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Environmental policies: designing acceptable road pricing and voluntary waste sorting schemes

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Abstract

Growing urban population implies many challenges for the municipalities in terms of mobility, housing, waste management or infrastructures. Public policies are thus needed to ensure a sustainable development. The main objective of this thesis is to analyze different environmental policies in the domain of mobility and waste management in order to help municipalities in designing more efficient measures.

Firstly, Chapter 2 focuses on traffic congestion and in particular the acceptability of a congestion charge. We design a large survey with different plausible schemes for the Canton of Geneva, Switzerland and assess their acceptability with a discrete choice experiment (DCE). Results show that public support depends crucially on the policy design and the information provided. We find an important demand for exemptions and a preference for constant pricing. This implies a clear trade-off between efficiency and acceptability. However, the gap can be partly closed by information provision. Analyzing heterogeneity, we observe that preferences vary according to personal characteristics, especially where people live and how they commute.

Chapter 3 analyzes the determinants of households' municipal waste sorting. We design a survey to investigate households' sorting motivation and use a DCE to assess households' waste sorting scheme preferences in the Canton of Geneva. We observe that households' waste sorting depends on personal characteristics such as sensitivity to the environment, guilty conscience or information level. However, it is the satisfaction with the existing sorting scheme that increases most the probability to sort waste. Our results show clear preferences for better infrastructures, but with thresholds. Interestingly, the best infrastructures and services are not always needed. By looking at heterogeneity and linking personal beliefs and characteristics with preferences, we find different groups sorting a similar number of categories, but with different underlying mechanisms like a lack of knowledge or a need for more convenient infrastructures and services.

To complement our analysis on voluntary policies and in particular on the effectiveness of convenient infrastructures, Chapter 4 assesses a new voluntary environmental policy implemented in the Canton of Geneva and compares the results with a bag tax, a monetary incentive policy introduced in the neighboring canton, Vaud. The voluntary policy consists of the distribution to households of specific bins for organic waste to increase the sorting rate and decrease the amount of unsorted waste. We use a difference-in-differences methodology to assess the causal impact of the policy on organic waste as well as on overall waste generation. We find that the introduction of the voluntary policy increases significantly the proportion of households sorting organic waste. Interestingly, we observe some positive spillover effects on other waste sorted. By comparing the voluntary policy in the Canton of Geneva and the bag tax in the Canton of Vaud, we find similar effects on organic waste sorting. However, the impact of the voluntary policy is smaller on unsorted waste than the short-term effect of the bag tax.

In conclusion, we show that price is not the only factor to consider in environmental policies. More stringent policies can be acceptable if well designed. Furthermore, the power of non-monetary incentives should not be underestimated.

Keywords Policy design; Voluntary policy; Public support; Household preferences; Norms; Road pricing; Waste sorting; Organic waste; Discrete choice experiment; Difference-in-differences

Résumé

La croissance de la population implique de nombreux défis pour les municipalités en termes de mobilité, de logement, de gestion des déchets ou d'infrastructures. Les politiques publiques sont donc nécessaire pour assurer un développement durable. L'objectif principal de cette thèse est d'analyser différentes politiques dans le domaine de la mobilité et de la gestion des déchets afin d'aider les municipalités à concevoir des mesures plus efficaces.

Le chapitre 2 se concentre sur la congestion liées au trafic, en particulier sur l'acceptabilité d'un péage urbain. Nous avons conçu une enquête avec différents péages possibles pour le canton de Genève, en Suisse, et évalué leur acceptabilité à l'aide d'une expérience de choix discret (DCE). Les résultats montrent que l'acceptabilité dépend essentiellement de la conception de la politique et des informations fournies. Nous constatons une préférence pour les rabais et une tarification constante. Il y a donc un écart entre efficience et acceptabilité. Cependant, il peut partiellement être comblé par les informations fournies. De plus, nous observons que les préférences varient en fonction des caractéristiques personnelles, notamment le lieu de résidence et le mode de déplacement.

Le chapitre 3 analyse les déterminants du tri des déchets urbains par les ménages. Nous avons conçu une enquête incluant un DCE pour étudier les motivations et évaluer les préférences des ménages en matière de tri des déchets dans le canton de Genève. Nous observons que le tri dépend des caractéristiques des ménages comme leur sensibilité à l'environnement, leur mauvaise conscience ou leurs connaissances. Cependant, c'est leur satisfaction du système de tri existant qui augmente le plus la probabilité de trier. Nos résultats montrent des préférences claires pour de meilleures infrastructures, mais avec des seuils. En examinant l'hétérogénéité et en reliant les croyances et caractéristiques personnelles aux préférences, nous constatons que différents groupes trient un nombre similaire de catégories de déchets, mais avec des mécanismes sous-jacents différents comme le manque de connaissances ou le besoin d'un système de tri plus pratiques.

Pour compléter notre analyse des incitations non-monétaires, le chapitre 4 évalue l'effet d' une nouvelle politique environnementale volontaire introduite dans le canton de Genève, qui consiste en la distribution aux ménages de poubelles spécifiques pour les déchets organiques. Le but est d'augmenter le tri et de diminuer la quantité de déchets incinérés. Nous utilisons la méthode de différence en différences pour évaluer l'impact causal de la politique volontaire sur le tri et la production globale de déchets. Nous observons une augmentation significative de la proportion de ménages qui trient les déchets organiques, ainsi que des effets d'entraînement positifs sur les autres déchets triés. En comparant avec l'effet de la taxe au sac, incitation monétaire introduite dans le canton voisin, Vaud, nous constatons des effets similaires sur le tri des déchets organiques. En revanche, la politique volontaire a un effet plus faible que celui à court terme de la taxe au sac sur les déchets incinérés.

En conclusion, nous montrons que le prix n'est pas le seul facteur à prendre en compte dans les politiques environnementales. Des politiques plus strictes peuvent être acceptables si elles sont conçues correctement. En outre, le pouvoir des incitations non-monétaires ne doit pas être sous-estimé.

Mots-clés Conception de politiques ; politique volontaire ; soutien public ; préférences des ménages ; normes ; péage urbain ; tarification routière ; tri des déchets ; déchets organiques ; expérience de choix discret ; modèle de classe latente ; différence en différences.

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Chapter 1

Introduction

According to United Nations (2019), the World's population living in urban areas will increase from 55% to 68% by 2050. With urbanization and population growth, municipalities face many challenges in terms of housing, transportation, energy systems, waste management and other infrastructures. In this thesis, we take a particular interest in mobility and waste management. The World Bank estimates a waste generation increase from 2.01 billion tonnes to 3.40 billion tonnes in 2050 and Switzerland is among the worst municipal solid waste producer with more than 1.5 kilos per capita per day (Kaza et al., 2018). Regarding mobility, total motorized vehicles should increase by 90% by 2050 compared to 2015 (OECD/ITF, 2017). In addition to management issues, waste and traffic cause important external costs to society like noise, pollution and loss of precious material and resources. Sustainable development depends thus crucially on public policies. Hence, it is fundamental to understand households' behaviors and preferences to design the most efficient policies.

Environmental policies combine different types of instruments to change behaviors, that can be classified in three groups according to the European Environment Agency (2016): regulations also called command-and-control measures, monetary incentives, sometime entitled market-based approaches, and non-monetary incentives, seen as information instruments, voluntary or awareness rising measures. The choice of the environmental policy instrument is a crucial and difficult decision. No instrument is superior on all dimensions and circumstances (Goulder and Parry, 2008). For this reason, various measures have been undertaken in different municipalities around the world to solve mobility and waste sorting issues.

Command-and-control measures rely on permissions, prohibitions, standards setting and enforcement. To reduce traffic externalities, several cities have implemented command-and-control measures like vehicle bans or restrictions. For example, Madrid entirely banned old type vehicles from its city center, which deceased air pollution inside as well as outside the perimeter of the ban (Salas et al., 2021). Different cities around the world, including Beijing, Bogota, Caracas, Delhi, La Paz, Mexico City, Santiago de Chile or Medellin, adopted driving restrictions based on license plate numbers. However, results of such restrictions are mixed depending on response behaviors like the purchase of a second vehicle, cheating or shifting car trips to unrestricted times and enforcement strategies (Guerra et al., 2022).

Known as more economically efficient measures, many municipalities introduce market-based instruments, which include, waste pricing by the bag or by volume (see Bel and Gradus (2016)) to decrease the total amount of waste generated and increase recycling, as well as cordon or zone pricing schemes (e.g. Leape (2006)), tolled roads and bridges (e.g. Currie and Walker (2011)), toll lanes (e.g. Bento et al. (2020)) or smart-parking programs (e.g. Krishnamurthy and Ngo (2020)) to solve congestion issues. Pigou (1920) already advocated for the introduction of pricing scheme in order to make individuals internalize the social cost they generate. Nevertheless, pricing policies face an extremely slow emergence in world cities arguably due to lack of public support (Gu et al., 2018). In Latin America cities for example, vehicle bans have been more popular than congestion pricing schemes to manage negative externalities of congestion (Mahendra, 2008). Only Buenos Aires and Santiago have implemented some market-based approaches to fight congestion, whereas Bogota, Caracas, La Paz, Lima, Mexico City and Sao Paulo have implemented vehicle circulation restrictions (Wang et al., 2021). The success of a policy crucially depends on its public acceptance (Li and Zhao, 2017). A rapidly growing literature has thus emerged to address this issue (cf Carattini et al. (2018b) and Gu et al. (2018) for a review).

The existing literature points out various factors influencing the public support of a pricing policy. A general finding is that public acceptability tends to decline as the level of stringency, measured by the tax rate, increases (e.g. Sælen and Kallbekken (2011); Brännlund and Persson (2012); Gevrek and Uyduranoglu (2015); Carattini et al. (2017)). Furthermore, people may have a tendency to overestimate the downsides of a policy change, and underestimate the upsides, in particular the incentive effect of environmental taxes and their ability to change behavior (e.g. Dresner et al. (2006); Steg et al. (2006); Baranzini and Carattini (2017)). Consequently, it has been observed that public support increases after a policy is implemented and people experience it (e.g. Schuitema et al. (2010); Hansla et al. (2017); Janusch et al. (2020)). Finally, the use of the generated revenue plays a crucial role in the public support of a policy. According to Jaensirisak et al. (2005), public support is higher for schemes that earmark revenues for environmental purposes than for schemes in which revenues are not earmarked.

To contribute to this growing literature on public support for environmental taxes, as well as to the literature on the design of effective road pricing schemes, we examine design issues and public support for congestion charges in Switzerland, a context in which policymakers are planning to implement such a policy, but voters have the final say. Based on the existing literature, we identify a set of plausible congestion charge designs and assess their public support with a large, transnational discrete choice experiment (DCE), combined with randomized informational treatments, a unique methodology in this context. We provide evidence on people's preferences for different design parameters and identify clear trade-offs between efficiency and public acceptability. Furthermore, we can directly test the role of information on public support with the use of randomized treatments. We highlight the role of information asymmetries in voting behavior.

The public acceptability issue can be solved with the use of non-monetary incentives. Many municipalities implement information strategies through the distribution of flyers or leaflets or even door-to-door campaigns in various domain. Regarding waste sorting, municipalities try to increase convenience by curbside collection or closer collection points. Even if, voluntary measures are often considered as less stringent and effective measures since they are not mandatory, their effect in changing individual's behavior is well recognized, e.g. Titmuss (1970); Andreoni (1989); Frey and Oberholzer Gee (1997); Bénabou and Tirole (2006). Information and education are seen as key drivers to participation in pro-environmental behaviors, for example in sorting activities and the good quality of recycling (Perrin and Barton, 2001; Smeesters et al., 2003; Timlett and Williams, 2009; Ladele et al., 2021). Nevertheless, people will mainly not engage in pro-environmental behaviors if it is not convenient to do it. Convenience, which can be improved with better infrastructures and services, is even considered as the strongest determinant of waste sorting behavior (Miafodzyeva and Brandt, 2012). Furthermore, it has been found that a high degree of individual responsibility can replace economic incentive (Bazin et al., 2004). Increasing moral motivation is thus crucial in pro-environmental behaviors. In addition to the fact that people want to think about themselves as responsible, they also want to be seen as responsible people by others (Halvorsen, 2012). Social norm interventions can thus be effective in inducing pro-environmental behaviors (Farrow et al., 2017).

To contribute to the literature on non-monetary incentives and on the determinants of households waste sorting, we refer to Geneva, the last Swiss canton without unit-based waste pricing in order to evaluate households' norms and waste collection scheme preferences. We use a survey including a DCE to investigate household preferences regarding waste sorting schemes. The use of DCE is still limited in the literature on waste sorting, but it allows analyzing precisely behavioral determinants, while particularly relevant in the Swiss context. We analyze the sample heterogeneity with a latent class model in a novel way, by linking personal beliefs and characteristics with preferences. We provide evidence on the determinants of waste sorting and people's preferences for different waste collection schemes and identify clear thresholds and heterogeneous preferences.

To complement our analysis on non-monetary incentives, we use a difference-in-differences methodology to analyze the effectiveness of a new voluntary environmental policy introduced in the Canton of Geneva, Switzerland, to increase organic waste sorting and hence the overall sorting rate. Furthermore, through the unique opportunity to have a monetary incentive and a voluntary policy in place in the same country, we compare the impact of both policies.

1.1 The Swiss context and Geneva

The topics covered in this thesis are related to Switzerland, a case study of special interest regarding public interventions and public support. The country is governed under a federal system at three levels: the Confederation, the cantons and the communes. As much power as possible is given to the communes and it is delegated to the cantons and Confederation only when necessary. Thanks to direct democracy, citizens have a right to say on decisions at all political levels. In addition to the right to vote, citizens have the opportunity to put issues to the vote themselves through three instruments: the popular initiative and optional and mandatory referendums. Policies need thus to be accepted by the population to be implemented, which makes public support crucial in this context.

The Swiss political system is based on the Federal Constitution of 1848, which is regularly revised with the approbation of the population and the cantons. The initial text does not explicitly mention, for example, the tax exemption for public roads. However, nowadays, the public roads in Switzerland should be free of tolls. This is the result of a proposal by the Federal Council in 1957 to write in the Federal Constitution the principle of tax exemption for public roads, with the possibility for the Parliament to grant exemptions. The citizens approved this constitutional amendment the following year. The road infrastructure is thus currently mainly funded by specific taxes, such as fuel tax and a highway sticker. The latter was introduced in 1994, after a public ballot. Since then, holding a vignette is compulsory for driving on Swiss highways. Swiss people are used to vote 3 to 4 times a year on about 3-4 subjects of national or local politics each time. Public support is thus very important in this context. Recently, due to the high and increasing level of congestion, the Swiss government introduced mobility pricing to the policy agenda. The Canton of Geneva, among other candidates, stepped forward for a pilot scheme with a local congestion charge. This is not surprising, since Geneva is a highly congested city. However, the introduction of a congestion charge would have to be voted.

In 1974, unit-based pricing on municipal solid waste was introduced for the first time in a municipality in Switzerland. From 1983, the polluter pays principle is listed in the article 74 of the Federal Constitution: “The costs of prevention and repair are to be borne by those who cause them”. Hence, the cost of municipal waste disposal has to be supported by the emitters and consequently can be covered only partly by lump-sum taxes. By the nineties, the large majority of the German-speaking municipalities implemented a bag tax, while the French-speaking municipalities implemented it during the last decade only. In 2011, a case law of the supreme court reminded that the polluter pays principle should be applied, by specifying that the use of lump-sum taxes to finance waste management and treatment should be used as a complementary source of revenue only. To date, all the Swiss cantons except Geneva have implemented a bag tax to finance their waste management systems. The way the Canton of Geneva finances its waste management system is illegal. However, even if the authorities are aware of their situation, they prefer to rely on voluntary measures and the cooperation of the inhabitants. In 2016, for example, they decided to distribute to households a specific bin for organic waste to increase the sorting rate and decrease the total amount of unsorted waste.

It is important to note the particular geographical configuration of the Canton of Geneva. Located at the western end of Switzerland and at the end of Lake Geneva, the Canton of Geneva is bowl-shaped and shares 103 km of border with France for only 4.5 km with its neighboring canton, Vaud and thus Switzerland. The city of Geneva, which is the unique urban center of the Canton, has become the heart of a vast cross-border agglomeration. It concentrates 54% of the Canton's job and 35% of the cross-border agglomeration on a territory that occupies only 6% of the canton and 0.8% of the agglomeration (Ville de Genève, 2009). The small territory and relatively high density of the city of Geneva lead to a tight housing market and an expansion of the urban area to suburban and French municipalities. However, the specific topography of the Canton complicates the development of public transport and soft mobility, which results in an intensive use of individual motorized vehicles and its externalities (congestion, pollution, noise, ...). The close french boarder has not only a major impact on mobility, but on all public policies. In fact, it might be a reason for the Canton's refusal to introduce unit-based pricing on municipal solid waste. In France, there is no pricing policy on waste which might lead to export of waste from Swiss inhabitants in addition to the other drawbacks of such pricing policies.

Switzerland has also a long tradition in voluntary policies. In 1990, Switzerland launched the Energy 2000 program in the context of the Swiss Energy Law, which relies mainly on voluntary approaches. It was the first Swiss policy to specifically target climate change. In 1994, following the Rio Earth summit, the Federal Council prepared a project for a Law on reducing CO_2 emissions. The idea was to raise a CO_2 tax on fossil fuels. However, the project had to be abandoned due to a strong public opposition. After the ratification of the Kyoto Protocol in 1997, the Federal Council prepared a new project to meet its commitment. This time, it decided to put voluntary approaches forward and to keep the CO_2 tax on reserve. This new project was approved by the Parliament and came into force without opposition. The new Energy Law implemented in 1999 had a similar approach to the CO_2 Law. It encouraged voluntary approaches and planned to implement other instruments only if they were insufficient. In 2005 and 2008, since objectives were not achieved, Switzerland introduced an incentive tax on fossil fuels and on CO_2, respectively. In 2021, the population rejected the new CO_2 Law proposition, which included an increase of the CO_2 tax.

In this context, the Canton of Geneva is the perfect example to study public support of pricing policies as well as the design and effect of voluntary policies.

1.2 Objectives and outlines of the thesis

The aim of this thesis is to analyze behaviors and environmental policies in order to help municipalities designing more efficient measures. Pricing policies suffer from a lack of public support and voluntary policies are often seen as ineffective. To do so, this thesis is divided in three different chapters, each analyzing a specific environmental policy in the Canton of Geneva, Switzerland.

Chapter 2 focuses on the design of an effective and acceptable congestion charge. It builds on existing theoretical and empirical literature on congestion charges to first identify a set of plausible designs that could fit the context of Geneva. Their acceptability is then assessed with the help of a large survey of respondents in both the Canton of Geneva and the neighboring regions of Switzerland and France. We use a discrete choice experiment (DCE), a methodology that is perfectly suited to assess individual preferences regarding the attributes chosen to characterize the congestion charge: charge rate, perimeter of the charge, modulation of the charge, level of exemptions, beneficiaries of exemptions (if any), and use of revenues. We combine the DCE with informational treatments that address potential biased beliefs concerning the charge's expected effects on congestion and pollution. This allows us to test the fact that very salient environmental policies tend to be more popular ex post than ex ante. Finally, given our large sample and its cross-national feature, we analyze carefully the heterogeneity across respondents with a latent-class and a multinomial logit model. Our results show that public support depends closely on the design as well as the information provided, in particular with respect to the environmental benefits of a congestion charge like air quality improvements. We observe also a clear trade-off between public support and efficiency, but the gap can be partially closed thanks to information provision. With the heterogeneity analysis, we show that preferences vary according to personal characteristics. Finally, we identify different congestion charge designs that reach majority support.

Chapter 3 analyzes the determinants of households' municipal waste sorting behavior to understand and develop voluntary waste recycling policies. We design a survey to investigate households' sorting habits, personal and social norms, preferences about waste collection schemes and socioeconomic characteristics in the Canton of Geneva, the last Swiss canton without a bag tax. We assess waste collection schemes' preferences with a DCE including the following attributes: curb collection frequency, waste categories collected at curb, distance to the collection point and price. We also consider the heterogeneity in preferences with a latent class model and study their interaction with moral and social norms with a multinomial logit model. We confirm the importance of convenient infrastructures. However, interestingly, we find threshold in preferences. Better infrastructures are preferred, but only to some extent. Furthermore, as expected, the higher the cost of a collection scheme, the lower its popularity. However, even if the price is an important determinant in preferences and sorting behaviors, it is by far not the only one. By analyzing the heterogeneity of our sample, we find different classes with similar sorting habits, but with different motivation and characteristics. We show that waste sorting can be encouraged without monetary incentives.

After analyzing the determinants of voluntary waste sorting, Chapter 4 evaluates the impact of a new voluntary environmental policy implemented in the Canton of Geneva, Switzerland and compare the results with a monetary incentive policy introduced in its neighboring canton, Vaud. We assess the causal impact of the bins for organic waste distributed in 2016 in the Canton of Geneva on organic as well as overall waste with the help of a difference-in-differences methodology. Data are collected at the household level with a survey before and after the introduction of the policy. We use the neighboring canton, Vaud, which did not implement such a voluntary policy, as a control. To supplement the survey data, we exploit administrative data collected at the municipal level. We show that the voluntary policy increases significantly the proportion of households sorting organic waste. This confirms the positive effect of convenient infrastructures and information on sorting. In addition we find some spillover effects: an increase in the number of other sorted categories, as well as in the quantities of other waste sorted. By comparing the effect of the voluntary waste policy to the bag tax implemented in the neighboring canton, Vaud, we observe a similar impact on organic waste. Regarding unsorted waste, the effect of the voluntary policy is comparable to the long-term effect of the bag tax, which is smaller than its short-term effect. We thus show that voluntary and pricing policies perform similarly on specific targets. However, overall, voluntary policies seem less stringent and effective than pricing policies.

Finally, the concluding chapter highlights the main findings of the thesis and discuss possible limitations and directions for future research.

Chapter 2

Designing effective and acceptable road pricing schemes: Evidence from the Geneva congestion charge[1]

This Chapter is a slightly modified version of a paper written together with Andrea Baranzini and Stefano Carattini (Baranzini et al., 2021) published in Environmental and Resource Economics.

