules, are most often less efficiently occupied than the cooperative ones (see Section 10.2.1).

For both types of housing owners, the scenario 'shrinking household' lies in-between the strongest and lightest effects on floor space per capita and contributes to a better fit between supply and demand, bringing about a decrease, although small, in the average number of one-person households.

Lastly, and as previously observed, a larger network does not show any relevant effect on individual space consumption. On the opposite, by creating more competition between searching tenants, it leads to even greater difficulty in finding compatible people to cohabit with.

10.4 Discussion and conclusion

The goal of this paper was to explore and compare measures that target a reduction of floor space per capita and thereby contribute to the goal of mitigating one of the major drivers of energy consumption in housing, i.e. housing size. For this purpose, we used ReMoTe-S, an empirical agent-based model that simulates the reciprocal influence between households and dwellings in the framework of residential mobility. The advantage of the model lies in its parametrisation, which is based on real-wold data on the tenants of two Swiss housing cooperatives and a private asset manager, and thus accounts for the context specific factors characterizing the three owners. Below, we discuss the findings presented in this paper and their limitations and conclude by outlining recommendations for the three Swiss housing providers as well as future avenues of research.

10.4.1 Results in perspective

The simulations presented in this paper targeted the need to overcome several obstacles to a reduction of housing size, which the baseline scenario accounted for. In particular:

1. The preference for large housing: via occupancy rules allowing the households renting from the asset manager to occupy dwellings with two rooms more than the number of group members;
2. The inadequate offer of dwelling sizes: via a distribution that privileges 3- and 4-rooms dwellings over smaller or larger ones;
3. The large number of one- and two-persons households: via rules that restrict groups' compatibility (i.e. age difference) and the easiness to find them (i.e. number of households visited);
4. The reluctance of households to relocate: via a low probability to move after the household shrinks.

The simulation of measures to overcome these barriers demonstrated that an increase in floor area per capita is predominantly the consequence of a discrepancy between demand and supply. More specifically, a more diverse offer of dwelling sizes can lead to an important reduction in floor area per capita when occupancy rules control the minimum amount of household members in a dwelling. In fact, and conversely, the lack of a housing supply able to accommodate small households is forcing cooperatives to 'adapt' (i.e. ease) their occupancy rules accordingly (see ABZ in Zurich[39]). However, when occupancy rules allow for more freedom (i.e. non-cooperative housing), the effect of a more diversified offer of dwelling sizes on individual space consumption is not as relevant as expected. In fact, if the housing stock were to offer a more equally distributed size of dwellings without enforcing occupancy rules, housing would keep being under-occupied.

From better accommodating smaller households, the interest therefore shifts to increasing their size. For the asset manager, enabling the formation of multigenerational groups results in a

[39] https://www.abz.ch/erleben/belegungsvorschriften/. Accessed 27 Apr. 2021.

reduction of floor space per capita even similar to the application of occupancy rules. The many advantages of co-living, micro-living and shared living—i.e. larger households, sharing spaces—in reducing housing size while meeting households' needs have been largely discussed in the literature (see e.g. Harris & Nowicki, 2020; Williams, 2002) and explored in practice (see e.g. the concept of 'cluster' implemented by the cooperative CODHA[40]). On the other hand, helping tenants to more easily find groups to join with unchanged rules to form groups showed no effect on floor space per capita. This finding reflects the obstacles posed by the very low vacancy rate in Switzerland, which can be overcome only via a more efficient match between the housing stock and its occupants.

Lastly, our findings have shown that the relocation of shrinking households to dwellings of a more appropriate size is relevant for reducing floor area per capita, which is of importance considering that the share of people aged 65 years or more living in under-occupied dwellings in Switzerland was above 60% in 2018 (Eurostat, 2018). This measure aligns with the policy already adopted by certain cooperatives (see footnote 39), which, however, are not always strictly applied (e.g. due to a lack of smaller dwellings to move to, or to prevent the loss of one's established social environment when alternatives in the surroundings are not available; Lorek & Spangenberg, 2019).

10.4.2 Limitations

Before providing recommendations for the housing providers simulated in this paper, relevant limitations have to be acknowledged.

Firstly, the model rests on assumptions derived from a survey of tenants renting from three Swiss housing owners; our findings are context dependent and do not aim for generalisation (Knoeri et al., 2011). Secondly, and for the same reason, the ABM only accounts for the determinants of residential mobility investigated in the survey and thereby excludes, for instance, the rental market dynamics (e.g. rent evolution), which also encompass key obstacles to downsizing. Thirdly, due the setting of the occupancy rules—which are more flexible than what theorized (see footnote 39)—the average floor space per capita in the model (about 39 sqm/tenant) does not accurately depicts the one of the tenants' survey (46 sqm/tenant) but is close to Swiss statistics (41 sqm/tenant; FSO, 2019b). Nevertheless, considering that the simulation experiments were aimed to compare differences between scenarios of space occupancy *within* the model, this discrepancy doesn't affect our interpretation of the results. Fourthly, it is relevant to mention that ReMoTe-S simulates the preferences for housing at the *household* scale; at the scale of a relocating tenant agent, criteria for the selection of a dwelling are reduced to compatibility with age, type, and occupancy rules, the latter of which indirectly accounts for space preferences. Lastly, it should be considered that the simulated measures might affect a wider number of parameters than what discussed in this paper. For instance, varying the age for group compatibility also impacts the creation of couples, which might increase in number and bring about other unexplored effects; also, increasing the standard deviation of the number of rooms per dwelling might generate a greater vacancy rate, considering that the model offers the same number of dwellings but with different sizes and not an increase in the number of smaller and larger dwellings.

[40] https://www.codha.ch/fr/soiree-cluster-12-04-16. Accessed 27 Apr. 2021.

10.4.3 Recommendations and future research

Housing size may continue to pose one of the greatest environmental challenges of the twenty-first century (Bradbury et al., 2014). The increasing size of dwellings, exacerbated by a concomitant decrease in household size, underlines the urgency to envision strategies that improve the match between housing supply and demand, the success of which entails societal benefits beyond reducing energy consumption (Huebner & Shipworth, 2017).

Our results have shown that, above all, occupancy rules are a key tool to reduce floor area per capita, as they allow for the adaptation of the demand to any type of supply. As already advocated in previous work (Karlen et al., 2021; Pagani, Ballestrazzi, et al., 2021), these rules should be extended to dwellings belonging to providers other than the cooperatives.

For occupancy standards to be implemented successfully, however, non-monetary costs of moving should be mitigated, i.e. by assisting downsizing households in finding a new dwelling (e.g. prioritising moves to smaller dwellings, providing alternatives in the same building; Karlen et al., 2021). Furthermore, these rules may be inapplicable when the offer of dwellings is incompatible with the structure of the demand (i.e. lack of small dwellings for smaller households). Therefore, as our findings indicate, dwellings of different sizes should be provided for this purpose. On the other hand, to avoid reinforcing the formation of one-person households, investing in a culture of sharing is crucial.

More specifically, although a reduction in individual space consumption requires efforts from the demand-side, the supply of dwellings can play a key role in supporting them. As shown by cooperative and other communal housing projects, obstacles to shared living can be mitigated by the supply of residential buildings that simultaneously reduce personal space, preserve occupants' privacy, and provide shared rooms and facilities (e.g. music rooms, storage space, guest rooms; see e.g. footnote 39 and 40).

In summary, 'sufficiency' (Princen, 2005) can only be achieved if accompanied by the provision of adequate housing, meaning dwellings that fulfil households' needs and preferences. In this regard, future research should explore combinations of the investigated measures to include efforts from both the demand-and the supply-side (e.g. diversified offer + multigenerational housing). While doing so, it should especially look at other key indicators to evaluate housing's sustainability: households' satisfaction; months waited before relocation; vacancy rate; etc.

PART V

Main contributions and future avenues

This final section of the thesis comprises two chapters.

Chapter 11 summarises the answers provided to the research questions introduced in Part I. Moving from analysis to synthesis, the main contributions of the work conducted are then discussed, focusing in particular on (i) the benefits of using the 'universal' language of systems science for 'context-specific' sustainable design and (ii) the role played by digital tools in building bridges between theory and practice, different epistemologies, as well as divergent perspectives, visions and goals. Finally, the chapter 'zooms out' to acknowledge the limitations common to our investigations.

Based on this overview, Chapter 12 outlines the next steps on the path towards sustainable housing. Firstly, several avenues for future research are delineated; these investigations should run in parallel with and support the application of findings to practice, for which a set of recommendations is proposed. As their implementation requires a profound change of mindset, and based on the belief that the primary role of academia is to disseminate knowledge, the last section is devoted to a critical discussion of teaching in architecture, which must evolve to be able to tackle the timely challenges that this thesis has sought to address.

11

From analysis to synthesis: findings and contributions

11.1 Key findings

This research was conducted in response to the urgent need to provide sustainable housing that is environmentally sustainable as well as supportive of the culture, values and needs of its residents. On the premise that this challenge cannot be captured by a conventional problem-solving approach, we explored, dug into and disentangled the complex multilevel interactions between households' preferences and dwellings, which are made explicit in the relocation process.

The thesis started by exploring the potential of applying a systems perspective to the study of these interactions, focusing in particular on the role played by the system's *functions* in orchestrating them. Accordingly, Part II addressed the following research question:

Research question 1
How does the concept of housing functions contribute to the understanding of the relationship between residential preferences and dwellings?

We conceptualised residential preferences and dwellings as behaviours of the human and material housing subsystems, respectively. Based on systems science terminology, the system's behaviour (i.e. what it does) is determined by the system's function (i.e. what it is for). We therefore developed an operational framework that enabled the identification of nine functions of the housing system and, for given environmental and societal supersystem elements (culture, location), their possible human and material manifestations. The results of two group discussions with the tenants of our project collaboration partners showed that these functions contribute to a better understanding of residential mobility in the Swiss rental housing context. More specifically, the functions were found to offer analytical support in studying the linkages between tenants' determinants to move and select a dwelling, which are the subject of heterogeneous and divergent research. These findings were organised into four hypotheses, namely, (i) the nine housing functions derived from the literature are credible; (ii) there is a relationship between residential satisfaction and the event that triggers moving, which can be organised into three types depending on their trigger power (i.e. an opportunity, a problem to solve, a radical change); (iii) depending on the trigger type, the functions of the housing system and its material elements (i.e. dwellings features) are more or less prone to change; (iv) housing functions influence tenants' propensity to move.

Questions 2 of Part III built on the hypotheses elaborated in this first qualitative exploratory research on the housing system and its functions to address knowledge gaps in the interactions between the determinants of residential mobility, and more specifically in their link with sustainability-related issues.

Research questions 2

a) *What role do housing functions play in orchestrating the factors determining the moves of Swiss tenants?*
b) *What determinants of Swiss households' relocation decisions present opportunities or obstacles for reducing housing size?*
c) *How were residential preferences, i.e. housing functions, affected by the first wave of COVID-19 in Switzerland?*

We formalised the hypotheses of Part II in a multi-step model, which we explored quantitatively by means of a survey of the tenants of our project partners. The results of the statistical analyses confirmed that the notion of housing function can be used to better understand the system of interrelations between the determinants of residential mobility. Firstly, functions were found to offer a shortcut to link residential satisfaction, the objective and subjectively-perceived features of the residential environment, and households' socio-demographic characteristics—associations which are widely debated and questioned in the literature. More specifically, results showed that the gap between ideal housing functions and those fulfilled by the current dwelling is a significant predictor of residential satisfaction, and that these ideal functions vary depending on housing attributes, such as socio-demographic characteristics and tenancy type. Secondly, we observed that housing functions directly and indirectly influence the likelihood of an event triggering a move. For instance, households considering their home as a 'place to belong' (i.e. permanence function) were found to be more likely to move due to relevant changes in their life-course or imposed circumstances (e.g. forced to move) rather than a decrease in comfort. Lastly, statistical analyses indicated that trigger events can be categorized into the previously-identified types, which arbitrate the change in function for the new dwelling differently. In particular, the trigger type 'radical change' was found to bring about the strongest change in functions between tenants' past and current dwellings.

A first application of the multi-step model to the study of tenants' preferences for and choices of housing size demonstrated its usefulness for identifying obstacles and opportunities for reducing individual space consumption. Findings revealed that housing functions influence housing *size* as one of the system's material elements, and therefore help explain the observed preference for larger dwellings; more specifically, the tenants who had relocated to a dwelling that more strongly fulfilled the functions of 'status symbol' or 'privacy' were less likely to have reduced housing size. Also, in line with our qualitative explorations, housing functions were found to influence in various ways the likelihood of a reduction in household size triggering a move. The willingness to move if the household were to shrink was significantly lower for tenants who lived in a dwelling fulfilling the functions of 'status symbol' or 'permanence'. Related to the former, we observed that tenants with higher incomes were less likely to be ready to move to smaller dwellings; regarding the latter, and in addition to monetary costs, non-monetary costs (e.g. sentimental value, attachment) were reported as relevant factors hindering such a move.

In a second application, the model was proven useful to identify the effects of the first wave of COVID-19 on residential preferences in Switzerland. The results of our studies showed that, although Swiss residents were allowed to leave their home at any time and for any reason, the "lockdown light" triggered a change in their ideal housing functions. In fact, the functions residents selected to define an ideal pre- and post-pandemic dwelling were found to differ for 60% of the sample. More specifically, while the desire for a place for ‘production, consumption’ (e.g. eating, laundering, sleeping) decreased, the function ‘self-representation’ gained considerably in importance during the pandemic. This result highlighted the need to empower residents to adapt their residential environment for their health and well-being.

The advantage of the notion of housing function in accounting for the plethora of determinants of residential mobility, as well as the effectiveness of the multi-step model in investigating hitherto unexplored links between preferences and sustainability issues prepared the ground for moving beyond empirical analyses. Research questions 3 reflected the need to provide concrete tools for stakeholders to design, explore and assess measures targeting the supply of sustainable housing while accounting for the complexity inherent in the statistical model.

Research questions 3

a) *How to model the recursive effects between households and dwellings in the context of Swiss rental housing?*
b) *What are the effects of changing quantitative and qualitative dwelling attributes on individual space consumption, residential satisfaction and vacancy rate?*
c) *Which measures are the most successful in reducing floor space per capita?*

To answer these questions, we developed ReMoTe-S, an empirically-based and context-specific ABM of the residential mobility of tenants in Switzerland. To the best of the authors’ knowledge, the model is the first in Switzerland that allows the analysis of the macrolevel outcomes of households’ residential mobility. As described in Part IV, ReMoTe-S was used to conduct several experiments. In particular, simulations of the supply of ‘sustainable’ versus ‘unsustainable’ housing showed that certain combinations of dwelling, building, and neighbourhood qualitative features are more relevant to the generation of functions in the model, and thus bring about a higher satisfaction and lower vacancy rate. This result demonstrated that satisfaction is not the result of a mechanistic correspondence between a set of desired and actual housing features, but the outcome of complex trade-offs made to fulfil needs at a ‘higher systemic level’.

Furthermore, experiments varying the average size of dwellings in the model confirmed our statistical findings, indicating that less strict occupancy rules and higher households’ financial resources can bring about an increase in individual space consumption when housing supply privileges medium-to-large size dwellings. Additional explorations showed that the application of occupancy rules together with a wider offer of dwellings’ sizes and the diffusion of a culture of sharing (i.e. multigenerational housing) are effective measures to achieve the goal to reduce space consumption, and therefore housing’s environmental footprint.

In conclusion, this research has shown that a systems perspective is crucial to clarify the determinants of residential mobility and their interrelations. By identifying the systems’ functions and analysing the role they play in tenants’ residential mobility, our findings demonstrated possible ways to overcome disciplinary fragmentation and consequent gaps in the study of residential preferences, satisfaction and mobility. Moreover, the application of the resulting systems knowledge to context-specific simulations of residential dynamics was fundamental to illuminate the effects of measures aimed at reducing housing’s environmental footprint while meeting the needs of its households. Figure 11.1 provides an overview of these key findings.

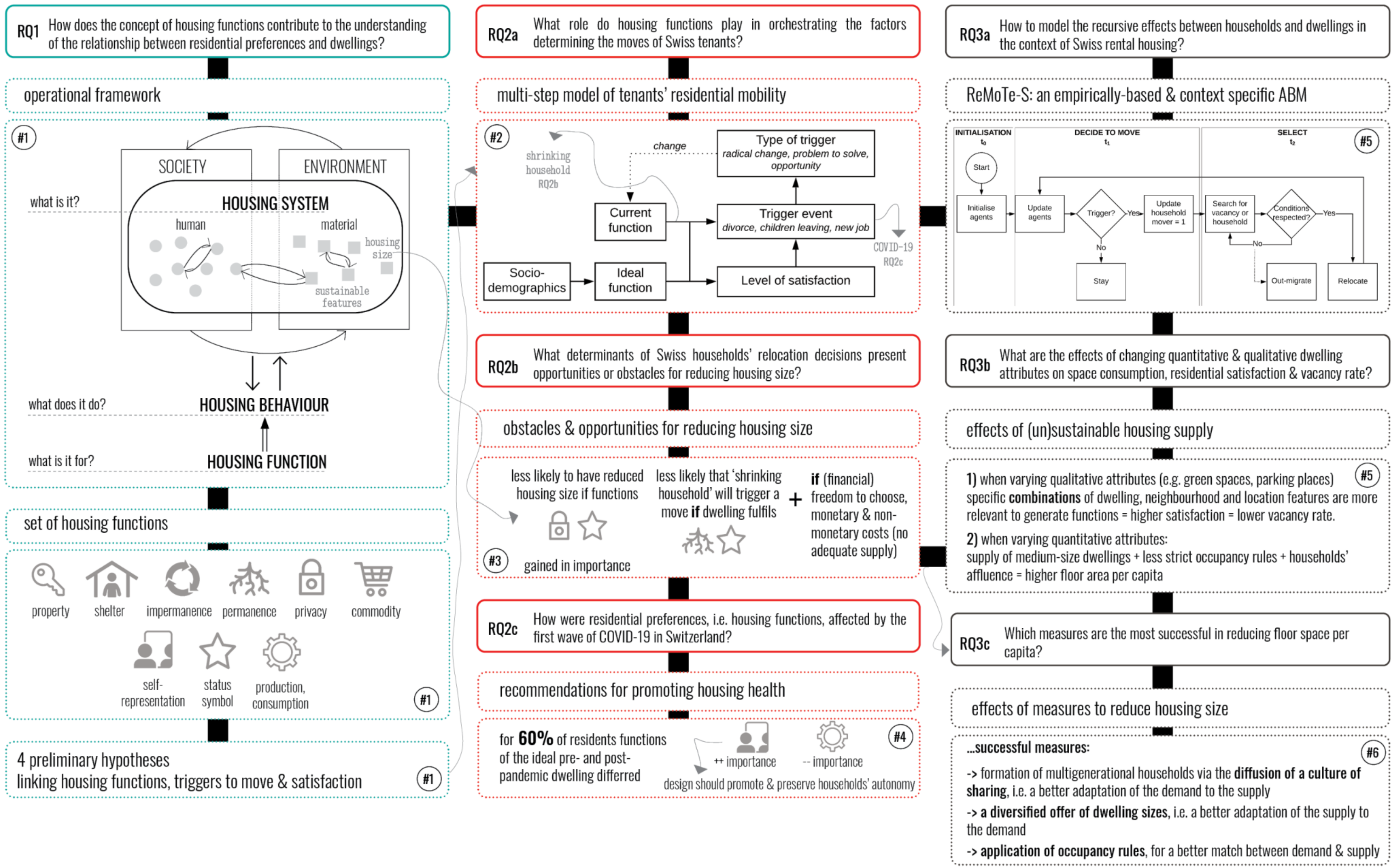

Figure 11.1. Research questions, outputs and key findings of the thesis. Circles indicate the manuscript number (#).

11.2 Main contributions

The investigations conducted in this thesis aimed to contribute to both research and practice in fields that collectively strive and must strive to support the transition to sustainable housing. As we have argued that currently adopted approaches overlook the complexity of the housing system and/or lack the tools to navigate it, we articulate the discussion of the main contributions in two parts. The first reflects on the use of a 'universal' systemic language for rearticulating knowledge about housing into a new semantic field suitable for 'context-specific' research and design. The second focuses on the way digital tools, i.e. computer models, contribute to the fruition of this language by building bridges between and among different scientists and practitioners and their knowledges.

11.2.1 The universal language of systems science for context-specific sustainable design

"Most of the major disasters in complex sociotechnical systems have been severely impacted and sometimes caused by a lack of good human-factors and human-centered design" (Norman & Stappers, 2015, p. 86). In fact, disagreement persists between housing providers and users as well as among each of the two stakeholders on what constitutes residential *quality* (Franklin, 2001; Jansen, 2014a; Lawrence, 2009; Marans, 1976)**.** This disagreement extends to scholarly production, where researchers have approached the study of residents' needs and preferences using their own lenses and vocabulary, thereby revealing greater complexity rather than helping practitioners navigate it.

The research conducted in this thesis offered a new take on the study of the dynamic relationships between humans and their residential environments using the universal language of systems science. In particular, introducing the notion of housing function made it possible to conduct analyses at higher system's levels, i.e. to emancipate our investigations from considering micro-level elements, e.g. dwelling, neighbourhood, location features, and thereby overcome the analytical challenges encountered so far when using them as dependent or independent variables in the study of housing choice (see e.g. Box 2). The housing function is a *synthetic* and *holistic* notion, i.e. it organises elements to form "a unique whole that recognises the different and unique characteristics of each component" and their mutual interdependence (Lawrence, 2021f, p. 192); it is *integrative*, i.e. it allows researchers to build bridges between apparently-divergent disciplinary findings; finally, it is *inclusive*, i.e. its use accounts for all stakeholders, their manifold interpretations of home, and their different perspectives on what the latter ought to be. **The first main contribution of this thesis was therefore to articulate knowledge in a new *reseau sémantique*, orchestrated by the notion of housing function.**

The way of understanding this concept distances itself from ordinary language. In fact, the term 'function' is not new to architecture; on the contrary, it was widely used by the Modern Movement, which considered it as the prime determinant of form—i.e. 'form follows function'. This maxim, however, is still strongly criticised for having contributed to a design that emptied space "out of meaning" (Franklin, 2006, p. 28). As pointed by De Carlo (1980):

> The equation form-function could have been much more fruitful if the second factor had not been limited to a bare representation of conventional behaviours, but instead, had been expanded to include the entire range of social behaviours, with all their contradictions and conflicts. But this sort of comprehension would had required the direct

> participation of the protagonists, whereas, according to the method pursued, the protagonists were inevitably unheeded and even strictly excluded. (p. 85)

In this thesis, we assigned a new connotation to the notion of function, the purpose of which is actually to account for the needs and preferences of the 'housing protagonists'. Contrary to the aforementioned void of meaning generated by Modern Movement architecture through function-centred design, the nine sub-functions identified in our study contribute to and depend on the primary function of the built environment, understood as meaning itself. The way in which the meaning assigned to housing manifests itself depends on the interactions between and among the levels that structure the housing system (from the macro-level, e.g. society, to the micro-level, e.g. household life course). Therefore, although this thesis argued in favour of using a universal language for a holistic design of residential environments, far be it from proposing projects that can be constructed anywhere in the world. On the contrary, it aimed at providing tools to reconcile the design of 'environmentally sustainable' housing with "the context that it want[s] to act" (De Carlo, 1980, p. 74). Therefore, **a second key contribution of this thesis was to provide a universal operational framework for context-specific research and design**, the applicability of which must be supported by context-based empirical evidence.

11.2.2 Building bridges with the support of digital tools

Moving from the operational framework to its context-specific application and use required a concatenation of different methods. Qualitative data were collected to examine the possible benefits of using the framework to study the residential mobility of Swiss tenants (Chapter 5); this exploratory research was followed by a quantitative one with preponderantly analytical purposes (Chapter 6). Although both investigations contributed to theory and practice in different ways, an additional step was needed to ensure that the knowledge gained transcended academic boundaries. Built on and enabling a better understanding of the housing system, the ABM served this purpose; more specifically, as shown in Chapter 9 and Chapter 10, the model allows for the exploration and assessment of the effectiveness and effects of measures to shrink housing's footprint, and can therefore support a sustainable design and management of the housing stock. **A third contribution of this thesis was therefore to offer a bridge between theory and the policy and practice arenas via a numerical model that enabled tapping into a systemic understanding of the effects of measures aimed at steering the housing system toward sustainability.**

Other studies have shown the advantages of using computer models to make explicit, understand, and explore the dynamics of complex systems, while at the same time bringing together different disciplines and types of knowledge. In particular, recent research on building retrofit, energy, and well-being has emphasised the need to integrate the positivist dimension of quantitative simulation models with a better understanding of the actors' processes and motivations that lead to system's behaviours—i.e. the interpretivist dimension (Eker et al., 2018; Macmillan et al., 2016; Schweber & Leiringer, 2012; Stopps et al., 2021). Grounded in rich empirical data, our agent-based model combines these two dimensions by simulating individual household agents over their life course (including their changing characteristics, preferences and needs) and allowing for the exploration of emergent effects of their residential decisions. **Modelling of autonomous and heterogeneous agents provided a meeting point between the constructivist epistemological position adopted in the research and the positivist premises on which simulation methods are based, which is the fourth contribution of this thesis.**

From linking different types of knowledge to reconciling contradictory epistemologies, the last bridge is the one reconnecting housing actors. Empirical research allowed tenants from cooperatives and non-cooperatives to engage in dialogue with each other (i.e. during group discussions), while giving housing owners the chance to get to know their tenants in a way that goes beyond preconceptions (e.g. that housing choice is only based on costs). The ABM made it possible to further increase this mutual understanding by acting as a boundary object or a mediator between different needs and goals and the complex economic, political, institutional and environmental requirements in which they are embedded. As described in Box 5, the ABM was used in a transdisciplinary workshop with policy-makers, architects, scientists, and housing owners as a base to co-construct and discuss the effects of possible strategies to reduce housing's environmental footprint while accounting for different stakeholders' priorities and needs. **In summary, this thesis offered a platform for 'systemic co-inquiry', built on and enabling the dialogue between multiple actors and their sometimes-divergent perspectives, visions and goals.**

Box 5. Beyond the thesis: which measures to shrink housing's environmental footprint?

As introduced in Chapter 4.1, SHEF project aimed to integrate the results of three doctoral researches into a single model allowing for the simulation of measures accounting for the environmental, social and economic dimensions of housing. To explore the usefulness of the integrated model and perform a 'reality check', the research team organised a two-day transdisciplinary workshop in October 2020 involving scientists, housing owners, practitioners and Swiss policy-makers. By applying a design thinking approach, we co-developed strategies that accounted for the priorities and interests of four stakeholder groups, namely tenants, owners, and representatives of the 'present' and 'future' generation. The strategies were simulated in the ABM and assessed according to each stakeholder's normative perspective using a Participatory Multi Criteria Approach (PMCA). Once the best performing strategy was identified, we reflected on potential levers to implement it, which are summarised in Appendix D.

In the workshop, the ABM demonstrated its value as a platform for systemic co-inquiry. Firstly, it rendered participants attentive to the divergent stakeholders' desires and needs as well as the different effects that the prioritising of each can have in determining the most performant strategy. Secondly, it led to an increased awareness of the limits of academic and non-academic knowledges; on the one hand, practitioners discussed and shared with the researchers the shortcomings of the integrated version of the ABM. On the other hand, in analysing the results of the workshop, the researchers observed that tenants are still widely perceived as 'passive' actors (i.e., consumers; e.g., 'to be sensitised', 'to benefit from non-profit housing').

11.3 Limitations: prendre du recul

The mixed method strategy of inquiry adopted in this thesis offered the opportunity to overcome the limitations inherent in each method sequentially (Figure 4.2). Chapter 5 proposed tackling the constraints of the small sample size of the qualitative exploratory group discussions (i.e. Step 2) by conducting a survey. In response, Chapter 6 presented the analysis of the tenants' survey data (Step 3), pointing to the need to integrate context dynamics for a better understanding of the relocation process. Finally, Chapter 9 showed how agent-based modelling (Step 4) can allow for the integration of opportunities and constraints generated by the housing market. Although this *fil rouge* made up for the shortcomings specific to each method, several limitations relating to the overall research framework remain unaddressed.

A first limitation is inherent in the assumptions on which the research was based. According to Bertalanffy (1972, p. 416), system-theoretical arguments are valuable as long as general structures are concerned; specific explanations, instead, require an introduction of the conditions that characterise the system. Our application of systems science notions to the housing context and in particular to Swiss tenants' residential dynamics required making assumptions on these conditions, which resulted in models that are, like any other, *constructs* (Scholz, 2011, p. 348). Hence, we acknowledge that other aspects of residential mobility might have been relevant but excluded from our conceptual model, and therefore, due to the methods concatenation, from the group discussions, the survey questionnaire, and the agent-based model design and/or experiments. On the other hand, as argued above, the combination of literature review with qualitative and quantitative methods allowed us to triangulate our results and critically revise our assumptions when needed. [41]

A second limitation concerns the choice of systems boundaries. Lacunae in our research can also be attributed to the way systems boundaries were drawn or narrowed down when applying the housing system's framework to the study of Swiss tenants' residential mobility. For instance, the focus on households' preferences and their interaction with housing form side-lined research on the influence of supersystem structures on the relocation process (i.e. the Swiss socio-economic-political system; see Chapter 8). Possible ways to broaden system boundaries, e.g. by integrating the dynamics of the housing market in the ABM, were pointed out across our scientific papers.

A third constraint has to do with generalisability and context-specificity. As reiterated throughout the manuscripts, the outputs of this research are clearly dependent on the context analysed, understood both as the housing field and as the sample of tenants of the project collaboration partners. More specifically, although the vocabulary of systems science can potentially be used to study any system, its application to the housing context was inevitably subject to the researcher's bias and assumptions, e.g. through the choice of literature reviewed (see Chapter 4.3 and Chapter 5). Furthermore, the restriction of our study to a particular context limited the transferability of the research findings to, for instance, other types of Swiss rental housing or homeowners; also, it overlooked critical housing situations that were not captured by our sample, such as overcrowding or housing exclusion. Lastly, the ambition of using the function

[41] An example of trade-offs between our theoretical assumptions, the questions included in the survey, and the requirements of practitioners is the relationship between housing functions and features. Due to the several multiscale factors that influence the way functions can manifests themselves, our exploration of the linkages between the functions and characteristics of a dwelling in the tenants' survey did not lead to significant results. Nevertheless, to be more talkative to decision-makers, the ABM incorporated housing features as one of the attributes of the dwelling-agent, by relying on frequencies rather than, e.g., regression coefficients (see Chapter 9).

of the housing system as a ‘general’ concept facilitating the dialogue between and inclusion of different housing stakeholders also bore significant limitations. According to Lawrence (2021a, p. 185), “reducing the concepts of different knowledge cultures to a lingua franca forfeits the specificity of different concepts and meanings in each knowledge culture, and it does not guarantee mutual understanding and agreement.” In fact, since the way housing functions manifest themselves in the imaginary of different households or owners can greatly differ, the analytical advantages of their use are currently greater than those of practical applicability.

A fourth limitation is related to the transdisciplinary approach adopted. What constitutes a good transdisciplinary process is a source of debate; however, we believe that more could have been achieved if all housing stakeholders, including tenants, had been involved in the research process in a way that goes beyond participation in the empirical studies and/or material and organisational support. Overcoming this drawback would have required a redefinition of the role and responsibilities of non-academic actors to actively contribute to knowledge production, e.g., by participating in the design of the survey questionnaire, checking the plausibility of ABM outputs during its implementation. This type of involvement would have allowed stakeholders to develop trust in our results and thereby potentially increase their real-world impact. These limitations however did not stem from a lack of willingness to perform transdisciplinary research, but rather from constraints inherent to the complex factors and processes that shape TD research and its outcomes, including for instance the potential lack of personal interest of actors such as tenants to engage in the research process, the way research agendas and rules are set, the power relations between funders, researchers, practitioners, as well as the boundaries drawn to ensure research integrity (for an extensive analysis, see Fritz, 2020).

12
Future avenues

12.1 Research

To lay new stones in the path *towards sustainability through housing functions,* this chapter proposes an overview of the next steps we recommend scholars to take in collaboration with non-academic partners. As this path requires a global effort, the systems approach adopted in this thesis should be applied to other housing contexts (geographical, cultural). However, to enhance our understanding of the housing system and potentially contribute to steering its behaviour in the desired direction, we believe that additional parallel research avenues should be followed.

Firstly, to increase our knowledge about the manifestations of housing functions in dwelling forms, **future research should focus on collecting possible material behaviours for each of the nine housing functions**. Different system boundaries could be drawn for this purpose; for instance, research could focus on various geographical locations (i.e. environmental supersystem boundaries), a specific population of residents (i.e. human subsystem boundaries; e.g. subsidised households), or the influence of friends, neighbours or colleagues on the expression of a function (i.e. social supersystem boundaries; e.g. what a status symbol is). In practice, to identify otherwise difficult-to-unravel patterns resulting from the combinations of dwelling, location, and neighbourhood features, explorations of the function-behaviour linkages could be conducted using machine learning and neural networks, where training, validation and test data (image and text) would be collected from the web using keywords (e.g. 'a shelter') and/or from a survey (e.g. collecting, for a given function, a picture of a dwelling and a description of some aspects of it). Since behaviours are contextually determined, these analyses should carefully consider supersystem and subsystem elements as intervening variables in the functions' material manifestations.

Secondly, and conversely, further studies should focus on which functions are fulfilled by a given material behaviour, thereby assisting practitioners in a design and management of the housing stock compatible with households' needs and preferences. [42] When doing so, scholars should first critically question the extent to which a material form (i.e. modern, economically convenient, single-family housing; Chapter 5) is a sufficient element to enable the fulfilment of a function. In any case, the gained knowledge would be beneficial to the exploration of the

[42] A reminder is that a material form, as presented in Chapter 5, is more than just the *shape* of a dwelling but is structured by several elements including the price, the location, etc. Therefore, the same housing 'typology' could fulfil different functions depending on e.g. its closeness to public transports.

functions' incommensurability and compatibility; i.e. certain material behaviours might enable the fulfilment of more than one function, but also hinder the realisation of others.[43]

Overall, a better understanding of the material manifestations of housing functions would be key to identifying obstacles and opportunities for sustainable housing provision; for instance, our results indicated that functions such as status symbol, permanence, and security can hinder households' relocation to smaller dwellings and thus the mitigation of the largest contributor to domestic energy consumption (Chapter 7). Similarly, other sustainability-related aspects of housing could be explored in relation to functions—e.g. choice of construction materials; regulation of indoor temperature; preference for urban, periurban or suburban location—, thereby unravelling possibilities for and social acceptance of sustainable housing forms.

Based on these results, the ABM could be expanded to generate functions based on housing features for different groups of households. These relationships, however, cannot be considered as static. More specifically, our analyses have shown that the functions tenants ascribe to their ideal dwelling change over their life course and as a result of triggers. In addition, the environment should be considered as responsive to the changes in its micro structural elements, i.e. in the characteristics or desires of tenant- and household-agents. **A third line of research is therefore essential to study the *adaptive* dimension of the housing system.** For instance, in the ABM, dwellings could gain or lose their functions because of changes in the way in which they express themselves for a given group of tenants (as a result of, e.g., the influence of their peers). Also, building design could respond to (changing) occupants' needs by providing complementary functions to those of dwellings (via e.g. shared music rooms, ateliers, working spaces).

Accounting for these multiscale interactions entails a fundamental shift from viewing tenants as passive *consumers*—of spaces and services provided by the landlord, borrowing a commodity "which is not theirs to change" (Palmer, Instone, et al., 2015, p. 934)—to active *agents*, shaping their residential environment over time and in response to various challenges (e.g. the confinement due to the spread of COVID-19; Chapter 8). Future research should consequently involve a wider community of TD partners through channels that, within the framework of this thesis, have not been explored. Therefore, **a fourth avenue of research has to do with new ways of engaging stakeholders in the process.** As shown in Box 5, the ABM offers great potential for integrating different actors into the systems inquiry; their collaboration could be enhanced through an iterative research process ("field work-> modelling -> simulation -> field work"), in which tenants, landlords, policy makers, architects, or engineers would be in a position to contribute directly to knowledge production, thus enabling the identification of gaps and possible extensions of ReMoTe-S (Barreteau & et. al, 2003).[44]

These four research pathways will be key to increasing the value of this thesis findings for practice. However, we believe that there is no need to wait for further research to take action. Therefore, the next subchapter outlines measures that practitioners can engage in now.

[43] According to Pattaroni (2007, p. 24), "la poursuite d'un bien spécifique est toujours susceptible de rendre indisponible la réalisation d'autres formes de bien" (i.e. the pursuit of a specific 'good' is bound to preclude the realisation of other forms of 'good').

[44] While this process would potentially increase the understanding of the model and the development of trust in its results, it would be appropriate for future research to evaluate the utility and (dis)advantages of improving the model's direct accessibility (e.g. via a user-friendly interface).

12.2 Practice

According to Franklin (2001):

> [...] there is a real concern that unless attempts are made to engage with the more interpretative discourses, the policy agenda on housing design issues will be limited to the mechanistic and deterministic formulations which have led in the past to so many failures in housing. (p. 89)

Providing residential environments congruent with the diverse, dynamic and hard-to-foresee needs of its users while meeting several other requirements (e.g. limited environmental impact, architectural heritage protection) is not straightforward (Lawrence, 2021f; Studer & Vliet, 1987; Swiss Confederation, 2018). Therefore, this subchapter provides housing practitioners with three key recommendations.

First and foremost, move away from the problem-solving approach; use housing functions as a support to understand, navigate and redesign the system.

The CBS news journalist Eric Sevareid remarked that "the chief cause of problems is solutions" (Mobus & Kalton, 2015, p. 14). Measures designed to reduce the footprint of housing but lacking an understanding of the conditions necessary for their implementation can lead to unintended consequences that are detrimental to the success of sustainable residential buildings. A key example is given by our study on housing size, where a relocation to smaller dwellings was found to be perceived as undesirable for 75% of the tenants for reasons ranging from preferences for certain housing functions to non-monetary and monetary costs of moving (e.g. lack of adequate housing alternatives, attachment to the dwelling, rent gap; Chapter 7). These findings suggested that although the application of occupancy rules is essential to better match household and dwelling sizes, these rules may be unenforceable if not accompanied by measures aimed at mitigating the costs of moving and by housing designs able to accommodate individual needs and desires in less private space (Figure 12.1). Regarding the latter, the idea that the fulfilment of preferences can be addressed through a linear approach and universal solutions hinders the development of housing alternatives that offer the same functions with a lower environmental footprint. More specifically, our results have shown that a design based on a perfect correspondence between dwelling characteristics and tenant preferences (i.e. the desire for large dwellings = the provision of large dwellings) underestimates the many trade-offs that households make to satisfy needs at a higher systemic level and is therefore insufficient to ensure objective and subjective housing *quality* (Chapter 9).

To navigate such complexity, we recommend that practitioners use the notion of housing function as a tool to assess the complex correspondence between dwelling forms and tenants' desires and needs through the housing design, construction, use and management phases. Furthermore, we invite practitioners *and* citizens to collectively and creatively reimagine the way housing functions contextually express themselves in material forms in order to comply with sustainability requirements, e.g. *what is a small sustainable housing form for a status symbol?* As the spatial boundaries of the functions extend beyond the dwelling, this 'redesign process' should also involve the relative location, neighbourhood and building; for instance, Chapter 7 and Chapter 8 proposed to satisfy the need for privacy, for production-consumption as well as the growing desire for self-representation through an offer of rentable rooms in the building for both shared and private use (e.g. music rooms), rather than by providing more space in the dwelling. Within these boundaries, practitioners should carefully consider synergies and incompatibilities between functions.

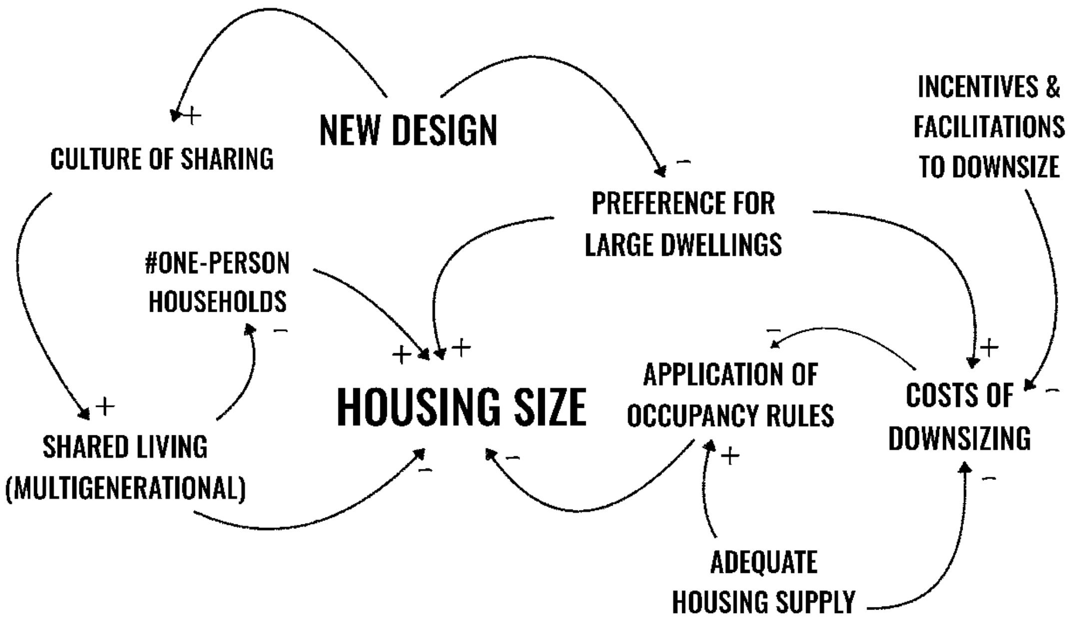

Figure 12.1. Interdependence of measures to shrink the residential space consumption of Swiss tenants. The '+' sign indicates a positive relationship (e.g. the more, the more); the '-' sign indicates a negative one (e.g. the more, the less). 'New design' refers to a housing design compatible with households' preferences while reducing private space.

Secondly, consider the contribution of residents for the success of sustainable housing provision.

Housing design should be 'plural', i.e. dwellings should be able to *accommodate differences* in cultures and lifestyles while reducing their negative social and natural impact (e.g. segregation, land use; Lawrence, 2021d, p. 109; Pattaroni, Thomas, et al., 2009, p. 10). This recommendation is not new; as discussed in Chapter 2.1, in the 1960s and 1970s structuralist architects already advocated in favour of material forms suitable for more purposes, "so that everyone will then be able to react to it for himself, interpreting it in his own way, annexing it to his familiar environment, to which it will then make a contribution" (Lüchinger, 1980, p. 56). These arguments become even more critical now that homes are being and will increasingly be asked to provide more than just residential functions to cope with several complex societal challenges i.e. climate change or the progression of the pandemic (Jefferies et al., 2020; Kaufmann, 2021; Lawrence, 2020; Tokazhanov et al., 2020). For this purpose, a shift of responsibilities is urgently needed in the rental housing sector, for which tenants should be enabled to appropriate and adapt their residential space for their health and well-being.

It could be argued that the importance given to 'individual responsibility' in the Swiss Federal Constitution already goes in this direction. However, such a principle hardly finds room to be applied in a housing market where a third of the population lives in buildings constructed before 1960, vacancy rates are below 2%, and housing costs affect a fourth of households in their ability to fulfil basic needs (FSO, 2019b; Hugentobler, 2017; Zimmermann, 1992). All of the above restricts residents' housing choices and misleads owners and policy-makers in their understanding of the demand dynamics. Therefore, instead of tackling each of these issues directly, much more could be achieved if tenants' agency was enabled (see Box 6).

Box 6. Bridging gaps, designing the future: *Que pouvons-nous faire ensemble que nous ne pouvons pas faire seuls ?*

The Citizens Think Tanks (CTTs) organised in May and June 2020 in the framework of the Swiss Corona Citizen Science project aimed to offer "spaces for mutual learning and for designing possible post-Covid-19 futures."[45] The set-up involved ten 'strangers' (two moderators, one expert, and five to seven participants), two sessions of 2.5 hours, a Zoom platform, and one topic: "*Mon logement à l'épreuve du confinement: Quelles orientations pour l'après ?*." During the first session, citizens and scientists discussed their housing conditions before and during the confinement, from which three key areas emerged: (i) individual, i.e. the possibility to 're-centre'; (ii) space, i.e. the (dis)advantages of our living spaces (e.g. housing size, access to outdoor areas); (iii) society, i.e. the importance of our interactions with others. Playing with different combinations of these three variables, we designed possible scenarios for post-pandemic housing and discussed the feasibility and desirability of each (i.e. *what if our individual time and physical space were reduced, in favour of more social life?*). "Reinvesting the community" (i.e. réinvestir le voisinage) was eventually chosen as the most desirable scenario. Collective reflection followed on the pathways to this future, built around the diversity of needs, personalities, housing conditions and backgrounds of the participants. The numerous trade-offs, risks, obstacles, but also advantages and opportunities that such a vision entails were then highlighted. More specifically, the conversation focused on the question of how to recreate a 'neighbourhood spirit;' we reflected on housing projects that allow encounters, welcome a plurality of residential cultures, and take into account desires for appropriation; we highlighted the economic advantages of sharing (space, objects, services, e.g. childcare); we realised the importance of *learning* to share, carefully considering *what can be shared* and for whom; we stressed the importance of non-violent communication to maintain good relations in the community. The final result of this collective work was a report, co-authored by the citizens who wanted to contribute to writing it, which was followed by a third CTT proposed by the participants themselves, to continue discussing these issues 'outside' the project (see Pagani, Gonzalez, et al., 2020; Appendix E).

The three CTTs highlighted how different types of knowledge can actively contribute to the production of a holistic understanding of housing problems, needs and desires, stimulating new questions, opening up new avenues of research, giving space to different opinions, underlining the importance of humility in researchers' and practitioners' skills and the need to make these available to residents. Overall, the CTTs demonstrated the need for greater interaction between universities and citizens, and offered an example of how architects and housing owners can interact with and benefit from the multiple voices of inhabitants.

[45] A description of the CTTs can be found at the following link: https://coronacitizenscience.ch/fr/le-questionnaire-2. Accessed 28.09.2021. In addition, the manuscript of Fritz, Vilsmaier, Clément, Daffe, Pagani, Pang, Gatica-Perez, Kaufmann, Santiago Delefosse & Binder (2021) illustrates the way in which the CTTs allowed citizens and scientists to explore and engage with the crisis while stimulating empowerment.

Empowerment of tenants however should not be translated in disempowerment of other housing actors (architects, owners); on the opposite, it requires the *top-down* provision of supportive structures for *bottom-up* co-construction of domestic spaces. In practice, housing design should first ensure *inherent adaptability* by providing support to the fulfilment of different and sometimes incompatible functions between and within households (through e.g. external or shared spaces to voluntarily interact with the community; extra rental rooms in a building for leisure activities or for working). Secondly, housing owners should *involve residents in collective decisions* on e.g. heating system, energy source. Additional results of our survey indicated that a relevant share of tenants is unaware of the sustainability of the building where they live (see the report in Appendix C). Giving residents control over decisions regarding the housing environmental, economic and sociocultural sustainability could trigger a positive reinforcing loop, whereby participation brings about the need for more information, and therefore more conscious decisions.

Finally, start today.

The sixth report of the Intergovernmental Panel on Climate Change (IPCC, 2021) published during the writing of this doctoral thesis underlined the urgency of limiting human-induced global warming. Buildings and especially the residential sector play a fundamental role in this collective effort (Lucon et al., 2014). The results obtained in this research and the recommendations outlined in this chapter must therefore be put into practice now. Doing so, however, requires a profound change in the mindset of the actors operating in the residential sector; a powerful channel of communication to enable this transition is education.

12.3 Teaching in architecture

The approaches and methods adopted in this thesis are relatively new to academic research. While transdisciplinarity is not the norm in academia in general (Lawrence, 2015), the use of systems language and tools has not yet permeated research and teaching in architecture and planning. Filling this gap is urgent, considering that current and future practitioners must be able to work in complex sociotechnical arenas to provide housing that is adequate for the people *and* has a low environmental impact (Norman & Stappers, 2015). As this thesis was conducted under the umbrella of *The Doctoral Program Architecture and Sciences of the City (EDAR)*[46], and based on our knowledge of architectural teaching programs, we delineate three objectives for education of current and future professionals in the field.

Teaching needs to be transdisciplinary; architecture is itself transdisciplinary.

According to Lawrence and Després (2004),

> [a]rchitecture and planning seem to be fertile domains for transdisciplinary contributions because of their very nature as “multidisciplinary” disciplines involving both the natural and social sciences, and action-oriented practices aimed at transforming the built and natural environment, as well as education programmes based on solving multidimensional problem. (p. 397)

Given its ability to integrate *through design* knowledge of e.g. building physics, economics, history, geography, and considering its necessity to dialogue and negotiate with other disciplines

[46] The Program description can be found at the following link. https://www.epfl.ch/education/phd/edar-architecture-and-sciences-of-the-city/. Accessed 29.09.2021.

and professions within the built environment (e.g. civil or environmental engineers, investors, property managers), architecture is a transdisciplinary field. Therefore, the notions of inter- and transdisciplinarity should be introduced into architectural curricula. More specifically, for students to be able to interact with stakeholders and with other disciplines, we encourage the setting up of collaborative activities involving different faculties of the built environment; an example is the ENAC week at EPFL, where undergraduate architecture, civil and environmental engineering students work in teams to tackle a real-world problem that requires the contributions of more than one discipline.[47] Shared vocabulary and tools would be crucial to support these activities, and this is where systems science comes in.

Systems science notions and tools must permeate teaching in fields related to the built environment to train future practitioners to manage complexity.

In his publication '*Introduction to Systems Thinking*', Kim (1999) writes:

> It's been said that systems thinking is one of the key management competencies for the 21st century. As our world becomes ever more tightly interwoven globally and as the pace of change continues to increase, we will all need to become increasingly "system-wise." (p. 1)

Applying systems thinking in the architectural field implies considering the structure, behaviour and functions of the system under study (i.e. be it a city, a neighbourhood, a buildings' complex, a dwelling) throughout the design process. This perspective makes it possible to develop an awareness of the interactions between the elements of and across systems (e.g. the design of the housing material subsystem and its impact on the environmental supersystem) as well as a better understanding of the system's emergent behaviour and the variables that determine it, i.e. "to get the beat of the system" (Blizzard & Klotz, 2012; Meadows, 2008, p. 170).

The combination of systems and design thinking has given rise to a new discipline, called 'systemic design' (Bistagnino, 2011; Jones, 2014, 2020; Norman & Stappers, 2015; Sevaldson, 2019). Several methods and tools are used in these fields, e.g. causal loops diagrams, system maps, synthesis maps, gigamaps (Irwin, 2018; Jones & Bowes, 2016; Sevaldson, 2011).[48] While ways to train the new generation of systemic designers are being explored and assessed (see Battistoni & Barbero, 2017), the adoption of a systems perspective should concomitantly become a requirement in architecture and urban projects with the goal of delivering designs that are able to account for the complexity of the reality in which they are inscribed, and that are thus *inherently* sustainable.

Architecture cannot be separated from sustainability, nor can it privilege one aspect of it. Students must learn how to embed *all* dimensions of sustainability in their design projects.

In their study of sufficiency in housing, Lorek & Spagenberg (2019) state that:

> Architects and planners can develop a vital function for the advancement and integration of sustainability practices in societies. They are capable of communicating and presenting the pro and contras of sufficiency solutions through working with clients, customers and other relevant disciplines such as engineers or economists. Therefore it is necessary to

[47] To learn more about the ENAC week, see https://www.epfl.ch/schools/enac/education/design-together-en/enac-week/. Accessed 29.09.2021.
[48] For more information on what systemic design is, including its community, theory, practice, and publications see https://systemic-design.org/. For examples of Gigamaps: https://www.systemsorienteddesign.net/index.php/giga-mapping; for Synthesis maps: https://slab.ocadu.ca/project/synthesis-maps-gigamaps. Accessed 29.09.2021.

> expand the scope of design education and practice beyond style and fashion, economic issues (mainstream design) and environmental concerns (Ecodesign) to include social and institutional issues whenever possible [...]. (p. 290)

Nowadays, we can no longer consider design and environmental, economic and sociocultural sustainability as separate spheres. The need arises to give a new identity to the architect, as a professional at the service of the common good (Lawrence, 2021c, p. 165). Her duty becomes that of integrating the knowledge of different actors while making available to them her understanding of the built environment system and her ability to create spaces that can accommodate its complexity. To this end, the approaches and tools presented in this thesis must quickly permeate teaching so that architecture students can learn to understand and navigate systems as well as to evaluate the systemic effects of their designs, aware of their moral responsibility towards society and the environment.

Of course, we do not think that tomorrow's architects should know *everything*—especially considering the increasing specialisation and fragmentation of disciplines in the built environment. Certainly, however, they cannot ignore the potential that a systemic perspective offers to understand, manage, and potentially shape the ὅλος, i.e. the whole, towards sustainability.

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Appendix

The Appendix is organised into five parts.

The first part contains the invitation letter, the questionnaire and the posters used during the group discussion with tenants in Lausanne. Whilst the questionnaire had the purpose to trigger participants' individual reflections and collect data before the discussion, the posters served to guide the exchanges between peers. Another group discussion was conducted in Zurich, where the questions were translated in German.

The second part includes the invitation letter (shipped by mail) and the questionnaire of the tenants' online survey in its French version.

The third part is a report written for our collaboration partner Swiss Mobiliar, which summarises the survey results and provides a concise list of recommendations accordingly. Two similar reports were compiled for the cooperatives ABZ and SCHL.

The fourth part is a summary of the goal, methods, and results of the TD workshop that took place during the Mobiliar Forum Thun. Box 5 in the main body text of this thesis provides a synthesis of the findings.

The last part contains the report of the Citizen Think Tank on the future of housing, co-written by some of the participants. A summary of the CTT contributions is outlined in Box 6.

A.

Group discussion

A1. Invitation to the group discussion

SCHOOL OF ARCHITECTURE, CIVIL & ENVIRONMENTAL ENGINEERING, **ENAC**
Environmental Engineering Institute, **IIE**
HUMAN-ENVIRONMENT RELATIONS IN URBAN SYSTEMS LAB, **HERUS**
Swiss Mobiliar Chair in urban ecology and sustainable living

HEAD: Prof. Dr. Claudia R. **Binder**
Direct ☎: +41 21 693 39362 http://herus.epfl.ch

SCHOOL OF ARCHITECTURE, CIVIL & ENVIRONMENTAL ENGINEERING, **ENAC**
Architecture Section, **SAR**
LABORATORY OF ENVIRONMENTAL AND URBAN ECONOMICS, **LEURE**

HEAD: Prof. Dr. Philippe **Thalmann**
Direct ☎: +41 21 69 37321 https://leure.epfl.ch/

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

NOTICE D'INFORMATION AUX PARTICIPANTS AU PROJET DE RECHERCHE « REDUIRE L'EMPREINTE ECOLOGIQUE DU LOGEMENT »

Ce projet de recherche a été approuvé par le Comité d'éthique de la recherche humaine de l'EPFL (HREC No: : 037-2018/07.08.2018).

Nom chercheur principal : Prof. Philippe Thalmann

Institution / Adresse professionnelle :
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Station 16
CH-1015 Lausanne

Comment nous contacter :
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Margarita Agriantoni : Tél: +41 21 69 37183 ; e-mail: margarita.agriantoni@epfl.ch

Nous aimerions vous inviter à participer à ce projet de recherche.

Détails du projet :

L'objectif du projet est de mieux comprendre quelles mesures pourraient réduire l'empreinte environnementale des bâtiments et dans quelle proportion. Nous discutons pour cette raison avec différents types de propriétaires d'immeubles et leurs locataires. Dans le cadre de cette étude, nous souhaitons comprendre quels sont les facteurs qui vous ont poussé(e) à déménager, ainsi que les facteurs que vous avez considérés lors du choix d'un nouveau logement. Pour faire cela, nous organisons une discussion en petits groupes.

Cette recherche est financée par le Fond National Suisse (SNFNS) dans le cadre du Programme national de recherche 73 – Economie Durable (PNR73).

Ils sont invités à participer les locataires de la SCHL et de la Mobilière du canton de Vaud. La majorité civile (18 ans) est requise, ainsi qu'un bon état de santé vous permettant de prendre part à la discussion.

Vous êtes invité(e) à vous présenter à **l'EPFL- Ecole Polytechnique Fédérale de Lausanne, salle AAC 006, le mardi 20 novembre 2018 à 18h30,** pour une durée d'environ 1h30.

Après une introduction sur le thème, vous serez invité(e) à partager de manière interactive (post-it et discussions) votre expérience concernant les raisons de votre déménagement et la sélection de votre logement.

Lors des discussions les chercheurs et chercheuses serviront de modérateurs et feront de telle sorte qu'aucune information considérée sensible ne vous soit demandée.
Ils/Elles seront responsables de modérer la discussion.

En participant à notre étude, vous aurez l'occasion de vous exprimer à propos de vos critères de choix d'une résidence, ce qui vous rendra plus sensibles à **comment ces critères influencent les choix durables dans le domaine du logement.** Vous aurez aussi l'occasion de rester en contact avec les chercheurs et chercheuses pour avoir des nouvelles par rapport aux résultats du projet.

Votre billet de train et/ou métro vous sera remboursé et un riche apéro sera offert en fin de séance.

Vous êtes invité(e) à nous demander toute clarification nécessaire ou toute information complémentaire.
La décision de participer ou non au projet vous revient. En tant que participant, vous avez le droit de vous retirer du projet à tout moment, sans aucune conséquence négative pour vous.

Une copie de ce formulaire est pour vous.

Dans le cadre du projet de recherche, les données collectées auprès des Régies seront pseudonymisées par les chercheurs. Toutes les données traitées seront sauvegardées de manière sécurisée et anonyme, conformément à la Loi fédérale sur la protection des données (RS 235.1). Seuls les chercheurs principaux auront accès aux données originales, et seront soumis à une obligation de stricte confidentialité. En ce qui concerne la diffusion des résultats, la publication dans des revues scientifiques ou présentation lors de conférences seront faites sur la base des résultats précédemment anonymisés, à partir desquels aucun profil ne pourra être identifié. Ainsi, aucune information présentée ne pourra reconduire à sa source.

Tout dommage corporel ou matériel dû à la participation au projet de recherche ci-dessus et pour lequel la responsabilité de l'EPFL peut être établie est couvert par l'assurance responsabilité civile de l'EPFL (police d'assurance No 501 402430.002 de La Mobilière Assurances), en application des conditions générales d'assurance.

De plus et dans tous les cas, il est de votre responsabilité d'avoir une couverture suffisante en cas de maladie et d'accident.
En cas de doute, tout comme en cas de malaise lié à votre participation à cette étude, nous vous invitons à contacter directement le chercheur principal.

A2. Group discussion questionnaire for individual reflection

73 NRP Sustainable Economy National Research Programme

die Mobiliar

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Réduire l'empreinte écologique du logement

Quelles mesures pourraient réduire l'empreinte environnementale des bâtiments ?

...Et dans quelle proportion ?