Abstract

While instruments to price congestion exist since the 1970s, less than a dozen cities around the world have a cordon or zone pricing scheme. Geneva, Switzerland, may be soon joining them. This chapter builds on a detailed review of the existing schemes to identify a set of plausible design options for the Geneva congestion charge. In turn, it analyzes their acceptability, leveraging a large survey of residents of both Geneva and the surrounding areas of Switzerland and France. Our original approach combines a discrete choice experiment with randomized informational treatments. We consider an extensive set of attributes, such as perimeter, price and price modulation, use of revenues, and exemption levels and beneficiaries. The informational treatments address potential biased beliefs concerning the charge's expected effects on congestion and pollution. We find that public support depends crucially on the policy design. We identify an important demand for exemptions, which, albeit frequently used

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in the design of environmental taxation, is underexplored in the analysis of public support. This demand for exemptions is not motivated by efficiency reasons. It comes mostly by local residents, for local residents. Further, people show a marked preference for constant prices, even if efficiency would point to dynamic pricing based on external costs. Hence, we highlight a clear trade-off between efficiency and acceptability. However, we also show, causally, that this gap can in part be closed, with information provision. Analyzing heterogeneity, we show that preferences vary substantially with where people live and how they commute. Even so, we identify several designs that reach majority support.

Keywords Acceptability; Congestion charge; Policy design; Public support; Road pricing

2.1 Introduction

Traffic congestion is among the top issues in many cities in the world. Congestion generates important costs to society, due to extended journeys, local and global pollution, noise, and accidents. Over the next few decades, projections predict a large increase in urban population, in both developed and developing countries (United Nations, 2015), potentially increasing total motorized mobility by about 40 % by 2030 with respect to 2015, and by over 90 % by 2050 (OECD/ITF, 2017). However, the extent to which an increasing urban population translates into higher traffic congestion depends on public policy. Interest in curbing traffic congestion and reducing local air pollution has likely increased following the recent COVID-19 lockdowns, which made very salient the contribution of motorized traffic to air pollution and other exernal costs (Berman and Ebisu, 2020; Cicala et al., 2020; He et al., 2020; Muhammad et al., 2020). Congestion is one of the classic textbook examples of an externality, whose economic theory dates back to Pigou (1920). Time lost in traffic is the main externality from traffic congestion (Small et al., 2005, Table 3.3; Small et al., 2007), followed by car accidents and pollution among others (e.g. Li et al., 2012; Jacobsen, 2013). The solution to the external costs of driving is well known since the 1960s: pricing road traffic (Walters, 1961; Reynolds, 1963; Vickrey, 1963). However, very few jurisdictions in the world have implemented congestion charges. Unlike the climate externality, traffic congestion is a very local issue, and intergenerational equity issues are largely absent. Yet, there are only a handful of cities in the world with a cordon or zone pricing scheme, compared to some 60 jurisdictions pricing carbon (World Bank, 2020). Hence, the 1963 statement by William S. Vickrey, that "in no other major area are pricing practices so irrational, so out of date, and so conducive to waste as in urban transportation" is even more relevant today than it was in the '60s (Vickrey, 1963, p. 452).

The main reason for the extremely slow emergence of congestion charges in world cities is arguably lack of public support (Gu et al., 2018). Policymakers in many cities, including New York, have in the past abandoned their plans for a congestion charge due to lack of public support. A congestion charge was rejected at the ballot box in Birmingham, Edinburgh, and Manchester. Voters in Gothenburg rejected it in a referendum, although the scheme was nevertheless implemented given the non-binding character of the referendum. Voters in Stockholm approved it, but only after a trial period.

Standard political economy theory shows that even policies that are clearly beneficial for society may not actually be implemented, mainly because of the mismatch between policy-makers' incentive to be reelected and society's welfare (e.g. Dixit et al., 1997; Samuelson and Zeckhauser, 1988; Hahn, 1989; Maskin and Tirole, 2004). However, reforms may not only create discontent among losers, but potentially also among winners, if the latter do not correctly anticipate, ex ante, the benefits of the policy change (Kallbekken et al., 2011; Dal Bó et al., 2018). Winners may also have preferences towards fairness, related to both the polluter-pay principle and distributional effects. Equity issues may thus be in conflict with efficient congestion charge designs (see Kristoffersson et al., 2017), which implies that the more efficient designs proposed in economic theory could be less accepted by the population.

The federal government of Switzerland recently encouraged cantons to consider mobility pricing, a dynamic pricing approach to mobility that includes the use of congestion charges, to tackle congestion on roads as well as other transportation modes. Despite the high levels of congestion in Swiss cities, not many cantons stepped forward. In a country where public ballots take place about 4 times a year on multiple issues, the political stakes are very high. The Canton of Geneva, however, did so, launching a policy process aimed at identifying the best congestion charge design for the city of Geneva. Geneva is the most congested city in Switzerland, with about 2'000'000 trips per day in the agglomeration in 2010, at an average speed of about 20 kilometers per hour in the city center (DETA, 2014). Geneva has struggled for years to find solutions to its ever increasing traffic.

The aim of this chapter is twofold. First, it builds on the existing theoretical and empirical literature on congestion charges to identify a set of plausible designs that could fit the context of Geneva. Second, it tackles the issue of public support related to the implementation of environmental policy instruments. It uses a large survey of respondents in both the Canton of Geneva and the neighboring regions of Switzerland and France to assess public support for the policy designs identified in this study. It relies on a discrete choice experiment to estimate preferences for the following parameters: charge rate, perimeter of the charge, modulation of the charge, level of exemptions, beneficiaries of exemptions (if any), and use of revenues. Given the large sample, and its cross-national feature, heterogeneity across respondents is analyzed in detail. Public support may also depend on the information available to respondents. A stylized fact, discussed in detail in the following sections, is that very salient environmental policies tend to be more popular ex post than ex ante. This finding may rationalize the fact that, in some contexts, congestion charges might have been implemented without majority support, while never being repealed (De Borger and Proost, 2012). Specifically, people may revise their beliefs while experiencing their effectiveness (Cherry et al., 2014; Janusch et al., 2020). The acceptability of congestion charges increased after their implementation in Stockholm (Winslott-Hiselius et al., 2009; Eliasson, 2014) and in London (Schade and Baum, 2007). However, implementing a congestion charge, even if only for a trial period, implies considerable sunk costs and requires important political capital. Hence, providing more information to the general public, ex ante, may represent an effective alternative to trialing in increasing public support (see Carattini et al., 2017, 2019). In this chapter, we go a step forward and explicitly test this hypothesis in a stated preference context, by coupling the discrete choice experiment with a split sample design introducing two randomized informational treatments, and a control group.

Our results show that public support depends closely on the design as well as the information provided, in particular with respect to the environmental benefits of a congestion charge. Public support decreases (increases) considerably with the charge rate (exemptions). However, the provision of information, especially on indirect benefits that may not be immediately factored in voters' opinions, such as improved air quality, can increase public support and make more ambitious policies politically palatable. Providing information seems a relatively inexpensive strategy that could allow policymakers to push more stringent policies past the majority threshold. However, even so, concessions from the ideal of efficiency may be necessary. For instance, public support is stronger for exemptions to residents, rather than motorbikes or alternative fuel vehicles. Also, while on efficiency grounds congestion charging should match as closely as possible the marginal damage of driving, people tend to have a strong preference for a constant, predictable modulation. Similarly, most people demand earmarking for improvements in public transportation rather than a revenue-neutral approach. Finally, we identify substantial heterogeneity in our sample. Preferences for either a more compact perimeter or an extended area depend on where people live and how they commute. The same applies to spending, and exemptions. That is, public support can vary considerably depending on who has the right to say over the implementation of a congestion charge, in particular between residents of the charged area and people in the suburban areas around it.

This chapter contributes to two strands of literature. First, it contributes to the literature on congestion charges, and road pricing more in general. Second, it contributes to the literature on public support for environmental policy. In this respect, the contribution is twofold. First, it provides evidence on people's preferences for different design parameters and on their role for public support in a context wherein a congestion charge is an option under serious consideration. Its design also allows assessing the role of exemptions, whose effect on public support has been underexamined despite exemptions having been widely used not only for congestion charges but for environmental taxes at large, including carbon taxes (see World Bank, 2020). Second, it provides a methodological contribution. It tackles the issue of information asymmetries with randomized informational treatments in combination with a discrete choice experiment. It shows, more in general, that hypotheses on the role of information on public support can be tested directly, with the simple use of randomized treatments.

The remainder of this chapter is given as follows. Section 2.2 provides background information about congestion charges and institutional knowledge about the local context of this study. Section 2.3 describes the survey design and data. Section 2.4 provides the main empirical findings. Section 2.5 concludes.

2.2 Background

2.2.1 The external costs of driving

In the spirit of Pigou (1920), Vickrey (1963) suggested the implementation of pricing systems attributing to drivers the social cost of their driving, inclusive of the cost borne by the other commuters. Given the traffic externality, Pigouvian pricing should be introduced to make drivers pay for the (high) marginal cost of their use of street space. Vickrey's analysis pointed to large welfare gains from road pricing, derived in particular by the change in traffic during peak hours, when the extra cost of an additional car is the highest, as the infrastructure capacity is pushed to the limit and the speed of other drivers is affected. Welfare gains of different road pricing designs have been estimated by several studies, including Walters (1961), Arnott et al. (1993), Parry (2002), and Yang et al. (2020).

Congestion may not be the only externality of driving. An emerging literature has recently developed, linking traffic, pollution, and health (see Currie et al., 2014 for a review). Following the implementation of electronic tolls in New Jersey and Pennsylvania, Currie and Walker (2011) find a decrease in nitrogen dioxide (NO_2) and in the probability of prematurity and low-weight births by about 10 % in the areas surrounding the tolls. Knittel et al. (2016) show with data for California that a standard deviation increase in traffic around a given area is related with a 0.2 % standard deviation increase in mortality. Higher pollution levels are also related to higher infant mortality. Simeonova et al. (2018) find an immediate reduction in asthma among young children after the Stockholm congestion charge was initially trialed, but a much larger effect once it became permanent, pointing to the non-linear effects of exposure to pollution on health.

Recent work extends the analysis of the impacts of air pollution from traffic to adults. For instance, Zhong et al. (2017) show that in periods with higher traffic, emergency room visits in Beijing for fever and heart-related symptoms become substantially more frequent. Other health impacts related to air pollution include depressive symptoms (Zhang et al., 2017) and lower cognitive skills, in both the short and long run, such as productivity losses leading to lower test scores (Lavy et al., 2014) and lower lifetime earnings (Bharadwaj et al., 2017). The recent COVID-19 pandemic adds to this list. Contemporaneous exposure to fine particulate matter from various sources, including traffic, has been shown to have a substantial detrimental effect on COVID-19 morbidity and mortality (Austin et al., 2020).

Additionally, congestion charges may also have an effect on accidents, but this effect is a priori ambiguous. Lower congestion may decrease the risk of collision between cars and other road users, but may also imply higher speed and thus a higher likelihood of severe accidents (Shefer and Rietveld, 1997). Cyclists and pedestrians are the most vulnerable road users, and their number tends to increase if people are incentivized not to use cars (Wang et al., 2009; Li et al., 2012). Also, congestion charges can potentially divert traffic to other, unpriced areas (Parry and Bento, 2002). Green et al. (2016) conclude for the London congestion charge that its net effects on accidents and severe accidents are such that the congestion charge is beneficial.

2.2.2 Existing congestion charges

Table 2.1 summarizes the characteristics of all cordon and zone pricing schemes currently in function. We are aware that other schemes to tackle traffic congestion directly or indirectly exists, such as tolled roads and bridges (e.g. Currie and Walker, 2011), toll lanes (e.g. Bento et al., 2020) or smart-parking programs (e.g. Krishnamurthy and Ngo, 2020). These road pricing options are related to our study, but do not inform directly its design.

The first congestion charge scheme was implemented in the central business district of Singapore in 1975. As a result, traffic entering the zone (circulating within the zone) decreased by 25 % (45 %) and travel speed doubled in the morning peaks (Khan, 2001; Goh, 2002). In 1990, the coverage was expanded to include a number of expressways. In 1998, the manual road pricing system was replaced, and Singapore became the first city to introduce electronic tolls. Thanks to the electronic system, drivers can be charged according to their vehicle type and their travel speed, which is used as a proxy for congestion.

TABLE 2.1: Summary of existing congestion charges schemes

	Stated goal	Perimeter	Type and price level	Modulation	Partial exemption	Use of revenue	References
Singapore (1975 and 1998)	Congestion	Center (central business district), 7 km^2, and some highways	Zone, \$0.5-\$6 per passage through the gantry	7 am to 8 pm and by vehicle type, exact location	None		Khan (2001); Goh (2002); Agarwal and Koo (2016)
Bergen (1986)	Financial, environmental	Center, 18 km^2	Cordon, NOK 19 to NOK 90 per way in	6.30 to 8.59 am and 2.30 to 4.59 pm Monday to Friday and by vehicle type (car vs. truck)	Seasonal passes (1, 3, 6, 12 months) and pre-paid passes (20 crossings)	Initially only for financing road projects, then 45 % for road construction and 55 % for improving environmental quality and road safety	Ramjerdi et al. (2004); Ieromonachou et al. (2006)
Oslo (1990)	Financial	Center, 64 km^2	Cordon, NOK 40 to NOK 193 per way in	24/7 365 days a year, pricing by vehicle type (light vs. heavy and fuel type)	Seasonal passes (1, 6, 12 months) and pre-paid passes (25, 175, 350 crossings)	For investments in road capacity and public transportation projects	
Trondheim (1991)	Financial	Center, 24 km^2 then 50 km^2	Cordon, NOK 11 to NOK 72 per way in and hour depending on toll station	6 am to 6 pm Monday to Friday, and by vehicle type	Online payment	For financing road infrastructure (road capacity, with some earmaking to public transportation and to cycling and walking)	
London (2003)	Congestion	Center, 21km^2	Zone, £11.50 per day	7 am to 6 pm Monday to Friday	By vehicle type (more than 9 seats, ultra low emissions, motorcycles) and resident status	For financing public transportation (80 %), road safety (11 %), cycling and walking (9 %)	Leape (2006); Green et al. (2016); Tang (2016); Croci (2016)
Stockholm (permanent 2007)	Congestion	Center, 30 km^2	Cordon, SEK 11 to SEK 35 per way in and out	6.30 am to 6.29 pm Monday to Friday, pricing depending on congestion levels (revised every 30 minutes)	None, but maximum SEK 105 per day	For financing road infrastructure and public transportation	Hensher and Li (2013); Croci (2016); Simeonova et al. (2018)
Milan (2008 and 2012)	Environmental, then congestion	Center, 8.2 km^2	Cordon, € 5 per day when entering	7.30 am to 7.30 pm Monday to Friday and by vehicule type (Euro 0, 1, 2, 3)	By resident status, discounts for multiple days	For financing public transportation and cycling and walking	Percoco (2013); Hensher and Li (2013); Percoco (2014); Gibson and Carnovale (2015); Croci (2016)
Gothenburg (2013)	Congestion, environmental, financial	Center and highway	Cordon, SEK 9 to SEK 22 per way in and out	6 am to 6.29 pm Monday to Friday	None, but maximum SEK 60/day	For financing road infrastructure and public transportation	Börjesson and Kristoffersson (2015); Andersson and Nässén (2016)

After Singapore, several urban toll rings were implemented in Norway; in Bergen in 1986, in Oslo in 1990, in Trondheim in 1991, in Kristiansand in 1997, and in Stavanger in 2001. The toll rings of Bergen and Oslo were then converted to congestion charges in 2016 and 2017, respectively. The main objective of the Norwegian toll rings was originally to finance road infrastructures, rather than reduce congestion (Ramjerdi et al., 2004). Since 2003, however, only 45 % of the revenues generated by the congestion charge of Bergen are still used to finance road constructions, while the rest is used to improve environmental quality and road safety. Users have to pay each time they enter the city center, but not when they exit. Users may also benefit from some discounts if they buy monthly, biannual or annual permits, which affect the marginal cost of commuting.

In 2003, London implemented a congestion charge of £5 per vehicle per day for either entering, or circulating within central London (Leape, 2006). The rate has been revised upward several times and is currently at £15. As in other cities, exemptions include bicycles, motorcycles, taxis, people with disabilities, and buses. Residents pay only 10 % of the charge when crossing or traveling within the London congestion charge zone. Revenues are used to fund public transportation (about 80 %), road safety (11 %), and cycling and walking projects (9 %). The main objective of the London congestion charge was to reduce traffic and congestion. The drop in traffic between 2002 and 2003 has been estimated at about 30 %, exceeding expectations. Transport for London estimated that most of the decrease was due to a switch to public transportation, and a small fraction related to the use of bicycles or taxis. However, about 25 % of drivers had adapted their journey, avoiding the congestion charge, and up to 10 % may be now traveling outside of charged areas. Average travel speeds also increased in central London, from 8.9 miles per hour to 10.4 miles per hour, based on a simple before-after comparison for 2003 (Leape, 2006).

In Sweden, Stockholm implemented a congestion charge in 2007 after a trial period and a referendum, accepted by 53 % of the city's voters (Eliasson et al., 2009). Gothenburg followed in 2013, after a non-binding referendum, in which the congestion charge was rejected by 56 % of voters, but nevertheless implemented. An important debate on the use of revenues, which were supposed to finance a rather unpopular rail tunnel under the city, might have contributed to its rejection (Börjesson and Kristoffersson, 2015; Andersson and Nässén, 2016). In both Gothenburg and Stockholm, road users have to pay to enter as well as to exit the city center. In contrast to other cities, taxis are not exempted in Stockholm, albeit they represent around 8 % of the cordon passages. In Stockholm, following the implementation of the congestion charge, traffic volume decreased by about 20 % and kilometers driven in the inner city by about 15 % (Eliasson et al., 2009; Börjesson et al., 2012; Croci, 2016). Travel times decreased between one third and one half during the peak periods and a 4.5 % increase in the number of passengers by public transit is attributed to the road toll.

In 2008, Milan implemented a road pricing scheme, called Ecopass, to curb pollution. Ecopass was a cordon pricing scheme, charging a daily fee for entering the cordoned zone depending on the vehicle's emissions of PM_{10} (Croci and Douvan, 2015). Registered residents of the cordoned area received a 60 % discount. In 2011, a majority of voters (79 %) supported the extension of the road pricing scheme with a congestion charge called Area C. After a trial period, Area C became permanent in 2013. With the new scheme, highly polluting vehicles are outright banned from the city center, whereas all other vehicles pay a daily charge of €5. As its predecessor, Area C also includes a system of privileges for residents, who receive the right to cross the cordon 40 times a year for free, and then face a reduced charge of €2. Milan's scheme also exempts alternative fuel vehicles, among others. Percoco (2013) provides an initial assessment of Area C, showing a decrease in charged vehicles of about 56 % and an increase in the purchase of alternative fuel vehicles of about 5 %. During a suspension of the scheme due to a court ruling, Gibson and Carnovale (2015) find that traffic in the cordoned area increased by up to 20 %, while it decreased right before and right after Area C's standard charging hours (by about 23 %), and on the roads surrounding the cordoned area (by about 18 %). While the charge was inactive, CO and PM_{10} emissions increased by 6 % to 17 % inside and outside Area C, respectively.

2.2.3 Public support

Public support is, in several contexts, the main obstacle to the implementation of environmental pricing. A rapidly growing literature has emerged to address this issue, and a few stylized facts have emerged (cf. Carattini et al., 2018b for a review).

First, public support tends to decline as the level of stringency, measured by the tax rate, increases. Choice-experiment surveys are particularly suited to detect this phenomenon (e.g. Sælen and Kallbekken, 2011; Brännlund and Persson, 2012; Gevrek and Uyduranoglu, 2015; Carattini et al., 2017).

Second, people may have a tendency to overestimate the downsides of a policy change, and underestimate the upsides, in particular the incentive effect of environmental taxes and their ability to change behavior (e.g. Dresner et al., 2006; Steg et al., 2006; Baranzini and Carattini, 2017; Carattini et al., 2017).

Third, it follows from the previous point that public support may increase after a policy is implemented and people experience it. This stylized fact follows from two types of studies. First, lab studies, in which trial periods are manipulated by the experimenters. Cherry et al. (2014) is the first study to exogenously allocate trial periods across experimental groups before a vote on a Pigouvian tax. Janusch et al. (2020) expand on this approach by looking specifically at a congestion game, in which players have heterogeneous time preferences and can vote on a congestion charge, before, during, or after a trial, which allows isolating the effect of learning via different trial durations on public support. Janusch et al. (2020) also randomize information provision, which in their context focuses on the costs of the congestion charge. Second, observational studies, comparing public support across control and treatment groups before and after the plausibly exogenous introduction of a Pigouvian tax. Carattini et al. (2018a) leverages the decision of the Supreme Court of Switzerland to impose the implementation of pricing garbage by the bag in a Swiss canton, part of which already uses this instrument. Pricing garbage by the bag substantially reduces residential waste with little unintended effects and this leads many voters to reconsider the policy. No change in perceptions is observed in the control group, which had already experienced the policy. This study confirms the findings of previous studies on congestion charges relying on simple before-after comparisons. In particular, Schuitema et al. (2010) and Hansla et al. (2017) study, respectively, the abovementioned referenda of Stockholm, and Gothenburg, which both followed a trial period and show higher public support after the trial runs. Several other studies show that preferences and attitudes towards road pricing improve over time. For instance, after a single year of implementation, the fraction of surveyed people opposing the tolls decreased from 54 % to 34 % in Bergen, from 70 % to 64 % in Oslo, and from 72 % to 48 % in Trondheim (Odeck and Br\aathen, 2002). These findings are consistent with Winslott-Hiselius et al. (2009), who argue that a trial period contributes to making the benefits of a congestion charge salient to voters (see also Gu et al., 2018 for a review of the literature with specific focus on congestion charges).

Fourth, people tend to have a preference for earmarking the generated revenues for environmental purposes. Many people do not expect environmental taxes to change behavior, and thus do not expect any effect on the environment unless revenues are earmarked for environmental purposes. The review of road pricing schemes by Jaensirisak et al. (2005) suggests that ex-post acceptability is higher for schemes (19 in total) that earmark revenues for environmental purposes (an average of 55 % of support) than for schemes (32 in total) in which revenues are not earmarked (35 % of support). Earmarking guarantees that the tax is not implemented for fiscal purposes. Revenue redistribution, for instance by reducing existing, distortionary taxes, may also be seen with suspicion. People may not see the rationale for taxing here and redistributing there, especially when redistribution takes place in an area unrelated to environmental policy. Sælen and Kallbekken (2011) refer to this phenomenon as issue-linkage. In our context, since people may believe that drivers are inelastic to road charges (Ubbels and Verhoef, 2006), they may then have a preference for earmarked revenues for public transportation. People may also like to vote on explicit policy packages, charging road transportation on one hand, and expanding public transportation in the other, as for instance in Stockholm (cf. Kottenhoff and Brundell Freij, 2009).

Public support is most likely the main obstacle to the implementation of congestion charges (see again Gu et al., 2018 for a review). While in Sweden referenda on congestion charges were organized under the pressure of the central government, in several other contexts policymakers backed away at an earlier stage, as in Cambridge, Hong Kong (Ison and Rye 2005), and New York City. In New York City, people perceived a scheme charging traffic in Manhattan as particularly unfair, especially for people living in the outer boroughs. Also, proposed exemptions to taxi drivers, a significant contributor to New York City's traffic, were a source of public opposition (Schaller 2010). New York City has more recently tried again to implement a congestion charge, with a slightly revised design compared to the earlier attempts. The charge was initially expected to be introduced in 2021 with revenues earmarked for public transit. However, the congestion charge is, at the time of writing, still pending approval from the federal government. In Manchester and Edinburgh, public ballots were organized and the congestion charges rejected by 79 % and 75 % of voters, respectively (Hensher and Li, 2013). The double cordon scheme proposed in both cities was perceived as too complicated by the general public. In the case of Edinburgh, a survey shows that only 47.8 % of the respondents knew the charge level that would have been implemented and only 37.4 % believed that the scheme could reduce congestion (Allen et al. 2006). While in Gothenburg the referendum was non-binding, in Manchester and Edinburgh the project of a congestion charge was abandoned after the rejection on the ballot.

2.2.4 The Geneva congestion charge

Rationale

About 75 % of the Swiss population (8.4 million in 2016) lives in urban agglomerations, which cover about one quarter of the territory and provide 70 % of the jobs (ARE, 2018). Population density is thus relatively high, with most people being concentrated around major cities, connected by an intense network of roads and railways. If rail represented more than half of the passenger traffic in 1950 (40 % for roads), in 2015 only 15 % of the trips across Switzerland were undertaken by train (75 % for roads, see Litra, 2017). In absolute terms, road traffic volumes increased 15 times from 1950 to 2015, whereas train traffic 3 times only. Many city centers are located near the border with Germany, France, Italy, and Austria. About 2.2 million people cross the Swiss border every day, 96 % of them by car (OFS, 2017). As a result, the road network is often congested, especially around urban agglomerations. The direct cost of traffic jams are estimated to exceed one billion CHF a year (Keller and Wüthrich, 2016), while the external costs from accidents and environmental pollution from driving at about CHF 8 billions a year (ARE, 2016).[2]

[2] 1CHF ≈ 1USD at the time of the study.

According to the Swiss Constitution, public roads should be free of tolls. The road infrastructure is currently mainly funded by specific taxes, such as fuel tax and a highway sticker. The latter was introduced in 1994, after a public ballot. Since then, holding a vignette is compulsory for driving on highways. Ten years later, voters accepted an increase from CHF 30 to CHF 40 a year in the price of the vignette. A further increase to CHF 100 was, however, rejected in 2013 by 60% of the voters. Public ballots take place 3 to 4 times a year in Switzerland, with people voting in each occasion on about 3-4 subjects of national or local politics. While public support has been instrumental for the implementation of congestion charges in virtually all contexts where it exists, acceptance by voters is all the more necessary in Switzerland.

Until recently, mobility pricing in general, and congestion charges in particular, were only a theoretical concept in Switzerland. However, given the high level of traffic congestion, the Swiss government introduced mobility pricing to the policy agenda, and invited cantons and cities to step forward. Geneva was among the candidates for a congestion charge pilot program. According to the latest release of the TomTom Traffic Index, which ranks some 400 cities by their congestion levels using data from location devices, Geneva is a heavily congested city in which the average commuter loses about 146 hours per year due to traffic congestion, especially during weekdays (about 60 % of extra time in the morning peak and about 70 % of extra time in the evening peak). With more than 2 millions trips per day in the agglomeration of Geneva, of which more than half a million are undertaken in the city center, the cost of congestion is very large. A similar pattern emerges from INRIX's Global Traffic Scorecard 2019, another ranking of almost 1,000 cities based on pollution levels.[3]

There are several reasons for this particular situation. First, similarly to many European cities, the city center was built before the advent of the automobile. Second, Geneva has a small territory with relatively high density, leading to a tight housing market (Drechsel and Funk, 2017). As a result, the urban area is expanding into the neighboring areas of France, increasing the pressure on road infrastructures.

Geneva also suffers from an important air pollution problem. According to recent administrative data, the total external costs of PM_{10} and NO_x on health, life quality, buildings, forests, and agriculture reach almost CHF 120 millions a year (Baranzini et al. 2017). Furthermore, the concentration of most pollutants is higher in the city center than in the suburban areas. Concentrations of NO_x and PM_{10} per km^2 are almost four times higher in the smaller perimeter than in the rest of the canton.

According to a recent survey on the quality of life in Geneva and surroundings, including the adjacent areas of France, 45 % of respondents consider traffic the top policy priority in the region, up from 34 % in 2016 (Baranzini et al., 2018b). It does not surprise, then, that the

[3] See https://www.tomtom.com/ (last accessed on July 10, 2020) and https://inrix.com/scorecard (last accessed on July 10, 2020).

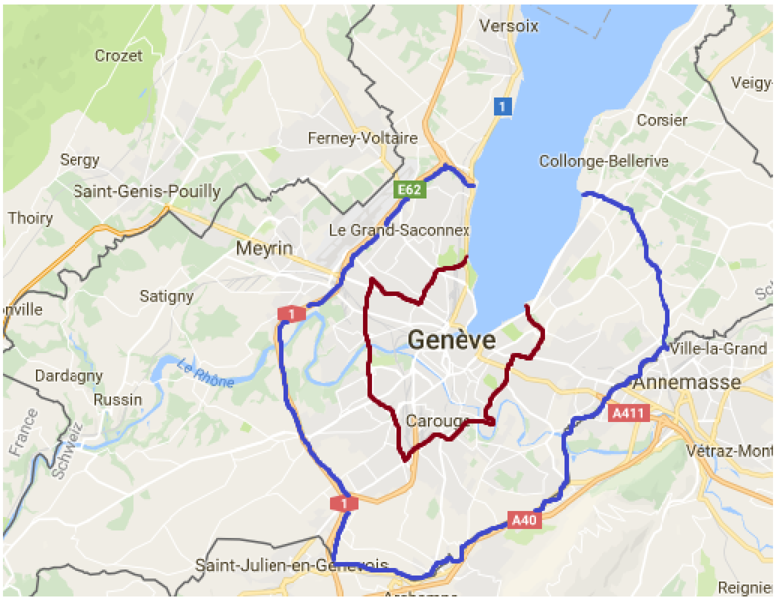
Canton of Geneva is willing to run a pilot scheme with a local congestion charge. Geneva tried several options to tackle congestion in the past, but many faced strong political resistance. Only recently, a project to build either a tunnel under, or a bridge over, the lake of Geneva to connect the right and left banks, which dates back to 1896, was accepted in a public ballot. In 2016, 68 % of the population also accepted a policy package addressing mobility issues, including additional pedestrian areas, and bike lanes, as well as low emission zones. While this positive outcome is a strong signal that the local population is supportive of major changes in mobility, important concerns remain for policymakers on the potential acceptability of a congestion charge.

Design

Following a decision by the local parliament, a task force was instituted to study different options for a potential congestion charge. This study is part of these efforts. In what follows, we consider a set of possible suitable designs for the context of Geneva. We test their acceptability by the general public in Geneva and the neighboring areas. Based on the local context, and lessons from existing schemes, we consider the following dimensions: charge rate, perimeter of the charge, modulation of the charge, level of exemptions, beneficiaries of exemptions, and use of revenues. Figure 2.1 illustrates the two options for the perimeter, which are given by the political process and the local topography. Being surrounded by France, it is legally difficult to conceive a perimeter either in France or right at the border. The perimeters that we consider include all the areas with very high levels of congestion in the region ("hotspots" identified by TomTom) and were validated by policymakers. First, a perimeter mainly overlapping the Geneva highway ring, which encircles most urban and suburban areas. Driving on the highway to bypass the city of Geneva would remain free of charge. Second, a perimeter around the urban center, where walking, cycling, and public transportation are already credible alternatives to driving, but motorized traffic remains important. Every day, more than 600'000 trips entering, leaving or crossing this area are undertaken. According to internal simulations by the local government, the number of trips to the urban center could be dramatically decreased with a congestion charge. For instance, implementing around the urban center a congestion charge set at CHF 1, with a CHF 1.50 top-up at peak hours and a 50 % exemption to residents, could potentially lead to a reduction in traffic of about 50 %. In either case, the congestion charge would use cordon pricing. With this design, users would be charged only when crossing the cordon, not for internal rides. We, however, also consider a distance-based charge in our survey.

In terms of pricing, we consider a CHF 0.20 - 5 range, to be paid, as in Stockholm, for both entering and leaving the zone in order to reduce both morning and evening congestion peaks. In Geneva, almost one fourth of the traffic takes place in the morning and evening peaks. We

FIGURE 2.1: The two perimeters of the congestion charge: the highway ring (blue) and the urban center (red)



consider CHF 5 (CHF 10 for a two-way trip) as the upper bound of a politically plausible charge. We assume the congestion charge to be in force from Monday to Friday, with the exception of public holidays, from 6 am to 7.30 pm, the interval of time when congestion is the highest. For simplicity, we do not consider alternative timing options in this study.

However, we do consider five different modulation options, either on top or instead of the standard charge. First, we consider a top-up charge of CHF 1 during periods of high pollution, in response to variation in pollution levels (Coria et al., 2015), with the magnitude of the top-up charge being based on recent studies on the external cost of road traffic in terms of air pollution in Switzerland (Ecoplan/Infras, 2018). Second, we consider a top-up charge of CHF 1.50 between 6.30 am and 9 am and between 4 pm and 7 pm, when congestion is at its peak (peak hours). The top-up charge is computed to reflect average time lost in traffic and the median wage in the local market. Third, we consider a top-up charge of CHF 0.20 for each kilometer driven inside the perimeter. With this option, we come close to the textbook ideal of pricing according to marginal damage, although, for ensuring comparability in the survey part of this study, we consider marginal pricing on top of the fixed charge of crossing the cordon. CHF 0.20 follows from the literature, which estimates the social cost of congestion in our and similar contexts (Maibach et al., 2007; Ecoplan/Infras, 2014). Fourth, we consider a scheme in which the standard charge applies, but only during peak hours. During off-peak hours, crossing the cordon is free. Everything else equal, this modulation produces the lowest cost for drivers. Fifth, we consider a reference scenario wherein pricing is constant during the day, i.e.

there is neither a top-up charge nor an uncharged period. For simplicity, we refrained from including real-time pricing, as implemented in Singapore, among the modulation options of this study.

In the existing road pricing schemes, subgroups of users are often totally or partially exempted. Some exemptions can be rationalized on efficiency grounds, others are implemented to increase perceived fairness and acceptability. In our study, exemptions can go from 0 % (no exemption) to 100 % (total exemption). Building on the existing schemes, we consider the following groups as potential beneficiaries of a partial or total exemption: people living within the cordoned area (residents); motorized two-wheel vehicles (e.g. motorbikes); professional with an economic activity within the perimeter; electric vehicles; frequent commuters. Residents are exempted in most current schemes, essentially for fairness reasons. They have sometimes no alternative to crossing the cordon, for instance for special shopping or long-distance trips, and, as a result, cannot avoid the charge. They may, however, be its primary beneficiaries. In London, residents are exempted at 90 %. In the case of Stockholm, Eliasson and Mattsson (2006) show that the congestion charge's burden is borne mainly by residents of the cordoned area. Motorbikes are exempted in several cities, including Bergen, London, Milan, and Stockholm, mainly because they generate less congestion and pollution. Business rides can be exempted to limit adverse competitiveness effects on shops and businesses located within the area, beyond the potential variation in customers that the congestion charge may generate (e.g. Leape, 2006). Electric vehicles do not generate less congestion, but they do generate less pollution, at least in the location where they are used. Highly polluted cities, such as London, exempt electric vehicles, possibly beyond the differential in marginal damage, to spur their adoption by private households and professional drivers. Frequent commuters are partially exempt in the Norwegian schemes and in Milan. While from an efficiency perspective each trip should be charged in the same way, from a fairness perspective there may be a rationale for reducing the marginal charge for people crossing the border particularly often. Following the Norwegian example, we define as frequent commuters people who would register for 200 journeys across the perimeter and would benefit from a reduced charge on the following 200.

Revenues generated from the congestion charge could be used in many ways. We consider five of them: earmarked for public transportation improvements; earmarked for measures improving road infrastructure; earmarked for measures tackling air and noise pollution; earmarked to fund a tunnel, or bridge, to cross the lake of Geneva; redistributed back to the population of the Canton of Geneva through a reduction in the annual vehicle registration fee. From an efficiency perspective, the best use of revenues would imply allocating them to the general budget for policymakers to determine their use based on the expected social return, which may include reducing distortionary taxes. However, we refrain to include the option to simply allocate the revenues to the general budget, as the literature points to this option as generally politically unfeasible. Reducing existing taxes, for instance on labor, tends also to be rather unpopular. Since there is a general consensus in the literature that using revenues in the same domain as the charge is generally better understood by the general public than an allocation to the general budget or a reduction in an non-related tax (Jaensirisak et al., 2005; Steg et al., 2006; Kallbekken and Aasen, 2010), and given that reasons of power limit the number of possible attribute levels that we could test, the options that we consider imply either earmarking or rebating revenues in areas related to the congestion charge. That is, we follow the lessons from the literature on public support on the importance of issue-linkage. Further, in the context of Switzerland, the guidelines imposed by the Swiss Confederation to implement pilot programs for congestion charges explicitly excluded allocating revenues to the general budget.

Earmarking for public transportation improvements usually increases public support for road pricing schemes (Grisolía et al., 2015; Corvec et al., 2016), unless people do not expect additional funding for public transportation to lead to sizable improvements in their daily life (Allen et al., 2006). Public transportation improvements may not only benefit the residents of the Canton of Geneva, but also commuters from the surrounding areas. Similarly, improving transport infrastructure, including road and bicycle lanes, could generate benefits for individuals living in the areas surrounding the Canton of Geneva. According to the above-mentioned 2016 ballot on mobility, a majority of citizens in the Canton of Geneva supported a policy allocating additional funding to mobility investments, including in favor of cyclists and pedestrians. In our context, earmarking for transport infrastructure is meant to cover part of the expenditures for those transport policy measures. Earmarking for air and noise pollution would address one of the main externalities of driving, beyond the incentive effect of the congestion charge. This measure would, however, mainly benefit the inhabitants of the Canton of Geneva, which would collect the revenues and spend them within its boundaries. The rationale for considering earmarking revenues to fund a road infrastructure to cross the Lake Geneva is twofold. First, the population of Geneva recently voted on a constitutional article supporting the construction of either a bridge or a tunnel. However, how exactly this infrastructure is going to be funded remains open to the decisions of lawmakers. Second, as discussed, the case of Gothenburg suggests that earmarking revenues for a specific, large investment may play a significant role in defining public support, especially if such investment is very controversial among the general public. Reducing the vehicle registration fee would meet the revenue-neutrality criterion requested by the federal government. It would imply a transfer among the vehicle owners of the Canton of Geneva from a one-off fee that does not depend on kilometers driven to a congestion charge. This redistribution scheme would, however, not benefit individuals whose vehicle is registered in another canton or country.

TABLE 2.2: Congestion charge design: characteristics (attributes) and levels

	Attributes					
	Perimeter	Charge rate	Modulation	Exemption	Beneficiaries	Revenues
Levels	Center	0.2	Constant	0 %	Residents	Public transportation
	Ring	1	Peak hours only	25 %	Motorbikes	Transport infrastructure
		2	Peak hours top-up	50 %	Business deliveries	Pollution reduction
		3	Pollution top-up	75 %	Electric vehicles	Tunnel or bridge
		4	Distance top-up	100 %	Frequent commuters	Vehicle registration fee
		5				

Table 2.2 summarizes the dimensions and levels considered for the design of the Geneva congestion charge, which correspond to the attribute and levels in the empirical analysis of public support.

2.3 Methodology

2.3.1 Survey design

We analyze the question of acceptability as follows. We are interested in public support for different hypothetical policy designs. Hence, we opt for stated preferences and more precisely for a discrete choice experiment (DCE). A DCE allows evaluating individual choices and the relative importance of each characteristic (attribute level) of a given option (alternative). DCEs are deemed particularly suited to inform the choice and design of multidimensional policies (Hanley et al., 2001). The DCE follows from the random utility model (RUM). Most commonly the utility function is defined as additively separable:

$$U_{ij} = V_{ij}(X_{ij}) + \varepsilon_{ij}$$

where U_{ij} is the unobservable utility that individual *i* associates with alternative *j*, V_{ij} is the deterministic part of the utility that individual *i* associates with alternative *j* depending on its attributes (X), and ε_{ij} is the error term, which represents a random component associated with individual *i* and alternative *j*. It follows that the probability that individual *i* chooses alternative *j* from the choice set C_i equals the probability that the utility associated with alternative *j* exceeds that associated with all other alternatives *h* of the choice set. This implies:

$$P(j|C_i) = Pr[(V_{ij}(X_{ij}) - V_{ih}(X_{ih})\,) > (\varepsilon_{ih} - \varepsilon_{ij})]\ \forall \text{ h in } C_i \text{ and } h \neq j$$

We usually assume that the error terms are independently and identically distributed with an extreme-value distribution. This implies that the probability of alternative *j* being chosen over all other alternatives in the choice set can be expressed as following a logistic distribution (McFadden, 1973). The conditional logit model follows:

$$P(j|C_i) = \frac{exp(\mu V_{ij})}{\sum_h exp(\mu V_{ih})}$$

where μ is a scale parameter.

This model is estimated by maximum likelihood.

In our DCE, each respondent is requested to answer to 10 different choice tasks. Each choice task includes three alternatives: two different congestion charge designs, leveraging the simplicity of pairwise comparison, and the status quo. The rationale for including the status quo is threefold. First, this survey is designed to replicate as closely as possible the context of a public ballot, thus mimicking an actual choice context (Harrison, 2006). In a public ballot, voters have generally the possibility to refuse all options and maintain the status quo. Second, the status quo ensures that respondents are not forced to choose an alternative they may not desire (Hanley et al., 2001). If the status quo is preferred to the proposed alternatives, a model that does not include the option of rejecting all alternatives would lead to inaccurate estimates, as respondents would be forced to choose an alternative that provides a lower utility than the status quo. Third, the status quo provides us with the possibility to measure the overall acceptability of a congestion charge in Geneva, and not only the relative preference for a given attribute level.

Each congestion charge design in our survey results from the combination of the different levels of the six attributes presented in Table 2.2: charge rate, perimeter of the charge, modulation, level of exemption, exemption beneficiaries (if any), and use of revenues. When designing the DCE, we consider both statistical efficiency, which implies minimizing the length of confidence intervals, as well as response efficiency, which implies minimizing potential measurement error due to respondent inattention (Reed Johnson et al., 2013). A perfectly efficient design is balanced and orthogonal, which means that each level, and pair of levels, appear an equal number of times within an attribute, and the design, respectively. Our design relaxes the restriction of minimal overlap to allow a modest degree of level overlap. This means that the same level of an attribute can appear twice in the same choice task, but the very same combination of attributes and levels (duplicates) cannot. Respondents use heuristics to simplify decisions. They may for example eliminate an alternative if an attribute has a specific level, without even considering the other attribute levels. Level overlap can thus improve the precision of the utility estimates.

To improve the measurement of the coefficients of interest, each respondent receives one of 100 randomly-generated, pre-tested, versions of the questionnaire.[4] To avoid order effects, the order of choice tasks is randomized within versions.

The survey was structured as follows. Prior to voting on the 10 hypothetical ballots, each respondent received general information about the local context, including figures on the level of traffic in Geneva, and the functioning of a congestion charge. We explained to respondents that the implementation of such a mechanism in Geneva would allow a better use of road

[4] The questionnaire was pre-tested with about 300 individuals. Qualitative interviews had also been conducted, to inform the questionnaire.

infrastructures, reducing traffic at rush hours, and air pollution. In our introductory text, we stressed that the impact on traffic, the environment, the household's purchasing power, and the generated revenue would depend on the specific design of the congestion charge that will be implemented (if any). After these introductory explanations, we provided a description of the attributes and levels. At each point in time during the completion of the choice-experiment part of the survey, respondents could access essential information, describing each attribute, through tooltips. This information is reported in Table A.1. In providing this information, we reproduced the structure of an official ballot. Indeed, in Switzerland, weeks before the ballot day, each voter receives by post a set of voting materials, which includes detailed information on the items in the agenda. The survey instrument can be found in Appendix A.1.

An important, and original feature of this survey is that, on top of the discrete choice experiment, we use a split sample design to test the impact on public support of randomized information provision concerning the effectiveness of existing congestion charge schemes. We use two separate treatments. Hence, about two thirds of our sample receive either one or the other treatment, while the remaining third represents our control group, which is subject to the baseline level of information provided to all respondents. This approach allows us to causally infer on the effect of informational treatments on public support. Our treatments focus on two potential benefits of congestion charges, respectively. The first treatment stresses the benefits of congestion charges in reducing congestion, drawing from the experiences of existing schemes for which empirical evidence on traffic is available (Leape, 2006; Eliasson et al., 2009; Percoco, 2013). The second treatment stresses the benefits of congestion charges in reducing pollution, and noise, drawing from the experiences of existing schemes for which empirical evidence on air pollution is available (Croci, 2016). The exact wording of each treatment, as translated from French, is provided in Table 2.3.