Participant ID : Anna

20.11.2018

Salle AAC 006 EPFL - Lausanne

Cette recherche est financée par le Fond National Suisse (SNFNS) dans le cadre du Programme national de recherche 73 – Economie Durable (PNR73). Ce projet de recherche a été approuvé par le Comité d'éthique de la recherche humaine de l'EPFL HREC N° : 037-2018/07.08.2018).

1

Sustainable Economy
National Research Programme

Un peu de contexte…

Le logement joue un rôle fondamental dans la transition vers une société plus durable. La durabilité du secteur du logement est assurée par la prise en compte des facteurs physiques, sociaux et économiques, qui contribuent respectivement aux objectifs de réduction de l'empreinte environnementale et d'approvisionnement de logements abordables et adéquats.

Aujourd'hui, les fournisseurs de logements doivent relever le défi de promouvoir des logements écologiquement durables tout en s'adaptant à l'évolution de la demande. Mais qui est cette demande ? Et comment choisi-t-elle ?

Dans le cadre de cette étude, nous souhaitons comprendre quels sont les facteurs qui vous ont poussé(e) à déménager, ainsi que les facteurs que vous avez considérés lors du choix d'un nouveau logement.

La discussion de groupe vise à répondre au trois questions suivantes :

Q1 Quels sont les facteurs qui poussent à bouger, et quelle est leur influence sur la décision finale ?

Q2 Quels facteurs jouent un rôle dans la sélection d'un nouveau logement ?

Q3 Quelle est la relation entre la fonction du logement souhaitée et le choix final ?

Pour commencer…

En groupes de deux, faites connaissance de votre partenaire. Essayez de mémoriser 3 informations que l'autre personne vous présentera. Après 3 minutes de discussion, présentez votre partenaire à l'ensemble du groupe, à l'aide de ces 3 informations (le nom ne compte pas !).

2

Sustainable Economy
National Research Programme

Questionnaire

Notes, mots-clés, dessins sont acceptés.

Il n'y a aucune bonne ou mauvaise réponse, nous sommes intéressés pas des opinions personnelles.

En réponse aux questions ci-dessous, veuillez énumérer les idées qui vous viennent immédiatement à l'esprit.

Le questionnaire est structuré sur la base d'un modèle scientifique (développé par I. Ajzen en 2013). Pour plus d'informations, contactez la chercheuse.

Partie 1 : Les déclencheurs

1) Écrivez sur différents post-it 1 à 3 raisons principales pour lesquelles vous avez décidé de changer de maison et collez-les au tableau (déclencheurs). *(N'oubliez-pas d'écrire votre ID sur les post-it !)*

Ex : changement de taille de la famille ; nouveau travail

2) Remplissez la feuille de questions avec des **mots-clés**

3) Formez un groupe et dessinez ensemble sur la table

3

1a. Quand votre désir de déménager s'est-il manifesté et pourquoi ?

………

………

1b. Quel était le niveau de satisfaction de votre ancienne maison (moyen, élevé) ?

………

………

2a. Quels étaient les avantages du déménagement ?

………

………

2b. Quels étaient les inconvénients du déménagement ?

………

………

3a. Qui a pris la décision de déménager ?

………

………

3b. Qui (individu, groupe) a approuvé et qui a désapprouvé votre décision de déménager ?

………

………

4a. Veuillez énumérer les facteurs ou circonstances qui vous ont facilité la tâche ou vous ont permis de suivre votre décision (de déménager).

………

………

4b. Veuillez énumérer les facteurs ou circonstances qui vous ont rendu le déménagement difficile.

………

………

4

Sustainable Economy
National Research Programme

Partie 2 : La 'fonction' du logement

1) Ma maison sert à…

Classez les 9 fonctions que votre maison actuelle a pour vous en fonction de leur importance : marquez la plus importante avec le numéro 1, la moins importante avec le numéro 9. Si une ou plusieurs fonction(s) ne correspond(ent) pas à votre logement, ne lui/leur attribuez aucun numéro.

Abris	Sécurité	Permanence
Propriété	Impermanence	Production, Consommation
Symbole de statut	Autoreprésentation	Atout

Définitions :

Abris *: refuge, protection contre les conditions climatiques et la société*
Sécurité, Confidentialité *: un endroit pour la famille et les amis restreints*
Permanence *: continuité, appartenance de générations multiples*
Propriété *: un lieu qui vous 'appartient'*
Impermanence *: un espace transitoire, qui répond à vos besoins courants*
Production, consommation *: un endroit fonctionnel, pour dormir, manger, prendre un bain…*
Symbole de statut *: un lieu adapté à votre statut social, pour inviter vos amis, par exemple, à diner*
Autoreprésentation *: un lieu d'expression, un moyen de communication*
Atout, Marchandise *: un pied-à-terre en cas de besoin, un bon rapport prix-qualité*

2) Écrivez sur un post-it :

-la taille de votre ménage

-le nombre de pièces de votre logement

-l'étage auquel votre logement est situé

-l'emplacement (la ville)

Ex : 5 personnes ; 3,5 pièces ; 3e ; Préverenges

et collez-le dans la case de la fonction numéro 1, la plus importante.

3) Remplissez la feuille de questions avec des mots-clés

4) Formez un groupe et dessinez ensemble sur la table

5

Sustainable Economy
National Research Programme

1. Qu'est-ce que la '*maison*' pour vous ?

……

……

2. Que faites-vous à la maison ?

……

……

3. Est-ce que la « *fonction* » de votre logement actuel correspond à celle que vous désiriez lors de votre décision de déménager ?

……

……

4. Est-ce que la « *fonction* » de votre logement actuel est la même de celle de votre résidence précédente ?

……

……

5. Selon vous, qui sont les personnes les plus susceptibles d'emménager dans une maison avec la *fonction* que vous avez choisie ?

……

……

6

Sustainable Economy
National Research Programme

Partie 3 : Les caractéristiques

1) Ecrivez sur différents post-it les 5 caractéristiques les plus importantes pour vous que vous avez dans votre maison, et collez-les sous la fonction qui selon vous leur convient (les 5 peuvent être collées sous la même fonction).

Exemples : pas de bruit (abris), atout (bien localisé), possibilité d'entretien (permanence), quartier sûr (sécurité)

2) Remplissez le tableau avec des mots-clés

3) Formez un groupe et dessinez ensemble sur la table

Sustainable Economy
National Research Programme

1. Rappeler les 5 caractéristiques principales de votre maison, précédemment énumérées

2. Quelles caractéristiques ne pouvaient pas manquer lors du choix de votre appartement ?

3. Lesquelles de ces caractéristiques ont ou n'ont pas changé par rapport à votre maison précédente ?

Question 1	**Question 2**	**Question 3**

8

Sustainable Economy
National Research Programme

Partie 4 : La décision

1) Remplissez le tableau avec des mots-clés

2) Formez un groupe et dessinez ensemble sur la table

1a. Quels étaient les avantages de choisir votre appartement actuel ?

………

………

1b. Quels étaient les inconvénients ?

………

………

2. Qui (individu, groupe) a approuvé <u>et</u> qui a désapprouvé votre choix de l'appartement actuel ?

………

………

3a. Veuillez énumérer les facteurs ou circonstances qui vous ont facilité la tâche ou vous ont permis de suivre votre décision (de choisir le nouvel appartement).

………

………

3b. Veuillez énumérer les facteurs ou circonstances qui vous ont rendu le choix difficile.

………

………

9

S'il avance du temps…

Formez deux groupes avec le premier chiffre de votre ID.

Votre groupe est un petit ménage. Il vous faut choisir un appartement commun. Quelles fonctions, caractéristiques choisissez-vous ? Pourquoi ?

Trouvez une solution commune.

Appartement Final

Fonction :

Caractéristiques :

10

73 NRP Sustainable Economy National Research Programme

die Mobiliar

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Les conclusions

Relisez de manière critique votre dossier, puis répondez aux questions suivantes.

1. Avez-vous appris quelque chose sur vos choix par rapport à votre logement aujourd'hui ?

……

……

2. Qu'est ce qui a changé dans votre opinion par rapport au début de la discussion ?

……

……

3. Est-ce qu'il y a une fonction qui vous parait manquer parmi celles proposées ?

……

……

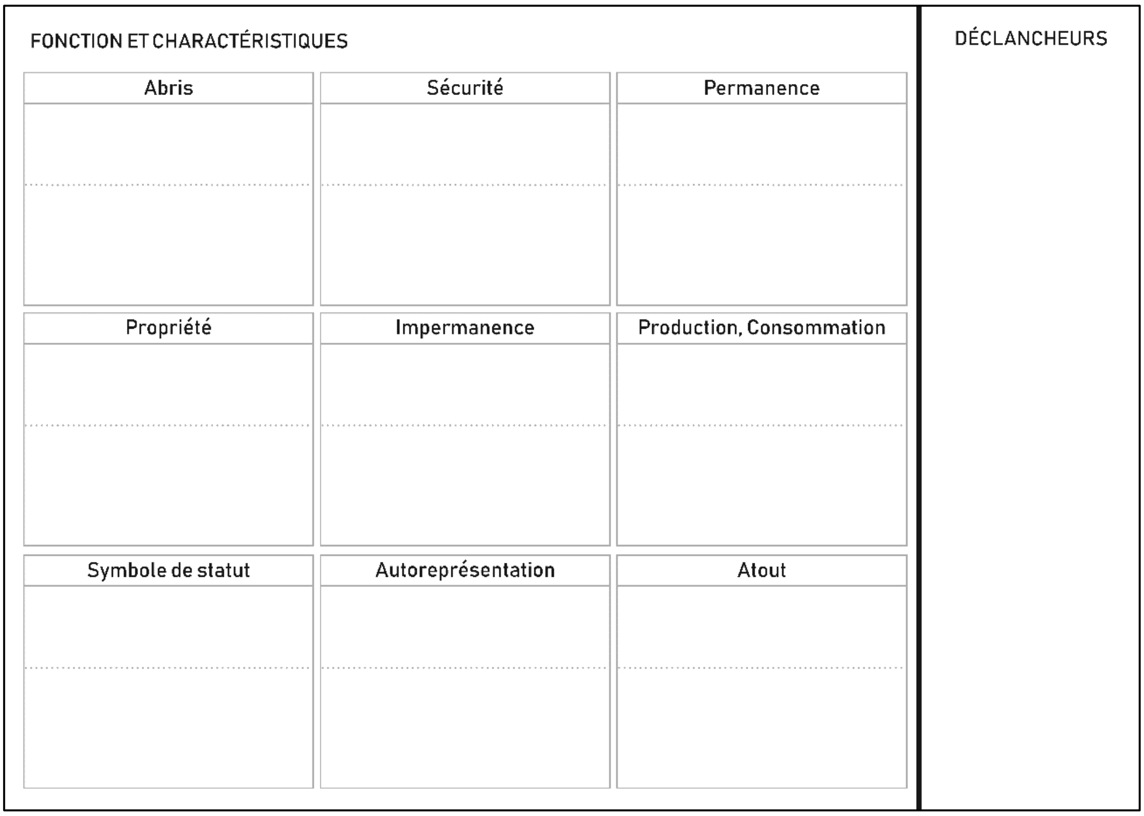
4. Est-ce qu'il y a quelque chose d'important qui méritait être discuté ou partagé ?

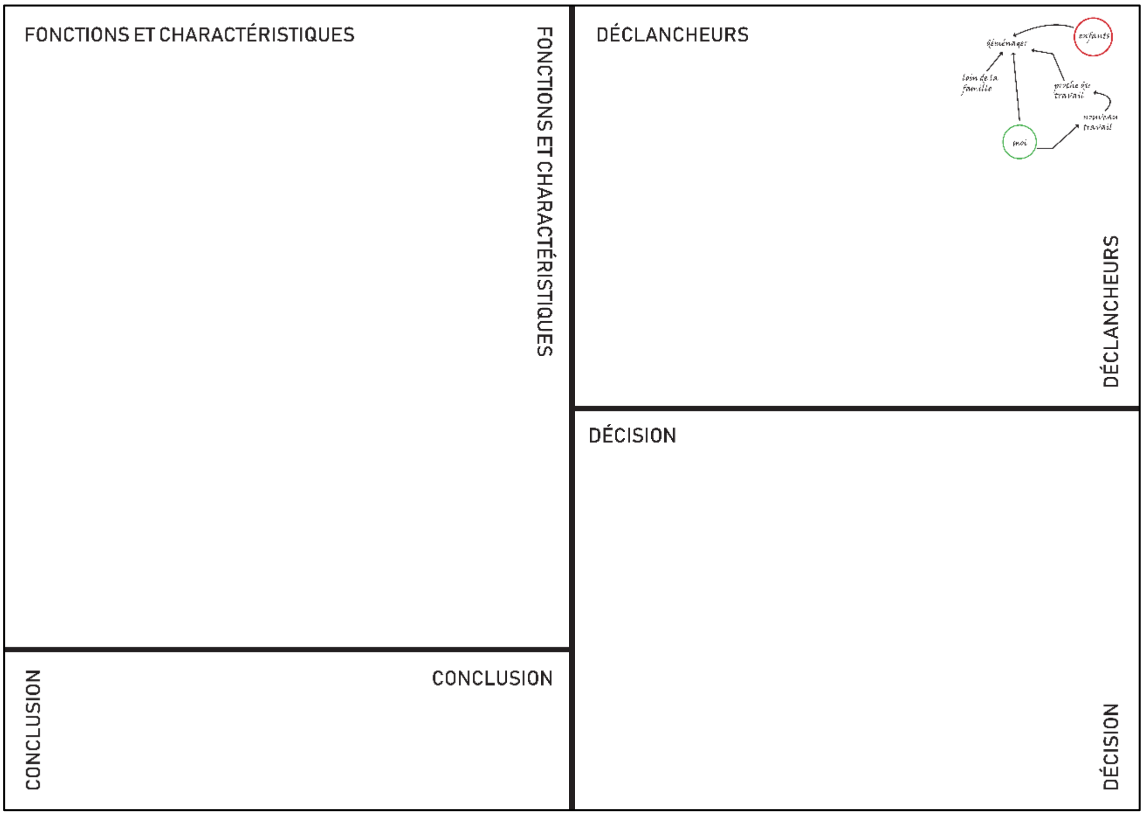
……

……

11

A3. Posters for collective brainstorming





B.

Tenants' survey

B.1 Invitation letter

Logo of
housing owner

GENRE1 PRENOM1 NOM1
GENRE2 PRENOM2 NOM2
Rue
NPA Lieu

USR

Lausanne, le 16 septembre 2019

Enquête sur les choix résidentiels des locataires

GENRE1, GENRE2,

Dans le cadre du projet "Réduire l'empreinte environnementale du logement" l'Ecole Polytechnique Fédérale de Lausanne (EPFL) et l'Ecole Polytechnique Fédérale de Zurich (ETHZ) réalisent une enquête auprès de la population des locataires. L'enquête est réalisée en partenariat avec nom du partenaire du projet, qui soutient le projet de recherche. Vous avez été sélectionné-e de manière aléatoire pour participer à cette enquête avec 2'500 autres ménages.

L'enquête vise à mieux comprendre pourquoi les ménages choisissent de déménager et comment ils choisissent leur logement. Pour cette raison, le questionnaire ne peut être rempli que par **la·le signataire de bail ou par un·e des habitant·e·s, pourvu qu'elle·il ait eu une influence dans le choix du logement.**

Dès aujourd'hui, vous avez la possibilité de remplir le questionnaire sur la page d'accueil de l'Institut LINK : www.link.ch/homeproject

Une fois à la page d'accueil, veuillez inscrire vos codes d'accès personnels :

- **Nom d'utilisateur/utilisatrice : USR**
- **Mot de passe : PWD**

Remplir ce questionnaire ne devrait pas vous prendre plus de 20 minutes. Nous vous serions reconnaissants si vous pouviez le compléter **en ligne d'ici au 3 octobre 2019**. Pour que les résultats soient significatifs, il est important que le plus grand nombre possible de locataires y participent.

Si vous avez des questions d'ordre technique, si vous n'avez pas d'accès Internet ou si vous préférez ***participer par téléphone***, vous pouvez composer le numéro gratuit **0800 524 524** à partir du 17 septembre 2019 (horaires : du lundi au vendredi de 8h30 à 12h00 et de 13h00 à 17h00). Si vous optez pour l'appel téléphonique, nous vous prions de mentionner votre code de sécurité imprimé dans cette lettre sous votre adresse. Si vous avez des difficultés à accéder au questionnaire, veuillez envoyer un message électronique à homeproject@link.ch en incluant votre code de sécurité personnel.

La protection de vos données est garantie par la loi. Vos informations seront traitées de manière confidentielle et l'**anonymat des réponses est garanti**. Si vous souhaitez plus de renseignements, n'hésitez pas à contacter Madame Anna Pagani (tél : 021 693 37 19 ; e-mail : anna.pagani@epfl.ch) ou Madame Margarita Agriantoni (tél : 021 693 71 83 ; margarita.agriantoni@epfl.ch), doctorantes à l'EPFL sous la direction des professeurs Philippe Thalmann et Claudia R. Binder.

En vous remerciant d'avance de votre précieuse collaboration, nous vous prions de croire, GENRE1, GENRE2, à l'assurance de notre parfaite considération.

Signature of housing owner & SHEF Principal Investigator

B.2 Survey questionnaire

Question	***Instruction***	***Resp Value***	***Response Label***
Bienvenu(e) sur le site de l'étude réalisée par l'École Polytechnique Fédérale de Lausanne (EPFL) et l'École Polytechnique Fédérale de Zurich (ETHZ) en collaboration avec l'Institut LINK sur les choix résidentiels des locataires. Nous tenons avant tout à vous remercier pour votre participation. Avec nos questions, nous souhaitons comprendre pourquoi les ménages décident de déménager et comment ils choisissent leur logement. Pour cela il est important que le questionnaire soit rempli par la/le signataire de bail ou par un des habitants, pourvu qu'elle ou il ait eu une influence dans le choix du logement. Nous vous prions de bien vouloir répondre à chacune des questions et de sélectionner la réponse qui décrit le mieux ou convient le mieux à votre situation. Toutes les informations et réponses que vous donnerez seront traitées de manière strictement confidentielle. **L'anonymat des réponses individuelles est garanti.** Aucun lien ne sera réalisé entre les données personnelles et les réponses. La durée du questionnaire est d'environ 20 minutes. Vous pouvez interrompre à tout moment le remplissage du questionnaire. Grâce à votre code personnel, vous pourrez à nouveau accéder au questionnaire et continuer à répondre aux questions à un autre moment. Les questions auxquelles vous aurez déjà répondu seront enregistrées. Attention : - Pour la navigation d'un écran à l'autre, veuillez utiliser les boutons « suivant » et « précédent » afin de ne pas sortir involontairement du questionnaire. - Si vous quittez le questionnaire, un retour immédiat n'est pas possible pour des raisons de sécurité. Veuillez essayer à nouveau après environ 10 à 15 minutes. Dans tous les cas, les réponses que vous aurez indiquées seront conservées. Merci d'avance pour votre précieuse collaboration.			
Locataire_Personnel			
Nous allons tout d'abord commencer par quelques questions de base concernant votre ménage.			
Quel est votre sexe ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Femme
		2	Homme
		3	Autre
En quelle année êtes-vous né(e) ?	*Vous ne pouvez donner qu'une réponse à cette question*	— — — —	
Quel est votre état civil ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Célibataire
		2	Marié(e) ou en couple
		3	Veuf/veuve
		4	Divorcé(e) ou séparé(e)
		5	Autre

Comment décririez-vous votre ménage ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Ménage d'une personne
		2	Couple sans enfants
		3	Couple avec enfant(s) (vivant au foyer ou hors du foyer)
		4	Ménage monoparental avec enfant(s) (vivant au foyer ou hors du foyer)
		5	Autre ménage familial sans enfants
		6	Ménage non-familial de plusieurs personnes (colocation)
		7	Autre ménage
Combien de personnes, enfants et adultes, partagent leur domicile principal avec vous (vous y compris) ?	*Vous ne pouvez donner qu'une réponse à cette question*	— —	
Combien d'enfants avez-vous?	*Vous ne pouvez donner qu'une réponse à cette question*	— —	
Pourriez-vous nous indiquer les informations suivantes?			
Enfant **[response pe6 [1 … #]**		— — — —	Année de naissance
		1	Vit dans mon ménage
		0	Ne vit pas dans mon ménage
		99998	Je ne souhaite pas répondre à cette question
Logement_Consommation			
Dans cette section, nous allons vous poser des questions concernant la consommation d'énergie de votre logement.			
Lesquels des appareils-électroménagers suivants avez-vous dans votre logement ou votre bâtiment ?	*Pour cette question, vous pouvez donner plusieurs réponses*	1	Lave-linge privé
		2	Lave-linge en commun
		3	Lave-vaisselle
		4	Micro-ondes
		5	Four
		6	Frigo
		7	Congélateur
		8	Aucun
À quelle fréquence utilisez-vous…	*Veuillez donner une réponse pour chaque ligne*		

item 1 selected in da2		1	Quotidiennement
		2	Plusieurs fois par semaine
		3	Plusieurs fois par mois
		4	Plusieurs fois par an
		5	Moins souvent
		6	Jamais
item 2 selected in da2		same as da2_1	
item 3 selected in da2		same as da2_1	
item 4 selected in da2		same as da2_1	
item 5 selected in da2		same as da2_1	
Quelle température visez-vous à maintenir dans votre appartement en hiver ?	*Vous ne pouvez donner qu'une réponse à cette question*	__ __ °C	
		99999	Je ne sais pas
Logement_Fonctions			
Nous vous présentons ci-dessous diverses définitions du logement. Veuillez indiquer dans quelle mesure vous êtes d'accord pour dire que la définition proposée correspond à votre logement idéal, à votre logement actuel ou à votre logement précédent			
Mon logement IDÉAL est…	***Veuillez donner une réponse pour chaque ligne***		
Un lieu qui m'appartient, dont j'ai le droit de faire ce que je veux.		1	Pas du tout d'accord
		2	Pas d'accord
		3	Ni en désaccord ni d'accord
		4	D'accord
		5	Tout à fait d'accord
Un endroit qui me facilite l'exécution d'activités telles que dormir, manger, faire la lessive, accueillir des invités…		same as df1_1	
Un lieu affranchi de toute 'tradition' ou 'mémoire', qui correspond juste à l'étape actuelle de ma vie.		same as df1_1	
Une marque de prestige, une vitrine qui me permet de présenter mon statut.		same as df1_1	

Un lieu intime, principalement pour les besoins des membres de la famille et les amis restreints. Mes loisirs se déroulent en dehors de la maison.		same as df1_1
Un lieu temporaire, ou un point de départ : peut-être attrayant pour son prix ou son emplacement.		same as df1_1
Un lieu d'expression, de satisfaction de mes aspirations.		same as df1_1
Un refuge, une forteresse où je peux retourner me reposer, avant de repartir "dans le monde". Mon chez-moi.		same as df1_1
Un lieu où je me sens enraciné(e), auquel j'ai le sentiment d'appartenir.		same as df1_1
Mon logement ACTUEL est…	***Veuillez donner une réponse pour chaque ligne***	
Un lieu qui m'appartient, dont j'ai le droit de faire ce que je veux.		same as df1_1
Un endroit qui me facilite l'exécution d'activités telles que dormir, manger, faire la lessive, accueillir des invités…		same as df1_1
Un lieu affranchi de toute 'tradition' ou 'mémoire', qui correspond juste à l'étape actuelle de ma vie.		same as df1_1
Une marque de prestige, une vitrine qui me permet de présenter mon statut.		same as df1_1
Un lieu intime, principalement pour les besoins des membres de la famille et les amis restreints. Mes loisirs se déroulent en dehors de la maison.		same as df1_1
Un lieu temporaire, ou un point de départ : peut-être attrayant pour son prix ou son emplacement.		same as df1_1
Un lieu d'expression, de satisfaction de mes aspirations.		same as df1_1
Un refuge, une forteresse où je peux retourner me reposer, avant de repartir "dans le monde". Mon chez-moi.		same as df1_1
Un lieu où je me sens enraciné(e), auquel j'ai le sentiment d'appartenir.		same as df1_1
Mon logement PRÉCÉDENT était...	***Veuillez donner une réponse pour chaque ligne***	
Un lieu qui m'appartient, dont j'ai le droit de faire ce que je veux.		same as df1_1
Un endroit qui me facilite l'exécution d'activités telles que dormir, manger, faire la lessive, accueillir des invités…		same as df1_1

Un lieu affranchi de toute 'tradition' ou 'mémoire', qui correspond juste à l'étape actuelle de ma vie.		same as df1_1	
Une marque de prestige, une vitrine qui me permet de présenter mon statut.		same as df1_1	
Un lieu intime, principalement pour les besoins des membres de la famille et les amis restreints. Mes loisirs se déroulent en dehors de la maison.		same as df1_1	
Un lieu temporaire, ou un point de départ : peut-être attrayant pour son prix ou son emplacement.		same as df1_1	
Un lieu d'expression, de satisfaction de mes aspirations.		same as df1_1	
Un refuge, une forteresse où je peux retourner me reposer, avant de repartir "dans le monde". Mon chez-moi.		same as df1_1	
Un lieu où je me sens enraciné(e), auquel j'ai le sentiment d'appartenir.		same as df1_1	
Déménagement_Facteurs contextuels			
Combien de fois avez-vous déménagé au cours des 10 dernières années (2009-2019) ?	*Vous ne pouvez donner qu'une réponse à cette question*	— —	
En quelle année avez-vous emménagé dans votre logement actuel ?	*Vous ne pouvez donner qu'une réponse à cette question*	— — — —	
Où se situait votre logement précédent ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	En Suisse
		2	En Europe
		3	Hors Europe
Dans quelle commune de Suisse se situait votre logement précédent? Veuillez indiquer le numéro postal.	*Vous ne pouvez donner qu'une réponse à cette question*	— — — —	
Pourquoi avez-vous <u>décidé</u> de quitter votre précédent logement ? Veuillez choisir seulement la raison principale.	*Vous ne pouvez donner qu'une réponse à cette question*	1	J'ai bénéficié d'une augmentation de salaire
		2	J'ai pris ma retraite
		3	J'ai pris connaissance de la possibilité de louer un autre appartement
		4	J'avais besoin d'un logement accessible aux personnes handicapées ou disposant d'un ascenseur
		5	J'ai changé de lieu de travail (éloigné du lieu actuel)

		6	Mon contrat de bail arrivait à échéance ou a été résilié
		7	J'avais des problèmes interpersonnels avec les propriétaires, la communauté, mes colocataires
		8	Mon logement était de moins en moins confortable, ce qui me causait du stress (p. ex., des bruits)
		9	J'ai divorcé ou je me suis séparé(e)
		10	J'ai emménagé avec mon/ma partenaire
		11	J'ai eu un enfant
		12	J'avais un désir d'autonomie
		13	Je ressentais le désir d'un changement radical dans ma vie
		14	Mon loyer était trop élevé
		15	Mes enfants ont quitté le ménage
		16	Autre, veuillez préciser dans le champ ci-dessous: __________
Considériez-vous que la raison **[# item selected in ms4]** était …	*Vous ne pouvez donner qu'une réponse à cette question*	1	Une opportunité d'améliorer les caractéristiques de mon logement
		2	Un problème à résoudre
		3	Un changement radical dans ma vie
Quel était votre niveau de satisfaction à l'égard de votre ancien logement, quartier et emplacement avant d'avoir **[# item selected in ms4_1]**?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Très insatisfait(e)
		2	Plutôt insatisfait(e)
		3	Ni satisfait(e), ni insatisfait(e)
		4	Plutôt satisfait(e)
		5	Très satisfait(e)
Logement_Caractéristiques passées et présentes			
Pour les questions suivantes, veuillez indiquer quelles sont, pour vous, les caractéristiques essentielles de votre logement idéal et de votre logement actuel			

Mon logement IDÉAL offre un accès aisé à …	*Veuillez choisir **les 2 caractéristiques** qui sont les plus importantes pour vous.*	1	école (ou crèche)
		2	travail
		3	services
		4	transports publics
		5	amis
		6	famille
		7	activités culturelles
		8	loisirs
		9	sites religieux
		10	centre-ville
		11	Autre, veuillez préciser dans le champ ci-dessous: __________
Mon logement ACTUEL offre un accès aisé à …	*Veuillez choisir **les 2 caractéristiques** qui sont les plus importantes pour vous.*	same as dc1_5	
Mon logement IDÉAL est situé dans un quartier …	*Veuillez choisir **les 2 caractéristiques** qui sont les plus importantes pour vous.*	1	sûr
		2	charmant
		3	me procurant un sentiment d'appartenance à la communauté
		4	permettant de tisser des liens
		5	résidentiel chic
		6	populaire et animé
		7	avec un mélange intergénérationnel
		8	avec une mixité socioculturelle
		9	disposant d'écoles (ou crèches) avec une bonne réputation
		10	accessible en voiture
		11	Autre, veuillez préciser dans le champ ci-dessous: __________
		12	Pas dans un quartier, mais à la campagne

Mon logement ACTUEL est situé dans un quartier …	*Veuillez choisir **les 2 caractéristiques** qui sont les plus importantes pour vous.*	same as dc1_3	
Mon logement IDEAL est un logement …	*Veuillez choisir **les 3 caractéristiques** qui sont les plus importantes pour vous.*	1	spacieux
		2	avec des espaces partagés
		3	permettant une utilisation flexible des espaces / adaptable
		4	indépendant (maison indépendante)
		5	moderne
		6	lumineux
		7	avec une belle vue / horizon
		8	avec balcon
		9	de bonne qualité (par ex., matériaux)
		10	bien aménagé
		11	rénové
		12	facile à entretenir
		13	protecteur de mon intimité (visuelle, acoustique)
		14	calme et silencieux
		15	fonctionnel (cuisine, espace de rangement)
		16	écologique (par ex., Minergie)
		17	avec des espaces verts devant ou à proximité du bâtiment
		18	avec place de parking
		19	accessible (avec ascenseur et/ou adaptée aux handicapés)
		20	avec machine à laver privée
		21	avec un loyer faible
		22	sans risque de résiliation du bail
		23	Autre, veuillez préciser dans le champ ci-dessous: __________

Mon logement ACTUEL est un logement …	*Veuillez choisir **les 3 caractéristiques** qui sont les plus importantes pour vous.*	same as dc1_2	
Comparées à votre logement précédent, la plupart des charactéristiques qui comptent pour vous dans votre logement actuel….	*Veuillez donner une réponse pour chaque ligne*		
ont changé : le logement n'en disposait pas, ou elles n'étaient pas importantes pour vous avant (e.g., la distance des crèches).		1	Pas du tout d'accord
		2	Pas d'accord
		3	Ni en désaccord ni d'accord
		4	D'accord
		5	Tout à fait d'accord
se sont améliorées en qualité (e.g., meilleure vue, plus d'espace).		same as md1_1	
ont résolu un problème (e.g., réduit la distance du travail, réduit le loyer).		same as md1_1	
Étiez-vous propriétaire ou locataire de votre logement précédent, ou viviez-vous avec vos parents ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Propriétaire
		2	Locataire
		3	Avec les parents
		4	Autre, veuillez préciser dans le champ ci-dessous: __________
Louiez-vous votre logement précédent auprès de la même coopérative / du même propriétaire ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Oui, dans le même bâtiment
		2	Oui, dans un autre bâtiment
		3	Non
		99999	Je ne sais pas
Combien de personnes vivaient dans votre ménage précédent (vous y compris) quand vous avez déménagé ?	*Vous ne pouvez donner qu'une réponse à cette question*	— —	
Quel était le montant mensuel du loyer de votre **logement précédent**, charges comprises ? Si vous viviez en colocation, veuillez indiquer le loyer de votre chambre. *Si vous ne le savez pas précisément, essayez de donner une estimation.*	*Vous ne pouvez donner qu'une réponse à cette question*	— — — — — CHF/mois	
		99998	Je ne souhaite pas répondre à cette question

Quel est le montant mensuel de votre **loyer actuel**, charges comprises ?	*Vous ne pouvez donner qu'une réponse à cette question*	— — — — — CHF/mois	
		99998	Je ne souhaite pas répondre à cette question
Quel est le nombre de pièces de **votre logement actuel**, à l'exclusion de la salle de bain et des toilettes ? *Une cuisine habitable d'au moins 4 m2 compte comme une pièce, les pièces combinées "cuisine et salle à manger" comptent comme une pièce.*	*Vous ne pouvez donner qu'une réponse à cette question*	1	1-1,5
		2	2-2,5
		3	3-3,5
		4	4-4,5
		5	5-5,5
		6	6
		7	7
		8	8
		9	9
		10	10 +
Quel était le nombre de pièces de **votre précédent logement**, à l'exclusion de la salle de bain et des toilettes ? *Une cuisine habitable d'au moins 4 m2 compte comme une pièce, les pièces combinées "cuisine et salle à manger" comptent comme une pièce.*	*Vous ne pouvez donner qu'une réponse à cette question*	same as dc_7	
Quelle est la superficie en mètres carrés de **votre logement actuel**. *Si vous ne le savez pas précisément, essayez de donner une estimation.*	*Vous ne pouvez donner qu'une réponse à cette question*	__ __ __ __ m2	
Quelle était la superficie en mètres carrés de **votre logement précédent**. *Si vous ne le savez pas précisément, essayez de donner une estimation.*	*Vous ne pouvez donner qu'une réponse à cette question*	__ __ __ __ m2	
Gardez-vous une ou plusieurs chambres pour les personnes qui habitent en dehors de votre foyer (p. ex. membres de la famille, invités, enfants ne vivant plus toute la semaine chez vous...) ?	*Vous ne pouvez donner qu'une réponse à cette question.*	1	Oui
		2	Non
Déménagement_Décision			
Dans cette section, nous allons vous poser des questions concernant votre décision de quitter votre ancien logement. Essayez de répondre en accord avec ce que vous pensiez au moment où vous avez décidé de déménager (ce qui peut différer d'aujourd'hui).			