TABLE 2.3: Randomized informational treatments

Group	**Information given**
Congestion	"We would like to remind you that the goal of the congestion charge is to reduce congestion. In London and Milan, congestion decreased by 30 % and 25 %, respectively, following the implementation of a congestion charge. In Stockholm, traffic was reduced by more than 20 %. We expect similar effects in Geneva."
Pollution	"We would like to remind you that the goal of the congestion charge is to reduce pollution and noise due to traffic. In London and Stockholm, small particles decreased by 10 to 15 % and carbon dioxyde by 13 to 16% following the implementation of a congestion charge. The decline in pollution has had a positive impact on public health. In addition to improvements in air quality, the level of noise declined as well. We expect similar effects in Geneva."
Control	Only standard information provided.

The rationale for these randomized treatments is the following. While the literature on public support emphasizes the information asymmetries between experts, in particular economists, and the general public, with lay people overestimating (underestimating), especially ex ante, the drawbacks (the benefits) of new environmental taxes, the causal effect of informational campaigns, addressing these information asymmetries, remains largely unexplored. In their review of voting behavior on road pricing, Hensher and Li (2013) emphasize the importance of information deficits as one of the main barriers to public support. People's understanding of the effects of a congestion charge, and perception of its effectiveness, strongly correlates with public support. According to Eliasson and Jonsson (2011), beliefs on the potential effects of the congestion charge played a crucial role in its approval in Stockholm following a trial period. Local policymakers, in particular, emphasized the potential benefits from the congestion charge in terms of better air quality (which eventually materialized, as examined in Simeonova et al., 2018).

Hence, additional information needs to be provided to voters before a ballot to ensure that they take an informed decision. There is, hence, a strong rationale for trial periods. However, trial periods require, themselves, sufficient political buy-in. An alternative is represented by information provision through informational campaigns. In this respect, Carattini et al. (2017) and Carattini et al. (2019) analyze public support for carbon taxes by providing information on their impacts assessed with general computable equilibrium (CGE) models. Carattini et al. (2017) analyze voting behavior on an energy tax initiative, rejected by the Swiss population, and compare it through a discrete choice experiment with alternative policy designs, whose effects on different outcomes are provided to respondents as simulated by a CGE model. Carattini et al. (2019) provide information from a CGE model of the world economy to survey respondents in Australia, India, South Africa, the United Kingdom, and the United States to analyze public support for a global carbon tax or a global system of harmonized carbon taxes. In this chapter, we push the frontier further by testing directly the provision of additional specific information to randomly-selected subsamples for causal inference in combination with a discrete choice experiment.[5]

2.3.2 Data and descriptive statistics

The survey was administered online in September 2017 by a professional market research company with the goal of obtaining about 1,500 responses. We recruited individuals of adult

[5]The novel approach that we present in this chapter combines a discrete choice experiment with randomized information provision about policy effectiveness. Other contexts in which information provision about policy effectiveness has been provided as a randomized treatment include split-sample surveys (e.g. Kaplowitz and McCright 2015) and lab experiments (e.g. Baranzini et al. 2018a). Unlike before-after comparisons (e.g. Rhodes et al. 2014), random assignment to treatment and control groups allows for clean identification and limits experimenter effects.

age (at least 18 years old) living in the Canton of Geneva, the surrounding regions of Switzerland (the district of Nyon in the Canton of Vaud) and of France (Annemasse, Bas-Chablais, Genevois, and Pays de Gex). Respondents were informed that the study was conducted in partnership with the local authorities and that their response could impact actual policymaking. Such an approach builds on Harrison and List (2004) and was already applied in Switzerland by Carattini et al. (2017). Respondents did not receive any monetary compensation. The survey was completed by 1,430 respondents, which corresponds to 90 % of those who acknowledged receipt of our invitation to fill the survey, but a smaller fraction of all prospective respondents who were contacted by the market research company. The final sample, composed of valid questionnaires only, covers 1,414 respondents. In this section, we compare our sample with the underlying population and comment on its representativity.

Table A.2 in the Appendix displays the summary statistics for the socioeconomic variables collected in our survey. Swiss residents are overrepresented by design, since our focus is mainly on the political constituency that could affect the outcome of a potential ballot on the Geneva congestion charge. Hence, Table A.4 compares our Geneva-based sample with the characteristics of the underlying population of the Canton of Geneva. In Table A.5 we compare our entire sample to the entire region, known as “Grand-Genève”. In either case, if anything, we slightly overestimate the number of cars per inhabitants and the fraction of low-educated people, which may lead us to underestimate public support. Finally, Table A.3 in the Appendix provides the standard balance of covariates. Table A.3 shows that the three groups to which respondents were randomly assigned (pollution, congestion, and control) are very well, albeit not perfectly, balanced in terms of covariates. As per standard procedure, we thus include covariates as control variables in our empirical estimations of the treatments.

2.4 Empirical results

2.4.1 Attributes

In this section, we discuss the overall level of public support and the relative preference for each attribute. We begin by presenting a set of descriptive statistics for our main outcome variables, in Table 2.4. Overall, 23 % of the respondents reject all proposals of a congestion charge, no matter the design. Inversely, 23 % of our sample always accepts one of the two congestion charge schemes proposed in each hypothetical ballot. For the remaining 54 %, public support is contingent on the design. The average level of public support, measured as the number of accepted schemes over the total number of votes, is relatively high in our sample, at about 53.66 %. Note that two thirds of our sample are subject to additional information. For one specific design, average public support reaches 65 %. This design implies a small perimeter, at the boundaries of the city center, a price of CHF 0.2 per trip applied only during peak hours and only to non-residents (residents are fully exempted), and revenues earmarked for investments in public transportation. While the design that receives most support is relatively unambitious, there are other designs, which we may expect to have a stronger effect on commuters' behavior, that receive majority support. In what follows, we identify the attributes and characteristics that increase, or decrease, public support. We consider that the goal for policymakers is not to find a design that creates unanimity, but get legislation passed.

TABLE 2.4: Public support: summary statistics for our outcome variables from the DCE

	Overall public support	Accept all	Reject all	Design dependent
Entire sample	53.66%	23.34%	22.50%	54.16%
Residence location				
Living within the perimeter	57.77%	28.85%	20.83%	50.32%
Living in the Canton of Geneva, but outside the perimeter	51.28%	23.26%	25.38%	51.16%
Living outside the Canton of Geneva	50.35%	18.04%	23.27%	58.65%
Commuting mode				
Commuting by car	48.90%	17.20%	25.17%	57.63%
Commuting by motorbike	50.85%	27.85%	30.38%	41.77%
Commuting by car or motorbike	49.19%	18.75%	25.93%	55.32%
Commuting by public transportation, cycling and walking	59.68%	27.09%	16.52%	56.39%
Commuting frequency				
Living in the Canton of Geneva	55.79%	27.38%	21.95%	50.67%
6-7 trips/week to Geneva	53.31%	22.29%	24.54%	53.17%
1-5 trips/week to Geneva	51.98%	20.34%	21.88%	57.78%

Public support seems to vary also along standard voter characteristics. On average, public support is higher among residents than for the remaining respondents, and among individuals who already commute by public transport, cycling, or walking. In what follows, we also analyze the role of heterogeneity across voters.

We now analyze the main set of findings concerning people's preferences for the different attributes, and levels, covered by the survey. To this end, we bundle all observations together. We note that our analyses do not find any evidence of fatigue and learning effects and no significant variation on the time spent per task across tasks.

Table 2.5 provides the main results. Table 2.5 displays average marginal effects, for each attribute level, as estimated by the conditional logit model. Column (1) provides estimates for the full sample. Column (2) restricts the sample to the residents of the Canton of Geneva and column (3) to respondents living outside the Canton of Geneva. Only members of the second group would be entitled to vote, in a cantonal ballot in Geneva, on the congestion charge. Note that, as shown in Figure 2.1, the perimeter covers only part of the Canton, even when located on the highway ring. Hence, a potential ballot would include as voters both people from the urban areas within or close to the perimeters and people from the adjacent suburbs and countryside. This makes the situation of Geneva relatively similar to that of Stockholm. Recall that the referendum on the congestion charge was held in the city of Stockholm, as well as in several neighboring municipalities experiencing different degrees of congestion. This contrasts, for instance, with Edinburgh, where only residents of the city were entitled to vote.

A standard public choice result is that, the higher the level of a proposed charge, the lower its acceptability. This result is confirmed in Table 2.5, where public support decreases almost linearly with the charge. Figure 2.2 illustrates for each charge rate the average public support, across attributes and levels, for both the full sample and the subsample of potential voters. Even with very low charge rates, public support never exceeds 50 % when the average over all attributes and levels is taken. As mentioned, however, public support can reach majority for some specific designs.

FIGURE 2.2: Charge rate and public support

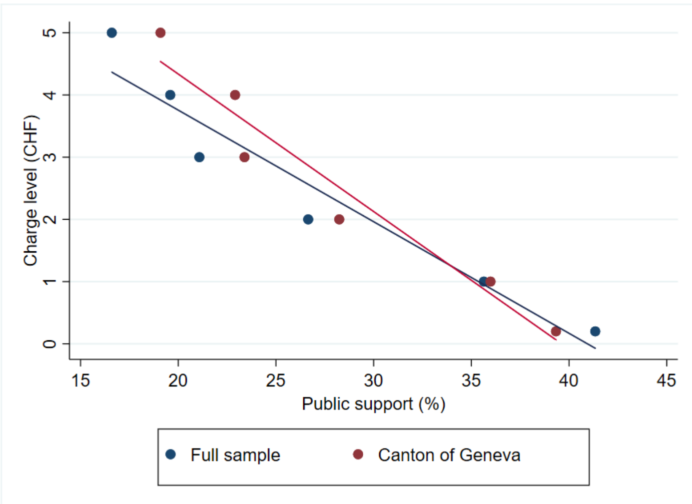


Figure 2.2 suggests that people in the Canton of Geneva tend to be significantly less sensitive to higher charge rates than the remaining individuals in the sample. Note that people living in the Canton experience both the direct benefits of the congestion charge, through a reduction

TABLE 2.5: Estimates from conditional logit: full sample, voters, and non-voters

	(1) Full sample		(2) Potential voters		(3) Non-voters	
Charge rate						
CHF 0 (reference)						
CHF 0.2	-0.051***	(0.017)	-0.065***	(0.023)	-0.034	(0.025)
CHF 1	-0.109***	(0.017)	-0.099***	(0.024)	-0.119***	(0.025)
CHF 2	-0.195***	(0.017)	-0.173***	(0.023)	-0.22***	(0.024)
CHF 3	-0.262***	(0.017)	-0.232***	(0.023)	-0.296***	(0.025)
CHF 4	-0.283***	(0.017)	-0.239***	(0.023)	-0.34***	(0.024)
CHF 5	-0.33***	(0.017)	-0.291***	(0.023)	-0.375***	(0.025)
Perimeter						
Center (reference)						
Ring	-0.008	(0.007)	0.0001	(0.009)	-0.02*	(0.011)
Modulation						
Constant (reference)						
Peak hours only	0.018**	(0.009)	0.009	(0.012)	0.029**	(0.014)
Peak hours top-up	0.008	(0.009)	-0.0003	(0.012)	0.017	(0.014)
Distance top-up	-0.045***	(0.01)	-0.073***	(0.013)	-0.009	(0.015)
Pollution top-up	-0.008	(0.009)	-0.016	(0.012)	0.001	(0.014)
Exemption level						
0% (reference)						
25%	0.002	(0.009)	0.0004	(0.013)	0.004	(0.014)
50%	0.036***	(0.009)	0.036***	(0.013)	0.036**	(0.014)
75%	0.044***	(0.01)	0.041***	(0.013)	0.049***	(0.014)
100%	0.069***	(0.01)	0.046***	(0.013)	0.098***	(0.015)
Beneficiaries						
Business deliveries (reference)						
Residents	0.029***	(0.01)	0.060***	(0.013)	-0.014	(0.014)
Motorbikes	-0.015	(0.010)	-0.001	(0.014)	-0.035**	(0.015)
Frequent commuters	0.016*	(0.01)	0.022*	(0.013)	0.006	(0.014)
Electric vehicles	-0.023**	(0.010)	-0.003	(0.013)	-0.05***	(0.016)
Use of revenue						
Vehicle registration fee (reference)						
Public transportation	0.082***	(0.010)	0.084***	(0.013)	0.080***	(0.015)
Transport infrastructure	0.050***	(0.01)	0.056***	(0.013)	0.044***	(0.015)
Pollution reduction	0.051***	(0.010)	0.062***	(0.013)	0.039**	(0.016)
Tunnel or bridge	0.035***	(0.010)	0.025*	(0.014)	0.05***	(0.016)
Number of respondents	1’414		782		632	
Number of observations	42’408		23’454		18’954	
Pseudo-R^2	0.0748		0.0523		0.1148	

Estimates report average marginal effects from conditional logit.
Heteroscedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.14.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

in congestion and pollution, and the indirect benefits from the use of revenues, which takes place mainly at the local level. Table A.6 in the Appendix reproduces the analysis of Table 2.5 splitting our sample into three groups: people living within the perimeter and people living outside the perimeter, either in the Canton of Geneva or in the surrounding areas. Note that since the perimeter changes with the design, the answers of some people are attributed to one group for some choice tasks, and to the other group for others. As shown in Table A.6, non-residents, especially those not living in the Canton of Geneva, tend to be much more sensitive to the charge rate than residents. The divergence starts, in statistical terms, at a charge rate of CHF 2. In what follows, we consider people's preferences for the other attributes, analyzing the behavior of the full sample, based on Table 2.5, as well as comparing residents and non-residents, based on Table A.6.

When taking the entire sample, we observe no specific preference for either perimeter, i.e. a smaller perimeter corresponding to the urban center, and a larger one, located on the highway ring. This may be due, however, to the fact that the sample as a whole includes both people who would benefit from a smaller perimeter, as well as people for which the prediction is more ambiguous. Non-residents are expected to have a preference for a smaller perimeter, since they do not experience the benefits of a congestion charge, except perhaps for a faster commute, and with a smaller perimeter they would save money on all trips with a destination point between the two perimeters. For those who switch from one sub-sample to the other, the effect is ambiguous. Depending on where they work, with a larger perimeter they may no longer need to cross the cordon to commute. Note that about 57 % of them work in the area within the smallest perimeter. Furthermore, with a larger perimeter, they may have the chance to live within the area and enjoy a better living environment, and to be eligible for potential exemptions for residents when crossing the cordon.

In Table A.6, we do find a difference when comparing residents and non-residents. Non-residents living outside the Canton of Geneva have, as expected, a preference for a smaller perimeter. Currently, 26 % of them work between the two perimeters and 88 % commute by car or motorbike. Another 40 % of our respondents live in the Canton of Geneva but outside the large perimeter. 40% of them work in-between the two perimeters and 60 % commute by car or motorbike.

We now turn to the preferences for various modulation options. We observe, in general, that the least preferred option is the one involving a surcharge based on kilometers driven. No preference is observed for a top-up, be it based on pollution or peak hours, compared to a constant pricing. This confirms the trade-off, observed in the literature, between efficiency and public support. As suggested by Li and Hensher (2010) and Hensher et al. (2013), people may have a preference for fixed over variable charges, because their effect on the household budget is more predictable. In the survey, we only consider top-ups, i.e. additions that make the charge higher. In the specific case of the distance top-up, however, we should note that privacy concerns may also influence public support (or lack thereof). While this modulation integrates more closely marginal damages into marginal costs, the associated system could also allow the government to track with relatively high precision the movements of each citizen. In Hong Kong, for instance, the implementation of such a system was opposed on privacy grounds (Hau, 1990; Khan, 2001). According to Table 2.5, the most popular modulation implies a charging scheme that only applies to peak hours, which is the least stringent option, everything else equal. This option, as shown in column (3) of Table 2.5 and in Table A.6, is favored in particular by people living outside the Canton, who may be able to adjust the timing of part of their rides through the congestion area. Note that 64 % of them work in either one of the perimeters and a large majority of them commute by car or motorbike. Table A.7 confirms that, in general, people commuting by car or motorbike would have a preference for a congestion charge that only covers peak hours.

From Table 2.5, we observe that, everything else equal, a higher exemption level leads to higher public support. This result is consistent with the effect of the charge rate. The relationship between the level of exemption and public support is again relatively linear. The same effect is observed for both the full sample and the sub-sample of potential voters. Note, however, that inhabitants of the Canton of Geneva, as shown in column (2), tend to be slightly less generous in the provision of exemptions. This makes sense. In most designs, revenues are recycled in a way that favors only, or mostly, people living in the Canton. Moreover, these would also benefit more from less congestion and better environmental quality.

In terms of beneficiaries, we find, as expected, a strong support for (partial) exemptions for residents living within the cordon. Unsurprisingly, this result is driven mainly by people living within the cordon, as shown in Table A.6. That is, a trade-off between efficiency and acceptability may also be present when it comes to exemptions. As discussed, partial exemptions may be efficient if some vehicles are likely to generate less externalities. However, in our sample exemptions to motorbikes and electric vehicles receive, if anything, lower public support than business deliveries, the reference category. According to the Federal Office of Statistics, the penetration of electric vehicles in Switzerland is still very low, at about 0.3 % of the total fleet in 2017. In the Canton of Geneva, in 2017, there were only 530 electric cars and 150 electric scooters, which also corresponds to the 0.2-0.3 % range. The only group that seems to strongly support exemptions for motorbikes, are the bikers themselves, as shown in Table A.9. A strong preference, driven by the response of residents, is found for exemptions to frequent commuters. Although efficiency dictates that each ride should be charged in the same way, everything else equal, fairness reasons could dominate people's preferences. To further analyze the preference for exemptions for frequent commuters, we divide the sample into two sub-samples, based on the number of journeys per week to Geneva. Table A.8 presents the relevant findings. As shown in column (2), the preference for partial exemptions for frequent commuters is mainly driven by people currently driving across the hypothetical cordon about 6-7 times a week.

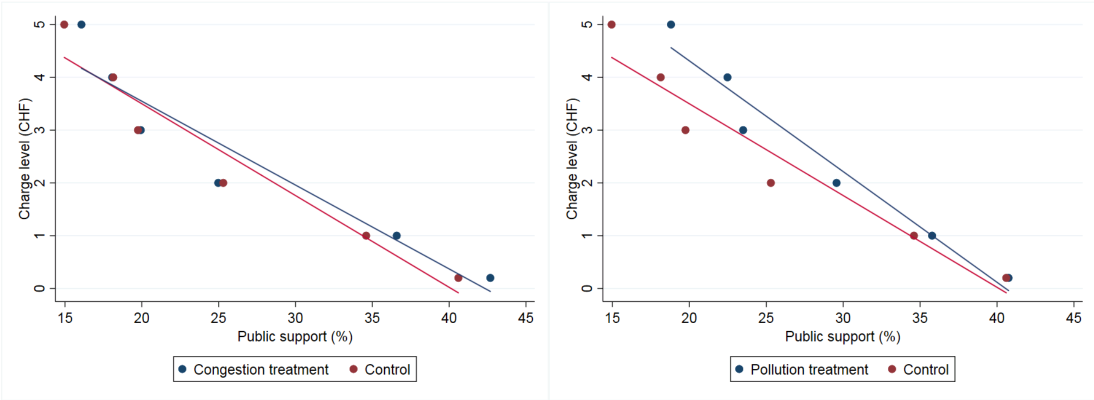
In terms of revenue recycling, in line with the literature, we observe a strong preference for earmarking for improvements in public transportation. The preference for public transportation over the other revenue use options is shared by all subgroups analyzed in Tables A.6, A.8, and A.9. The revenue-neutral option of redistributing revenues back to the population through a reduction in the vehicle registration fee, the variable of reference, is the least popular option for all groups, including the inhabitants of the Canton of Geneva, who would benefit from it. This finding is also in line with the literature. People may tend to have a preference for earmarking over revenue-neutral designs, even when there is a direct linkage between the new charge and the mode of rebate. We also find little support for financing a tunnel or bridge across the Lake Geneva. This result mirrors the case of Gothenburg, where part of the opposition to the congestion charge was related to the use of its revenues for a rail tunnel under the city (Börjesson and Kristoffersson, 2015; Andersson and Nässén, 2016).

Overall, we find that most design parameters affect public support. Within designs, differences across respondents seem to be mainly due to the respondent's residence location and commuting mode. That is, the standard public choice tenet that people's preferences are mainly driven by their own interests seem to be largely confirmed in our context (see Downs, 1957; Kramer, 1983; Ferejohn, 1986). However, no matter the different individual characteristics, we confirm the important trade-off between efficiency and acceptability. The section 2.4.3 further investigates the role of heterogeneity within our sample.

2.4.2 Information

In this section, we analyze the impact of the randomized informational treatments on public support for the different designs. Overall public support, measured again as the number of votes in favor of a congestion charge over the total number of votes, amounts to 51.07 % in the control group, 52.83 % in the Congestion treatment, and 57.07 % in the Pollution treatment. Figure 2.3 compares public support across different charge rates for each treatment compared to the control group. The left panel shows the Congestion treatment, the right panel the Pollution treatment. Both treatments tend to increase public support, but the Congestion treatment does so only marginally. Stressing the observed effects of existing congestion charges on traffic may not affect behavior in our sample. People in our sample may tend, in general, to factor in the effect of a congestion charge in reducing traffic. Note that in French, and so in our survey, the term for congestion charge is "péage urbain" (urban toll), which does not explicitly relate to congestion.

FIGURE 2.3: Informational treatments, charge rate, and public support



The difference in public support in the control group and in the Pollution treatment is very small at low charge rates, when public support is relatively high, but increases with policy stringency. To test whether this difference is statistically significant and to assess the pattern of divergence, we analyze the causal effect of both randomized treatments on public support at each charge rate. Table 2.6 displays the results (see Table A.10 in the Appendix for the inclusion of control variables, to which our results are robust). As expected following Figure 2.3, regardless of the charge rate, the Congestion treatment has no significant impact on public support. The difference observed in Figure 2.3 is not only marginal, but also statistically insignificant. The coefficient is also statistically insignificant for the Pollution treatment, as long as the charge rate remains below CHF 2. Starting from CHF 2, we observe a statistically significant divergence in public support between the Pollution treatment and the control group.

TABLE 2.6: The impact of informational treatments on public support, for each charge rate

	(1) CHF 0.2	(2) CHF 1	(3) CHF 2	(4) CHF 3	(5) CHF 4	(6) CHF 5
Congestion	0.020	0.020	-0.003	0.002	-0.001	0.012
	(0.018)	(0.017)	(0.016)	(0.015)	(0.015)	(0.014)
Pollution	0.002	0.012	0.042**	0.037**	0.042***	0.038***
	(0.017)	(0.017)	(0.016)	(0.014)	(0.014)	(0.013)
Number of respondents	1414	1414	1414	1414	1414	1414
Number of observations	4’736	4’711	4’702	4’702	4’711	4’710
R^2	0.0003	0.0002	0.0019	0.0017	0.0027	0.0021

Estimates report average marginal effects from logit.
Heteroskedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.15 .
** $p < 0.05$, *** $p < 0.01$.

In Table 2.7, we test whether this result carries over also to different modulations (see Table A.11 in the Appendix for the inclusion of control variables, to which our results are robust). Recall that we consider several options that deviate from constant pricing throughout the day, including a series of top-up charges. We are now interested in analyzing the impact of the informational treatments on public support for each modulation, i.e. whether the randomized informational treatments also lead to higher support for more stringent designs. While the effect of the Congestion treatment remains marginal, we do observe higher support for a peak hour top-up as well as for a pollution top-up. Support for the pollution top-up increases by about 5 %. Hence, the findings show that, in our survey, the randomized informational treatments contribute to close the gap between efficiency and acceptability.

TABLE 2.7: The impact of informational treatments on public support, for each modulation

	(1) Constant	(2) Peak hours only	(3) Peak hours top-up	(4) Distance top-up	(5) Pollution top-up
Congestion	0.019	-0.007	0.001	0.025	0.006
	(0.015)	(0.015)	(0.015)	(0.014)	(0.015)
Pollution	0.018	0.017	0.046***	0.022	0.045***
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)
Number of respondents	1414	1414	1414	1414	1414
Number of observations	5’638	5’678	5’646	5’659	5’651
R^2	0.0003	0.0004	0.002	0.0007	0.0018

Estimates report average marginal effects from logit.
Heteroskedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.16.
*** $p < 0.01$.

2.4.3 Heterogeneity

In this section, we further investigate the role of heterogeneity across individuals to better understand how preferences vary with voter characteristics. To this end, we apply a latent-class model. We can identify 5 latent classes in our data.[6] The number of respondents per class goes from 201 (class 5) to 393 (class 1). Overall public support varies between 97 % (in Class 1) to 1.37 % (in Class 4). Hence, we can define Class 1 as (virtually) always in favor, and Class 4 as (virtually) always against. Overall public support is 60 %, 36 %, and 76 % in Classes 2, 3, and 5, respectively.

Table A.12 in the Appendix shows how attribute and level preferences change across classes,

[6] As per standard procedure, we minimize the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). AIC (BIC) values are given as follows: for two classes, 23049 (23002); for three classes, 21902 (21831); for four classes, 21658 (21563); for five classes, 21602 (21483); for six classes, 21644 (21501).

based on a conditional logit model. In Table A.13, also in the Appendix, we use a multinomial logit model to analyze the composition of the different classes.

This analysis provides a set of additional findings. While over the whole sample we observe a clear negative relationship between the level of the charge and public support, the latent class analysis points to varying degrees of price sensitivity as well as a preference, in three classes, for a moderate charge over no charge. In general, Classes 1 and 2 tend to be relatively price inelastic, while in Classes 3, 4, and 5, public support reacts much more strongly to an increase in the charge. In Class 1 and 5, there is a preference for a positive charge compared to no charge at all, after which the standard negative relationship between charge rate and public support is observed. The other differences among Classes 1, 2, and 5, which all show (relatively) high support, relate with modulation and use of revenue. In Class 2, no modulation is statistically preferred to a constant modulation. Class 2 also shows a preference for large exemptions, especially for residents, frequent commuters, and electric vehicles. Class 3 shows the strongest price sensitivity. While a small charge is preferred to the status quo, public support drops rapidly as the charge increases. Respondents in Class 3 also exhibit strong preferences for large exemptions, similarly to Class 5. Respondents in Class 5 tend to favor revenue earmarking for the tunnel, or bridge, crossing the Lake Geneva.

Members of Class 1 are more likely to be residents of the Swiss Cantons of Geneva and Vaud and located within the area of the hypothetical perimeters. Members of Class 2, and Class 3, tend to be relatively younger than the rest of the sample. Car and motorbike commuters are overrepresented in Class 3. Members of Class 4 tend to be residents of the Swiss Cantons of Geneva and Vaud, who commute by car or motorbike. Members of Class 5 are more likely to live in France, hence the preference for the tunnel, or bridge, crossing the Lake Geneva, which would benefit mainly individuals living in the surrounding of Geneva and trying to bypass part of the city center.

2.5 Conclusions

Economists have long advocated for congestion charges to internalize the externalities of driving. However, only a few cities in the world have implemented a congestion charge. Others have considered it, but later abandoned it before lawmakers would suffer a political defeat. In some other cities, proposals for a congestion charge were abandoned after an unsuccessful public ballot.

Switzerland recently changed its regulation to allow congestion charge trials in a number of cities willing to act as forerunners. Geneva, one of the most congested cities in the world, stepped forward. Policymakers are currently considering a potential design to be trialed over the next few years. In a country where people vote very often, reaching sufficient public support for such a radical change in transportation policy represents a sine qua non. This chapter builds on the theoretical literature, and draws lessons from the existing congestion charge schemes in the world, to put forward a set of plausible designs for a Geneva congestion charge. Then, it evaluates public support for each of them, using a large survey of respondents from Geneva and the surrounding regions of both Switzerland and France. The literature on public support for environmental policy suggests that acceptability may change dramatically with the design. Hence, public support for each policy design is tested with a discrete choice experiment. The parameters considered for the design are the following: charge rate, perimeter of the charge, modulation of the charge, level of exemptions, beneficiaries of exemptions (if any), and use of revenues. According to the literature, information asymmetries may represent another obstacle to public support. The general public may not expect congestion charges to work as well as economists do. However, no causal evidence on the effect of additional information on public support for congestion charges has so far been provided. With a split sample design on top of the standard discrete choice experiment, we test the effectiveness of two randomized informational treatments stressing the benefits of congestion charges for abating pollution and reducing congestion, respectively.

Our findings confirm the importance of design for public support. Public support decreases (increases) considerably when increasing the level of the charge (exemptions), although important heterogeneity in the sample is observed and some groups tend to be much more sensitive to the level of the charge than others. Heterogeneity determines most of the findings in this chapter. Preferences for either a more compact perimeter or an extended area depend on where people live and how they commute. Our findings also highlight an important trade-off between acceptability and efficiency. While on efficiency ground congestion charging should match as closely as possible the marginal damage of driving, people tend to have a strong preference for a constant, predictable modulation. Similarly, people do not favor exemptions to the vehicles causing less congestion or pollution, such as motorbikes, or electric vehicles. Only bikers support exemptions for motorbikes. Residents demand exemptions for residents. Frequent commuters have a preference for a scheme providing a discount when prepaying for many rides, as in use in Norwegian cities. Most people demand earmarking for improvements in public transportation. Revenue-neutral schemes, favored by the Swiss federal authorities, are especially disliked by the general public. Finally, we show that information asymmetries do contribute to lower public support, as our randomized informational campaigns contribute to higher public support. That is, in the context of our study, we find that tackling information asymmetries increases public support. The treatment providing information about expected pollution reduction increases public support the most, especially for relatively ambitious designs.

A set of policy implications follow from our results. First, testing the waters to quantify the trade-offs between public support and efficiency for different designs is crucial, as it may reduce the risk that policymakers would make the wrong bet, and hence face a political failure that could prevent the implementation of a congestion charge for a long time. Second, providing information to voters, for instance drawing on the successful experience of other schemes, may contribute to close the gap between efficiency and public support. This is especially true for benefits that may not be immediately perceived by voters, such as improved air quality. The COVID-19 pandemic has, for instance, provided an excellent opportunity to policymakers around the world to convey to voters information about how their city and the sky above it would look like with fewer cars around. Third, identifying designs that can gather support among the local residents as well as commuters from the surrounding areas, and at the same time have a bite, may be especially hard. In line with standard public choice tenets, voters' preferences tend to be very much driven by their own costs and benefits. Hence, depending on who has the right to say over the implementation of a congestion charge, public support can vary considerably. However, we identify several designs that reach and exceed majority support. In particular, public support is the highest among the residents of Geneva, who will be ultimately tasked with taking a decision. While this bodes well for the prospects of a congestion charge in Geneva, the variation in public support across designs should remind policymakers of the importance of carefully crafting legislation on potentially unpopular matters.

Chapter 3

Household waste sorting behavior: the impact of norms and infrastructures[1]

This chapter is a slightly modified version of a paper written together with Andrea Baranzini and Tobias Brosch submitted to a journal for publication.

Abstract

Understanding the determinants of households' municipal waste sorting behavior is crucial to develop and improve waste recycling policies. We design a survey to investigate households' sorting motivation and a discrete choice experiment (DCE) to asses households' waste collection scheme preferences in the Canton of Geneva, Switzerland. Our results show that households who sort more waste are more sensitive to the environment, have guilty conscience when not sorting, and believe in the effectiveness of their action and their self-efficacy. Satisfaction with existing sorting schemes most strongly increases the probability to sort households' waste. We note that households have clear preferences for better infrastructures, but with thresholds. By analyzing the sample heterogeneity with a latent class model and linking personal beliefs and characteristics with preferences, we find that different groups sort a similar number of waste categories, but are driven by different underlying mechanisms like a lack of knowledge or looking for more convenient infrastructures and services. Our study provides major insights to give the correct information to the right households and to develop the most suitable waste collection schemes.

[1]We thank Laurent Cornaglia and Donatella Vretenar Sabelli for useful discussions and help on the questionnaire. We acknowledge financial support by the Department of the territory, Canton of Geneva, Switzerland. The usual disclaimer applies.

Keywords Waste sorting; Recycling; Policy design; Voluntary policy; Norms; Household preferences; Discrete choice experiment; Latent class model

3.1 Introduction

Waste generates important costs to society through air and water pollution, as well as the significant loss in valuable raw materials, such as glass or aluminum. According to the World Bank, 2.01 billion tonnes of municipal solid waste were generated in 2016 and carbon dioxide (CO_2) equivalent greenhouse gas emissions from their treatment is estimated at 1.6 billion tonnes, corresponding to 5% of global emissions (Kaza et al., 2018). To tackle this issue and following the seminal proposition of Pigou (1920) to internalize external effects, many municipalities around the world including the EU, the United States, Japan and South Korea implemented unit-based pricing on municipal solid waste. The goal of such environmental taxes is to decrease the total amount of garbage collected as well as to increase recycling. Common practice is pricing by the bag or by volume (see Bel and Gradus (2016)).

The impact of unit-based waste pricing on recycling is debated in the literature, with some studies showing no significant effects (Jenkins et al., 2003; Kipperberg, 2007). The review by Kinnaman (2006) finds that only households with low opportunity costs and who are already sorting respond positively to unit-based pricing. Furthermore, monetary incentives can lead to undesired effects, as the introduction of unit-based pricing can crowd-out the pro-environmental behavior, lead to the export of waste, illegal dumping or burning (Fullerton and Kinnaman, 1995; Gneezy et al., 2011; Kellenberg, 2012).

The important potential of non-monetary incentives in determining individuals' behaviors is well recognized, e.g. Titmuss (1970); Andreoni (1989); Frey and Oberholzer Gee (1997); Bénabou and Tirole (2006). The review of more than 40 studies by Farrow et al. (2017) highlights that social norm interventions can be effective in inducing pro-environmental behaviors. Moral motivation is crucial in the success of a recycling scheme since sorting is costly in time and effort. It has been observed that personal and social norms can increase recycling (Hage et al., 2009; Brekke et al., 2010; Halvorsen, 2012; Wang et al., 2019). However, households will not sort their waste if it is inconvenient for them to do it (Knussen et al., 2004). Thus, appropriate sorting infrastructures and services are also needed to obtain higher recycling rates. Curbside collection and drop-off centers, for example, are expected to increase recycling rates since they reduce the opportunity cost of sorting (Sidique et al., 2010a) and increase intrinsic motivation by enhancing the autonomy and the perceived capacities of the households (De Young, 1996; Thøgersen, 2003).

Therefore, although economic incentives have an impact on household behavior, a better understanding of household motivations, preferences and behaviors is crucial to enhance recycling rates and encourage a circular economy. Our study contributes to this growing literature field by analyzing the determinants of municipal waste sorting using a discrete choice experiment (DCE). This method allows us to uncover how individuals value different waste sorting scheme attributes. We also consider the heterogeneity in preferences and study their interaction with moral and social norms. Based on the literature, we identify the perceived norms that can potentially increase voluntary waste sorting, including self-efficacy (Bandura, 1982), morality (Dietz et al., 2005), action efficacy (Kaiser and Fuhrer, 2003), social pressure (Hage et al., 2009), environmental concern (Viscusi et al., 2013), financial interest and external pressure (Berglund, 2006; Halvorsen, 2012). We define waste sorting schemes according to characteristics, which have an impact on household sorting behaviors: curb collection frequency, waste categories collected at curb, distance to the nearest collection point, and price of the scheme. The use of a DCE to investigate household preferences for waste sorting scheme is limited and existing papers are mostly focusing on curbside collection (e.g. Karousakis and Birol 2008; Czajkowski et al. 2014, 2017). The possible existence of latent classes has been explored for the first time by Nainggolan et al. (2019) and Massarutto et al. (2019). Furthermore, associating norms with a DCE to investigate how beliefs and household characteristics can influence waste sorting behavior has previously been studied only by Czajkowski et al. (2017) and Massarutto et al. (2019). Massarutto et al. (2019) is the only study exploring a full waste sorting scheme including a drop-off option, the possible existence of latent classes, as well as the impact of a limited number of norms and personal characteristics. This chapter contributes to this recent literature, explaining waste sorting behaviors by integrating a large range of attribute and levels, exploring the existence of latent classes, as well as investigating the interaction of preferences with various norms and personal characteristics in a unique manner. Contrary to other studies, sorting at a central facility is not an option in our case (Czajkowski et al., 2014; Lee et al., 2017). The only way to recycle is household source sorting, but sorting is not compulsory and households are not facing any monetary incentives. Hence if households value recycling, they have to make an effort and sort. It allows us to observe if households are ready to sort and what can motivate or influence their sorting behavior. This context is interesting, since sorting can only be motivated by intrinsic motivation or non-monetary incentives.

The survey was conducted in the Geneva Canton, Switzerland. Due to the environmental regulatory framework, pricing by the bag is widespread in all Swiss cantons except the Canton of Geneva. To avoid the implementation of a bag tax, Geneva aims to increase recycling by influencing household waste sorting behavior with non-monetary incentives. The objective is to reach a higher recycling level (60% in 2022) than the other Swiss cantons possessing unit-based pricing (52% in 2017). Geneva is thus a very interesting case study for all municipalities around the world without a unit-based pricing system and without the willingness to implement one.

The contribution of this chapter to the literature is twofold. First, it adds to the literature on the determinants of household waste sorting in general. It contributes in closing the gap explaining the heterogeneity in preferences by associating beliefs and household characteristics with a choice experiment. Second, it contributes to the literature on non-monetary motivations to support the common good environmental quality, and more in general non-monetary policy instruments.

The overarching goal of this chapter is to identify waste collection schemes features that increase households' waste sorting, as well as identifying the individual factors that impact these preferences. The results will help authorities to develop effective voluntary policies and thus improve sorting rates without the use of constraints or monetary incentives.

The chapter is structured as follows. Section 3.2 provides an overview of the existing literature on household waste sorting. Section 3.3 presents the economic and empirical approach. Section 3.4 discusses the survey design and the data. Section 3.5 provides the findings of the research and section 3.6 concludes and highlights policy implications.

3.2 Background and context

3.2.1 Determinants of household waste sorting

The use of economic incentives in environmental policies emerged over the last decades. In solid waste management, several municipalities and countries have implemented unit-based pricing to charge households for their actual waste generation costs. Ideally, unit-based pricing should incentivize households to sort more and to generate less waste (Jenkins et al., 2003). The impact of unit-based waste pricing is studied for instance by Allers and Hoeben (2010) on a ten-year data set of 458 Dutch municipalities and by Carattini et al. (2018a) in the canton of Vaud, Switzerland. Applying a difference-in-difference approach, both studies reveal that pricing caused a decrease in incinerated waste and an increase in the sorting of, e.g. organic waste, paper and aluminum. However, other research indicates that economic incentives may have some unintended effects. Dahlén and Lagerkvist (2010), for instance, analyze the effect of garbage pricing, mainly weight-based billing, in Swedish municipalities and find clear reductions in waste generation in some municipalities, but almost none in others. They show that the decrease in waste can not be explained by an increase in sorting, suggesting that the difference is either due to illegal disposal or to a decrease in household waste production. Fullerton and Kinnaman (1996) find a 37% decrease in waste and a 14% decrease in weight after the introduction of a charge of 0.80 US$ per 32-gallon bag in Virginia in 1992. However, they conclude that 28% to 43% of this waste reduction is due to additional illegal dumping. Indeed, Choe and Fraser (1999) show theoretically that garbage pricing encourages waste reduction, but at the same time illegal disposal. Erhardt (2019) has taken advantage of the local differences in waste policies in Switzerland to analyze illegal disposal. He analyzes whether waste is transported from one municipality to another to avoid unit-based pricing. He finds that the quantity of waste per capita is higher when the distance to municipalities with garbage pricing decreases. Unauthorized garbage disposal seems thus a major drawback of economic incentives.

Besides misbehaviors, the psychological literature raises additional doubts about the effectiveness of policies based on monetary incentives. In line with Dahlén and Lagerkvist (2010), Heller and Vatn (2017) find in a Norwegian municipality that only half of the households improved their sorting behaviors with the introduction of economic incentives, while the other half continued just as before. They highlight the crucial role of moral norms, which are related to personal beliefs about what are right or wrong behaviors. Waste sorting depends on convictions and internal values such as “doing the right thing for the environment” and “being a responsible person”. Thøgersen (1994) already pointed out that economic incentives may re-frame the waste and sorting questions from a moral issue to a financial issue and that the negative effect of this re-framing could not only cancel the economic incentive as observed in Heller and Vatn (2017), but even have a negative impact. Indeed, external interventions such as economic incentives can crowd-out or crowd-in intrinsic motivation under specific conditions (Frey and Jegen, 2001). The crowding-out effect has been explained in two ways. According to Frey (1997), the change in behavior may be due to a change in preferences when an extrinsic motivation is introduced. Thus, when the motivation is extrinsic, the behavior is performed to obtain a reward or avoid a negative outcome and not for its own sake, resulting in reduced effort (Levesque et al., 2010). Bénabou and Tirole (2006) rather think that the change in behavior is the consequence of a change in the perception of the task due to the impact of the extrinsic motivation on the altruistic motivation, the self-interest or the self-image attached to the task. This approach is consistent with the standard economic assumption of fixed preferences. The effect of extrinsic motivations may not only influence the task itself, but spill over to other duties (Frey, 1994). In the case of waste sorting, decreasing recycling effort for one material may spill over on other categories or other household tasks. Furthermore, if motivation is crowded-out by economic incentives, the incentive becomes less effective and needs to be reinforced to reach a given goal (Bowles and Hwang, 2008).

Bazin et al. (2004) claim that taxation as an economic incentive can be completely replaced by a high degree of personal responsibility since taxation may decrease the sense of responsibility and thus pro-environmental behaviors. Moral motivation to contribute to a public good may be reduced if the perceived responsibility is shifted from the individual to the government through monetary incentives (Brekke et al., 2003). People want to think about themselves as responsible and will thus act in a way that appears morally right to them. Even if some households are willing to pay to avoid waste sorting and the associated opportunity cost of time (Bartelings and Sterner, 1999; Bruvoll et al., 2002), many people prefer to sort at home, rather than to leave it to a central facility even at a cost (Czajkowski et al., 2014). Sorting at home may be perceived as morally better than sorting at a central facility (Czajkowski et al., 2017). Hage et al. (2009) conducted a postal survey on 2'800 households in four Swedish municipalities and found that the self-reported recycling rate increases with the feeling of personal responsibility. In addition to personal norms, they also stress the importance of social norms, the individual perception of others' sorting efforts, as recycling rate increases with the perceived degree of neighbors' sorting behavior (Nyborg et al., 2006).

Close others such as relatives and friends also have been shown to have an effect on the perception of social norms and thus on sorting. Brekke et al. (2010) found that perceived responsibility increases glass sorting and that the feeling of responsibility increases with the belief that family and friends sort. People not only want to think about themselves as responsible, but they also want to be seen as responsible people by others (Halvorsen, 2012). Thus, Abbott et al. (2013) suggest that policymakers should rely on social norms to improve household sorting. Social pressure can increase sorting through the belief that neighbors are expecting others to sort, the feeling that sorting is compulsory or a civil duty, and the belief that a majority of the population sort (Berglund, 2006; Viscusi et al., 2011). Videras et al. (2012) found that a strong connection to neighbors and the belief that they are contributing to a better environment improve the probability of sorting.