Dans quelle mesure êtes-vous d'accord avec les énoncés suivants concernant la période précédant votre décision de déménager ?	***Veuillez donner une réponse pour chaque ligne***		
À l'époque, je pensais que le déménagement allait me permettre d'améliorer certaines caractéristiques de mon logement (p. ex., emplacement, taille, balcon) .		1	Pas du tout d'accord
		2	Pas d'accord
		3	Ni en désaccord ni d'accord
		4	D'accord
		5	Tout à fait d'accord
Améliorer les caractéristiques de mon logement était particulièrement important pour moi.		same as md1_1	
Les personnes qui comptent pour moi, et faisant partie de mon foyer (mon partenaire, mon (mes) enfant(s) ou mes parents) pensaient que je devais/nous devions déménager.		same as md1_1	
Les personnes qui comptent pour moi en dehors de mon foyer (membres de la famille, collègues, amis, voisins, etc.) ou mes colocataires pensaient que je devais déménager.		same as md1_1	
Au sujet de la décision de quitter mon ancien domicile, je tenais à faire ce que les personnes qui comptent pour moi, et faisant partie de mon foyer, pensaient que je devais/nous devions faire.		same as md1_1	
Au sujet de la décision de quitter mon ancien domicile, je tenais à faire ce que les personnes qui comptent pour moi en dehors de mon foyer ou mes colocataires pensaient que je devais faire.		same as md1_1	
J'étais confiant(e) d'avoir assez de temps libre à disposition pour le déménagement.		same as md1_1	
J'étais sûr(e) de pouvoir faire face à des difficultés administratives et/ou pratiques (contrat, déménagement du mobilier).		same as md1_1	
Comment qualifierez-vous votre intention de quitter votre ancienne maison, à l'époque?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Très faible
		2	Faible
		3	Ni faible ni forte
		4	Forte
		5	Très forte

Emménagement_Décision			
Dans cette section, nous allons vous poser des questions concernant votre choix de votre logement actuel. Il est possible que vous n'ayez eu qu'un seul choix, mais vous avez néanmoins décidé d'y déménager pour des raisons spécifiques. Veuillez essayer de répondre conformément à ce que vous avez pensé au moment de faire ce choix.			
Dans quelle mesure êtes-vous d'accord avec les énoncés suivants concernant le moment du choix de votre logement actuel ?	***Veuillez donner une réponse pour chaque ligne***		
Je savais qu'en choisissant cet appartement, j'allais améliorer ma satisfaction à l'égard de mon logement.		1	Pas du tout d'accord
		2	Pas d'accord
		3	Ni en désaccord ni d'accord
		4	D'accord
		5	Tout à fait d'accord
Améliorer mon niveau de satisfaction à l'égard de mon logement était particulièrement important pour moi.		same as sd1_1	
Je savais que l'appartement choisi me permettrait de résoudre mon problème **[# item selected in ms4].**		same as sd1_1	
Pour moi, résoudre le problème **[# item selected in ms4]** était particulièrement important.		same as sd1_1	
Je savais que l'appartement choisi correspondrait à ma nouvelle vie.		same as sd1_1	
Pour moi, vivre dans un logement qui correspond à ma vie (en lien avec ma réponse **[# item selected in ms4]**) était particulièrement important.		same as sd1_1	
Les personnes qui comptent pour moi, et faisant partie de mon foyer (mon partenaire, mon (mes) enfant(s) ou mes parents) pensaient que je devais/nous devions choisir cet appartement.		same as sd1_1	
Les personnes qui comptent pour moi en dehors de mon foyer (membres de la famille, collègues, amis, voisins) ou mes colocataires pensaient que je devais choisir cet appartement.		same as sd1_1	
Je tenais à choisir l'appartement que les personnes qui comptent pour moi, et faisant partie de mon foyer, pensaient que je devais/nous devions choisir.		same as sd1_1	

Je tenais à choisir l'appartement que les personnes qui comptent pour moi en dehors de mon foyer ou mes colocataires pensaient que je devais choisir.		same as sd1_1	
J'étais sûr(e) d'être accepté(e) par la régie ou coopérative.		same as sd1_1	
J'étais sûr(e) d'avoir choisi l'offre la plus proche de mes souhaits disponible sur le marché.		same as sd1_1	
Comment qualifierez-vous votre intention de choisir le logement actuel ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Très faible
		2	Faible
		3	Ni faible ni forte
		4	Forte
		5	Très forte
Combien de logements avez-vous visité avant de choisir votre logement actuel ?	*Vous ne pouvez donner qu'une réponse à cette question*	— — —	
		51	50+
Combien de temps avez-vous cherché votre logement ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Moins de 3 mois
		2	Entre 3 et 6 mois
		3	Plus de 6 mois
Dans l'ensemble, dans quelle mesure êtes-vous satisfait(e) de votre logement actuel ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Très insatisfait(e)
		2	Plutôt insatisfait(e)
		3	Ni satisfait(e), ni insatisfait(e)
		4	Plutôt satisfait(e)
		5	Très satisfait(e)
Avez-vous l'impression que vous changerez de logement, volontairement ou pas, au cours des 5 prochaines années ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Oui - le ménage sera forcé de quitter le logement
		2	Oui - le ménage prévoit de changer de logement
		3	Peut-être - le ménage pourrait prévoir de changer de logement
		4	Non - le ménage ne prévoit pas de changer de logement
		99998	Je ne souhaite pas répondre à cette question

Quelle en serait la raison ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Une opportunité d'améliorer les caractéristiques de mon logement
		2	Un problème à résoudre
		3	Un changement radical dans ma vie
		99998	Je ne souhaite pas répondre à cette question
		99999	Je ne sais pas encore
Dans quelle mesure seriez-vous prêt(e) à déménager si la taille de votre ménage augmentait ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Pas du tout prêt(e)
		2	Pas prêt(e)
		3	Neutre
		4	Prêt(e)
		5	Tout à fait prêt(e)
Pourquoi ne seriez-vous pas prêt(e) ?	*Veuillez indiquer min. une raison (une phrase au maximum)*	Raison 1 : ___________ Raison 2 : ___________	
Qu'est-ce qui pourrait vous empêcher dans ce cas de déménager ?	*Veuillez indiquer min. une raison (une phrase au maximum)*	same as sd10a	
Dans quelle mesure seriez-vous prêt(e) à déménager si la taille de votre ménage diminuait ?	*Vous ne pouvez donner qu'une réponse à cette question*	same as sd10	
Pourquoi ne seriez-vous pas prêt(e) ?	*Veuillez indiquer min. une raison (une phrase au maximum)*	same as sd10a	
Qu'est-ce qui pourrait vous empêcher dans ce cas de déménager ?	*Veuillez indiquer min. une raison (une phrase au maximum)*	same as sd10a	
Durabilité			
Est-ce que votre logement actuel comporte les caractéristiques durables suivantes ?	*Veuillez marquer toutes les caractéristiques*	1	Standard Minergie
		2	Standard LEED
		3	Minergie P
		4	Matériaux ou éléments de construction recyclés
		5	Façade verte

		6	Énergie renouvelable
		7	Bonne performance énergétique (par ex., systèmes passifs de chauffage ou climatisation)
		8	Aucun
		9	Je ne sais pas
		10	Autre, veuillez préciser dans le champ ci-dessous: __________
Ces caractéristiques étaient-elles un critère dans votre choix de logement ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Oui, toutes
		2	Oui, certaines
		3	Non
Pourquoi votre logement actuel ne comporte aucune caractéristique durable ?	*Pour cette question, vous pouvez donner plusieurs réponses*	1	Je n'y avais pas pensé
		2	La durabilité n'était pas une priorité pour moi : J'avais besoin de trouver un appartement, qu'il soit durable ou pas
		3	Je n'étais pas intéressé(e) par la durabilité
		4	Je m'intéressais au thème de la durabilité, mais il n'y avait aucune offre sur le marché
		5	Les logements durables sur le marché ne répondaient pas à mes préférences (animation du quartier, prix, style, confort, liberté ou contrôle)
		6	Les logements durables sont chers
		7	Autre
Style de vie			
Dans quelle mesure les descriptions suivantes s'appliquent-elles à vous personnellement ?	***Veuillez donner une réponse pour chaque ligne***		
Je jouis d'un niveau de vie élevé		4	Tout à fait vrai
		3	Assez vrai
		2	Assez faux
		1	Tout à fait faux

Je sors souvent		4; 3; 2; 1	
Je me conforme à des principes religieux		1; 2; 3; 4	
Je tiens aux traditions de ma famille		1; 2; 3; 4	
Je profite pleinement de la vie		4; 3; 2; 1	
J'aime mieux ma vie lorsque je suis très occupé		4; 3; 2; 1	
À quelle fréquence vous consacrez-vous aux loisirs suivants ?	***Veuillez donner une réponse pour chaque ligne***		
Visiter des expositions artistiques ou des galeries		4	Souvent
		3	Parfois
		2	Rarement
		1	Jamais
Lire des livres		same as L_A2	
À quelle fréquence lisez-vous un quotidien suprarégional comme le "24 Heures"?	*Vous ne pouvez donner qu'une réponse à cette question*	same as L_A2	
Si vous allez manger un très bon repas au restaurant, combien de francs suisses dépensez-vous par personne au maximum, boissons comprises ?	*Vous ne pouvez donner qu'une réponse à cette question*	____CHF	≤40 CHF = 1 41-80 CHF = 2 81-100 CHF = 3 ≥101 CHF = 4
		99991	Je ne vais jamais au restaurant
		99999	Ne sais pas
Combien d'heures par jour êtes-vous habituellement à la maison ? *Essayez de donner une estimation d'un jour ordinaire de la semaine (Lundi-Vendredi), y compris la nuit.*	*Vous ne pouvez donner qu'une réponse à cette question*	— — heures/jour	
Locataire_Personnel_2			
Combien de voitures possédez-vous dans votre foyer ?	*Vous ne pouvez donner qu'une réponse à cette question*	— —	
Combien de places de parking louez-vous actuellement ?	*Vous ne pouvez donner qu'une réponse à cette question*	— —	
Êtes-vous propriétaires ou locataires d'un autre logement en Suisse ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Oui, propriétaire
		2	Oui, locataire
		3	Non
		99998	Je ne souhaite pas répondre à cette question

Quelle est votre situation professionnelle actuelle ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Activité à plein temps (80-100%)
		2	Activité à temps partiel (moins que 80%)
		3	Femme/homme au foyer à plein temps
		4	En formation (avec un emploi rémunéré pour moins d'un jour par semaine)
		5	Actuellement sans emploi
		6	À la retraite
		99998	Je ne souhaite pas répondre à cette question
À combien s'élève le salaire annuel brut de votre ménage ? Les familles et les couples vivant ensemble sont priés d'indiquer le revenu total, toutefois les colocataires sont priés d'indiquer uniquement leur propre revenu.	*Vous ne pouvez donner qu'une réponse à cette question*	1	Moins de 60 000 CHF/an (< 5 000 CHF/Mois)
		2	60 001 – 88 000 CHF/an (5 000 – 7 333 CHF/Mois)
		3	88 001 – 120 000 CHF/an (7 334 – 10 000 CHF/Mois)
		4	120 001 – 164 999 CHF/an (10 001 – 13 749 CHF/Mois)
		5	Plus de 165 000 CHF/an (plus de 13 750 CHF/Moi
		99998	Je ne souhaite pas répondre à cette question
Versez-vous une pension alimentaire ou une contribution au budget d'une ou plusieurs personne(s) ne vivant pas avec vous ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Oui
		2	Non
Est-ce que vous ou l'un des membres de votre ménage possède un permis C ou la nationalité suisse ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	Oui
		2	Non
		99998	Je ne souhaite pas répondre à cette question
À quel endroit avez-vous davantage le sentiment d'appartenir culturellement ? (s'il y a plusieurs endroits, pensez au prédominant)	*Vous ne pouvez donner qu'une réponse à cette question*	1	Suisse
		2	Autre, Europe

		3	Autre, hors Europe
		4	Aucun / Tous
		99999	Je ne sais pas
		99998	Je ne souhaite pas répondre à cette question
Quel est le plus haut niveau de formation que vous avez achevé ?	*Vous ne pouvez donner qu'une réponse à cette question*	1	École obligatoire inachevée
		2	École obligatoire
		3	École professionnelle ou école de commerce, Diplôme de commerce, École de culture générale, École de degré diplôme, Maturité professionnelle ou similaire
		4	Gymnase, maturité gymnasiale
		5	Diplôme d'une Haute École ou d'une Haute École Spécialisée (Bachelor/Master)
		6	Doctorat
		7	Autre
		99998	Je ne souhaite pas répondre à cette question
Souhaitez-vous faire une remarque sur le questionnaire, l'étude ou le thème du logement ?		___________	OPEN TEXT
		2	Non
Si vous souhaitez être informé(e) des résultats de cette enquête, veuillez inscrire votre adresse e-mail dans le champs ci-dessous :		___________	OPEN TEXT
		2	Non
Nous sommes arrivés au terme de ce questionnaire. Nous vous remercions chaleureusement pour votre collaboration et pour avoir pris le temps de répondre à nos questions. **Pour plus d'informations concernant le projet, veuillez consulter le lien suivant: L'empreinte environnementale des habitations**	(link to website project)		

C.

Survey report for the owners

Die Mieter*innen der Schweizer Mobiliar: Resultate einer Umfrage

Shrinking Housing's Environmental Footprint

SHEF

École Polytechnique Fédérale de Lausanne

Februar 2021

School of
Architecture,
Civil and
Environmental
Engineering

Die Umfrage wurde durchgeführt im Rahmen des Projekts SHEF Shrinking Housing's Environmental Footprint

EPFL ETH zürich

Finanziert durch:

FNSNF Swiss National Science Foundation

73 NRP Sustainable Economy National Research Programme

Projektpartner:

ABZ

SCHL Société Coopérative d'Habitation Lausanne

die Mobiliar

Konzeption der Umfrage: SHEF - Prof. Dr. Philippe Thalmann; Prof. Dr. Claudia Binder; Prof. Dr. Stefanie Hellweg; Margarita Agriantoni; Anna Pagani; Rhythima Shinde

Durchführung: LINK Institut für Markt- und Sozialforschung

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EPFL

Vorwort

Der Wohnsektor ist für ein Viertel des Energieverbrauchs und der CO_2-Emissionen der Schweiz verantwortlich (Internationale Energieagentur, 2018). Um den ökologischen Fussabdruck des Wohnens zu reduzieren, wurden neue Technologien, Vorschriften und Instrumente entwickelt. Diese Massnahmen allein sind jedoch nicht ausreichend. Ihr Erfolg hängt davon ab, wie sie mit den gegenwärtigen und zukünftigen Bedürfnissen aller Beteiligten in Einklang gebracht werden können.

Im diesem Zusammenhang untersucht das Forschungsprojekt «Shrinking Housing's Environmental Footprint» (SHEF), unterstützt vom Schweizerischen Nationalfonds und dem Nationalen Forschungsprogramm NFP73, Massnahmen zur Reduzierung des Ressourcenverbrauchs im Wohnraum, indem verschiedene Ansätze für Bewohner*innen, Gebäudeeigentümer*innen und Behörden entwickelt werden.

Die Sicherstellung einer nachhaltigen Wohnraumversorgung erfordert ein ganzheitliches Verständnis der Wechselwirkung zwischen Nachfrage und Angebot im Laufe der Zeit. Diese Wechselwirkung kann im Rahmen der Wohnmobilität untersucht werden, da die Haushalte ihre Wohnbedürfnisse mit den auf dem Markt verfügbaren Wohnungen abgleichen.

Zum besseren Verständnis der Wohnmobilität, und um effektive und konsensfähige nachhaltige Wohnlösungen entwerfen zu können, wurde von September bis November 2019 eine Umfrage mit Mieter*innen der Genossenschaften ABZ und SCHL und der Liegenschaften der Schweizer Mobiliar durchgeführt. Die drei genannten Immobilieneigentümer*innen sind Partner*innen des Forschungsprojektes und haben die Umfrage finanziell unterstützt.

Von insgesamt 3020 kontaktierten Mieter*innen wurden 968 Fragebögen ausgefüllt, was einer Teilnahmequote von 32% entspricht. Die Befragten und die Teilnahmequote sind wie folgt verteilt: 384 SCHL (46%), 327 ABZ (30%), 117 Mobiliar (deutschsprachiger Teil; 21%), 140 Mobiliar (französischsprachiger Teil, 25%).

Bei der Untersuchung der Wohnmobilität der Mieter*innen sollen drei Elemente berücksichtigt werden: 1) ihre Präferenzen (für die aktuelle oder künftige Wohnung), 2) die Gründe für den Umzug und 3) der Grad ihrer Zufriedenheit. Diese Elemente beeinflussen sich gegenseitig, werden aber auch von den soziodemografischen Merkmalen des Haushalts (Alter, Gehalt, Bildungsniveau) beeinflusst. In diesem Zusammenhang trägt die Umfrage insbesondere zur Beantwortung folgender Fragen bei:

*Wer sind die Mieter*innen?*
Weshalb entscheiden sie sich für einen Umzug? Anhand welcher Kriterien wählen sie ihre neue Wohnung? Sind Nachhaltigkeitsmerkmale für ihre Entscheidung relevant?

Das vorliegende Dokument soll Ihnen einen Überblick über die wichtigsten Resultate der Umfrage verschaffen und es Ihnen ermöglichen, etwas über die Entscheidungen Ihrer Mieter*innen zu lernen. Um allfällige Unterschiede im Vergleich mit den Bewohner*innen der anderen Eigentümer*innen festzustellen, werden im folgenden Bericht die Resultate Ihrer Mieter*innen und jene der Gesamtheit der Befragten jeweils separat ausgewiesen.

1. Beschreibung der Mieter*innen
2. Wohnpräferenzen
3. Umzugsverhalten
4. Nachhaltigkeit

Wir wünschen Ihnen eine anregende Lektüre.

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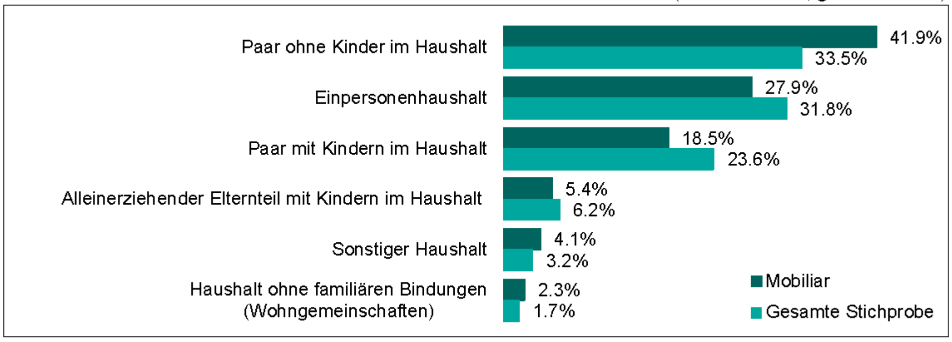
1. Beschreibung der Mieter*innen

Im ersten Teil der Umfrage ging es darum, die soziodemographischen Eigenschaften der Studienteilnehmenden zu erheben.

Die Resultate in Abbildung 1 zeigen, dass bei der Mobiliar sowie in der gesamten Stichprobe Paare ohne Kinder die häufigste und Einpersonenhaushalte die zweithäufigste Haushaltskonstellation darstellen. Alleinerziehende Elternteile sowie Wohngemeinschaften und sonstige Haushaltsformen sind vergleichsweise selten vertreten.

«In 66% der Haushalte bei der Mobiliar ist mindestens eine Person **Schweizer Nationalität** oder besitzt einen **Ausweis C**. Bei der Gesamtheit der befragten Mieter*innen sind dies 72%.»

Abbildung 1:
Haushaltskonstellationen
(Mobiliar: n=222; gesamt: n=809)



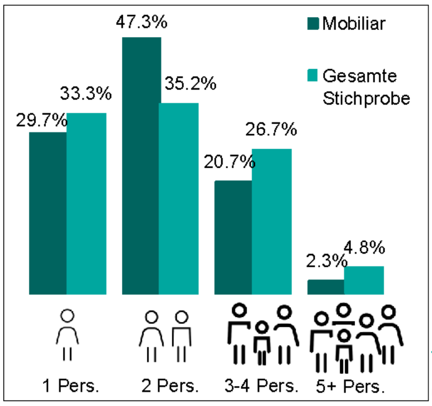


Abbildung 2:
Haushaltsgrössen
(Mobiliar: n=222; gesamt: n=809)

Entsprechend sind auch die Haushaltsgrössen in Abbildung 2 verteilt. Bei der Mobiliar sind am häufigsten Zweipersonenhaushalte anzutreffen, wobei der Anteil von 47% deutlich höher ist als bei der Gesamtheit. Dafür ist der Anteil an Haushalten mit einer oder drei bis vier Personen bei Mieter*innen der Mobiliar geringer als in der gesamten Stichprobe. Generell sind Haushalte mit fünf oder mehr Mitgliedern selten vertreten.

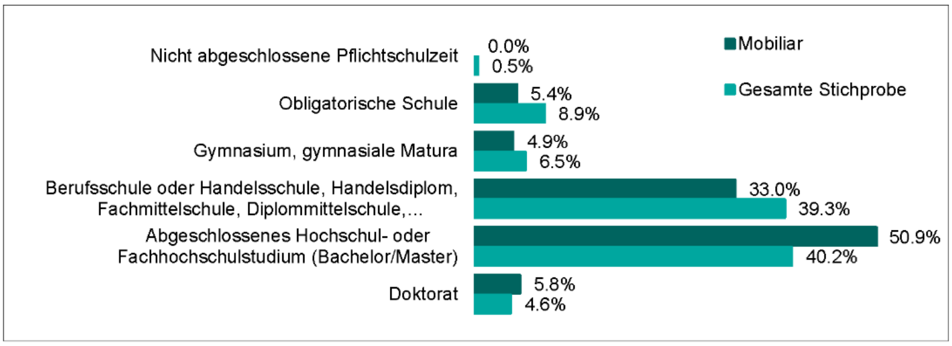


Abbildung 3:
Höchster Bildungsabschluss der*des Befragten
(Mobiliar: n=224; gesamt: n=811)

Bezüglich Bildungsniveau weisen die Hälfte der Mieter*innen der Mobiliar ein abgeschlossenes Hochschul- oder Fachhochschulstudium vor und ein Drittel eine höhere Berufsausbildung (vgl. Abbildung 3). Der Anteil Mieter*innen mit einer höheren Berufsausbildung oder höherem Bildungsniveau ist bei der Mobiliar geringfügig grösser als in der gesamten Stichprobe.
Bei der Mobiliar wohnhafte Haushalte sind, verglichen mit jenen der Gesamtstichprobe, häufiger in den höheren Einkommenskategorien und entsprechend weniger häufig in den tieferen Kategorien vertreten (vgl. Abbildung 4). Knapp 62% der Mieter*innen der Mobiliar haben ein jährliches Haushaltseinkommen von CHF 88'000 oder höher, wobei dies in der Gesamtstichprobe lediglich rund 37% ausmacht.

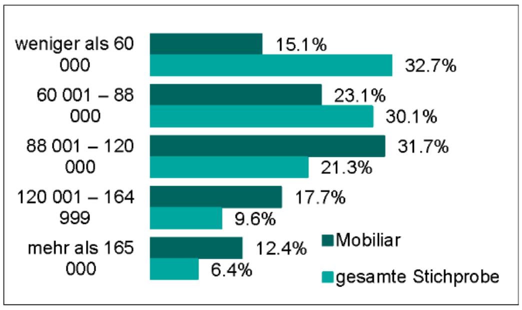


Abbildung 4:
Haushaltseinkommen in CHF/Jahr
(Mobiliar: n=186; gesamt: n=701)

Abbildung 5:
Lebensführungstypologien
(Mobiliar: n=237)

#1	Aufstiegsorientierte	27.8%
#2	Hedonist*innen	19.8%
#3	Heimzentrierte	16.0%
#9	Konservativ Gehobene	0.8%

Abbildung 5 zeigt die bei Mieter*innen der Mobiliar am häufigsten bzw. am seltensten vertretenen von neun Lebensführungs-typologien. Diese Typologien wurden anhand spezifischer Fragen zum Lebensstil gemäss Gunnar Otte (2004)[1] konstruiert. Knapp ein Drittel der Teilnehmenden kann als «aufstiegsorientiert» beschrieben werden und weitere 20% als «Hedonist*innen».

[1]Gunnar Otte (2004) Sozialstrukturanalysen mit Lebensstilen, VS Verlag für Sozialwissenschaften, Wiesbaden.

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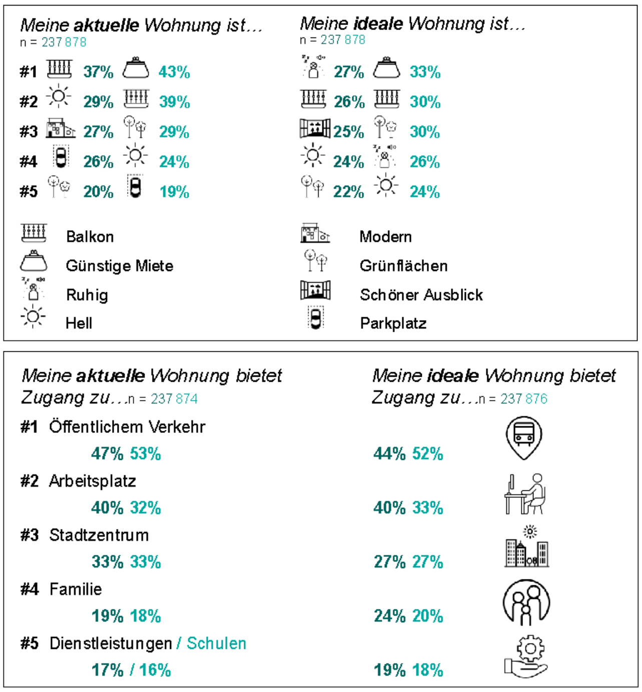
2. Wohnpräferenzen



«Die ideale Wohnung für Mieter*innen der Mobiliar ist **ruhig**, hat einen **Balkon** und einen schönen **Ausblick**. Die Lage, in einem **sicheren** Quartier, sollte eine gute Anbindung an **öffentliche Verkehrsmittel** und den **Arbeitsplatz** aufweisen.»

Abbildung 6:
Bevorzugte Eigenschaften der aktuellen und einer idealen Wohnung; aufgelistet sind jeweils die drei meistgenannten Eigenschaften mit dem Anteil der Befragten, die diese ausgewählt haben (zwei oder drei Antworten möglich).
Mobiliar; gesamte Stichprobe

Die bevorzugten Eigenschaften der aktuellen und einer idealen Wohnung wurden anhand eines Merkmalkatalogs erhoben. Die Befragten konnten jeweils die zwei bis drei für sie wichtigsten Merkmale auswählen. Abbildung 6 und Abbildung 7 zeigen die jeweils meistgenannten Eigenschaften in Bezug auf die Wohnung selbst, deren Vernetzung und das umliegende Quartier.

Die Resultate in Abbildung 6 lassen erkennen, dass bezüglich Wohnungseigenschaften die Elemente Balkon, hell und Grünflächen bei Mieter*innen der Mobiliar erwünscht und in der aktuellen Wohnung auch vorhanden sind. Ruhe und ein schöner Ausblick hingegen sind oft erwünscht aber nicht ebenso oft vorhanden, während ein Parkplatz bei der aktuellen Wohnung an vierter Stelle steht, bei einer idealen Wohnung jedoch eine weniger grosse Wichtigkeit einnimmt. Im Vergleich mit der gesamten Stichprobe ist auffällig, dass eine günstige Miete bei Bewohner*innen der Mobiliar nicht unter den fünf wichtigsten Wohnungseigenschaften erscheint. Hinsichtlich Vernetzung der Wohnung ist die aktuelle Situation der Mieter*innen nahe ihrer idealen und werden bei der Mobiliar die selben Eigenschaften bevorzugt wie beim Rest der Mieterschaft.

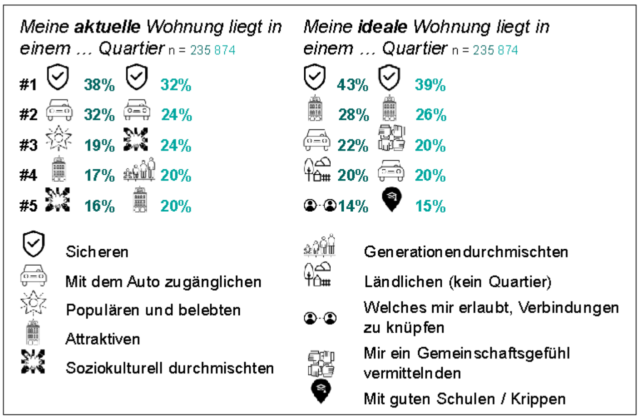
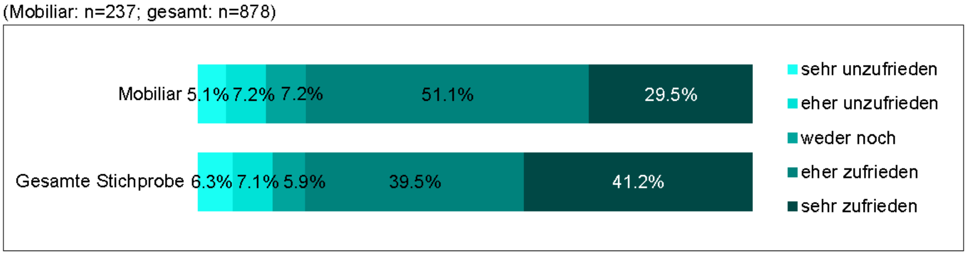


Abbildung 7:
Bevorzugte Eigenschaften der aktuellen und einer idealen Wohnung; aufgelistet sind jeweils die drei meistgenannten Eigenschaften mit dem Anteil der Befragten, die diese ausgewählt haben (zwei oder drei Antworten möglich)
Mobiliar; gesamte Stichprobe

Bezüglich des Wohnquartiers geniessen Sicherheit, Attraktivität und Zugänglichkeit mit dem Auto bei allen Mieter*innen eine hohe Wichtigkeit und sind bei den aktuellen Wohnungen auch gegeben (vgl. Abbildung 7). Bei den Bewohner*innen der Mobiliar besteht eine Vorliebe für Wohnungen in einer ländlichen Gegend oder einem Quartier, welches das Knüpfen von Verbindungen erlaubt. Diese Eigenschaften spiegeln sich allerdings nicht in den aktuellen Wohnungen wider. Bei den übrigen Mieter*innen besteht weiter ein Bedürfnis nach einem Gemeinschaftsgefühl im Quartier und nach guten Schulen oder Krippen.

Insgesamt besteht trotz gewisser Abweichungen der aktuellen von einer idealen Wohnsituation eine hohe Wohnzufriedenheit. Sowohl bei der Mobiliar als auch in der Gesamtstichprobe sind 81% der Mieter*innen eher oder sehr zufrieden mit ihrer jetzigen Wohnsituation (vgl. Abbildung 8).

Abbildung 8:
Zufriedenheit mit der aktuellen Wohnsituation
(Mobiliar: n=237; gesamt: n=878)



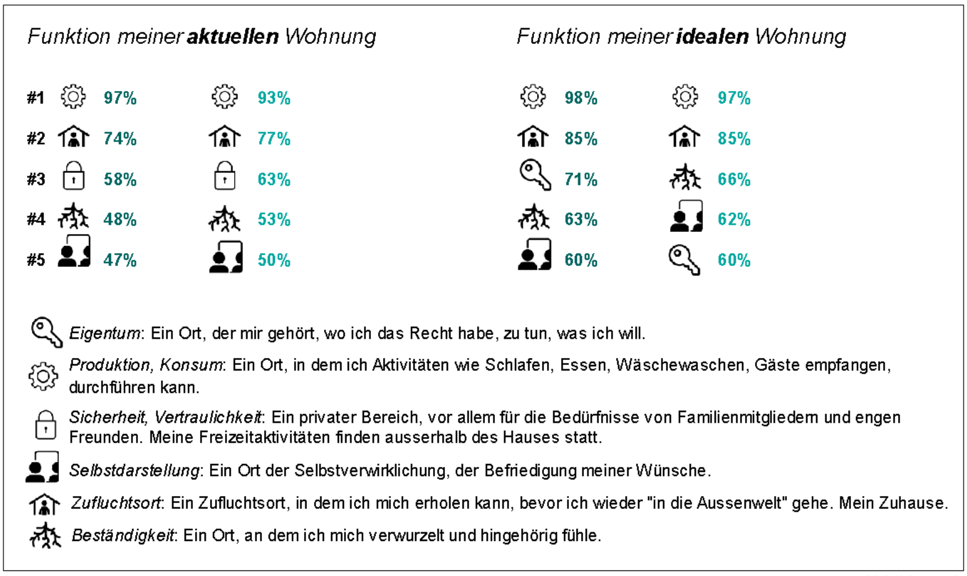


Abbildung 9:
Die fünf meistgenannten Funktionen der aktuellen und einer idealen Wohnung; die Prozentzahlen entsprechen dem Anteil der Befragen, die (absolut) einverstanden mit der Definition einer Funktion für ihre Wohnung waren (Mobiliar: n=237; gesamt: n=878).

Im Rahmen des Forschungsprojekt SHEF hat Anna Pagani (HERUS, EPFL) erstmals neun *Funktionen*, die Wohnungen erfüllen können, bestimmt. Dafür hat sie sich auf Fachliteratur und zwei Gruppendiskussionen mit Mieter*innen aus Zürich und Lausanne gestützt. In der hier beschriebenen Umfrage konnten die Teilnehmenden für jede Funktion auf einer Skala von eins bis fünf angeben, in welchem Ausmass ihre aktuelle bzw. ideale Wohnung diese Funktion erfüllt bzw. erfüllen soll.

Wie in Abbildung 9 ersichtlich, sind die Funktionen *Produktion und Konsum* und *Zufluchtsort* für eine grosse Mehrheit aller Studienteilnehmenden von Bedeutung, wobei diese von der aktuellen Wohnung auch erfüllt werden. Ebenfalls häufig erwünscht sind die Funktionen *Eigentum*, *Beständigkeit* und *Selbstdarstellung*, wobei *Eigentum* von den aktuellen Wohnungen in geringerem Masse erfüllt wird.

3. Umzugsverhalten

«Die Mieter*innen der Mobiliar bzw. die Gesamtheit der befragten Mieter*innen, sind in den letzten zehn Jahren im Schnitt 3.1 bzw. 2.5 mal **umgezogen** und **wohnen** seit 7.6 bzw. 9.8 Jahren in ihrer aktuellen Wohnung.»

In diesem Teil wird das Umzugsverhalten der Mieter*innen beschrieben, das anhand verschiedener Fragen erhoben wurde.

Abbildung 10 zeigt verschiedene Gründe für den letzten Wohnungswechsel. Bei deren Betrachtung sticht heraus, dass Bewohner*innen der Mobiliar im Vergleich mit der Gesamtheit deutlich häufiger aufgrund eines Wechsels der Arbeitsstelle, eines Zusammenzugs mit dem*r Partner*in oder einer ungemütlichen Wohnsituation umgezogen sind. Bei einem Grossteil aller Studienteilnehmenden hat die Suche nach der aktuellen Wohnung weniger als drei Monate gedauert (vgl. Abbildung 11). Die Wohnungssuche hat bei Mieter*innen der Mobiliar tendenziell weniger lange gedauert als bei der Gesamtheit.

Abbildung 10:
Grund für den letzten Wohnungswechsel; die sieben häufigsten Gründe werden separat ausgewiesen während die übrigen, selteneren Gründe unter *Andere* zusammengefasst werden (Mobiliar: n=232; gesamt: n=863).

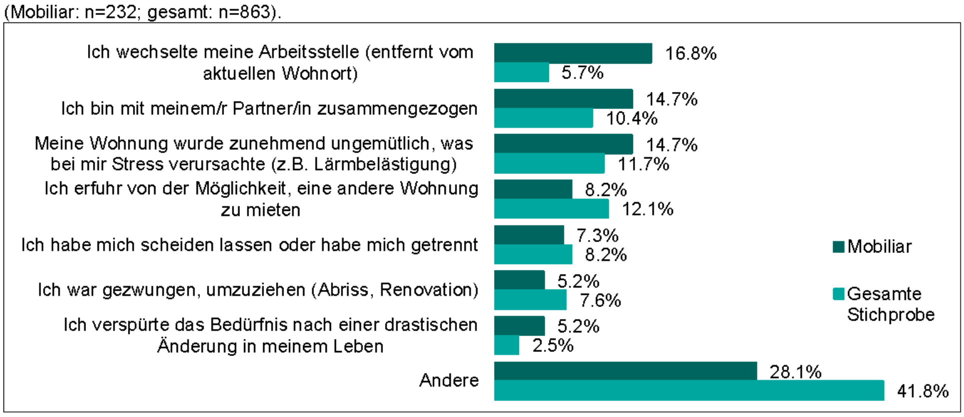


Abbildung 11:
Dauer der Suche nach der aktuellen Wohnung (Mobiliar: n=237; gesamt: n=878)

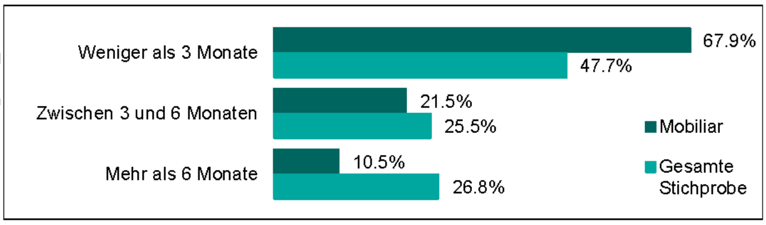


Abbildung 12 illustriert die Umzugsabsichten der Studienteilnehmenden für die nächsten fünf Jahre. Generell ist ersichtlich, dass eine Minderheit klare Umzugsabsichten hegt. Bei Mieter*innen der Mobiliar ist jedoch der Anteil geplanter Wohnungswechsel etwas höher als in der gesamten Stichprobe.

Die verschiedenen Gründe für einen geplanten Wohnungswechsel und deren Häufigkeit sind in Abbildung 13 dargestellt. Dabei sind gewisse Unterschiede zwischen den Mieter*innen der Mobiliar und der Gesamtheit festzustellen. Erstere beabsichtigen häufiger, die Wohnung aufgrund einer Möglichkeit, deren Eigenschaften zu verbessern, zu wechseln, jedoch seltener, um ein Problem zu lösen.

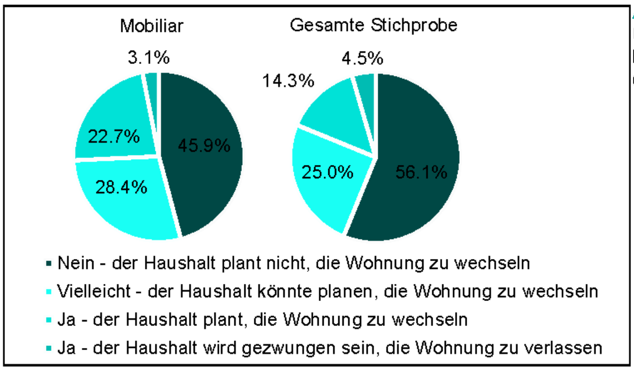


Abbildung 12:
Umzugsabsichten in den kommenden 5 Jahren
(Mobiliar: n=229; gesamt: n=839)

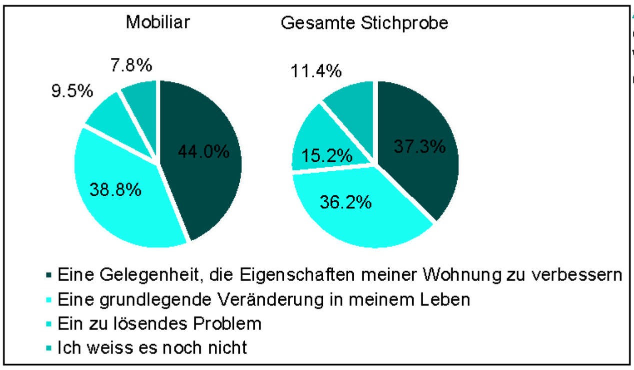
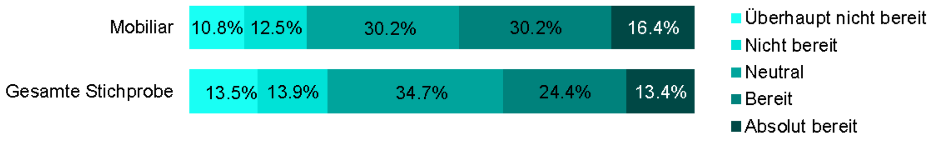


Abbildung 13:
Grund für einen zukünftigen Wohnungswechsel
(Mobiliar: n=116; gesamt: n=343)

Im Hinblick auf eine angemessene Belegungsdichte von Wohnungen wurden die Studienteilnehmenden nach ihrer Umzugsbereitschaft im Falle einer Änderung ihrer Haushaltsgrösse gefragt.

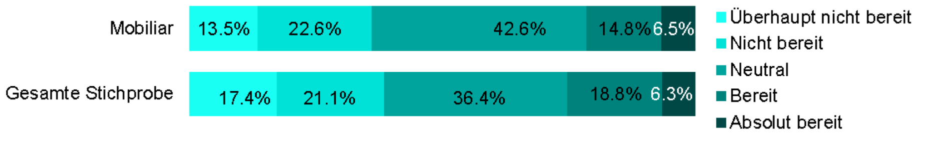
Die Resultate in Abbildung 14 und Abbildung 15 zeigen, dass sowohl im Falle einer Vergrösserung als auch einer Verkleinerung des Haushalts mehr als ein Drittel aller befragten Haushalte unschlüssig über einen Umzug ist. Dennoch ist die Umzugsbereitschaft bei einem wachsenden Haushalt grösser als bei einem schrumpfenden Haushalt. Weiter ist zu erkennen, dass Mieter*innen der Mobiliar in ersterem Falle eher gewillt sind umzuziehen als die übrigen Mieter*innen. In beiden Fällen ist die Zufriedenheit mit der aktuellen Wohnsituation der wichtigste Grund für mangelnden Umzugswillen. Des Weiteren entsprechen die aktuellen Platzverhältnisse oftmals bereits den im Falle einer Änderung der Haushaltsgrösse gewünschten.

Abbildung 14:
Bereitschaft umzuziehen, wenn sich der Haushalt vergrösserte (Mobiliar: n=232; gesamt: n=864); Antworten auf die Frage *Warum nicht?* beziehen sich auf Mieter*innen der Mobiliar und umfassen nur die häufigsten genannten Gründe.



Warum nicht? *Ich bin glücklich mit meiner jetzigen Wohnung und deren Lage (47%)*
Aufgrund meines Alters oder gesundheitlicher Situation (18%)
Meine jetzige Wohnung ist bereits gross genug (16%)

Abbildung 15:
Bereitschaft umzuziehen, wenn sich der Haushalt verkleinerte (Mobiliar: n=155; gesamt: n=569); Antworten auf die Frage *Warum nicht?* beziehen sich auf Mieter*innen der Mobiliar und umfassen nur die häufigsten genannten Gründe.



Warum nicht? *Ich bin glücklich mit meiner jetzigen Wohnung und deren Lage (54%)*
Meine jetzige Wohnung ist bereits klein / ich hätte gerne mehr Platz (25%)

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4. Nachhaltigkeit

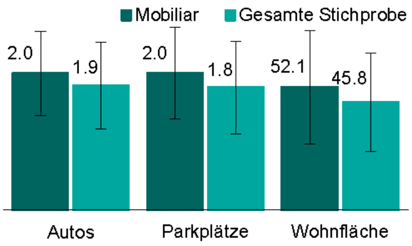


Abbildung 16:
Anzahl Autos und Parkplätze pro Haushalt und Flächenverbrauch pro Kopf [m²/Pers] (Mittelwert und Standardabweichung dargestellt; Mobiliar: n=236; gesamt: n=875)

«Die **bevorzugte Wohnungstemperatur** im Winter ist bei Mieter*innen der Mobiliar im Durchschnitt mit 22.6°C minimal höher als bei der Gesamtheit mit 22.5°C.»

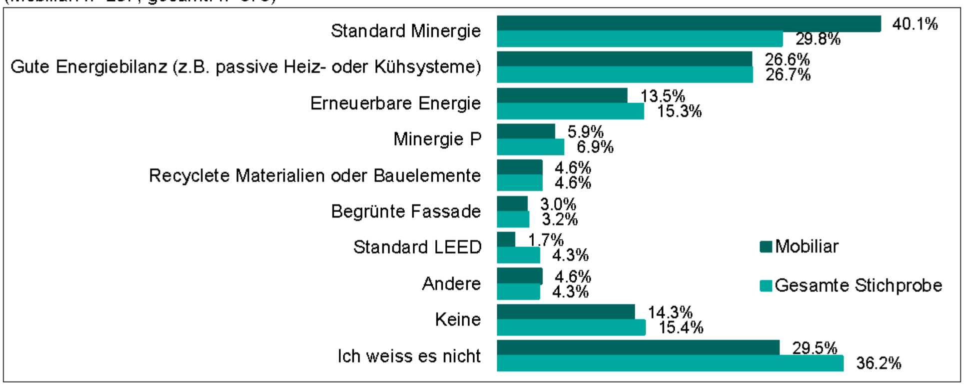
Abbildung 17:
Anteil der Haushalte, deren Wohnung über ein Nachhaltigkeitskriterium verfügt (Mobiliar: n=237; gesamt: n=878)

Abschliessend werden Aspekte der ökologischen Nachhaltigkeit beim Wohnen und deren Rolle in der Entscheidungsfindung der Mieter*innen beleuchtet.

Im Durchschnitt verfügt ein Haushalt über knapp zwei Autos und eine entsprechende Anzahl Parkplätze. Diese Zahl liegt bei Bewohner*innen der Mobiliar leicht höher als bei der Gesamtheit (vgl. Abbildung 16).

Deutlich höher als bei der Gesamtheit fällt bei Bewohner*innen der Mobiliar der durchschnittliche Wohnflächenverbrauch pro Kopf aus. Während erstere knapp 46 m² pro Person in Anspruch nehmen, sind es bei letzteren rund sechs m² mehr.

Wie in Abbildung 17 ersichtlich, sind die häufigsten Nachhaltigkeitsmerkmale der Wohnungen der Befragten der Standard Minergie, eine gute Energiebilanz und der Einsatz von erneuerbarer Energie. Der Standard Minergie wurde bei Wohnungen der Mobiliar deutlich häufiger berichtet; erneuerbare Energie kommt dafür etwas weniger häufig zum Einsatz als bei der Gesamtheit. Auffallend ist, dass ungefähr ein Drittel der gesamten Teilnehmenden nicht über etwaige Nachhaltigkeitsmerkmale ihrer Wohnung Bescheid weiss.



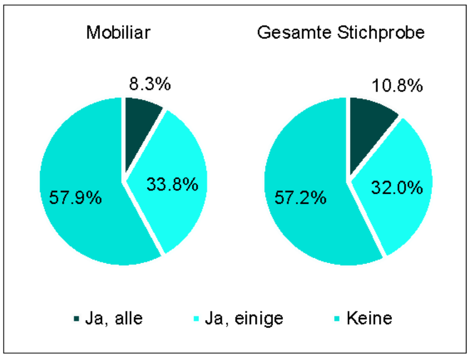
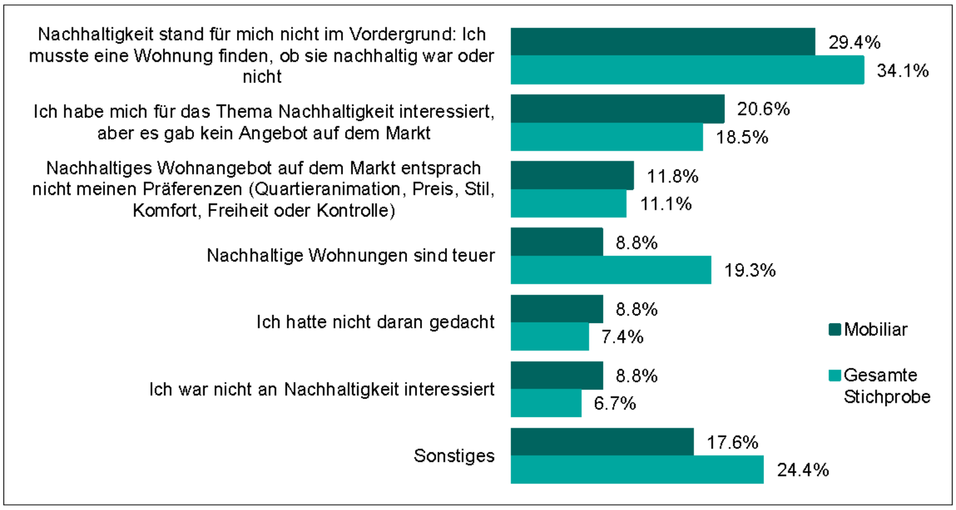


Abbildung 18:
Waren nachhaltige Eigenschaften ein Kriterium in der Wahl Ihrer Wohnung? (Mobiliar: n=133; gesamt: n=425)

Mieter*innen der Mobiliar haben sich beim Einbezug von Nachhaltigkeitskriterien bei der Wohnungswahl gleich verhalten wie die übrigen Befragten. Wie in Abbildung 18 erkennbar, war Nachhaltigkeit in beiden Gruppen mehrheitlich kein Kriterium bei der Wohnungswahl. Nur ein Drittel der Mieter*innen hat gewisse Kriterien berücksichtigt.

Der häufigste Grund, weshalb Nachhaltigkeit nicht in die Entscheidungsfindung miteinbezogen wurde, war die Dringlichkeit, eine Wohnung zu finden, wobei Nachhaltigkeit nicht berücksichtigt werden konnte (vgl. Abbildung 19). Des Weiteren bot der Markt kein passendes Angebot nachhaltiger Wohnungen oder werden solche als teuer empfunden, wobei letzteres in der Gesamtstichprobe deutlich häufiger der Fall war als bei Mieter*innen der Mobiliar.

Abbildung 19:
Warum hat Ihre aktuelle Wohnung keine nachhaltigen Eigenschaften? (Mobiliar: n=34; gesamt: n=135)



EPFL

Schlussfolgerungen

Ziel des Berichts war es, Ihnen einen Überblick über die Elemente zu geben, die im Entscheidungsprozess von Haushalten bezüglich ihrer aktuellen und zukünftigen Wohnsituation eine wichtige Rolle spielen. Die wichtigsten Erkenntnisse lassen sich wie folgt zusammenfassen.

Viele kleine Haushalte.

Aufgrund des demografischen Wandels (Überalterung der Bevölkerung, Scheidungen etc.) sowie des Lebensstils nehmen Einpersonenhaushalte in der Schweiz überhand. Auch in Anbetracht des hohen Anteils von 2-Personen-Haushalten unter den Befragten ist es von grosser Bedeutung, mit einem passenden Angebot kleiner Wohnungen eine Antwort auf diese Entwicklung zu geben. Solche Wohnungen sollten die Bedeutung der Umgebung und der Natur für die Mieter*innen berücksichtigen (Ruhe, Balkon, Aussicht, Grünflächen, ländliche Gegend). Sie sollten auch dem Wunsch der Mieter*innen nach Freiheit, den Raum zu „besitzen“, Rechnung tragen (z. B. Funktion „Eigentum“).

Optimierung der Wohnfläche pro Person?

Der durchschnittliche Wohnflächenverbrauch pro Kopf ist bei Bewohner*innen der Mobiliar deutlich höher als bei der Gesamtstichprobe. Obwohl die Mieter*innen der Mobiliar mobiler sind als die anderen Befragten (mehr als die Hälfte der Befragten plant, innerhalb der nächsten 5 Jahre umzuziehen!), ist eine Abnahme der Haushaltsgrösse nicht unbedingt ein Grund, die Wohnung zu wechseln. Zweifellos sind die hohe Zufriedenheit mit der aktuellen Wohnung und der Wunsch nach mehr Platz Gründe für eine Zurückhaltung beim Wohnungswechsel. Die Erleichterung des Umzugs zur Optimierung der Flächennutzung wird ein Schlüsselelement bei der künftigen Verwaltung des Wohnungsbestands sein, wobei andere nicht-monetäre Kosten eines Umzugs z. B. Alter oder lokale Bindung auch berücksichtigt werden müssen.

Und die Nachhaltigkeit…?

Mehr als ein Drittel der befragten Mieter*innen sind sich der „nachhaltigen“ Eigenschaften ihrer Wohnungen nicht bewusst. Dieser Anteil ist sehr hoch, wenn man bedenkt, welch zentrale Rolle das Wissen bei einem Wandel zu nachhaltigerem Wohnen spielt. Zur Förderung dieses Wissens, könnten neue Strategien entwickelt werden, um die Bewohner*innen über nachhaltige Eigenschaften der Wohnungen, in denen sie leben, und deren Vorteile zu informieren (z.B. Minergie-Wohnungen). Dies würde den Mieter*innen eine Vergleichsmöglichkeit bei ihrer künftigen Wohnungswahl geben und somit die Nachhaltigkeit zu einem ausschlaggebenden Faktor bei der Entscheidung machen, was derzeit noch nicht der Fall ist!

Weitere Informationen zum theoretischen Rahmen und zu den statistischen Analysen finden Sie in folgenden Veröffentlichungen, die bei wissenschaftlichen Fachzeitschriften eingereicht wurden:

Pagani, A., & Binder, C. R. (2021). A systems perspective for residential preferences and dwellings: the role of housing functions in Swiss residential mobility. *Housing Studies (accepted)*.

Pagani, A., Baur, I., & Binder, C. R. (2021). Tenants' residential mobility in Switzerland: the role of housing functions. *Journal of Housing and the Built Environment (submitted)*.

Karlen, C., Pagani, A., & Binder, C. R. (2021). Obstacles and opportunities for reducing housing size: tenants' residential preferences and housing choice. *Journal of Housing and the Built Environment (submitted)*.

Pagani, A., Laurenti, R., & Binder, C. R. (2020). Sustainability assessment of the housing system: exploring the interplay between the material system and the social structure. In C. R. Binder, R. Wyss, & E. Massaro (Eds.), *Sustainability Assessment of Urban Systems* (pp. 384–416). Cambridge: Cambridge University Press.

D.

Mobiliar Forum Thun workshop

Report

29.10.2020 – 30.10.2020 [49]

1 Context and goal

The residential sector is the second largest responsible for CO_2 emissions and energy consumption in Switzerland, after transportation (IEA, 2018a, 2018b). Reducing the use of resources in housing is therefore crucial to reduce human environmental footprint and mitigate the consequences of climate change. In this framework, the project *Shrinking Housing's Environmental Footprint (SHEF)* financed by the National Research Programme *Sustainable Economy: resource-friendly, future-oriented, innovative* (*NRP 73*) aims to develop measures to reduce the footprint of the residential stock in Switzerland. An interdisciplinary team of researchers developed an agent-based model (ABM) that simulates the reciprocal effects of tenants' preferences and decisions (i.e. to move or to select a dwelling), owners' strategies (e.g. demolishment, refurbishment) and their environmental impact. By considering the coupled dynamics of these housing 'subsystems', the model supports the exploration of potential effects of measures on social, economic and environmental indicators, and thereby the development of consensus-based recommendations and paths for sustainable living.