Believing in action effectiveness, i.e. that sorting contributes to a better environment, or being particularly concerned about the environment, e.g. being a member of an environmental organization, are other major contributors to sorting behaviors (Halvorsen, 2008; Hage et al., 2009; Halvorsen, 2012). Furthermore, since sorting requires a personal effort, in order to get involved in the sorting activity people have to believe in their own capacity to perform the action ("self-efficacy") (Bandura, 1997, 2002). Similarly, Tonglet et al. (2004) found that perceived behavior control is strongly correlated with sorting effort. Some households may not sort their waste due to a lack of knowledge about waste separation or the downsides of not doing it. Varotto and Spagnolli (2017) performed a meta-analysis of 36 studies reporting 70 interventions, assessing the effectiveness of different intervention strategies aiming to promote recycling. They found that providing information to households on how to sort and its importance has a positive effect on sorting behaviors. Nevertheless, information should be adequate and transmitted in the right way according to the institutional context (Refsgaard and Magnussen, 2009). Van der Werff et al. (2019) observe a reduction in residual waste after the implementation of an informational strategy on how to minimize waste and why it is important. Saladié and Santos-Lacueva (2016) estimated based on data collected among university students in South Catalonia that 17.9% of the improvement in the sorting rate is entirely due to awareness campaigns. Apart from traditional approaches like leaflets, door-to-door campaigns provide significant effects as well (Read, 1999; Cotterill et al., 2009; Dai et al., 2015).

Sorting requires efforts as well as time and space. Hence, another factor to take into account in waste policies is the "inconvenience factor". Households will not sort their waste if it is not convenient, even if they are able to do it (Knussen et al., 2004). In a meta-analysis of 63 studies, Miafodzyeva and Brandt (2012) identified convenience as the strongest determinant of sorting behavior. Therefore, in order to improve sorting the needed infrastructures should be provided, as well as some practical sorting solutions for the apartments (Timlett and Williams, 2009; Metcalfe et al., 2012). The provision of waste collection set up and sorting infrastructures has also been shown to be an important factor in recycling decisions (Gilli et al., 2018). Increasing distance to a drop-off point has a negative impact on the frequency of site usage (Sidique et al., 2010b). Berglund (2006) found that people are willing to pay more to delegate the sorting as the distance to drop-off centers increases. Collecting waste at the curb has a positive impact on sorting efforts, which is larger than the effect of drop-off centers (Jenkins et al., 2003; Halvorsen, 2008; Karousakis and Birol, 2008; Sidique et al., 2010a; Gilli et al., 2018). According to Dahlén and Lagerkvist (2009), Swedish households separate twice as much metal, plastic and paper if these materials are collected door-to-door rather than with drop-off points. More frequent collection systems tend also to be preferred by households (Karousakis and Birol, 2008; Czajkowski et al., 2017). Waste collection policies should thus either provide curbside collection or locate drop-off center close to the households (Saphores and Nixon, 2014). Increasing the number of collected materials has also a positive effect on sorting (Halvorsen, 2012). Households are willing to pay more for an increase in the number of materials collected at curb, especially compost (Karousakis and Birol, 2008). Regarding organic waste, the frequency of collection is important, which may not be the case for residual waste (Abbott et al., 2011). Decreasing the frequency of residual waste would however incentivize household to sort more.

Socioeconomic characteristics play also a significant role in sorting behaviors. Halvorsen (2012) found that living in suburban areas, in detached houses, in couple, in the same residence for a while or having higher revenues have a positive impact on the sorting rate. She explained lower sorting rates for residents of urban areas and for new inhabitants with lower social pressure on these types of households. Huhtala (2010) highlighted the importance of income in sorting, reporting that high income households prefer incineration to sorting due to their high opportunity cost of time.

3.2.2 The Geneva case

In 1974, unit-based pricing on municipal solid waste was introduced for the first time in a municipality in Switzerland. Since then, this economic instrument has spread all over the country, starting in the German-speaking municipalities and later in the French-speaking ones. By the nineties, the large majority of the German-speaking municipalities implemented a bag tax, while the French-speaking municipalities implemented it during the last decade only. In Switzerland municipalities have the right to set their own rules as long as they respect federal and cantonal laws. However, in 1997, the federal legislation imposed the application of the polluter pays principle in environmental policies, which limited municipalities' leeway. In 2011, following a lawsuit, the Swiss Federal Supreme Court has handed down a case law specifying that in order to apply the polluter pays principle and reduce the amount of unsorted waste, the use of lump-sum taxes to finance waste management and treatment should be used as a complementary source of revenue only. To date, all the Swiss cantons except Geneva have implemented a bag tax to finance their waste management systems. Even if the Canton of Geneva should also introduce unit-based pricing according to the Swiss Federal Supreme Court, it maintains voluntary policies to overcome a 50% recycling rate and thus approaching the mean recycling rate of Switzerland and trying to avoid a bag tax. The canton distributed for example, in 2016, small green bins to the households to favor organic waste sorting and developed recently a mobile phone application with various information on waste sorting.

According to the Cantonal Office of Statistics (OCSTAT), in the Canton of Geneva, the recycling rate increased by almost 10% between 2005 and 2019. However, the recycling rate remained unchanged between 2018 and 2019 at 47.8% due to a decrease in the quantities of recycling waste. At this stage, increasing the recycling rate and decreasing unsorted waste is challenging, but the goal of the canton for 2022 is to achieve a decrease of 20% in unsorted waste and a recycling rate of 60%, which means an increase of more than 10% in only 3 years. The authorities are thus interested in the main drivers of households waste sorting to give the right incentives to the right people and to implement the corresponding policies. In this chapter, we analyze the factors determining household sorting efforts and their preferences for waste collection schemes. Note that waste policies are implemented at the cantonal level, but waste collection and transport take place on the municipal level, which leads to some heterogeneity.

For the analysis of the waste collection schemes preferences, we consider a set of designs that could be suitable for Geneva. Based on the local context and the literature (e.g. Jenkins et al. 2003; Berglund 2006; Karousakis and Birol 2008; Halvorsen 2012; Czajkowski et al. 2014; Nainggolan et al. 2019), we choose the following dimensions of a waste collection scheme: curb collection frequency, categories collected at curb, distance to the nearest collection point by foot, and price of the scheme per person per month.

Currently, in the municipalities of the Canton of Geneva, waste is collected at curb either once or twice a week generally. Nainggolan et al. (2019) and Karousakis and Birol (2008)'s DCE design proposes twice a week, once a week and fortnightly for the curb collection frequency. Czajkowski et al. (2014) use frequencies between once a week and once a month. In our DCE, curb collection frequency varies from twice a week to once a month. In Geneva, waste collection points are already relatively dense and close to households. Based on existing information, we set the closest distance to the nearest collection point by foot from the household's living place at 2 minutes and the maximum distance at 8 minutes. From 5 minutes by foot, a majority of households will already take another mode of transportation (car, bicycle, etc) to reach the collection point. Concerning the different categories of waste collected at curb, in Geneva unsorted waste as well as paper are often collected at curb. We thus include in the DCE these two categories. Organic waste is the third proposed category since it is costly to sort and to store, and curb collection could reduce this cost. We moreover included a fourth category, glass, since it is relatively heavy to carry to a collection point and it is already collected at curb in some municipalities of the canton. The price attribute corresponds to the amount that needs to be paid by the households for the proposed waste collection scheme. It can be lower either because the quality of the service is lower (fewer collection points and less frequent collection) or because it is partly paid from other sources of revenue of the local community (which explains why a value of 0 can be possible). The price range is defined according to the price of the bag tax in Switzerland and the waste management cost in the municipalities of the Canton of Geneva. In the DCE, the choice possibilities are 0 CHF, 6 CHF, 12 CHF and 18 CHF per person per month, which are comparable to the levels in the existing DCEs[2].

Table 3.1 summarizes the attributes and levels considered for the design of the waste collection schemes in Geneva and in the following empirical analysis.

3.3 Economic model and empirical approach

The neoclassical rational choice model, maximizing household utility, highlights the behavioral impact of economic incentives like unit-based pricing. However, it can hardly explain why people contribute to a common good such as environmental quality without any economic incentive. Several studies discuss the limitation of external rewards and morally motivated behaviors (e.g. Andreoni 1990; Brekke et al. 2003; Gneezy et al. 2011). New and more complex models painting a more realistic picture of households' behavior emerged. The model pre-

[2] 6 CHF corresponds to the minimum cost for one person per month with a bag tax in Switzerland. It also corresponds to the waste management cost per month in the cheapest municipality of the canton (Satigny). In Switzerland, the most expensive bag tax corresponds to a cost of waste of about CHF 16 per month per person. At the time of the study, 1 CHF ≈1.13 US$ ≈ 0.93 EURO.

TABLE 3.1: Waste collection scheme design: attribute and levels

	Attributes			
	Curb collection frequency	Categories collected at curb	Distance to collection point	Price per person per month
Levels	Once a month	Unsorted waste	2 minutes by foot	0 CHF
	Twice a month	Unsorted waste and paper	4 minutes by foot	6 CHF
	Once a week	Unsorted waste, paper and organics	6 minutes by foot	12 CHF
	Twice a week	Unsorted waste, paper, organics, and glass	8 minutes by foot	18 CHF

sented in this section is based on the recycler utility model of Hage et al. (2009). This approach relies on an economic model of moral motivation introduced by Nyborg et al. (2006) and on Schwartz's psychological theory of altruistic behavior (Schwartz, 1970, 1973, 1977).

We assume that households engage in waste sorting activities by comparing the associated costs and benefits. As sorting waste is a costly activity in time, space and effort, there is an "inconvenience factor" I to sort, which is decreasing in the availability of infrastructures θ. However, sorting generates also two types of benefits. First, non-monetary environmental benefits, b, which increase the welfare of the household who is sorting waste, as well as the welfare of other households of the society. In the context of waste sorting, we can reasonably assume that the environmental benefits resulting from the household's own sorting behavior are negligible and thus that $b < I$. Second, sorting yields a self-image benefit S since we assume that sorting waste is morally superior to not sorting. People wish to be considered by themselves and by others as socially responsible. The self-image depends thus on the compliance with personal and social norms. The higher the importance of self-image or the compliance with norms, the higher the benefit of sorting. If the household does not care about her self-image, S = 0 and no sorting will take place, like in neoclassical rational choice models, since $b < I$.

The households' sorting intensity, r, can thus be expressed by the following function:

$$r = f(S(s, B, \alpha), b, I(\theta)) \tag{3.1}$$

The household's self-image S is increasing in the self-efficacy s, the perceived effectiveness and importance of one's sorting B, and the household's beliefs about other's sorting behaviors and expectations α. Since b is negligible, households will sort if $S > I$.

Empirically, we firstly analyze the determinants of sorting, more precisely the number of sorted categories as a proxy of the intensity of sorting. Following Jenkins et al. (2003) and Kipperberg (2007), we use a latent regression model for ordered data. We define three ordered categories, $r \in 0,1,2$: category 0 for less than average sorting, category 1 for average sorting and category 2 for over average sorting. Let r_i^* represent the true, unobserved sorting level of household i which can be expressed as :

$$r_i^* = \beta x_i + \varepsilon_i \tag{3.2}$$

where x_i is a vector of exogenous variables (self-efficacy s, perceived effectiveness and importance of sorting B, beliefs about other's recycling behaviors and expectations α, and satisfaction about infrastructure and services as a proxy for the availability of infrastructures θ, see (3.1)), β a vector of parameters estimated by maximum likelihood estimation (MLE) in an ordered logit model and ε_i the error term, a random component associated with household i, assumed to be distributed logistically. The probability to observe household i in category r, where $r = 0,1,2$, is thus:

$$P(r_i = 0) = \frac{1}{1 + e^{\beta x_i}} \tag{3.3}$$

$$P(r_i = 1) = \frac{1}{1 + e^{-\mu+\beta x_i}} - \frac{1}{1 + e^{\beta x_i}} \tag{3.4}$$

$$P(r_i = 2) = 1 - \frac{1}{1 + e^{-\mu+\beta x_i}} \tag{3.5}$$

where μ is a threshold parameter.

Secondly, we examine household's preferences about sorting infrastructures and services to better understand how to reduce the “inconvenience factor” I through the availability of infrastructures θ. We are thus interested in household's preferences for various waste sorting schemes. We apply a DCE to evaluate different choices and the relative importance of each characteristic (attribute level) of a given option (alternative). This approach follows the standard utility model (RUM), where the unobservable utility U_{ij} that individual i gains from waste sorting alternative j is most commonly defined as additively separable:

$$U_{ij} = V_{ij}(X_{ij}) + \varepsilon_{ij} \tag{3.6}$$

where V_{ij} is the deterministic component of the utility that individual i associates with alternative j, which is characterized by several attributes X. This first term, V_{ij}, is thus a linear function of the four chosen attributes defining the waste collection schemes. The second term, ε_{ij}, is a random component, which is assumed to be independently and identically distributed across respondents and alternatives. This implies that the probability that alternative j is chosen among all other alternatives in the choice set C_i can be expressed as following a logistic distribution (McFadden, 1973). The conditional logit model, estimated by maximum likelihood, follows:

$$P(j|C_i) = \frac{e^{\eta V_j}}{\sum_h e^{\eta V_h}} \tag{3.7}$$

where η is a scale parameter.

We compute the willingness to pay for each attribute level, i.e. the relative value of the coefficient $(-h_k/h_c)$, where h_k is the coefficient of the attribute level under consideration and h_c the cost coefficient. The willingness to pay reflects the trade-off households are willing to make between a specific waste collection scheme characteristic and the collection scheme cost. A positive willingness to pay means that households are willing to pay more to get a specific collection scheme characteristic.

Finally, we estimate a Latent Class Model (LCM) to account for heterogeneity; differences in norms, sorting habits and socioeconomic characteristics in household's preferences for different waste sorting schemes. This model identifies L number of classes in which households are assigned according to their waste sorting preferences. The probability of choosing alternative j over all other waste sorting schemes for individual i in class l $(l = 1, ..., L)$ can be written as:

$$P(il|j) = \frac{e^{\eta_l V_j}}{\sum_h e^{\eta_l V_h}} \tag{3.8}$$

Each individual i has a constant probability P_{il} to belong to each class, which sum to one across the classes, L. However, individuals are assigned to the class for which the membership is at highest. The composition of the classes are then analyzed with the help of a multinomial logit model. Class membership is used as the dependent variable and households sorting habits, norms and socioeconomic characteristics as predictors.

3.4 Survey design and data

We investigate households' sorting behavior with a survey among the population of the Canton of Geneva, Switzerland. The questionnaire consists of four parts. We ask questions about households sorting habits, including (1) the amount of waste generated and the types of waste sorted, (2) personal and social norms, (3) preferences about waste collection infrastructures and services, and (4) socioeconomic characteristics. To measure personal and social norms, we use various statements like "I have bad conscience if I do not sort my wastes", with the answers being Likert scales, 1 "strongly disagree" to 7 "strongly agree". To avoid bias, we take carefully into account neutrality, ambiguity and complexity of the questions (Choi and Pak, 2005). Based on the literature (e.g. Bandura 1982; Kaiser and Fuhrer 2003; Dietz et al. 2005) and Cronbach's alpha tests, we build three new variables, i.e. self-efficacy, action-efficacy and morality[3]. Self-efficacy refers to the individual's belief in his own capacity to sort, which includes the perceived knowledge on what, how and where to sort (see questions 13 to 15 of the survey in the Appendix B.1). Action efficacy means that the respondent is convinced that sorted waste are not mixed and burned or anyway sorted again after collection and that sorting contributes to a better environment (see questions 25 to 27 in the Appendix B.1). Morality is related with the principles that sorting is important, right and that one should do it for the environment (see questions 17, 20 and 21 in the Appendix B.1). This allows us to analyze the effect of, respectively, "I can do it", "It is efficient to do it" and "It is right to do it", which refers to self-efficacy, perceived effectiveness and personal responsibility, respectively.

Preferences regarding waste collection schemes are evaluated with a DCE. As mentioned above in section 3.2, we consider the following attributes of a waste collection scheme: curb collection frequency, waste categories collected at curb, distance to the collection point in minutes by foot and price per person per month. The respondent has to choose 8 times between two alternative waste collection schemes. Each waste collection scheme results from a combination of the different levels of the four above-mentioned attributes and displayed in Table 3.1. We do not include a status quo alternative or opt-out option to be closer to reality, because in the case of a change in sorting infrastructure and services, households would have no other alternative. Furthermore, we are interested in household preferences and not in the acceptability of the different alternatives. With the inclusion of an opt-out option, the "compromise effect" would be weaker and it would be a manner to save time and effort which would not represent real-life preferences (Simonson, 1989; Dhar and Simonson, 2003). There are six versions of the DCE and each respondent is randomly assigned to one of it. When designing the DCE with Sawtooth Software, we consider both statistical efficiency, which

[3] Action-efficacy and morality have Cronbach alpha values of 0.7127 and 0.7787, respectively. Self-efficacy reach 0.6557, which can be seen as a limit value, as the threshold is normally considered as 0.7. Nevertheless, over 0.6 is still considered as satisfactory by the literature (cf. Taber, 2018). Furthermore, we consider that self-efficacy is an important explanatory variable in our context.

implies minimizing the length of confidence intervals, as well as response efficiency, which implies minimizing potential measurement error due to respondent inattention (Reed Johnson et al., 2013). To be perfectly efficient, a design should be balanced and orthogonal. Each level and pair of levels should thus appear an equal number of times within an attribute and the entire design, respectively. However, to improve the precision of the utility estimates, we allow a modest degree of level overlap, since respondents use heuristics to simplify decision. They may for example focus only on some attribute levels and eliminate the alternative if not corresponding, without considering other attribute levels.

To reduce bias and fatigue effect, we tested the questionnaire quantitatively and qualitatively on 26 respondents. According to the results and discussions, we concluded that the length was adequate and the questions comprehensive. Data were collected during one month, between June 6, 2019 and July 6, 2019. One week before the beginning of the data collection, we provided some information and explanations about the survey and the DCE to 3'000 households randomly chosen in the Canton of Geneva. It should be noted that Swiss citizens are used to vote several times a year on federal and municipal matters. People receive information at home before the vote. Our approach is thus close to the vote procedure to which citizens are used. We then exploited Computer-assisted Telephone Interviews (CATI) to gather the information. The CATI method ensures a good quality of the sample, more spontaneity and sincerity of the respondent due to the absence of a visible interviewer and a good control of the interviewer's work. In addition to anonymity of the participants, the absence of a visible interviewer reduces the social desirability bias. Given the relatively low telephone response rate, we decided to send a second letter with, among other things, the phone number used to call them. We finally reached a sample of 609 residents, between the age of 18 and 74, representative of the population and divided in approximately six sample of 100 corresponding to the different versions of the DCE. Over the 3'000 mails sent, 312 were not eligible (sent back), 1'064 refused and 1'014 did not answer to the phone. The response rate is thus 22.7% and the maximum margin of error for the entire sample is ±4.0% (±9.8% for 100 respondents). The final sample, composed of valid questionnaires only, covers 591 respondents. Table B.1 in the Appendix displays summary statistics of the socioeconomic characteristics of the individuals in our sample.

Table B.2 in the Appendix compares our sample with the characteristics of the underlying population of the Canton of Geneva. Swiss citizens are slightly over-represented in the survey. This could be explained by the fact that the survey was in French and, although it is the official language, there are people who do not speak it.

3.5 Results

3.5.1 Descriptive statistics

More than 70% of the households sort a minimum of 8 waste categories over the 10 categories proposed and usually sorted in Switzerland (see Table B.3 in the Appendix). This means that a large part of the population already sort different categories of waste. Nevertheless, it is not enough to avoid a bag tax; sorting must be increased to achieve at least a 50% recycling rate to get close to the Swiss mean recycling rate (53%). It is thus crucial to understand why people sort less than others and which categories. A large majority of the households claims that they sort paper (98%), glass (97%) and PET (96%), whereas only 78% sort organic waste, 45% coffee capsules and 42% white plastic bottles (e.g. milk bottles). 60% of the households say that they do not sort more categories because they do not have those types of waste, whereas 14% say it is because they do not know what to do with those wastes. This means that 1 out of 7 households does not sort more because of a lack of knowledge on waste collection facilities, which is part of the self-efficacy norm and can be improved with better information. Furthermore, even if recently the Canton of Geneva encouraged organic sorting with an information campaign and the distribution of small green bins, 1 out of 5 households still do not sort organic waste. Only 46% of the household without a small green bin sort organic waste. Households satisfied with the sorting infrastructures and services sort an average of one more category of waste. 36% of unsatisfied households think that the nearest collection point is too far, 28% that too few categories are collected at curb and 13% that the curb collection frequency is too low. Households having a collection point at less than 8 minutes by foot sort on average 8.1 categories compared to 7.6 for other households. In addition, households thinking that sorting is easy sort on average 8.1 categories of waste, whereas other households only 6.8. Infrastructures thus seem crucial in sorting behavior. Households being sensitive to the environment also sort more. These results are summarized in Table B.3 and Table B.4 in the Appendix. In section 3.5.2, we analyze the determinants of waste sorting in general, as well as organic waste sorting more specifically. We assess waste collection scheme preferences in section 3.5.3 and finally, we study the heterogeneity in preferences in section 3.5.4.

3.5.2 Determinants of waste sorting

Table 3.2 presents the results of the ordered logit model in equation (3.2). We use the number of sorted categories as a proxy to the intensity of sorting (r in equation (3.1)), since it is difficult to collect precise data on the latter. The selected variables reported in Table 3.2 are the result of a step-wise estimation in STATA. We first introduce all predictors in the estimation and then select the best model based on statistical significance. We present the variables

TABLE 3.2: Coefficients from the ordered logit model for waste sorting behavior

Variable	Coefficient	Robust Standard Errors
Self-efficacy	0.307***	0.115
Bad conscience	0.159***	0.043
Maximum effort	0.351***	0.068
System satisfaction	0.763***	0.230
Use of the green bin	0.811***	0.173
Environmentalist	0.433**	0.191
Living in city	-0.497***	0.192
Years since moving-in	0.179***	0.051

Note: *Pseudo* $R^2 = 0.0818$, $N = 591$.
, * indicate significance at the 95%, 99% level of confidence, respectively.

with a statistically significant impact on the number of sorted categories only. Due to the non-linearity of the ordered logit model, the coefficients in Table 3.2 can only be interpreted qualitatively. The sign of the coefficient indicates a positive or negative impact of the variable on the number of sorted categories (1 to 10 sorted categories). The magnitude of the impacts are calculated in Table 3.3, which presents the estimated marginal effect[4]. We show in Table 3.3 the impact of the variables on the probability of sorting less ($r = 0$), average ($r = 1$) or more than the average number of categories ($r = 2$) (see equations (3.3) to (3.5)). Note that the average number of sorted categories is 8 and that 28% of the households sort less than average, 27% sort 8 categories and 45% sort more than average (see Table B.4 in the Appendix).

Table 3.2 shows that the longer the household lives in the current home, the more categories it sorts. On the contrary, living in a city rather than in a more rural area has a negative impact on the number of sorted categories. More precisely, the probability of sorting more categories than the average decreases by 10.9% for households living in cities and increases by 15.6% for households living for more than 6 years at the same place (see Table 3.3). These results are in line with the findings of Halvorsen (2012) who explains these effects by a lower social pressure in urban areas as well as on new inhabitants. New inhabitants may also need to get used to their new environment and learn what, where and how to sort. Indeed, households who believe that they have a good (over-average) knowledge of what, where and how to sort (self-efficacy) sort more than others, as well as households having more bad conscience when not sorting or with higher environmental concerns than the average household. These results confirm Tonglet et al. (2004) and Hage et al. (2009)'s findings. Being satisfied with the waste collection scheme of the municipality, and using the little green bin for organic waste increase the number of sorted categories by decreasing the "inconvenience factor", which is in line with Knussen et al. (2004) and Metcalfe et al. (2012). Being satisfied by the waste collection system

[4]Similar results are obtained with the ordered probit model and displayed in Table B.5 in the Appendix.

TABLE 3.3: Marginal effects from the ordered logit model for waste sorting behavior

Variable	Change in the probability of sorting		
	Less than average	Average	More than average
Self-efficacy	-0.076***	-0.018***	0.094***
	(0.028)	(0.007)	(0.034)
Bad conscience	-0.111***	-0.026***	0.137***
	(0.029)	(0.008)	(0.036)
Maximum effort	-0.117***	-0.028***	0.145***
	(0.027)	(0.008)	(0.034)
System satisfaction	-0.140***	-0.033***	0.173***
	(0.039)	(0.011)	(0.048)
Use of the green bin	-0.156***	-0.037***	0.193***
	(0.027)	(0.008)	(0.033)
Environmentalist	-0.092***	-0.022***	0.114***
	(0.032)	(0.008)	(0.039)
Living in a city	0.088**	0.021**	-0.109**
	(0.035)	(0.009)	(0.043)
Years since moving in	-0.126***	-0.030***	0.156***
	(0.034)	(0.009)	(0.042)

Note: *Pseudo* $R^2 = 0.0818$, $N = 591$. The average number of sorted categories is 8.
Estimates report average marginal effects from the ordered logit model.
, * indicate significance at the 95%, 99% level of confidence, respectively.

or using the little green bin increases the probability to sort more than average by 17.3% and 19.3% respectively. Waste sorting is influenced by social and personal norms as well as the available infrastructures.

Incentivizing the use of the little green bin seems a good policy to increase organic waste sorting. Since organic waste is generated in large amounts and still not sorted by about 20% of the population, in what follows we focus on the determinants of sorting or not this specific category ($r = 1$ or 0, respectively). The marginal effects of the logit model are reported in Table 3.4. Household size increases the probability to sort organic waste. An explanation could be that it seems worth sorting a specific waste category only when enough of that type of waste is produced. Since bigger households generate more organic waste, they will sort more this type of waste. Other factors influencing organic waste are similar to those increasing the number of sorted category: self-efficacy, bad conscience, maximum effort, and having environmental concerns. The latter is the factor which increases the most the probability of sorting organic waste (about 8%).

TABLE 3.4: Logit results for organic waste sorting

Variable	Marginal effect	Robust Standard Errors
Self-efficacy	0.032**	(0.014)
Bad conscience	0.015***	(0.005)
Maximum effort	0.042***	(0.009)
Distance to the nearest collection point	-0.007*	(0.004)
Environmentalist	0.077***	(0.026)
Age	0.002*	(0.001)
Household size	0.023**	(0.011)

Note: *Pseudo* $R^2 = 0.2261$, $N = 538$.
*, **, *** indicate significance at the 90%, 95%, 99% level of confidence, respectively.

3.5.3 Household preferences regarding waste collection schemes

Our results show that satisfaction in the waste collection scheme has a positive impact on waste sorting (see 3.5.2). In this section, we analyze household preferences regarding waste services and infrastructures. We identify the attributes and levels, including costs, which stimulate the most waste sorting. Table 3.5 reports the main results of the DCE. It displays the average marginal effects, for each attribute level, as estimated by the conditional logit model in equation (3.7).

As a standard public choice result, the higher the cost of a policy, the lower its popularity. This is confirmed in Table 3.5 where the probability to chose a waste collection scheme decreases almost linearly with the price. Introducing a price of CHF 6 per person per month, decreases the probability of choosing the proposed waste collection scheme by around 10%. We note that a free waste collection scheme is chosen in 64% of the cases, while at a price of CHF 18 only 35% of the time. This means that even if the price has a major influence on household preferences, some households are willing to pay for a more convenient waste collection scheme and accept its cost, which is interesting since waste sorting is encouraged but not compulsory and there are no monetary incentives.

The curb collection frequency is the most important feature after the price, which is in line with Almazán-Casali et al. (2019) who find that households highly value waste collected at home. Decreasing waste collection at curb from twice a week to once a month decreases the probability of choosing the proposed scheme by almost 20%. Households are thus willing to pay CHF 2 less per person per month for a curb collection once a month instead of twice a week, but would pay CHF 0.50 per person per month for a curb collection once a week rather than twice a week (see Table B.6 in the Appendix). We are aware of the potential hypothetical

TABLE 3.5: Estimates from conditional logit

Attributes of the waste collection schemes	Average marginal effect	Robust Standard Errors
Curb collection frequency		
Once a month	-0.195***	(0.014)
Twice a month	-0.102***	(0.013)
Once a week	0.046***	(0.014)
Twice a week (reference)		(0.015)
Waste categories collected at curb		
General waste (reference)		
General waste and paper	0.021	(0.014)
General waste, paper and organics	0.058***	(0.013)
General waste, paper, organics and glass	0.049***	(0.013)
Distance to the nearest collection point		
2 minutes by foot	0.041***	(0.015)
4 minutes by foot	0.097***	(0.014)
6 minutes by foot	0.087***	(0.013)
8 minutes by foot (reference)		
Price per person per month		
Free (reference)		
6 CHF	- 0.099***	(0.014)
12 CHF	- 0.191***	(0.013)
18 CHF	- 0.312***	(0.016)

Note: *Pseudo* R^2 = 0.1184, N = 591. Each respondent choosing between two alternatives 8 times, we use 9'456 observations.
*, **, *** indicate significance at the 90%, 95%, 99% level of confidence, respectively.

bias due to stated preferences, however we reduce it by pointing out to households that the survey is done in collaboration with the authorities of the Canton of Geneva and that the results will give indications to improve the waste sorting scheme.

Decreasing the curb collection frequency from twice a week to once a week increases the probability of choice by 4%. Decreasing the distance to the nearest drop-off point increases also the probability of choice; dividing the walking distance time by two, from 8 minutes to 4 minutes, increases the probability of choice by 10%. This is in line with the literature, which finds that collecting waste at curb has a larger impact on sorting effort than drop-off centers (Jenkins et al., 2003; Halvorsen, 2008; Karousakis and Birol, 2008; Sidique et al., 2010a; Gilli et al., 2018). The waste categories collected at curb are the least important feature. Households have a preference for more categories of waste collected at curb and especially a preference for the collection of organic waste at curb, a result in line with Karousakis and Birol (2008). This can be explained by the higher inconvenience costs of sorting organic waste compared to other types of waste. Overall, household are thus willing to sort and have convenient infrastructures and not only minimize financial costs.

Households have unambiguous preferences for better infrastructures, closer collection points, more frequent curb collection and more waste categories collected at curb. Nevertheless, the more is not necessarily the better. This interesting finding may be due to the cost of better infrastructures but also to disturbances. Proximity to the collection point generates back and forth, noises and bad smells. Collecting waste at curb induces noise every time the truck is passing. Households might want convenient infrastructures but not their downsides, which refers to the Not in My Backyard Phenomenon (NIMBY), a behavior often observed in the waste literature (e.g. Lober and Green (1994)) . Collecting waste at curb twice a week is preferred to once a month, but not to once a week. The same applies for the distance to the collecting point. Households have a preference for a 4 minutes walk distance compared to a 8 minutes walk, but reducing the distance to 2 minutes is less desired. In Table B.6 in the Appendix, we calculated the willingness-to-pay for each attribute level, using the estimated coefficients of equation (3.7). Households are willing to pay almost CHF 1 per person per month to reduce the distance from 8 minutes to 4 minutes, while about CHF 0.50 to reduce the distance from 8 minutes to 2 minutes. Of course, this means that 2 minutes is preferred to 8 minutes, but reducing from 4 to 2 minutes walk might not be necessary nor desired.

3.5.4 Heterogeneity in household preferences

In the previous sections, we analyzed the major determinants of the number of sorted categories, as well as household preferences for waste sorting schemes. In this section, we apply a latent-class model (see equation (3.8)) to further investigate the role of heterogeneity across households to better understand how preferences for sorting infrastructures and services vary with households' norms and characteristics. We identify 3 latent classes[5]. Nainggolan et al. (2019) found 4 differents classes, but class 1 and 2 have similar preference. Massarutto et al. (2019) found also 4 classes, but with similarities between class 2 and 3. Class 1 consists of 260 respondents, class 2 has 91 and class 3 240. Table 3.6 displays how preferences for the various sorting infrastructures characteristics change across classes, based on a conditional logit model. The overall fit of the model, as measured by McFadden's R^2 indicates a good fit, and the coefficients are statistically significant and possessing the expected sign.

This analysis qualifies the previous results. We confirm that the price is crucial in the pref-

[5]As per standard procedure, we minimize the Bayesian information criterion (BIC). BIC values are given as follows: for two classes, 5286; for three classes, 5263; for four classes, 5286.

TABLE 3.6: Latent classes: estimates from conditional logit

Attributes of the waste collection schemes	Class 1 "The minimalist"	Class 2 "The demanding"	Class 3 "The moderate"
Curb collection frequency			
Once a month	0.003	-1.578***	-0.193***
	(0.022)	(0.118)	(0.023)
Twice a month	0.053**	-0.613***	-0.087***
	(0.024)	(0.052)	(0.023)
Once a week	0.089***	-0.067***	0.023
	(0.024)	(0.026)	(0.023)
Twice a week (reference)			
Waste categories collected at curb			
General waste (reference)			
General waste and paper	0.013	-0.125***	0.019
	(0.018)	(0.039)	(0.023)
General waste, paper and organics	0.064***	0.102***	0.087***
	(0.021)	(0.030)	(0.023)
General waste, paper, organics and glass	-0.061***	0.158***	0.140***
	(0.020)	(0.024)	(0.021)
Distance to the nearest collection point			
2 minutes by foot	-0.044*	0.213***	0.179***
	(0.023)	(0.049)	(0.025)
4 minutes by foot	-0.011	0.262***	0.194***
	(0.025)	(0.039)	(0.026)
6 minutes by foot	0.117***	0.180***	0.072***
	(0.022)	(0.039)	(0.023)
8 minutes by foot (reference)			
Price per person per month			
Free (reference)			
6 CHF	-0.137***	-0.081**	-0.068***
	(0.022)	(0.032)	(0.024)
12 CHF	-0.342***	-0.021	-0.051**
	(0.014)	(0.020)	(0.022)
18 CHF	-0.568***	-0.098**	-0.126***
	(0.027)	(0.049)	(0.027)
Pseudo R^2	0.5630	0.7815	0.0789

Note: $N = 591$. Each respondent choosing between two alternatives 8 times, resulting in 9'456 valid observations (4'160 in class 1, 1'456 in class 2 and 3'840 in class 3).
This table reports marginal effects from conditional logit and robust standard errors in parenthesis.
*, **, *** indicate significance at the 90%, 95%, 99% level of confidence, respectively.

erences of all households classes. For households in class 1, the price is the most important factor of a sorting scheme. The higher the price, the lower the probability that they choose the proposed sorting scheme. Everything else being equal, the probability that they choose a specific scheme decreases by more than 50% if the price increases from 0 to 18 CHF and by more than 30% with an increase to 12 CHF. Households in class 2 have also a preference for lower prices, but they do not attach much importance to this factor, because infrastructures are more important. They have high expectations. They prefer that the maximum number of waste categories are collected at curb and twice a week. Households of class 3 are more moderated. They care about the price, but at the same level as the quality of the infrastructures. For them, it is important to collect the maximum number of waste categories at curb, but once a week only. 4 minutes walking distance to a collection point is also enough. Overall, even for household with limited willingness to pay, collecting waste at curb once a week seems necessary, as well as collecting organic at curb and not only paper and general waste. Organic waste sorting seems thus important for all different classes in opposition to Nainggolan et al. (2019) who found 1 class clearly not interested in sorting bio-waste. Note that Nainggolan et al. (2019) and Massarutto et al. (2019) also identified a class similar to class 1, that is less demanding regarding the infrastructures.

These three classes, that we could call the "minimalist", the "demanding" and the "moderate", respectively, might have different preferences due to their differences in term of norms and socioeconomic characteristics. We thus use a multinomial logit model to further analyze the composition of the different classes. Results are reported in Table B.7 in the Appendix[6]. The "minimalist" are households with adults over 30 years old, which are tenants and living in more rural areas with waste collected mainly through collection points. They do not feel really self-efficient and are against the implementation of a bag tax. On the contrary, the "demanding" households are more in favor of a bag tax and feel self-efficient. Furthermore, they believe in the benefits and effectiveness of sorting, have rather middle to high incomes and no children. The "moderate" households are more skeptical about the benefits and effectiveness of sorting, but would also be in favor of a bag tax, which might show their concern about the environment. They are mainly owners aged between 18 and 30 years old. Although they are skeptical about the utility and effectiveness of sorting, they are looking for a more convenient scheme even at a cost. Indeed, the probability to choose a given scheme decreases only by 4% if the price increases from 0 to 12 CHF. In line with Massarutto et al. (2019), education level and occupation do not determine the class belonging.

In line with Huhtala (2010), we find that income is an important factor in determining household preferences. Due to the higher opportunity cost of time, higher income households are willing to pay more for better infrastructures and services, which would save their time. However, we note that even if it is more costly for high-income households to sort, they are sorting

[6] Similar results are found with a probit model and reported in Table B.8 in the Appendix.

waste. To save time and money, high income households could simply throw everything in the dust bin for incineration, which is not the case in our context, in opposition to Huhtala (2010), where high income households prefer incineration.

On average, all three household classes sort 8 categories of waste, but the reasons for not sorting more are different among the classes. In “minimalist” households there is a lack of information regarding what, where and how to sort. “Demanding” households believe in the importance of sorting, but are looking for better infrastructures due to high opportunity cost of time, whereas in “moderate” households there is a lack of trust in the benefits and effectiveness of sorting. Consequently, households may not sort more due to a lack of information on what, where and how to sort, as well as on the effectiveness of sorting or due to a need for better sorting infrastructures and services.

3.6 Conclusion

In this chapter, we analyze the determinants of household waste sorting behaviors and the heterogeneity in preferences for sorting infrastructures and services. We use a survey with a DCE across the population of the Canton of Geneva, the last Swiss canton without a bag tax. We find that self-efficacy as well as bad conscience are important determinants of waste sorting behavior. Collection scheme satisfaction and the use of a specific “green” bin for organic waste have the greatest impact on the number of sorted categories. Better infrastructures are preferred, but only to some extent. We highlight the existence of thresholds. For example, collecting waste at curb once a week seems necessary, but twice a week seems not. We found that the distance to the nearest collection point impacts preferences even more than the waste categories collected at curb. This is an interesting result since in the literature DCEs integrated the different sorting categories but did not take into account the distance to the collection point. As expected, we also find that the price plays an important role in preferences since the higher the cost imposed by a policy, the lower its popularity. However, price is far from being the only factor that matters in preferences as well as in sorting behaviors. The present study contributes to a better understanding of household waste sorting behavior not only by looking at preferences with a DCE and the possible existence of latent classes, but also by associating beliefs and household characteristics to further explain differences in preferences. We identify three different household classes sorting almost the same number of categories, but having different preferences and characteristics. Some households do not have all the information to sort correctly or are skeptical about the effectiveness of sorting as others are not satisfied with the sorting scheme. These results highlight the importance for policy-makers to focus, on one side, on providing more information about the importance and the effectiveness of sorting, as well as on what, how and where to sort; and on the other side, on improving the infrastructures and services available. We find that improving waste collection schemes does not always mean providing more, but correctly targeting household needs. In this perspective, our study provides a major insight to give the correct information to the right households and to develop the most suitable collection schemes. It also highlights that unit-based pricing is not the only recycling policy that increases sorting and decreases unsorted waste. In fact, voluntary policies can replace the incentive effect. It would thus be interesting to assess and compare the effect of an implemented well-tailored voluntary policy with some implemented monetary incentives. Nevertheless, voluntary policies raises a fairness issue, since the costs of waste disposal are not distributed according to the polluters' pay principle.

Chapter 4

Sorting organic waste: the causal impact of a voluntary environmental policy[1]

This chapter is a slightly modified version of a paper written together with Andrea Baranzini submitted to a journal for publication.

Abstract

In this chapter, we evaluate the impact of a new voluntary environmental policy in the Canton of Geneva, Switzerland and compare the results with a monetary incentive policy introduced in its neighboring canton, Vaud. We apply a difference-in-differences methodology to assess the causal impact of this voluntary policy on organic waste sorting and on overall waste generation. Data are collected at the household level with a survey before and after the introduction of the policy and supplemented with administrative data per municipality. Our results show that the voluntary policy has a positive statistically significant impact on organic waste sorting. In addition, the policy produces positive spillover effects, since we observe that the policy targeting organic waste increases simultaneously the number of categories as well as the quantities of other waste sorted. Interestingly, we find that the impact of the voluntary policy implemented in the Canton of Geneva is similar to the policy based on a monetary incentive introduced in its neighboring canton, Vaud. However, at least in the short-term, the monetary

[1] We acknowledge financial support by the Department of the territory, Canton of Geneva, Switzerland. The usual disclaimer applies.

incentive policy causes a larger decrease in unsorted waste and in the proportion of waste sorted than the voluntary policy.

Keywords Waste sorting; Organic waste; Policy design; Voluntary policy; Difference-in-differences

4.1 Introduction

The call for a circular economy dates back from Boulding (1966), but gained in popularity over the last decades. Recycling plays a crucial role in recovering resources from waste and thus increasing the circularity of resource flows in the economy. According to the OCDE (2019), the use of material resources has more than tripled between 1970 and 2017, increasing from 27 to 89 billion tonnes, and the situation is expected to worsen with population growth and economic development. Environmental policies have a key role in stimulating the transition to circular economies and reaching sustainable development goals. In this context, organic waste is of particular interest since it can be transformed in useful resources such as compost or biogas, instead of land-filled, which generates pollutants such as methane, a greenhouse gas with a global warming potential about 30 times that of CO_2. It accounts for 30% to more than 60% of total waste depending on countries, which makes it a global problem (Kaza et al., 2018). Of course, the best solution would be to simply reduce organic waste (Lipinski et al., 2013). However, some 20% of the organic waste is unavoidable, e.g. peels, shells, and bones (Quested et al., 2013). Sorting and recycling the unavoidable organic waste is thus anyway necessary. Sorting at source by households seems the best option since mixed waste collection increases the risk of contamination, which decreases the quality of secondary materials that can be supplied (e.g. compost) and may reduce their marketing possibilities (Hoornweg and Bhada-Tata, 2012).

In this chapter, we analyze the effectiveness of a voluntary environmental policy introduced in the Canton of Geneva to increase organic waste sorting, which accounts for 1/3 of unsorted waste, and hence the overall sorting rate. The policy consists in distributing to households a specific waste bin to sort organic waste at home. This measure is accompanied by the implementation of curbside collection and an information campaign. There is a large literature analyzing the determinants of waste sorting at source (see Varotto and Spagnolli (2017) for a review). Monetary incentives are a popular policy tool to influence behaviors in various contexts including waste sorting. It has been found for example that unit-based pricing reduces unsorted waste and increases recycling (Allers and Hoeben, 2010; Carattini et al., 2018a). However, behaviors cannot always be easily changed by introducing monetary incentives. Waste pricing and monetary incentives might have some unintended effects like undermining the desired impact or increasing misbehaviors (see for e.g. Choe and Fraser, 1999; Dahlén and Lagerkvist, 2010; Heller and Vatn, 2017). Further considerations are thus needed when designing new incentive schemes. Information and education are seen as key drivers to participation in recycling schemes (Perrin and Barton, 2001; Timlett and Williams, 2009; Ladele et al., 2021) and the good quality of recycling (Smeesters et al., 2003). Refsgaard and Magnussen (2009) find that adequately transmitted information with the right institutional context can improve sorting efforts over time. Van der Werff et al. (2019) observe a reduction in residual waste after the implementation of an informational strategy on how to minimize waste and why it is important. Saladié and Santos-Lacueva (2016) estimate that about 20% of the improvement in the sorting rate among university students in South Catalonia is entirely due to awareness campaigns.