Based on these premises, a transdisciplinary workshop was organised during the Mobiliar Forum Thun (MFT), an innovation platform for companies and NGOs coordinated by the insurance company Swiss Mobiliar AG. The goal of the workshop was to develop strategies for realising the resource saving potential of housing together with relevant Swiss housing actors, including housing owners, architects, engineers and policy-makers. During the workshop, we co-developed several technical and behavioural measures; the ABM was then used to explore and evaluate their effectiveness and effects taking into account different normative perspectives; finally, we discussed their feasibility, looking for ways to promote and facilitate their adoption.

The next section illustrates the methodology adopted to organise the workshop, including a description of the approach, methods and instrumentation. We then present the results of this study and critically discuss its contributions and limitations, based on which we elaborate on future work.

[49] Authors of the report: Anna Pagani, Prof. Claudia R. Binder
Organisation team: Laboratory HERUS Prof. Claudia R. Binder, Anna Pagani; Laboratory LEURE Prof. Philippe Thalmann, Margarita Agriantoni; ESD Chair, Prof. Stefanie Hellweg, Dr. Andreas Frömelt, Rhythima Shinde.

2 Methodology

2.1 Transdisciplinary approach

The project SHEF follows an inter- and transdisciplinary approach. It gathers researchers with different expertise, collaboration partners and implementation partners. The three collaboration partners are two of the largest housing cooperatives in Switzerland—ABZ (Allgemeine Baugenossenschaft Zürich) and SCHL (Société Coopérative d'Habitation Lausanne)—and a large insurance company and institutional property owner—Swiss Mobiliar. The three housing owners offered support throughout the project, including the development of the proposal; in particular, the idea to perform the workshop during the MFT was launched and financially supported by Swiss Mobiliar. The implementation partners included the umbrella associations of housing cooperatives Wohnbaugenossenschaften Schweiz/Coopératives d'habitation Suisse (WBG-Schweiz, www.wbg-schweiz.ch); the non-profit associations "Sustainable construction network Switzerland NNBS" (www.nnbs.ch) and "Praktischer Umweltschutz Schweiz PUSCH" (www.pusch.ch). Their participation in the project was aimed at providing feedback on the work done, thus ensuring that scientific results are validated against real-world knowledge, thereby increasing their usefulness. Moreover, their practical experience was considered crucial for co-developing and evaluating measures to reduce the housing footprint while accounting for its social and economic dimensions.

In addition to the diversity of project partners' backgrounds and expertise, a key feature of transdisciplinary research is the type of knowledge it aims to produce. The latter can be organised into three types: (i) systems knowledge, which addresses questions concerning "the genesis, further development and interpretation of a problem"; (ii) target knowledge, where questions relate to "determining and explaining the need for change, desired goals and better practices"; (iii) transformation knowledge, which answers questions about "possible means of acting that aim to transform existing practices and introduce desired ones" (Hadorn et al., 2008). The three first phases or 'work packages' of the project SHEF focused (predominantly) on producing systems knowledge, whereby the output consisted in an agent-based model that simulates the residential mobility of tenants, the dynamics of the housing stock, and quantifies its material and energy flows. Based on the three first phases, work package 4 specifically focused on producing target and transformation knowledge, i.e. investigating desired futures and pathways to achieve them. For this purpose, research was articulated into three tasks:

- Development of measures with our implementation partners
- Simulation of scenarios[50] with measures and performance indicators
- Assessment of the scenarios and measures with our implementation partners

These tasks were performed during the Mobiliar Forum Thun using the methods detailed below.

2.2 Methods

The workshop required the combination of different methods related to the competences of the scientists on the one hand and the professional facilitators of Forum Thun on the other hand.

Design thinking. The experts from the MFT applied the 'Mobiliar Forum Thun' method, which originates from the cooperation with the Norwegian University of Science and Technology in

[50] In the workshop, the term 'strategies' was used instead of 'scenarios'; the goal of the workshop was in fact to design and assess 'packages' of several measures.

Trondheim (NTNU) and the Swiss Federal Institute of Technology Zurich (ETH Zurich) as an adaptation of the design thinking method.[51] Design thinking is a process consisting of five stages: (i) *empathise* (understand the problem through user research); (ii) *define* (i.e. state users' needs and problems); (iii) *ideate* (challenge assumptions and create ideas); (iv) *prototype* (start to create solutions); (v) *test* (try solutions out).[52] Accordingly, a key step of the workshop consisted in the development of *personas*, i.e. fictional characters created to represent different stakeholders and their needs, experiences, behaviours and goals. Four personas were pre-defined by the research team (i.e. a tenant, a housing owner, and two representatives of public interest in the present and future); workshop participants were free to choose which one they preferred to co-create. Following the design thinking method and through the lenses of each persona, participants elaborated strategies for sustainable housing. For these strategies to be implementable in the ABM, a set of model parameters was provided to each group with their respective definition (Table 1). Participants could assign a value to the parameters they found the most relevant, and combine the selected ones into a strategy.

Agent-based modelling. The ABM integrated three submodels: a model simulating tenants' residential mobility (see Pagani et al., 2021), a model focusing on the housing stock, and a model quantifying the flows (material, energy). The integrated model was fed with the values assigned by the participants' groups to the parameters of Table 1 for a total of four strategies. The model outputs were captured via a set of environmental, economic, and social indicators, defined based on previous work of Pagani and colleagues (2020; Table 1); their desired evolution (i.e. increase, decrease) was normatively set by the project team before the workshop.

Participatory Multi-Criteria Approach (PMCA). To compare the strategies between each other and against the baseline scenario we used a Participatory Multi-Criteria Approach (PMCA), a decision-aid tool largely applied in the field of sustainability when different actors and interest groups are involved (Merino-Saum, 2020). We provided the participants the set of indicators of Table 2 and asked each group to agree on a weighting scheme; i.e. the more relevant an indicator was for the persona they represented, the higher the weight (min = 1; max = 5). The final performance of a strategy was calculated using a weighted sum method (Janssen & Munda, 1999), whereby the performance score for each indicator is first standardised, then multiplied by the respective weights and added. The best option is the one with the highest normalised overall score. As standardization technique, we used the "distance from the group leader", according to which alternatives are ranked as percentage points from the leader.

When an increase in the score of an indicator is desirable:

$$100\,\frac{actual\ value}{best\ value} \tag{1}$$

When a decrease in score means a better performance:

$$100\,\frac{best\ value}{actual\ value} \tag{2}$$

[51] See the website of the MFT for more information: https://www.mobiliar.ch/die-mobiliar/engagement/wirtschaft-und-arbeit/innovationsplattform-mobiliar-forum-in-thun-lausanne-und-digital. Accessed 08.09.2021

[52] More information on Design Thinking can be found on the Interaction Design Foundation webpage (e.g. the definition of personas): https://www.interaction-design.org/literature/topics/design-thinking. Accessed 08.09.2021

Table 1. Model parameters provided to the participants.

#	Parameter	Description		Current value	Potential value
1	Number of dwellings searched by the tenants	Number of dwellings a tenant sees when he looks for a new apartment (i.e. *information*).		25	*e.g., 300*
2	Association characteristics-functions[53]	Which dwelling characteristics (should) allow for that function to be fulfilled (e.g., *status symbol -> car*)		*see table*	*see table*
3	Maximum and minimum size of a flatshare	Maximum and minimum number of tenants in a shared apartment		min 1 max 10	
4	Leaving with household shrinking	Probability that tenants will leave the dwelling when their children leave		50%	
5	Management of elderlies	Probability of the elderlies to leave the model		0%	
6	Yearly rate for light and heavy renovations	Rate that describes how many dwellings each partner can/decides to renovate per year (dwellings/year)	*Cooperatives:*	80	*e.g., + 20%*
			Mobiliar:	65	
7	Yearly new construction rate	Rate that describes how many dwellings each partner can/decides to construct per year (dwellings/year)	*Cooperatives:*	45	
			Mobiliar:	60	
8	Yearly demolitions-reconstructions rate	Rate that describes how many dwellings each partner can/decides to demolish-reconstruct per year (dwellings/year)	*Cooperatives:*	35	
			Mobiliar:	10	
9	Occupancy rules of the owners	Defines the minimum and maximum number of occupants that can stay in each dwelling size	*Cooperatives:*	min = #rooms -1 max = #rooms +2	*e.g., max = #rooms +3*
			Mobiliar:	no min max = #rooms +2	
10	Post renovation rent increase	The percentage of rent increase after a renovation	*Light renovation:*	+30%	*e.g., + 20%*
			Heavy renovation:	+80%	
11	Building Area/ footprint	Total living and/or constructed area of the building		1800 sqm	
12	Energy supply source	Heating source of energy		Oil (50%), Gas (15%), District heating (5%), Renewables (15%) Heat pumps (15%)	
13	Area per household (per apartment)	The size of apartment per household i.e. the square-metre of the apartment (constructed area)		100 sqm	
14	Material intensity (kg of material/m2 of the building area)	The weight of material (or proportion) used per building area		Concrete (50.53%) Mortar plaster (25.67%) Brick (18.87%) Glass (0.3%) Metal (0.07%) Insulation (1.54%) other (0.15%) Wood (2.92%)	*e.g., decrease 'concrete' to X%*

[53] An additional table was provided to the participants, with a list of 'housing functions' and a list of characteristics (see Pagani & Binder, 2021). Each group could use an 'X' to mark the desired association (if any) between a function (e.g. a shelter) and a characteristic (e.g. bright). In the agent-based model, dwellings were randomly attributed a set of features, based on which the housing functions were calculated (Pagani et al., 2021). In the overnight simulation of the proposed measures, the characteristics marked with an 'X' were given a probability of 1 to generate the chosen function.

Table 2. Indicators provided to the participants. DE: desired evolution.

Indicator	Description	Unit	DE
Floor area per capita	Dwelling surface divided by the number of occupants (average for the whole population of tenants)	m^2/person	decrease
Rotation of tenants in the dwellings	The average of the number of times there was a change of tenancy in each dwelling	times	decrease
Level of satisfaction of tenant with dwelling	Average tenants' satisfaction, depending on the correspondence between the functions of the dwelling and their ideal functions	1 to 5	increase
Months waited before relocation	Average number of months waited between searching for a dwelling and being assigned to a dwelling over total population	months	decrease
Occupant footprint	Global Warming Potential per household	kg CO_2-eq	decrease
Energy footprint	Global Warming Potential for building or the apartment (based on per kWh energy used for heating of the building)	kg CO_2-eq	decrease
Material footprint	Global Warming Potential for building or the apartment (based on per m^2 of material used in the building)	kg CO_2-eq	decrease

2.3 Design and instrumentation

MFT takes place twice a year, in spring and autumn. Due to the special circumstances posed by the second wave of the COVID-19 in Switzerland in autumn 2020, the workshop was held entirely online for a duration of one and a half days. We used the Zoom platform as virtual space and the collaborative digital whiteboard Miro for team collaboration.[54]

The moderation team (two people) and the participants (16 people) were composed of practitioners and experts with different backgrounds, for a total of 18 people. Discussions happened in small groups of four, the results of which were shared in the plenum.

As most of the attendees were German-speaking, the workshop was held in German, with the possibility of speaking or presenting in English when necessary.[55] In preparation for the workshop, the participants were informed about the research question, wished for outcome, and agenda (Figure 1).

Following a first icebreaker to get to know each other, the work of the researchers in the SHEF project was introduced to the participants, thereby setting the context of the workshop (step 2). Step 3 consisted in a free brainstorming about ‘possible futures’ of housing and measures to positively influence them. This brainstorming was followed by the definition of key housing stakeholders (i.e. ‘personas’, step 4) and the elaboration of strategies accounting for their preferences using the model parameters as guidelines (step 5). These strategies were then simulated overnight using the agent-based model. We compared the outputs of the model using a set of indicators, which were previously weighted by each stakeholder (step 6) and presented the results to the participants (step 7). Eventually, going back to their original roles, the experts discussed ways to achieve the best-performing strategy (step 8; Figure 1).

[54] Zoom platform: https://zoom.us/; Miro board: https://miro.com/
[55] Due to language constraints, members from SCHL cooperative did not attend the workshop.

QUESTION

How to shrink the environmental footprint of housing ?

WISHED FOR OUTCOME

Strategies for the future of housing, simulated in a model and assessed through indicators

MODERATION TEAM

1 session moderator — animating the discussion

1 manager of the Miro board — designing the digital whiteboard

1 moderator from the scientific team — providing more precise instructions when needed

PARTICIPANTS

6 members of the **research team** in the field of economics, socio-ecological-technical systems, environmental science and engineering

3 representatives of the **owners**: one of Mobiliar (Real Estate Operations) and two of the cooperative ABZ (Property Management; Tenants' Management)

5 **practitioners** in the area of sustainable housing (including architects and engineers), four of which affiliated to the NNBS network and one to academia

2 **policy-makers**, including representatives of the Swiss Federal Housing Office and of the City of Zurich

AGENDA

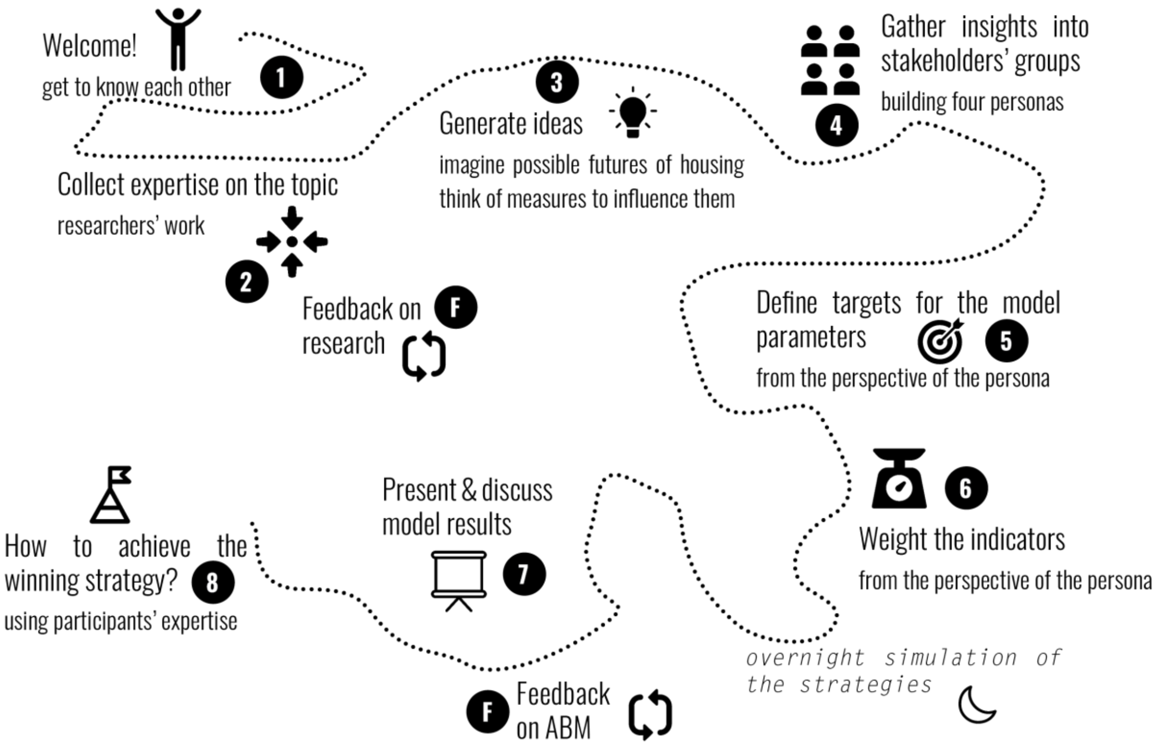


Figure 1. Research design. F indicates when participants provided feedback to the work of the researchers.

In parallel to these tasks, feedback was provided on the results of the SHEF project at the beginning and at the end of the workshop (F). Following the researchers' introduction of the topic and work conducted, the participants were asked to discuss in subgroups and share with the plenum first comments on / impressions regarding the problem conceptualisation (tenants' mobility, owners' decisions, environmental footprint) and the design of the ABM. The second round of discussions, on the next day, was instead targeting specifically three questions:

1. Is something missing in the model?
2. Do you have additional wishes for the model?
3. What do we learn from it?

3 Results

3.1 Possible futures of housing and how to influence them

Possible futures of housing. During the first brainstorming, participants imagined an overall positive future that included a decreasing use of primary resources (decarbonization of the building sector, no oil heating, fossil-free mobility, use of hybrid timber materials), a more efficient use of space (reuse of existing buildings, flexible dwellings, renovation) and distances (local procurement, decentralized energy production, urban agriculture). In addition, they anticipated societal changes such as a rise in ecological consciousness, in the willingness of citizens to provide support in reaching sustainability goal, in a culture of sharing (spaces, mobility), supported by innovative technologies (smart city devices, artificial intelligence).

Questions related to these futures also included several critical aspects that are foreseen to impact on the housing system, such as population growth and ageing, the rise in social inequalities, or the intensification of migration climate refugees. In particular, the situation related to the spread of the COVID-19 clearly influenced future projections; experts discussed whether home office would become the norm, highlighting the related increase in the attractiveness of country houses, the rising need for extra rooms for work, the urgency to convert empty offices into other usages, but also to reflect upon how to best integrate and protect elderly people, how to accommodate the need for social interactions, and how to rethink the work-life balance, giving more space to leisure.

Measures. Regarding the measures to adopt to positively influence the imagined housing futures described above (i.e. to achieve them, or improve them), we highlight below several categories emerging from the keywords used by the participants, translated from German.

1. Design

The design of residential spaces should focus on flexibility (including the possibility to convert office space into homes); a reduction of individual space, e.g. via the provision of Schaltzimmer (i.e. 'switch room' shared and accessible between adjacent apartments), extra rooms, or shared flats; a parsimonious use of land by e.g. adding storeys on existing buildings rather than constructing new ones; the provision of places for interaction (e.g. using the ground floor as co-working space); rethinking the feeling conveyed by urban dwellings (e.g. a 'country' house feeling), also via the use of natural materials.

2. Energy

Energy strategies should focus on replacing the heating system; using new materials e.g. clay for cooling; making energy labels mandatory; building ‘low tech’; installing climate-intelligent systems.

3. Circularity

Priority should be given to the use of existing buildings (i.e. rather than new construction); the promotion of partial instead of full demolition; the extension of buildings’ lifetime.

4. Residents’ and management actions

Residents’ and owners’ actions are also subject to measures. Tenants’ participation and autonomy should be enacted, e.g. via the use of apps or platforms provided by the owners (e.g. for sharing), while the owners should become providers of many services. They must play a more active role using advertisement campaigns, setting dwellings’ occupancy rules, creating role models, publicising their sustainability strategy and thereby creating benchmarking, peer-to-peer comparison and competitions

5. Finance

These measures come at a cost; measures for reducing it include supporting the costs for adaptation of offices and dwellings into one or the other; offering low cost sustainable construction; reflecting on sustainability-targeted financing within companies; providing affordable housing.

6. System (neighbourhood, city, mobility)

The housing system is not limited to the dwelling or building. Going beyond this system boundaries, measures should focus on including planning at the level of the district, instead of the city; harnessing the potential of 2000-Watt society initiative,[56] designing ‘sponge’ cities, including green islands and car-free areas.

3.2 Gather insights into the stakeholders’ groups: the personas

After this initial collective brainstorming, ideas were structured following the design thinking process. First, we focused on defining the main stakeholders to create the empathy needed to devise strategies that would benefit each of them. The four resulting personas were (i) Sandra, a 27-years-old tenant in a difficult financial situation, who works as teacher and lives alone with a very young child; (ii) Peter, a 52-years old single owner, with a portfolio with 5 multifamily inherited buildings, and an annual income consisting of rents; (iii) Stephan, a representative of the current generation, as described below, and (iv) ‘Alice’, a 18-years-old young woman and climate activist representing the future generation. Additional details included their political party, mottos, struggles and strengths. Figure 2 shows a *caricature* of the ‘current generation’, Stephan Egger, highlighting some key characteristics (sex, work, income, hobbies), his routines, and ‘pains and gains’ (e.g. his new Tesla).

[56] The premises and objectives of the 2000-Watt society can be found at this link: https://www.2000watt.swiss/english.html

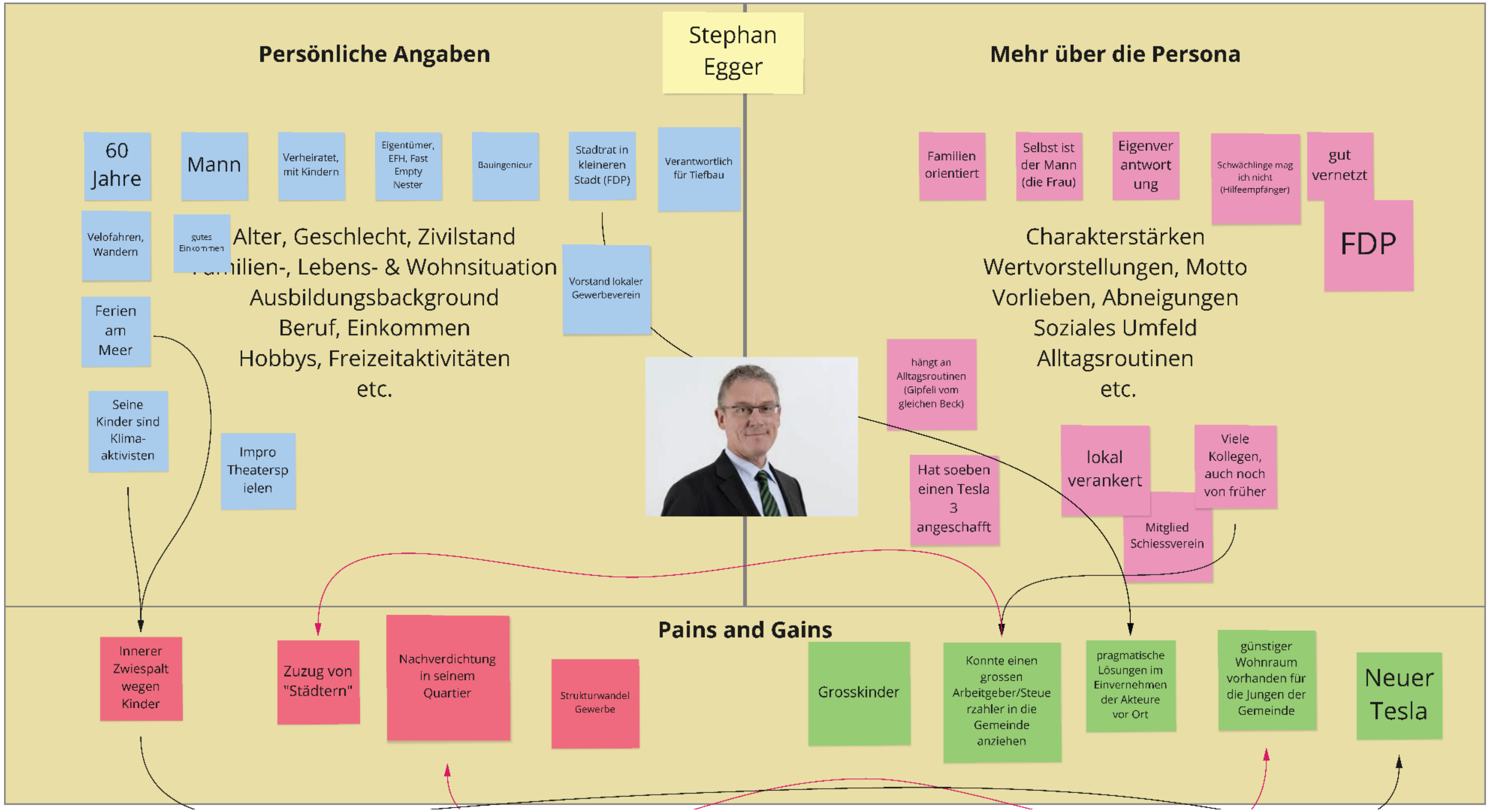


Figure 2. A Miro board describing one of the personas. Stephan Egger is a 60 years old civil engineer, married with kids, earning a good income. He enjoys biking and hiking in his free time, as well as going on holidays at the seaside. He is also part of the city council in a small city (FDP party; i.e. the Liberals) and of the board of a local industry association (i.e. Gewerbeverein); he doesn't like 'weak people who benefit from support'. Overall, he benefits from a good network. He's family-oriented; however, his children are climate activists, which causes him an 'inner conflict'. He practices improvisation theatre. He likes to stick to daily routines; he is locally rooted, has lots of friends 'from back in the days'. He is disturbed by e.g. immigration of 'city people' and densification in his district. However, he just bought a new Tesla, which is one of his 'gains', together with his grand-children, but also e.g. his success in attracting a big employer and tax payer to the community.

3.3 Define targets for the model parameters

By empathising with the persona, the participants selected the most pertinent parameters from Table 1 and assigned them a desired value. The strategies are summarised by Table 3, where we can distinguish some of the personal traits of the stakeholder.

Table 3. Strategies for each of the three personas.

P [a]	**Strategy**	**Parameter**		**Values**
T	**Access to affordable housing**	1	Number of dwellings searched by the tenants	50
		2	Association characteristics-functions	Permanence: close to the city-centre; with balcony; in a safe neighbourhood [b]
		4	Leaving with household shrinking	80%
		5	Management of elderlies	75%
		10	Post renovation rent increase	0%
O	**Leave the buildings alone**	7	Yearly new construction rate	-90%
		8	Yearly demolitions-reconstructions rate	-80%
		10	Post renovation rent increase	30% light 50% heavy
		12	Energy supply source	Oil (40%), Gas (15%), District heating (15%), Renewables (15%), Heat pumps (15%)
CG	**Prevention and innovation**	3	Maximum and minimum size of a flatshare	4-6
		6	Yearly rate for light and heavy renovations	rather lower (Cooperatives)
		7	Yearly new construction rate	-50%
		8	Yearly demolitions-reconstructions rate	-30%
		12	Energy supply source	Oil (25%), Gas (15%), District heating (10%), Renewables (20%), Heat pumps (30%)
FG	**Make climate great again**	3	Maximum and minimum size of a flatshare	max 12
		6	Yearly rate for light and heavy renovations	+50%
		8	Yearly demolitions-reconstructions rate	-100%
		9	Occupancy rules of the owners	min: rooms max: rooms+3
		12	Energy supply source	Oil (10%), Gas (15%) District heating (15%), Renewables (35%), Heat pumps (25%)

[a] P: Persona; T: tenant; O: owner; CG: current generation; FG: future generation
[b] The function *permanence* was selected as desirable and linked to the characteristics: close to the city-centre; with balcony; in a safe neighbourhood. The three characteristics were therefore given a probability of 1 to generate that function.

Table 4. Weighting scheme for the four personas. Gen: generation.

Indicator	Tenant	Owner	Current gen	Future gen
Surface of dwelling per person (m2/person)	3	2	1	2
Rotation of tenants in the dwellings	3	4	4	1
Level of satisfaction of tenant with dwelling	4	4	3	5
Months waited before relocation	5	1	4	3
Occupant footprint	2	3	2	5
Energy footprint	2	3	4	5
Material footprint	2	1	1	5

For instance, and in agreement with the profile described in Figure 2, the current generation chose a rather conservative strategy; 'Stephan' preferred building maintenance over renovation (like Mobiliar currently does); indicated densification (and therefore demolition and reconstruction) as undesirable; pointed to the need to find a compromise between protecting 'tradition' and achieving economic goals (and therefore reduce construction rate).

On the opposite, the group representing the future generation chose more extreme sustainability-oriented measures, such as increasing dwelling density (larger flatshares, occupancy rules) and renovations rates, bringing the demolitions down to zero, rebalancing the energy supply source.

3.4 Weight the indicators

Finally, each group assigned a weight to the indicators (min = 1, max = 5), resulting in the weighting scheme of Table 4. Results show, for instance, that the current generation attributed more weight to the indicators 'Energy footprint' (i.e. a decrease in footprint entails economic benefits) and 'Rotation of tenants in the dwelling' (i.e. the persona prefers more 'stable' neighbours; Figure 2). The latter is similar to the weight given by the tenant; however, for the latter, a rotation of tenants is undesirable for different reasons, i.e. instability of their residential situation. We therefore observe that, despite leading to the same results, the reasons behind the attribution of a weight to an indicator can sometimes greatly differ.

3.5 Simulation results and PMCA

Table 5 displays outputs of the overnight simulations assessed by the tenant-persona.

Table 5. Normalised performance of the four strategies (min = 0, max = 100) and weighting scheme of the tenant.

Indicator	Weight	Strategies				
		baseline	1	2	3	4
Surface of dwelling per person (for tenants)	0.14	100.00	95.75	95.95	96.72	67.95
Surface of dwelling per person (for others)		*67.95*	*70.97*	*70.82*	*70.26*	*100.00*
Rotation of tenants in the dwellings	0.14	90.54	74.44	72.43	96.40	100.00
Level of satisfaction of tenant with dwelling	0.19	97.60	100.00	97.01	97.90	98.80
Months waited before relocation	0.24	10.00	71.43	15.87	15.38	100.00
Occupant footprint	0.10	95.90	94.10	100.00	97.22	91.33
Energy footprint	0.10	100.00	71.88	79.03	76.11	83.94
Material footprint	0.10	82.21	91.74	67.21	85.42	100.00
Total	1	75	85	70	75	93

Table 6. Performance of the four strategies (min = 0, max = 100) for all personas. The best scores are highlighted in green. Gen: generation.

#	Strategy	Personas			
		Tenant	Owner	Present gen	Future gen
	Baseline	75	87	76	82
1	Access to affordable housing	85	83	81	85
2	Leave the buildings alone	70	80	68	76
3	Prevention and innovation	75	85	74	79
4	Make climate great again	93	96	96	95

The performance score of each indicator is calculated based on Eq. 1 and Eq. 2 and then aggregated in a final score (Total) according to the weight assigned. Given that the tenant attributed a higher weight to the indicator 'Months waited before relocation', the baseline strategy as well as strategy 2 and 3 score lower than strategy 1 and 4. An important point to mention is that the surface of dwelling per person is not calculated in the same way for all personas, i.e. we assumed that, contrary to other personas, tenants want to maximise the area of their dwelling. Therefore, strategy 4—where households can gather up to 12 members—performs the worse for the tenant but the best for the other stakeholder groups.

Overall, strategy 4 resulted in the **best score** (Table 6). More specifically, strategy 1, which focused on tenants' well-being, scored the best for the *tenant* and *future generation* and the worse for *present generation*. Strategy 2, whereby the *owner* asked to 'leave the buildings alone', scored the best for the *owner* but the worse for the *present generation*. The third strategy, 'Prevention and innovation', elaborated by the *present generation*, still scored the worse for this persona, but the best for the *owner*. The last strategy, 'Make climate great again', scored the best for all stakeholders.

3.6 Path towards shrinking housing's environmental footprint: 'make climate great again'

What levers and what measures can be used to implement the strategy "make climate great again"? The participants moved back to their original role and expertise to answer this challenging question in four small groups, and then identify the targeted stakeholder to which each measure was addressed. We summarise some key results in Figure 3.

3.7 Feedback to the researchers' work

<u>First impressions on SHEF – Day 1.</u> First impressions on the premises on which the workshop was organised and the design of the agent-based model were collected at the beginning of the workshop, during which research conducted on tenants preferences, the housing stock dynamics, and its environmental footprint where introduced by the scientific team. The ABM was found a good way to show complexity and navigate the many scales at which the housing system is organised; one post-it indeed reported "Understand the human and create transparency first". The presentation on tenants' motivations for moving and choosing a new apartment triggered reflections on how to stimulate interest in a reduction of resources consumption, focusing on factors other than price (e.g. comfort). Related to these were reflections on flexible housing, which would also contribute to limiting tenants' relocations (and avoid too frequent apartments 'refreshments', an advantage from the owners' perspective).

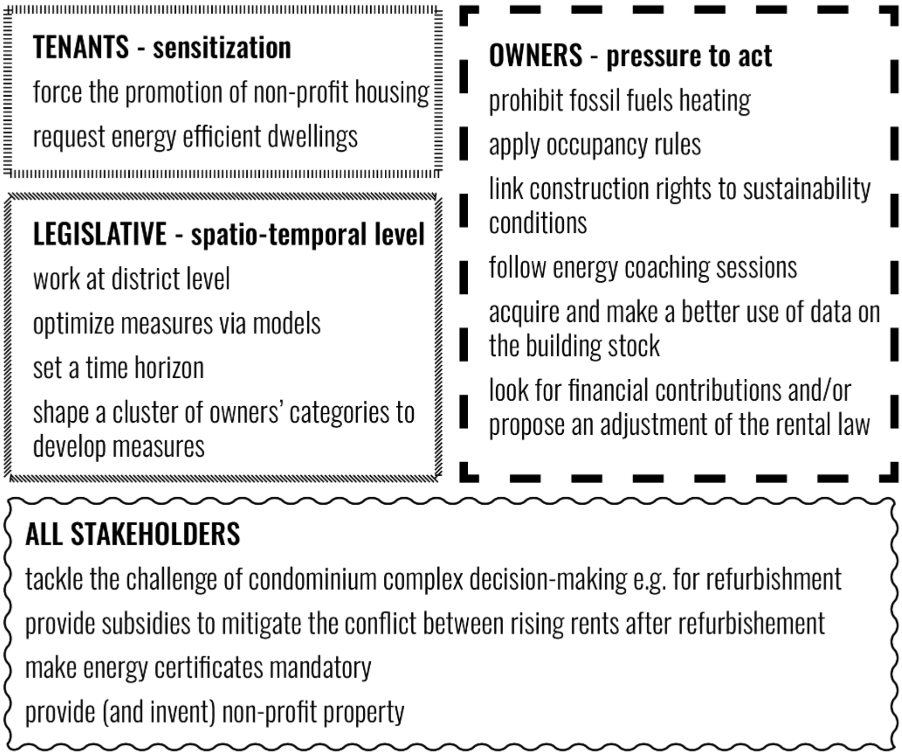


Figure 3. Summary of measures and levers for different housing stakeholders.

On the other hand, increasing space efficiency was also suggested as a potential driver for renovation; in fact, another point concerned the urgency to increase building refurbishment rate. Other deficiencies in the housing offer were highlighted, such as the lack of small dwellings adequate for elderly people. Eventually, first suggestions were made on possible expansions of the ABM (e.g. considering waste in the environmental model).

<u>Structured feedback on ABM – Day 2.</u> After the presentation of the PMCA, participants gave a structured feedback on the ABM, whose highlights can be summarised as follows:

- General comments. Firstly, the time frame of the model was questioned ("*Is it possible to extrapolate a model until 2050 and keep today's assumptions constant?*"). Secondly, there was agreement upon the need to use *research questions* as tools to select the indicators for the assessment ("*Indicators need to depend on specific questioning, then, the model becomes a great tool for reflection*"). Lastly, participants pointed to the need for checking the 'what if' questions simulated in the model against reality.
- Economic aspect. The economic pillar should be more strongly anchored in the model, e.g. profitability is a very important indicator for owners
- Environmental aspect. Firstly, the environmental indicators appeared to have too much weight (i.e. they could be aggregated in one indicator only). Secondly, experts mentioned the possibility for the ABM to account for change in building functions (e.g. from offices to dwellings). Lastly, participants suggested to consider the current elevated demand for wooden or ecological construction.
- Social aspect: only the possibility to represent social cohesion in the model was mentioned.

In addition to these points, one of the sub-groups proposed a new set of indicators (additions are marked in red).

- *Surface of dwelling per person*
- *Surface of common space in building per person*
- *Surface of outside space per person*
- *Tenants remain for a long time in the apartment*
- *Possibility to adjust rent to market at change of tenant*
- *Level of satisfaction of tenant with dwelling*
- *Months waited before relocation*
- *Gross rent is affordable for tenants*
- *Net rents cover costs*
- *Net rents allow for profit above costs*
- *Share of energy efficient / labelled buildings*
- *Share of better accessible dwellings*
- *Occupant footprint*
- *Energy footprint*
- *Material footprint*

4 Discussion and conclusions

4.1 Main findings

The analysis of the first impressions on the SHEF work (F; Figure 1), the measures elaborated in the first brainstorming activity (step 2), and the strategies built by the personas (step 5) shows recurring themes that researchers, practitioners, and policy-makers are attentive about. Although interlinked, we organise the illustration of these patterns according to the three dimensions of sustainability explored in this project.

Concerning the **environmental dimension**, the need to replace heating systems in housing was the most cited. In fact, despite a decrease in the use of heating oil in the past 30 years, almost two out of three buildings are still heated by fossil fuels (heating oil and gas) in Switzerland (FSO, 2017a). A second relevant topic of discussion concerned the materials used for construction; studies have been stressing the need to develop and use materials that are “low in production impacts, have energy-saving properties, and can ideally be reused or recycled after the use phase” (Pagani, Laurenti, et al., 2020, p. 392)—in this framework, new studies have been recently conducted on barriers to use recycled concrete in Switzerland (Superti et al., 2021). Lastly, emphasis was put on the building system as a whole, and in particular on the need to make energy labels mandatory and/or link construction rights to sustainability conditions.

The **economic dimension** was often mentioned as key for the successful implementation of the proposed measures, recurring topics included incentives, subsidises, or eventually modifications to the rental law to avoid an increase in rent after renovation. Housing affordability was also mentioned several times across the workshop, whereby accent was put in particular on new forms of non-profit ownership (which, according to the participants, still need to be invented).

Regarding the **social dimension**, experts stressed the need to better inform residents and owners (i.e. via coaching, information sessions, advertisement campaigns), thereby empowering them to make conscious decisions (to choose a dwelling, to renovate). However, it must be considered that tenants have limited power to adapt their residential environment (Rabinovich, 2009). In the workshop, the notion of flexibility—experimented in the housing sector for the past 50 years with the goal to empower residents (see Habraken, 1972; Turner, 1976)—was often only cited in relationship to the need to reduce individual space consumption, e.g. via the provision of extra (shared) rooms. While recent research has shown that these design solutions are key to shrink housing's footprint (Karlen et al., 2021), the lack of discussion around pure bottom-up approaches reveals that tenants are still widely perceived as 'passive' actors (i.e. to be sensitized, to benefit from non-profit housing). Together with others, this limitation is discussed in the following section.

4.2 Limitations

The organisation of the Forum Thun required adapting to the contextual constraints imposed by COVID-19 (e.g. high screen time), achieving a shared understanding of the approaches used by the moderators and the research team, and finding compromises between achieving the desired objectives and stimulate the interest of participants.

A first challenge regarded the online environment. The workshop took place only few days after the École Polytechnique Fédérale de Lausanne adopted measures to limit the spread of the COVID-19 in autumn 2020. Therefore, whilst participants expected to take part in a two-days workshop in the castle of Thun, the format had to be rapidly redesigned for an online participation. Considering that we did not have experience with online workshops, the program was very dense, which produced tiredness towards the end of the first day. Two important activities were skipped due to a lack of time; the first consisted in exploring linkages between the measures brainstormed in step 2 and the model parameters used in step 4. As this activity was cancelled, the relationship between the two steps was less evident. However, step 2 still generated relevant knowledge that was reiterated in the conclusions of the second day. The second activity skipped concerned a qualitative assessment, which would have given the possibility to compare model results with participants' 'intuitive' scoring of the indicators.

Another limitation concerns the building of personas. The resulting stakeholders were sometimes extreme caricature or contestable stereotypes. However, the humour and fun generated by this activity were very relevant to build connections between the participants, especially in an online environment.

Relevant to mention is that the workshop did not involve tenants (although many experts are, themselves, renting apartments). This gap could explain the lack of measures and results focused on the *empowerment* of these actors.

While some researchers did not master very well German, some other participants did not speak English, which created sometimes difficulties in communicating. However, thanks to the bilingual moderation, this issue was not perceived as a limitation by the participants.

Lastly, the ABM used for the simulations was in its first 'integrated' version, which presented several issues that made the outputs not fully reliable. However, during the workshop, emphasis was put on the quantitative output of the model, but rather on the reflections that the latter triggered.

4.3 Future work

The workshop at the MFT provided us with useful information to (i) improve the model, (ii) reflect on its limitations, (iii) revise the indicators set and (iv) design measures to simulate.

Future work should focus on increasing the number of parameters regarding the economic dimension of the housing system and the related indicators (e.g. profitability). Also, it should critically consider the extent to which the assumptions made based on the survey and data of 2019 are valid for simulations up to 2050. Whether to tackle this critical point will depend on the purpose of the model (i.e. *prediction* versus *description* ; see Edmonds and colleagues, 2019).[57] Linked to this issue is the definition of a research question, whose importance was stressed by the participants. As the general model is composed of three submodels, the three researchers will need to attentively define the research question that their model can answer. Lastly, the way in which the model was built did not allow for the exploration of the effects of design innovations, which were often mentioned during the workshop (e.g. shared spaces in a building, transformation of office space). The 'exploration space' of the model will have to be carefully described and its limitations acknowledged. Ways to overcome the latter should also be considered; for instance, to increase the amount of shared spaces in a building, the model could provide rooms without the purpose of occupancy in combination with more stringent occupancy rules; regarding housing flexibility, the frequency of the trigger pushing tenants to relocate when the structure of the household changes could be reduced.

Conclusion

At the Mobiliar Forum Thun we actively tested transdisciplinary and participatory methods; we engaged in dialogue with architects, engineers, policy makers and researchers and brought together their respective expertise on sustainable housing using design thinking and participatory multi-criteria approaches. In this way, we co-created, simulated, and assessed strategies for reducing the environmental footprint of Swiss housing, taking into account the knowledge and interests of all key stakeholders. Results indicated that the strategy developed by representatives of the 'future generation' was the most effective in reducing the environmental footprint of housing while simultaneously taking into account its social and economic dimensions. Participants identified the following leverage points to implement this strategy: (i) raising awareness among tenants in order to stimulate bottom-up action (e.g. requesting energy-efficient housing); (ii) putting pressure on housing owners with to, e.g., establish occupancy rules, acquire and make better use of data on their housing stock, follow energy coaching sessions; (iii) redefining the spatial-temporal level of intervention of legislative action, e.g. setting a new time horizon, working at district level; and (iv) considering several other interrelated measures that could be triggered collectively, e.g., the provision of non-profit property.

Overall, the workshop showed the valuable insights that can be gained when researchers and practitioners come together. It also stimulated reflections on how to make workshops in the digital space attractive and dynamic. At the end of the second day, participants expressed their satisfaction with the results and the enriching exchange, stressing that they had fun and experienced valuable interpersonal moments.[58]

[57] For instance, the sub-model of tenants' residential mobility is a descriptive model; it allows for the observation of system dynamics useful for decision-making.
[58] See the press release of Swiss Mobiliar: https://report.mobiliar.ch/2020/fr/le-plaisir-d-innover/ Accessed 10.09.2021

Appendix: newspapers in the future

As last workshop activity, participants were divided into three groups and asked to write a newspaper article for the year 2025, 2030 or 2050 (see an example in Figure 4); the resulting three articles are transated below.


30 minuten
30. Oktober 2025

Auftakt 2
Gleichberechtigung dank der Ampelfrau

People 15
Rita Ora: «Nicht nackt, dafür sexy»

Sport 35
Die Nati trainiert im schönen Porto Seguro

Wetter
MORGEN 17° NACHMITTAG 30°

Schadenskizze
Schliessen
Die Mobiliar

Zürich schaffts!

Zürich ist kurz vor dem Ziel: Nächstes Jahr wird sie die MuKen umgesetzt haben. Damit haben sie den vorgegebenen Zeitplan um nur 5 Jahre überzogen. Es wurden über 1 Mrd investiert und hunderte von Arbeitsplätzen geschaffen. Der wirtschaftliche Aufschwung kompensiert somit die Ausfälle der Coronakrise von 2020.
Die Stadt Zürich setzt ihre 2000 Watt Ziele um und wird zur Leuchtturm Stadt der Schweiz!

Wie hat sie das geschafft?
- Förderung und hoher Anteil von gemeinnützigem Wohnungsbau
- Ausbau des Fernwärmenetzes (70%) mit Anschlusspflicht
- Intensives Coaching der Eigentümer inkl. finanzielle Anrei
- Umsetzung der Baurechtverträge

Die Umsetzung war auch möglich weil die institutionellen Bauträger über die Agenda 2030 in die Pflic genommen werden.

ANZEIGE
Wir helfen Ihnen rasch und unkompliziert aus der Patsche. Die Mobiliar Was immer kommt

Figure 4. Newspaper article of 2025 elaborated by the participants.

Scenario 2025: Zurich makes it!

Zurich is close to its goal: next year they will have implemented the MuKen.[59] This means that they have exceeded the given schedule by only 5 years. Over 1 billion has been invested and hundreds of jobs created. The economic upswing compensates for the shortfalls of the Corona crisis of 2020. The city of Zurich implements its 2000 watt targets and becomes the beacon city of Switzerland! How did it achieve this?

- Promotion and high proportion of non-profit housing construction
- Expansion of the district heating network (70%) with mandatory connection
- Intensive coaching of the owners including financial incentives
- Implementation of the building law contracts The implementation was also possible because the institutional property developers are held accountable by the Agenda 2030.

[59] https://www.hev-schweiz.ch/politik/energie-umwelt/muken/ Accessed 10.09.2021

Scenario 2030: 10 years after Corona

- Due to the tense economic situation, low-cost living space is becoming increasingly important.
- The market demands affordable housing with low additional costs.
- Smart Home Concept
- People miss the social contact between work colleagues as they used to in the office
- Fossil heat generators are prohibited

Scenario 2050: Last oil-fired heating system handed over to the National museum

Sixteen clever minds gave the starting signal in 2020 - now the goal has been reached! After in a first phase many house owners voluntarily removed their fossil heating system, now the last remaining oil heating system could be shut down under police supervision. What has led to this:

- Information and advice for homeowners
- Development of a transition path through the EPFL
- The referendum of 2025 on a ban on fossil heating systems

E.

Citizen Think Tank

Link: https://www.coronacitizenscience.ch/wp-content/uploads/2020/08/CTT_-Rapport_Logement-1.pdf

Note: the format has been adapted

Citizen Think Tank

Mon logement à l'épreuve du confinement : Quelles orientations pour l'après ?

Rapport

Mai – Juillet 2020

Anna Pagani[60], Douglas Gonzalez, Garance Clément, Claudine Karlen, Valentin Bourdon, Sylvie Laffitte

Notre projet

Que pouvons-nous faire ensemble que nous ne pouvons pas faire seuls ?

Entre mai et juin 2020, des citoyen.ne.s scientifiques de toute la Suisse ont répondu à cette question dans des groupes de réflexion : les Citizen Think Tanks. Avec des chercheuses et chercheurs de l'EPFL, ils ont élaboré des scénarios pour l'avenir après la pandémie.

Touchant à plusieurs thématiques, ces Citizen Think Tanks s'inscrivent dans une recherche collective sur les conditions de logement et le bien être durant le confinement dû au Covid-19. La recherche, intitulée 'Corona Citizen Science', implique une grande équipe interdisciplinaire de chercheurs et chercheuses de l'EPFL et UNIL, et de leurs instituts (IDIAP et IP), ainsi que les citoyen.ne.s, concerné.e.s directement par la crise du COVID-19. Ensemble, ils forment l'équipe de recherche scientifique et citoyenne sur le Coronavirus en Suisse. Plus précisément, la recherche vise à un apprentissage *mutuel*, aboutissant à la *coproduction* de stratégies d'adaptation aux crises futures.

C'est dans ce cadre que, le 28 mai et 4 juin 2020, un groupe hétérogène de citoyen.ne.s scientifiques a réfléchi autour de notre logement… à l'épreuve du confinement.

Le logement pendant le confinement

[60] anna.pagani@epfl.ch

L'offre de logements ne peut pas être comprise uniquement dans ses aspects matériels ou en termes de standards techniques : les aspirations, attitudes, pratiques et valeurs de ses habitants doivent être prises en compte (Lawrence, 2009).

Entre mars et fin-mai 2020, le rapport entre la matérialité de l'habitat et ses occupants a été mis à l'épreuve. En effet, pendant la crise liée au Covid-19 le logement a pu être qualifié de « première ligne de défense face au coronavirus » voir renvoyé à « une question de vie ou de mort ».[61] Protégés par un seuil entre monde privé et public, nos espaces de vie sont devenus à la fois notre ancre de *sauvetage* et notre ville, des lieux de séjour, de travail, d'étude et de loisirs.[62] Mais aussi, ces endroits se sont parfois transformés en lieux d'enfermement et de contrainte. La pandémie a par conséquent porté l'attention sur les inégalités sociales du logement. Elle a mis en évidence des disparités en termes matériels (surface, présence d'espaces extérieurs, niveau d'équipement et de confort), mais aussi rappelé les rapports de pouvoir qui se jouent au sein du logement (violences domestiques, répartition des tâches ménagères, prise en charge des enfants et des personnes vulnérables…). Par ailleurs, le confinement a très clairement mis en évidence le lien entre notre fragilité au virus et nos modes de vie *non-durables* (p. ex., l'exposition à la pollution de l'air). Dans ce cadre, plusieurs expert.e.s ont été interpellé.e.s pour *repenser* le logement à la lumière de l'expérience acquise : *À quoi ressemblera le logement de demain ?*

Stefano Boeri –architecte de la forêt verticale, et future tour de Cèdres à Chavanne-près-Renens– propose de suivre le modèle anglais : se 'retirer' de l'urbain, redécouvrir, grâce au télétravail, le potentiel de nos villages abandonnés.[63] De son côté, Massimilano Fucsas s'interroge sur l'autre thème épineux mis en lumière par la crise : *l'habitabilité*. « Il faudrait une loi qui interdise de construire des maisons plus petites de 60 mètres carré », dit-il.[64] Selon l'architecte, les logements devraient intégrer des espaces pour s'isoler, ainsi que des espaces communs pour le télétravail, tout comme aujourd'hui on prévoit les garages ; des espaces donc qui combinent plusieurs *fonctions* (p.ex., sécurité, représentation, production et consommation), et s'adaptent à leur changement au fil du temps (Pagani & Binder, 2019).

À la lumière de ces considérations, il semble donc urgent de proposer une nouvelle vision de la durabilité comme compromis entre ses dimensions *environnementale, économique et sociale* : reconsidérer le chez-soi. C'est sur ces prémisses que les deux Citizen Think Tanks ont eu lieu.

Notre approche

Qu'était pour nous 'la maison, avant le confinement ? Qu'aurait-elle dû être pendant la crise ? Et que sera-t-elle après ?

Trois types de savoir étaient nécessaires pour répondre à ces questions : un savoir scientifique, un savoir expert, et un savoir citoyen. La totalité était représentée par l'équipe : une modératrice et une co-modératrice, un expert, et entre 5 et 7 participant.e.s citoyen.ne.s.

Le premier Think Tank avait pour but de discuter de notre rapport *personnel* au logement et à ses fonctions avant la crise, ainsi que d'identifier les éléments qui ont joué un rôle clé pour la traverser. Le contenu était structuré à partir de la recherche doctorale de Anna Pagani, qui vise à

[61] https://www.radiolac.ch/actualite/logement-une-question-de-vie-ou-de-mort-face-a-la-pandemie/
[62] https://www.toutimmo.ch/2020/05/habitat-post-covid-19/
[63] https://rep.repubblica.it/pwa/intervista/2020/04/20/news/coronavirus_boeri_via_dalle_citta_nei_vecchi_borghi_c_e_il_nostro_futuro2-254557453/
https://www.letemps.ch/economie/forets-verticales-senracinent-ville
[64] https://rep.repubblica.it/pwa/intervista/2020/04/18/news/fuksas_connessa_e_salutista_ecco_la_casa_dell_era_post_covid-254404522/

comprendre les critères utilisés par les locataires en Suisse pour choisir de déménager et emménager dans un logement.[65] Cet apport était enrichi par les 6'900 réponses des participant.e.s à l'enquête nationale, dirigée par l'équipe du Corona Citizen Science, qui a permis d'observer le changement de ces critères avant et après la crise. La séance s'est clôturée par la présentation de Valentin Bourdon (doctorant à l'EPFL et invité en qualité d'expert) de quatre scénarios possibles pour le futur du logement.[66]

Ces pistes, ainsi que les résultats de la première séance et les retours des participant.e.s sur celle-ci, ont servi de matière à réflexion pour le deuxième Think Tank.

Le but de cette deuxième séance était de discuter des scénarios futurs pour le logement et de comment les atteindre. Afin de comprendre ce que le logement pourra ou devra être dans le futur, les chercheurs ont premièrement analysé les réponses à ce que le logement *aurait dû être* pendant la pandémie, les besoins qu'il aurait dû satisfaire, et qu'il a satisfait avec succès ou non. Le matériel analysé a pris une forme écrite et audio (enregistrements de la séance).

À partir des premiers résultats, trois éléments ont été identifiés : l'individu, l'espace, et la société. Le premier reflète l'opportunité *unique* de se recentrer sur soi pendant la pandémie (pour laquelle, p.ex., une bonne insonorisation du logement est nécessaire). Le deuxième, les (dés)avantages de nos espaces de vie que la crise a mis en lumière (p.ex., un accès à l'extérieur, une surface suffisante par personne). Le troisième, l'importance de notre rapport aux autres, remis en discussion pendant ces trois mois (ou plus) (p.ex., se retrouver avec les voisins dans le parking).[67] Suite à cette identification, le futur de chacune de ces dimensions a été envisagé : quel scénario pourrait aboutir à, p.ex., moins de temps pour se recentrer, moins de surface par personne, mais plus de vie en société ? Et que se passerait-il si on inversait les '*plus*' et les '*moins*' ?

Une fois caractérisés par l'évolution de ces trois dimensions, les quatre scénarios proposés par l'expert ont été rédigés dans un texte, construit avec les mots des participant.e.s, et accompagné d'images, contribuant à former un imaginaire –souhaitable ou pas.

Lors du deuxième Think Tank, le scénario le plus envisageable a été voté. Afin que tout le monde puisse exprimer son point de vue, et utiliser ses propres compétences et expertises, deux sous-groupes mixtes ont donc été formés. [68] Les groupes avaient pour but d'échanger leur opinion à propos des opportunités et obstacles pour atteindre l'objectif – fixé à 2030. Pour évaluer si ce scénario représentait de manière exhaustive les significations attribuées au logement par tous les participant.e.s, les réponses à la question '*Qu'est-ce que la maison pour nous ?'* ont été classées et utilisées pour guider la discussion. Le classement, basé sur les recherches précédentes sur les choix des locataires, a été enrichi avec une nouvelle fonction : la 'rencontre'.[69]

[65] https://www.epfl.ch/labs/herus/wp-content/uploads/2018/12/Project-summary_Anna-Pagani.pdf
[66] https://www.rts.ch/play/radio/prise-de-terre/audio/repenser-larchitecture-a-laune-du-confinement?id=11203151
[67] Nous précisons que les catégories indiquées sont les résultats des discussions, et ne sont pas représentatives de la population Suisse. Par exemple, les participant.e.s n'ont pas exprimé un jugement négatif par rapport à l'isolement forcé, qui n'est donc pas discuté dans ce texte.
[68] Les groupes formés étaient 'mixtes' : suite à l'analyse des attentes partagées en début de séance, nous avons pu remarquer que certain.e.s participant.e.s avaient des intérêts plus orientés sur le partage d'expérience et le vécu, alors que d'autres sur la pratique, le projet.
[69] Il est important de mentionner que ces fonctions ne sont pas mutuellement exclusives et que, au contraire, la richesse du parc de logements émerge de la combinaison de celles-ci.

Table 1. Les fonctions du logement. Basé sur Pagani et Binder (2019), réélaboration à partir de la définition des participant.e.s

REFUGE (attachement, chez-soi, intime)
ACTIVITÉS (télétravail, atelier)
IMPERMANENT (nomadisme, plusieurs chez-soi)
PERMANENT (pied à terre, entasser)
EXPRESSION (créatif, musique, s'exprimer, atelier)
SÉCURITÉ (pas de bruits, silencieux)
ACCESSOIRE, PRATIQUE (petit, bien situé, réduire charges)
RENCONTRE (réunions de famille, cluster)
PROPRIÉTÉ (propriétaires, liberté)
SYMBOLE DE STATUT (à définir)[70]

Quelles orientations pour l'après ?

Les quatre scénarios sont le résultat des recherches de Valentin Bourdon (Bourdon, 2020; Solari & Bourdon, 2020). Ceux-ci touchent à plusieurs dimensions : celle architecturale, urbaine et individuelle.

> L'étude de principes architecturaux attachés au thème de l'habitat et croisés à l'appréhension récente de la notion de « commun », avance de nouvelles compréhensions du rapport contemporain entre ville et logements. Selon différentes interprétations, et à partir d'une analyse des expériences passées, elle permet d'identifier des directions manifestes qu'une lecture plus nuancée peut articuler de manière variable. Aussi, les quatre scénarios identifiés peuvent être aussi bien partiels, concomitants ou combinés.

Nous présentons par la suite les textes élaborés sur la base des apports des participant.e.s (en gras), ainsi que l'évaluation des scénarios par rapport aux trois catégories identifiées comme essentielles pour repenser le futur du logement.

[70] Nous n'avons pas identifié des éléments associés à cette catégorie lors du premier Think Tank. Cette catégorie a été utilisée en tout cas pour évaluer le scénario lors du deuxième.

« Nous sommes en 2030. Au cours des 10 dernières années, nous avons appris à cohabiter avec les épidémies, et pas uniquement, car le changement climatique a poussé les températures aux extrêmes. Il fait très froid en hiver, très chaud en été. Les accords sur le climat sont clairs : nous ne pouvons pas utiliser plus que ce que nous avons. Une série de mesures ont donc été mises en place au cours du temps pour limiter notre consommation, et en même temps pour protéger les plus vulnérables (psychologiquement, et physiquement). »

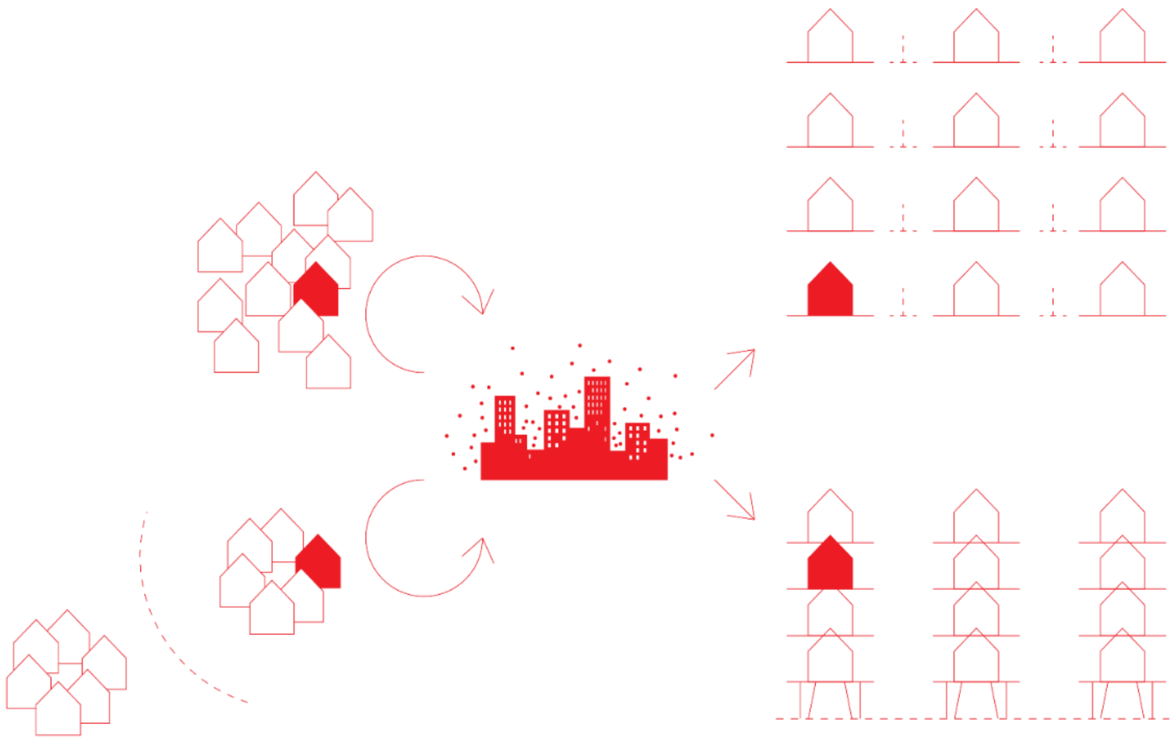


Image 1. Les quatre scénarios et leur rapport à la ville (illustration : V. Bourdon).

Scénario 1 : Retour à la terre

individu+ espace+ société-

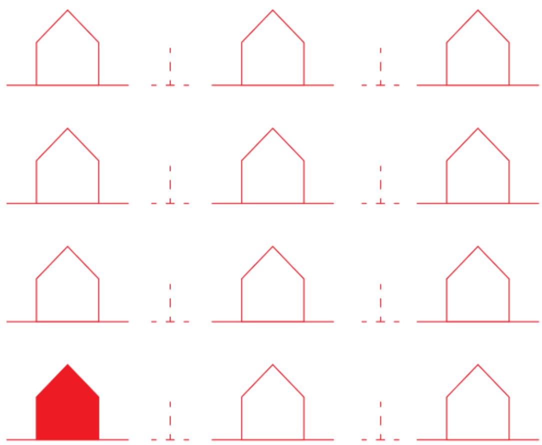


Image 2. Retour à la terre (illustration : V. Bourdon)

« Nous sommes en route vers la maison de nos amis, qui nous ont invités à dîner chez eux. Depuis notre voiture électrique, je vois les petites maisons individuelles qui s'étalent dans le territoire jusqu'à toucher les coins plus lointains de la campagne. Chaque maison a son petit jardin, son potager. Une fois arrivés, nos amis nous montrent comment, pour réduire leur consommation, ils ont réussi à s'émanciper de la société : l'énergie autoproduite, les meubles 'bricolés', jusqu'aux recettes qu'ils nous proposent...'fait-maison'! Leur maison est spacieuse et organisée : une chambre de travail, pour bien ***séparer le travail du loisir****, un* ***atelier****, des espaces pour* ***s'isoler, se concentrer, ou se 'recentrer'****. Le* ***silence et le calme*** *règnent. Ils sont très heureux de nous revoir...leur style de vie les coupe un peu du monde, et les* ***relations sociales*** *sont maintenant limitées aux amis les plus proches. »*

Scénario 2 : saut technologique

individu+ espace+ société-

« Il est temps d'aller se coucher, la journée a été très intense ; j'ai fait plein de choses. Sur mon écran, j'ai une longue liste : les courses en ligne, le ***projet*** *à envoyer pour le chantier, les appels sur Zoom* ***avec ma mère****... ça fait longtemps que je ne l'ai pas serrée dans mes bras. Puis, une vidéoconférence avec mon docteur, j'ai réservé déjà depuis le mois dernier. Il faut aussi que je n'oublie pas mon cours de méditation en ligne, à 6h du matin. C'est l'heure à laquelle j'aime regarder le soleil se lever depuis mon grand balcon. Heureusement mon logement a des petits coins pour faire tout cela. Pour* ***travailler, m'isoler****. Depuis le 17ème étage, j'ai une vue dégagée sur la nature environnante et le soleil inonde l'espace généreux de mon appartement. Ah, et aussi, j'ai prévu avec quelques amis de* ***jouer de la musique,*** *sur une nouvelle plateforme en ligne. Ça va être génial. Heureusement il ne faut plus prendre l'avion pour aller à la conférence où j'ai été invitée. Je n'aurais pas eu assez de budget carbone... »*

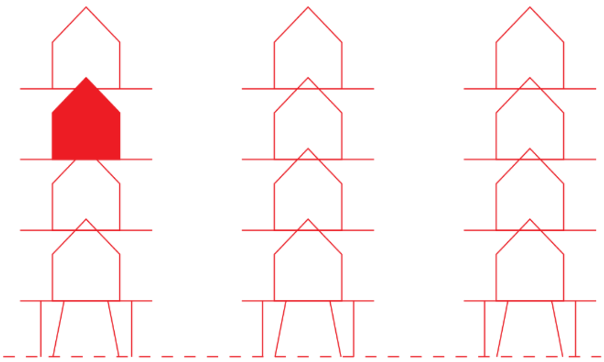


Image 3. Saut technologique (illustration : V. Bourdon)

Scénario 3 : Réinvestir la ville

individu+ espace- société+

« Quelle journée m'attend ! J'ai un rendez-vous au co-working space avec un collaborateur ***traducteur****, mais je dois vite passer au bar à côté pour prendre mon petit déjeuner. Depuis que les mesures de protection ont été mises en place, les espaces de restauration sont tellement grands, c'est presque un labyrinthe. Heureusement j'y ai travaillé aussi, et je sais m'orienter. Tous mes amis travaillent plutôt dans les services, maintenant. Serveurs, coiffeurs, il en faut tellement pour tout ce monde qui, à des rendez-vous précis, remplit et vide les espaces publics. Certes, il faut être ponctuels. On ne peut toujours pas dépasser les 50 personnes dans les*

restaurants. Bref, après ce rendez-vous, je dois passer vite chez ma mère. Il faut surtout que je me désinfecte, avant. Je peux acheter du ***street food*** *juste après. Je n'ai plus de cuisine chez moi (inutile !). Ma maison est toute petite,* ***20 mètres carrés me suffisent****.* ***Bien située, pas chère****. Nous ne pouvons plus consommer d'espace, qui est devenu très précieux, mais ce qui compte est que je peux m'isoler de cette ville palpitante qui remplit mes journées avec tant d'interactions sociales...retrouver le* ***plaisir du chez moi****. »*

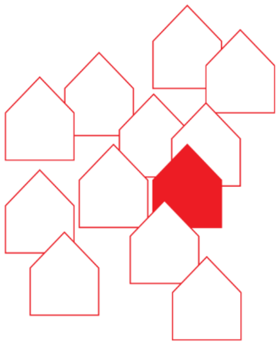


Image 4. Retrouver la ville (illustration : V. Bourdon)

Scénario 4 : Réinvestir le voisinage

individu- espace- société+

« Il faut que je demande à Sonja comment elle a réparé sa lampe. Je suis sûre qu'elle a la même. J'ouvre ma porte et la voilà, elle est en train de cuisiner pour tout le bâtiment, ce soir. Il y a le dîner de la coopérative. La petite Margot et Monsieur Salz l'aident à préparer. Monsieur Salz est très âgé, et aime bien passer du temps avec les enfants. Je suis heureuse dans ma petite communauté ***multigénérationnelle****. C'est mon* ***pied à terre****. Nous partageons de beaux espaces : des* ***salles de musique, des ateliers,*** *des salles de réunions, et des chambres d'ami. Notre logement est tout* ***petit*** *- c'est devenu obligatoire, pour réduire notre consommation. Cela a favorisé nos* ***liens avec nos voisins****. Ce n'a pas été simple avec la pandémie, c'est vrai, mais nous avons adopté d'intéressantes stratégies. Certes, j'apprécierais, de temps en temps, un peu plus de calme pour me* ***recentrer****... »*

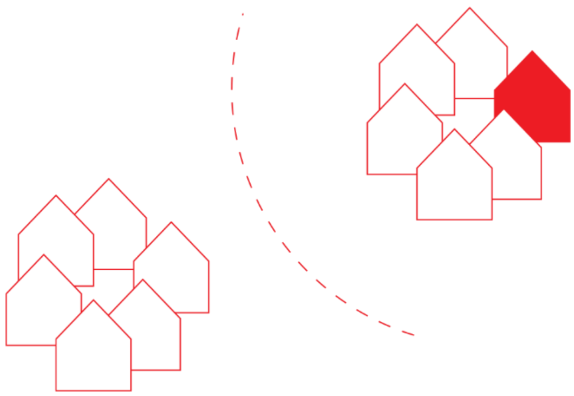


Image 5. Réinvestir le voisinage (illustration : V. Bourdon)

Quel futur envisagé ?

Choisir *un* des quatre scénarios n'est sans doute pas une tâche simple. Considérant la complexité de nos territoires urbains, une solution '*one fit all*', développée à tout niveau, n'est pas considérée comme envisageable. L'attention au contexte est fortement recommandée : une solution pourrait être adaptée pour un quartier ou une ville particulière, mais inapplicable ailleurs. Et encore, si une orientation *globale*, qui puisse guider une transformation avec un objectif à long terme, doit être envisagée, qui en serait le pilote ? Quel serait le rôle de l'état, de la propriété ?

En s'interrogeant sur la faisabilité des scénarios, les opportunités et obstacles pour les atteindre émergent naturellement. Si le *retour à la terre* était le plus désiré, comment avoir assez de terre pour tout le monde ? Quel est l'espace, physique, dont nous avons besoin pour répondre à toutes nos nécessités ? Et comment repenser radicalement cet espace physique (p.ex., verticaliser), tout en tenant compte de nos espaces de vie, ainsi que ceux des plus vulnérables ? Comment faire face aux défis que la rupture des limites de ces espaces, liée au télétravail, nous impose ?

Nous présentons ces questions comme des interrogations irrésolues, qui touchent aux quatre scénarios. Afin de mieux les explorer, un des scénarios a été choisi : le scénario 4 'réinvestir le voisinage' a été voté par la majorité comme plus désirable.[71] Nous résumons ici nos interrogations sur comment l'atteindre, ainsi que les obstacles et les opportunités que celui-ci nous présente.

Pourquoi ne vivons-nous pas en communauté, à l'heure actuelle ? Cette interrogation n'est peut-être pas pertinente, considérant les larges *networks* que nous avons aujourd'hui grâce à l'internet : en lien avec l'accroissement et l'intensification des mobilités, les liens affectifs ne sont plus seulement ceux que l'on entretient dans la proximité mais se nouent et se maintiennent aussi à distance. Comme ces larges réseaux sont créés tout au long du parcours de vie, « nous restons attachés, d'une façon ou d'une autre, aux lieux et, surtout, aux gens avec qui nous avons tissé des liens par le passé » mentionne un.e des participant.e.s. Les relations de voisinage n'ont pas pour autant disparu : « dans ce nouveau contexte, nous sommes invités à recréer des nouveaux liens, tout en gardant les anciens ». La question porterait donc sur comment la pandémie a contribué à réactiver ou transformer ces relations : *comment recréer l'esprit quartier ?*

Une réponse possible est suggérée aux architectes : au travers des espaces. Selon plusieur.e.s participant.e.s, à l'heure actuelle les bâtiments n'offrent pas la possibilité d'établir des liens affectifs. Contrairement aux 'quartiers dortoirs' ou aux quartiers protégés, isolés de la ville, les bâtiments pourraient offrir des opportunités agréables pour se rencontrer de manière *progressive*, créer le contact. Il faudrait donc imaginer différentes *formes de lieu*, ou une forme de voisinage non figée. Cela renvoie à plusieurs imaginaires : celui du petit village, permettant la formation de liens d'un côté, et de l'autre, au travers des services de proximité, la satisfaction des besoins de base assurée par la ville dense. La colocation, une forme qui aujourd'hui est imaginée plutôt pour les étudiants, pourrait se voir attribuer un nouveau statut. Dernièrement, des formes hybrides ont émergé, comme celles proposées par les coopératives : garder des espaces pour s'isoler, et d'autres pour partager, pour faire de la musique, cuisiner ensemble, *exc.* (p.ex., grâce au rajout d'une salle polyvalente).

Penser au partage nous fait rebondir sur la question de la propriété. Ces espaces doivent être gérés, respectés, et selon la logique dominante actuelle, générer *profit économique*. En termes matériels, nous pouvons déjà en apprécier les avantages : partager les outils de travail, de cuisine, ou autres

[71] Nous soulignons que ce scénario n'a pas été voté à l'unanimité : sur un total de 7 votants, un.e participant.e a choisi *réinvestir la ville* et un.e autre *le retour à la terre*.

a sans doutes un plus-value économique. Et encore, la formation de groupes solidaires permettrait de rentabiliser sur bien d'autres services, comme par exemple la garde des enfants.

Pourtant, cette solidarité n'est pas toujours simple à obtenir. Ce que le scénario semble prendre pour acquis est le succès des relations sociales : « les espaces partagés, ça fait intervenir le facteur humain, le relationnel », dit un.e des participant.e.s. Mais cette vie en communauté n'est pas sans obstacles : il faut *apprendre* à partager. En effet, pour plusieurs personnes, la culture du voisinage n'est pas développée. Et si sonner chez les voisins pour demander un service ne fait pas partie de nos habitudes, il y a un fort coût d'entrée à la construction de nouvelles relations de ce type.

Le désir d'être ensemble n'est pas le seul facteur qui permette à la vie en communauté de bien marcher, mais ce dernier pourrait déjà être assuré, selon un.e des participant.e.s, si les ménages pouvaient choisir leur logement. Hélas dans le contexte suisse, choisir l'appartement est déjà un gros défi, et choisir son groupe, poserai un problème de plus. Dans les deux cas, le vrai obstacle (et opportunité) est la *communication.* Une communication *non violente* (définie comme la communication du futur) est essentielle pour éviter l'échec du réinvestissement dans le voisinage.

Comment atteindre donc ce futur ?

Si la combinaison de plusieurs scénarios est envisageable, les obstacles et questionnements irrésolus restent nombreux pour le seul scénario 4. Réinvestir le voisinage signifie (re)créer une culture qui paraît — comme mentionné par un.e des participant.e.s — « revenir en arrière » tout en allant vers 2030.[72] Les espaces et les échelles du projet auxquelles ils sont conçus doivent permettre à cette culture de se développer : faciliter le partage, donner vie à des endroits –dans le bâtiment ou quartier-village– où se retrouver. Le projet d'espaces communs doit s'interroger sur leur propriété ou copropriété, dégageant ainsi un sens d'*interrelation*. C'est ce sentiment qui servira de support aux ménages et personnes vulnérables (p.ex., familles monoparentales, personnes âgées), dont la fragilité a été mise en lumière pendant la pandémie. La crainte de l'échec de ce modèle face à un changement radical du climat social met l'accent sur l'importance d'une communication non-violente, qui puisse apprendre aux habitants –qu'ils se choisissent ou pas– à cohabiter.

Le *besoin* de ville et l'importance du chez soi (se retirer, se recentrer) doivent pouvoir dialoguer sans s'imposer l'un sur l'autre, tout en questionnant ce qui peut et ne peut pas être partagé, et en assurant que toutes les significations ou *fonctions* du logement puissent être satisfaites. Pour cela, il ne s'agit pas seulement "d'augmenter" le logement en le dotant de multiples appendices, mais de réfléchir aux formes architecturales et aux modes d'organisation sociale permettant l'accueil d'une pluralité d'histoires de vie et de désirs d'appropriation.

Les deux Citizen Think Tanks sur le logement ont permis à ces réflexions de prendre forme de manière *collective*. Plusieurs éléments restent encore à discuter ; nous espérons pouvoir explorer dans le futur proche.

[72] La vie de voisinage au sens de "village" n'est pas un trait du passé mais une réalité actuelle pour de nombreuses personnes.

Curriculum Vitae – Anna Pagani

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LANGUAGES

IT ALIANO	FR ANÇAIS	EN GLISH	ES PANOL	DE UTSCH	CN - HANYU
madrelingua	langue maternelle	C2	C1	B2/C1	HSK2-HSK3

WORK EXPERIENCE

Dec2017 - Feb2022
Lausanne
CH

DOCTORAL STUDENT *Laboratory on Human-Environment Relations in Urban Systems*
project: Shrinking Housing's Environmental Footprint (SHEF- NRP73, duration: 4 years)
thesis title: Towards sustainability through housing functions: a systems perspective for the study of Swiss tenants' residential mobility

Jan2017 - Sep2017
Shanghai
CN

ARCHITECT *DEDODESIGN architects (DDA)*
sustainable design - technology and community (Edible City; Vertical Farming)
tasks: research, interaction with clients and companies, concept and design

Sep2016
Beijing
CN

CURATOR *Beijing Design Week 2016*
curator of the seminar Chinese New Towns @Beijing Design Week (CN)
tasks: interview of European experts, video-making, advertisement, design of the exhibition

Jan2016 - Jan2017
Torino
IT

COLLABORATOR *CeNTO_Chinese New Towns: negotiating citizenship and physical form*
"Research in Action": monitoring a case study of 'New Town'; proposing new processes of interaction between citizenship rights and physical form. task: research

Sep2015 - Jan2018
Torino
IT

WRITER *Edizioni Zero Torino*
contemporary art, photography and architecture journalist for the review Zero Torino.
tasks: writing, participation to press inaugurations, networking, reporting.

Mar2013 - May2013
Torino
IT

INTERN *Gruppo Thema Progetti srl*
design of TIM Company Centres and FIAT showrooms (Torino)
tasks: 3D making, concept discussion, visit of the construction sites.

EDUCATION AND GRANTS

Jan2014-Dec2015
Torino and Milano
IT

MSc double DEGREE cum laude
architecture
Politecnico di Milano - Alta Scuola Politecnica (ASP), technology talents

Sep2013-Sep2015
Torino
IT

MSc DEGREE cum laude
architecture & construction engineering
Politecnico di Torino

Sep2015
Torino
IT

HONORS THESIS *award*
Hutongs-Transformation: a battle between memories
Politecnico di Torino

Mar2015 - Aug2015
Lausanne - Beijing
CH - CN

MASTER PROJECT ABROAD *fellowship*
Swiss Network for International Studies (SNIS) project
Ecole Polytechnique Fédérale de Lausanne (EPFL)

Sep2014 - Feb2015
Lausanne
CH

ERASMUS PLUS *fellowship*
European Union Program
Ecole Polytechnique Fédérale de Lausanne (EPFL)

Oct2010-Jul2013
Torino
IT

BArch DEGREE cum laude
architecture
Politecnico di Torino

Sep2012 - Feb2013
Barcelona
ES

ERASMUS *fellowship*
European Union Program
EPSEB, Universitat Politècnica de Catalunya (UPC)

Jun2010
Torino
IT

BACCALAUREAT SCIENTIFIQUE
French Scientific Baccalaureate
Lycée Français Jean Giono

SKILLS, ACCOMPLISHEMENTS & OUTREACH

TECH SKILLS: Office | python | SPSS | Sketch Up | Auto CAD | Suite ADOBE | Final Cut Pro | Revit | 3dsmax

ORGANIZATIONAL *leadership spirit*

Mar2017 CN — organizer of the workshop "s[m2]art Shanghai" - *Italian Design Day 2017*. With East China Normal University (ECNU), Food Innovation Global Mission (FIGB), Istituto Italiano di Cultura.

2017 IT-CN — Board Member of Alta Scuola Politecnica ASP Alumni and ASP Asia HUB
responsible for the organization and communication of events in Europe and Asia

SOCIAL *communicative and team spirit*

May-Jun2020 CH — organizer of the Citizen Think Tank "Mon logement à l'épreuve du confinement: Quelles orientations pour l'après?"- *Swiss Corona Citizen Science project*

Mar2020 CH — EPFL finalist in the competition My Thesis in 180s (MT180)
video available at: https://www.youtube.com/watch?v=k7qaf2KXiB8

ARTISTIC *creative spirit*

Sep2010 IT — Literary Contest - Pro Loco di Revigliasco
Pagani, A. (2010). Il Pacco. In *Racconti della collina di mezzo*.

Jan2014 IT — Contemporary Dance Championship - Comitato Regionale Piemone della FIDS
Primo Premio Federazione Italiana Danza Sportiva (First Price)

May2003 IT — Piano National Contest - Associazione Pianistica J. Haydn
Diploma di Terzo Premio (Third Price)

INTERNATIONAL *globetrotter spirit*

I lived in..

IT ES CN CH

HIGHLIGHTS OF PUBLICATIONS

HOUSING SYSTEM

Pagani, A., & Binder, C. R. (2021). A systems perspective for residential preferences and dwellings: housing functions and their role in Swiss residential mobility. *Housing studies*.

Pagani, A., Baur, I., & Binder, C. R. (2021). Tenants' residential mobility in Switzerland: the role of housing functions. *Journal of Housing and the Built Environment.*

Karlen, C., **Pagani, A.**, & Binder, C. R. (2021). Obstacles and opportunities for reducing dwelling size to shrink the environmental footprint of housing: tenants' residential preferences and housing choice. *Journal of Housing and the Built Environment*.

Pagani, A., Ballestrazzi, F., Massaro, E., & Binder, C. R. (in review). ReMoTe-S. Residential Mobility of Tenants in Switzerland: an agent-based model. *Journal of Artificial Societies and Social Simulation.*

Pagani, A., Laurenti, R., & Binder, C. R. (2020). Sustainability assessment of the housing system: exploring the interplay between the material system and the social structure. In C. R. Binder, E. Massaro, & R. Wyss (Eds.), *Sustainability Assessment in Urban Systems* (pp. 384–416). Cambridge University Press.

COVID-19

Pagani, A., Hansmann, R., Fritz, L., & Binder, C. R. (2021). How the first wave of COVID-19 in Switzerland affected residential preferences. *Cities & Health.*

Hansmann, R., Fritz, L., **Pagani, A.**, Clément, G., & Binder, C. R. (2021). Activities, housing situation and further factors influencing psychological strain experienced during the first COVID-19 lockdown in Switzerland. *Frontiers in Psychology.*

CHINA

Bideau, F., & **Pagani, A.** (2019). Shaping urbanity. Politics and narratives. In M. Bonino, F. Governa, M.P. Repellino, & A. Sampieri (Eds.), *The City after Chinese New Towns* (pp. 90-96). Birkhäuser.

Pagani, A. (2015) *Hutongs-transformation: A battle between memories*. ISBN 9781326509965.

I am

a hybrid

of languages, cultures, disciplinary background, worldviews, goals, skills and passions

I've learnt

that a system is more than the sum of its parts

that we struggle to understand systems and their effects

that disciplinary silos are dangerous

that the sustainability of our built environment lies at the interface between multiple dimensions

that we need to act, now, to share this knowledge

I'd like to

have a real impact

do research

teach

FULL LIST OF PUBLICATIONS

JOURNALS

Pagani, A., & Binder, C. R. (2021). A systems perspective for residential preferences and dwellings: Housing functions and their role in Swiss residential mobility. *Housing studies*. https://doi.org/10.1080/02673037.2021.1900793

Pagani, A., Baur, I., & Binder, C. R. (2021). Tenants' residential mobility in Switzerland: The role of housing functions. *Journal of Housing and the Built Environment.* https://doi.org/10.1007/s10901-021-09874-5

Karlen, C., **Pagani, A.**, & Binder, C. R. (2021). Obstacles and opportunities for reducing dwelling size to shrink the environmental footprint of housing: tenants' residential preferences and housing choice. *Journal of Housing and the Built Environment*. https://doi.org/10.1007/s10901-021-09884-3

Pagani, A., Ballestrazzi, F., Massaro, E., & Binder, C. R. (in review). ReMoTe-S. Residential Mobility of Tenants in Switzerland: an agent-based model. *Journal of Artificial Societies and Social Simulation.*

Pagani, A., Hansmann, R., Fritz, L., & Binder, C. R. (2021). How the first wave of COVID-19 in Switzerland affected residential preferences. *Cities & Health.* https://doi.org/10.1080/23748834.2021.1982231

Fritz, L., Vilsmaier, U., Clément, G., Daffe, L., **Pagani, A.**, Pang, M., ... Binder, C. R. (in review). Explore, Engage, Empower: A Transformative Mixed-Methods Study Facing the Covid-19 Lockdown. *Journal of Action Research*.

Hansmann, R., Fritz, L., **Pagani, A.**, Clément, G., & Binder, C. R. (2021). Activities, housing situation and further factors influencing psychological strain experienced during the first COVID-19 lockdown in Switzerland. *Frontiers in Psychology.* https://doi.org/10.3389/fpsyg.2021.735293

BOOK CHAPTERS, THESIS

Pagani, A., Laurenti, R., & Binder, C. R. (2020). Sustainability assessment of the housing system: exploring the interplay between the material system and the social structure. In C. R. Binder, E. Massaro, & R. Wyss (Eds.), *Sustainability Assessment in Urban Systems* (pp. 384–416). Cambridge University Press. https://doi.org/10.1017/9781108574334.018

Mereilles, J., **Pagani, A.**, Athanassiadis A., & Binder, C. R. (2020). Sustainability issues in urban systems from a metabolic perspective. In C. R. Binder, E. Massaro, & R. Wyss (Eds.), *Sustainability Assessment in Urban Systems* (pp. 261–289). Cambridge University Press. https://doi.org/10.1017/9781108574334.013

Bideau, F., & **Pagani, A.** (2019). Shaping urbanity. Politics and narratives. In M. Bonino, F. Governa, M.P. Repellino, & A. Sampieri (Eds.), *The City after Chinese New Towns* (pp. 90-96). Birkhäuser. https://infoscience.epfl.ch/record/264857?ln=en

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Pagani, A. & Quaglia, G. (2013). Pechino 1970. In *La descrizione del mondo: Reportage immaginari della città asiatica*. Politecnico di Torino. ISBN: 978-88-8202-041-5 (ePub). http://porto.polito.it/id/eprint/2506018.

CONFERENCE PAPERS & POSTERS

Pagani, A., Ballestrazzi, F. & Binder, C. R. (2021). Shrinking housing's size: Using agent-based modelling to explore measures for a reduction of floor area per capita. In M. Czupryna and B. Kami´nski (Eds.), *Advances in Social Simulation. Proceedings of the 16th Social Simulation Conference, 20-24 September 2021.* Springer Proceedings in Complexity. https://doi.org/10.1007/978-3-030-92843-8_21

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Pagani, A., Baur, I. & Binder, C. R. (2020). *Housing functions: towards a new understanding of flexibility in architecture*. Digital poster presentation at BEYOND2020. World Sustainable Built Environment Conference, Online. https://infoscience.epfl.ch/record/282975

Pagani, A., & Binder, C. R. (2019). Towards housing sustainability: a framework for the decision-making process of tenants. *IOP Conference Series: Earth and Environmental Science*, 323, 012093. https://doi.org/10.1088/1755-1315/323/1/012093

Pagani, A., Shinde, R., Hellweg, S., & Binder, C. R. (2019). An agent-based model framework for understanding the decisions of households and exploring bottom-up effects on housing sustainability. *Journal of Physics: Conference Series*, 1343(012142). https://doi.org/10.1088/1742-6596/1343/1/012142

Pagani, A. & Binder, C. R. (2018). *Agent-Based Modeling for studying the choices of households in Switzerland*. Poster session and speed talk at the Swiss Inter- and Transdisciplinarity Day 2018. Inter- and Transdisciplinarity in a Digital World, EPFL, Lausanne.

Mangogna, A., Valagussa, D., Akintola, T.O., Arietti, M., Cicero, S., Mordillo, F., **Pagani, A.**, Sipione, R., & Corgnati, S.P. (2015). Towards Nearly-Zero Energy Buildings: HVAC System Performance in the Expected Operative Scenarios of Turin Energy Centre. *Proceedings of REHVA Annual Conference 2015 "Advanced HVAC and Natural Gas Technologies"*. Riga, Latvia, May 6 –9, 2015.

TALKS

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Pagani, A. (2019). The next 30 years: From a long-term to a short-term vision with systems science tools. RE-MEET: ENTHUSIASM AND VISION, Amsterdam, The Netherlands, 11 October 2019. https://infoscience.epfl.ch/record/274236?ln=en

MEDIA

Pagani, A. (2021). Les femmes et étudiants ont souffert de leur logement pendant le semi-confinement: interview d'Anna Pagani. *RTS*. https://www.rts.ch/audio-podcast/2021/audio/les-femmes-et-etudiants-ont-souffert-de-leur-logement-pendant-le-semi-confinement-interview-d-anna-pagani-25786281.html

Veillon, E. (2021). Rester ou déménager: mieux comprendre le choix des Suisses (avec interview de **Pagani, A.**). *Le Temps*.
https://www.letemps.ch/economie/rester-demenager-mieux-comprendre-choix-suisses

Pagani, A. (2017). "Shanghai, la vetrina da cui tutto ha avuto origine." *Il Giornale dell'Architettura.*
Retrieved from http://ilgiornaledellarchitettura.com/web/2017/05/31/shanghai-la-vetrina-da-cui-tutto-ha-avuto-origine/

TEACHING
2017-2021

LECTURER *EPFL*
Systems Thinking in the Age of Transition. ETHZ-EPFL MAS in Urban and Territorial Design

TEACHING ASSISTANT *EPFL*
Sustainability Assessment of Urban Systems, Environmental Sciences and Engineering, Master semester 2

SUPERVISOR *EPFL*
Master theses in Environmental Sciences and Engineering and in Architecture

ORGANISER *EPFL-ETHZ*
Summer School on Designing for Resiliency: RE:GENERATE alpine-urban circularity