However, households will not sort their waste if it is not convenient to do it. Indeed, the meta-analysis of 63 studies Miafodzyeva and Brandt (2012) identify convenience as the strongest determinant of waste sorting behavior. Major obstacles of waste sorting are the lack of facilities, inadequate storage, handling problems and the time devoted to this activity (Perrin and Barton, 2001). Convenience can be improved with the help of sorting infrastructures and services. Geislar (2017) finds greater participation if some supportive infrastructures like curbside services or collection points are in place. People are less willing to sort at source as the distance to the drop-off points increases (Berglund, 2006; Sidique et al., 2010a). Curb collection is seen as more convenient and has thus a larger effect than drop-off points in increasing sorting efforts (Jenkins et al., 2003; Halvorsen, 2008; Karousakis and Birol, 2008; Sidique et al., 2010b; Gilli et al., 2018). Dahlén and Lagerkvist (2009) find that collecting metal, plastic and paper at curb rather than only with drop-off points doubled the sorting of these materials. Furthermore, households prefer a higher collection frequency and a larger number of collected materials (Karousakis and Birol, 2008; Halvorsen, 2012; Czajkowski et al., 2017). Due to the high inconvenience cost of organic waste sorting and storage, curb collection and frequency are especially important for this type of material (Karousakis and Birol, 2008; Abbott et al., 2011). Bernstad (2014) highlights the importance of increasing convenience also inside the household and not only outside. Geiger et al. (2019) in their meta-analysis point out that possessing a bin at home increases recycling. Metcalfe et al. (2012) analyze the impact of apartment bins to sort organic waste and find that the bin, including its design, is crucial in increasing organic waste sorting. According to them, the bin can be the issue itself if it does not reduce inconveniences of sorting organic waste like smells or hygiene. Boonrod et al. (2015) analyze the effect of various mechanisms on organic waste separation behavior at source. They look at the introduction of a voluntary mechanism, including the distribution of small bins for organic waste separation to households. They find an increase in organic waste sorting compared to traditional mechanisms, as well as a decrease in contamination. Nevertheless, they note that some economic incentive mechanisms should be applied in combination, to strengthen the change in household behavior.

The policy under evaluation in this chapter is specifically targeting organic waste sorting, by distributing a particular waste bin to households. We thus analyze the main impact of this policy, i.e. on the amount of organic waste sorting by households. However, according to recent research, the policy may induce some spillovers, since it could impact household behaviors other than the one targeted, see e.g. Truelove et al. (2014). Positive spillovers will enhance the effects of the policy, while negative ones will reduce the total impact (Ek, 2018). In the specific context of organic waste sorting, Ek and Miliute-Plepiene (2018) and Alacevich et al. (2021) find that the introduction of organic waste separation increases waste sorting as well as waste reduction. Sintov et al. (2019) in line with Miliute-Plepiene and Plepys (2015) find a positive spillover behavior of organic waste sorting on waste generation.

In this study, we apply a difference-in-differences methodology to assess the causal impact of the distribution to households of a kitchen bin on organic waste, as well as on overall waste generation and sorting. Data are collected with a survey at the household level, before and after the introduction of the policy in the Canton of Geneva. We use the neighboring canton Vaud, which did not implement such a policy, as a control. To supplement the survey data, we exploit administrative data collected at the municipal level. Our results, which are robust to different specifications, show that this voluntary policy increases significantly the proportion of households sorting organic waste. We thus contribute to the waste sorting literature showing that convenient infrastructures and correct information have a positive effect on sorting. We also add to the spillover literature, since we observe an increase in the number of other sorted categories, as well as the quantities of other waste sorted. Through the unique opportunity to have a monetary incentive and a voluntary policy in place in the same country, we compare the effect of both policies. Interestingly, our results show that, the impacts on organic waste of the voluntary policy implemented in the Canton of Geneva is similar to those of a bag tax introduced in the Canton of Vaud a few years earlier and that the effect of the voluntary policy on unsorted waste is comparable to the long-term effect of the bag tax. Our research thus contributes in a unique manner to the vast literature on the choice of environmental policy instruments, and gives precious insights to policy makers.

Next section provides information on waste collection policy in Switzerland, the policy design and its implementation, as well as the data we use. Section 4.3 presents our empirical strategy to assess the causal impact of the policy, i.e. the difference-in-differences methodology. Section 4.4 presents the results. Section 4.5 discusses and concludes.

4.2 Background and data

4.2.1 Waste management in Switzerland and in the Cantons of Geneva and Vaud

In Switzerland, federal decentralization implies that municipalities are in charge of the waste collection, treatment and disposal in accordance with cantonal laws. Municipalities can do it either directly or with the help of private companies. Households are then charged for this service by the municipality in which they are living. In the absence of any waste pricing policy, waste management costs are covered by taxes that can be defined per person, household, number of persons per household, according to the living space, number of rooms in the dwelling, the built volume or even the insured value of the buildings. In this context, waste management charges paid by the individual household are independent of the quantity of garbage it generates. Of course, households still have the possibility to sort all kind of recyclable materials, and are encouraged to do so. All Swiss residents have access to many collection points and waste disposal centers, as well as in some municipalities to an additional curb collection service of specific waste categories like paper.

Unit-based pricing was introduced for the first time in a Swiss municipality in 1974. By the nineties, the large majority of German-speaking municipalities implemented a bag tax and some French-speaking municipalities followed in the last decade. According to the principle of subsidiarity, municipalities have the right to set their own rules as long as they respect cantonal and federal law's prescriptions. The 1997's federal legislation imposed the application of the polluter pays principle, which limited the principle of subsidiarity and might explain the large implementation of the bag tax in Switzerland. Nevertheless, some cantons and municipalities were still reluctant to the introduction of a waste pricing policy. In the Canton of Vaud, a bag tax was only introduced in a majority of municipalities in January 2013 and January 2014, which amount 1 CHF[2] for a 17-litre bag, 2 CHF for a 35-litre bag, etc. As mentioned, each municipality is in charge of its own waste policy with respect to cantonal laws and this wave of bag tax implementation was due to a 2011 lawsuit that led to a new case law of the Swiss Federal Supreme Court, which specifies that in order to apply the polluter pays principle and reduce the amount of unsorted waste, the use of lump-sum taxes to finance waste management and treatment should be used as a complementary source of revenue only (maximum 30% of total revenues). To date, all Swiss municipalities except those of the Canton of Geneva have introduced a bag tax to comply with this legal framework. The Canton of Geneva should also introduce unit-based pricing according to the Swiss Federal Supreme Court. However, it is trying to avoid it, by implementing voluntary policies in order to overcome a 50% recycling rate and thus approach the mean recycling rate of Switzerland (53%). In this way, the Canton of Geneva would like to prove that voluntary policies can be as effective as pricing policies.

[2] At the time of writing 1 CHF is about 1 USD and 1 EURO

FIGURE 4.1: Policy information

An analysis of the content of Geneva trash bags in 2011 showed that 1/3 was composed of organic waste. The Canton of Geneva thus decided to increase the recycling rate focusing on organic waste. It began the distribution of small aerated kitchen bins together with compostable bags and related information (illustrated in Figure 4.1), which should facilitate organic waste sorting at home and improve the final quality of the compost. The combination of an aerated bin thanks to the holes and compostable bags allows the waste to dehydrate and the elimination of fermentation, drips and odors, which are the main inconveniences of organic waste sorting. The distribution of the bins took place at the end of 2016 with an information campaign and the implementation of a convenient collection system for organic waste.

4.2.2 Data and descriptive statistics

To analyze the effectiveness of this new voluntary policy, we collect data before and after the distribution of the organic waste sorting kits in the Canton of Geneva and Vaud. We use the Canton of Vaud as a control group since it is the neighboring canton of Geneva, has similar features (language, urban population, similar preferences on federal ballots, etc) and has not implemented the voluntary policy under evaluation nor any other waste policy over the same period. We use two sources of data for our analysis: a household survey and municipality level data on waste.

For the household survey, we contacted a professional survey company which provided us with a random sample of 3'000 addresses in the Canton of Geneva and 2'000 in the Canton of Vaud. We then mandated a group of ten students to conduct the first round of telephone interviews before the introduction of the policy, between August and September 2016. We collected data from 345 households in the Canton of Geneva and 324 in in the Canton of Vaud. One year after the distribution of the organic waste sorting kits, between end of November 2017 and beginning of February 2018, four students conducted the second round of telephone interviews. They called back all households who answered to the first survey. 173 out of 345 households participated to both rounds in the Canton of Geneva and 177 out of 324 in the Canton of Vaud.

We find no significant difference between the 2016 and the 2017 sample. However, we note that households answering to both surveys are more green and with a slightly higher education than the respondents of 2016 survey only (see Table C.1 and Table C.2 in the Appendix). Table C.3 in the Appendix compares our sample with the underlying population. Since only a fraction of the initial sample answered to both survey, we are not surprised that our sample is not representative of the cantonal population. This means that our survey data limits its external validity. To address this issue, we account for the risk of sample selection bias by performing the analysis with and without covariates and use some administrative data at the municipal level to confirm the survey results.

The survey is looking at household habits regarding waste generation and sorting. We first ask some questions about the categories of waste sorted (PET, carton, paper, textiles, glass, cans, organic waste, batteries, and aluminum) and the number of trash bags used per week and their volume. In the second part of the survey, we focus on household's behavior about organic waste. The final questions collect the socioeconomic characteristics.

Table 4.1 presents the descriptive statistics for the control (Canton of Vaud) and the treatment (Canton of Geneva) samples, before and after the policy implementation in the Canton of Geneva. The table reports the waste quantities and the sorted categories. Waste quantities are given in liters per week and computed according to the number of bags filled by the household and their volume. Each category of waste sorted takes a value of one if it is sorted and zero otherwise. More than 95% of the households in our sample sort PET, paper and carton. Note however that only 63% of the households in the treatment group sort organic waste before the implementation of the policy. This share increases to 86% after the policy introduction. We observe that almost 90% of the households in the Canton of Geneva have kept the kitchen bin after distribution. 62% of these households sorted already organic waste before the policy introduction and their share raises to 93% after. Households that have not kept or gotten the

TABLE 4.1: Unsorted and sorted waste before and after the policy introduction: mean comparison

	Before		After	
	Control	Treatment	Control	Treatment
Unsorted waste (liters)	42	62	40	55
Organic waste	0.88	0.63	0.82	0.86
PET	0.97	0.94	0.93	0.95
Carton	0.97	0.97	0.97	0.97
Paper	0.96	0.97	0.97	0.98
Glass	0.94	0.85	0.97	0.93
Textiles	0.81	0.57	0.87	0.76
Cans	0.86	0.61	0.83	0.70
Batteries	0.90	0.75	0.90	0.84
Aluminum	0.86	0.66	0.84	0.73
Number of sorted categories	8.14	6.94	8.12	7.70
Number of sorted categories (without organic waste)	7.26	6.31	7.27	6.87
Filling level of organic waste containers when emptied		6.94		7.73
N	173	165	173	165

Note: The maximum number of categories that can be sorted is 9.
The filling level of organic waste containers when emptied varies from 0 (completely empty) to 10 (completly full). The question is only asked to participants of the Canton of Geneva who sort organic waste. We have thus 98 respondents before and 134 after.

kitchen bin sorted almost the same proportion (65%) of organic waste before the policy than the households that got it. However, after the policy introduction the proportion of sorting (71%) is not statistically different compared with before the policy.

The main reason that all households mention for not sorting organic waste is the bad smell. Interestingly, after the policy introduction, households fill up organic waste containers more before emptying them, difference is statistically significant at the 1% level. This can be explained by a lower inconvenience of sorting organic waste thanks to the new kitchen bin. Furthermore, households sort significantly more categories of waste after the policy introduction even without taking into account organic waste.

As already mentioned, to complement the households survey, we collect administrative data at the municipal level on the quantities of sorted and unsorted waste from 2007 to 2019 (last year available). Those additional data are used to confirm the robustness of the results obtained with the survey data. Since the municipalities in the Canton of Vaud introduced a bag tax at different points in time, for the analysis of the causal impact of the kitchen bins in 2017 in the

Canton of Geneva with the administrative data, we use as control group the 34 municipalities of the Canton Vaud that introduced the bag tax before 2008.

In addition, we use the administrative data to analyze the causal impact of the bag tax policy implemented in the Canton of Vaud, and compare it with the impact of the voluntary policy in the Canton of Geneva. In this case, the treatment group are the municipalities of the Canton of Vaud that introduced the bag tax and the control group the municipalities of the Canton of Geneva, before the introduction of the waste bin. More precisely, for this analysis we use as treatment group the 58 municipalities of the Canton of Vaud that implemented the bag tax in 2014 and as control group the municipalities of the Canton of Geneva over the period 2007 to 2016.

4.3 Empirical strategy

To assess the causal impact of the voluntary organic waste policy introduced in the Canton of Geneva, we collect data in a treatment (Canton of Geneva) and a control group (Canton of Vaud) before (in 2016) and after its implementation (in 2017) and apply a difference-in-differences approach. The treatment status $T = 0, 1$ indicates whether the households are living in the Canton of Vaud and thus are not subject to the new policy ($T = 0$), i.e. control group, or in the Canton of Geneva and received the organic waste sorting kit ($T = 1$), i.e. treatment group. Households are observed in two time periods, $t = 0, 1$ where 0 indicates the time period before the implementation of the policy (2016), i.e. pre-treatment, and 1 the time period after the introduction of the policy in the Canton of Geneva, i.e. post-treatment. Each household i is observed twice, once before the policy introduction and once after. The outcome Y_i, which corresponds to the percentage of households sorting organic waste or to the number of sorted categories, is thus modeled as follows:

$$Y_i = \beta T_i + \gamma t_i + \delta(T_i \times t_i) + \varepsilon_i \qquad (4.1)$$

where the error term ε_i is such that $E(\varepsilon_i) = 0$. β represents the effect of municipal characteristics, it accounts for the permanent differences between the Canton of Vaud and the Canton of Geneva. γ captures the time trend which is common to both cantons. Finally, δ is the true effect of the introduction of the voluntary policy in the Canton of Geneva. A good estimation of δ, $\hat{\delta}$, is given by the difference in average outcome in the Canton of Geneva before and after the implementation of the policy, minus the difference in the average outcome in the Canton of Vaud, before and after the organic waste sorting kits distribution in the Canton of Geneva, which is called the difference-in-differences estimator. The average effect of the policy introduction is thus given by:

$$\hat{\delta} = \bar{Y}_1^T - \bar{Y}_0^T - (\bar{Y}_1^C - \bar{Y}_0^C) \tag{4.2}$$

where $\bar{Y}_0^T$ and $\bar{Y}_1^T$ are the sample average of the outcome of the Canton of Geneva before and after the policy introduction, respectively, and $\bar{Y}_0^C$ and $\bar{Y}_1^C$ the corresponding sample average of the Canton of Vaud.

The key assumption for an unbiased estimator requires a parallel trend, which means that the trend of the outcome is the same in both cantons before the policy introduction in the Canton of Geneva, i.e. before 2017. The parallel-trend assumption enables an unbiased OLS estimation of the average causal effect of the policy. We assess the parallel-trend assumption using several years of data before the policy. We compare the average weight of unsorted waste, as well as the proportions of other waste sorted per inhabitant in the treatment and the control group. Figure 4.2 and Figure 4.3 give a visual representation of the parallel trends for unsorted and sorted waste respectively. To test the parallel trends, we conduct placebo tests. We implement a placebo introduction of the policy for the treated group in different years before the policy introduction (2014, 2015, 2016) and we find in fact no statistically significant placebo effect, which excludes non-parallel trends. We also perform a parallel trends analysis for the causal impact of the bag tax analysis implemented in Canton of Vaud, see Figure C.1 and Figure C.2 in the Appendix. Placebo tests are also conducted for the bag tax introduction in each year from 2008 to 2013 and all placebo effects are not statistically significant.

As robustness check, we include control variables $X_i^{'}$ (all control variables are listed in Table C.4 in the Appendix) in (4.1) since household characteristics may differ between municipalities and cantons:

$$Y_i = \beta T_i + \gamma t_i + \delta (T_i \times t_i) + \theta X_i^{'} + \varepsilon_i \tag{4.3}$$

To evaluate the causal impact of the bag tax implemented in the Canton of Vaud, we also apply a similar difference-in-differences approach. This allows us to compare the effect of both policies. However, the control group in that case is the Canton of Geneva ($T = 0$) since it has not implemented any waste pricing policy, whereas the treatment group is the Canton of Vaud ($T = 1$). The pre-treatment period is now before the introduction of the bag tax, thus before 2014 ($t = 0$) and the post-treatment period from 2014 onward ($t = 1$).

FIGURE 4.2: Parallel trends unsorted waste: treatment (GE) and control (VD) groups (2013-2017)

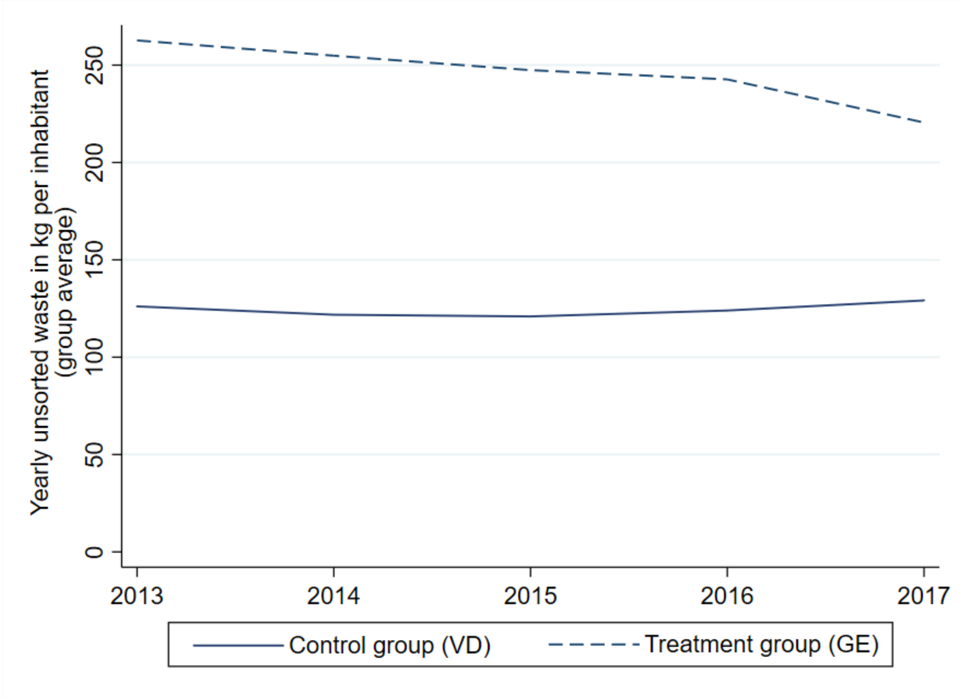
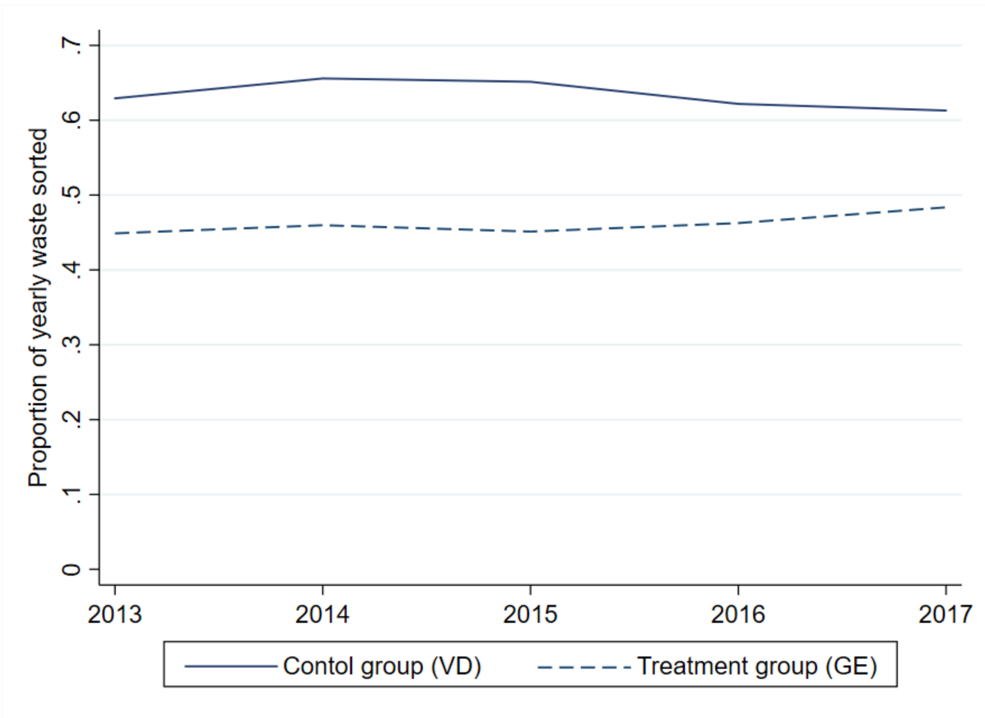


FIGURE 4.3: Parallel trends sorted waste: treatment (GE) and control (VD) groups (2013-2017)



4.4 Results

4.4.1 Survey data

We start by assessing the causal impact of the kitchen bins distribution in the Canton of Geneva on organic waste, as well as on other sorted categories with the survey data. The results are shown in Table 4.2. We first estimate equation (4.1) and then equation (4.3) by introducing control variables to test robustness of the results to possible differences in the groups' socioeconomic composition. Looking at the coefficients of the policy on organic waste and on sorted categories, we observe that there is no statistically significant differences in the results with or without control variables. Since several control variables are statistically significant and the R^2 goodness-of-fit measure improves, we limit our discussion to the estimates of equation (4.3). The results with the estimates for all control variables are displayed in Table C.4 in the Appendix. The number of observations decreases from 670 to 607 when introducing control variables due to some missing values.

TABLE 4.2: Treatment effect on organic waste sorting and number of sorted categories: survey data

	Organic waste		Sorted categories		Sorted categories without organic waste	
	(1)	(2)	(3)	(4)	(5)	(6)
Group (GE)	-0.243***	-0.240***	-1.207***	-1.143***	-0.964***	-0.902***
	(0.033)	(0.045)	(0.178)	(0.191)	(0.169)	(0.177)
Year 2017	-0.053*	-0.061**	-0.029	-0.106	0.023	-0.045
	(0.028)	(0.029)	(0.133)	(0.136)	(0.124)	(0.126)
Policy	0.278***	0.287***	0.804***	0.896***	0.525***	0.609***
	(0.039)	(0.038)	(0.187)	(0.189)	(0.176)	(0.184)
Constant	0.877***	0.599***	8.152***	6.998***	7.275***	6.399***
	(0.023)	(0.146)	(0.131)	(0.592)	(0.122)	(0.573)
Control	No	Yes	No	Yes	No	Yes
R^2	0.0580	0.1175	0.0799	0.1780	0.0645	0.1521
N	670	607	670	607	670	607

Clustered standard errors in parentheses (cluster per municipality).
* p<0.1, ** p<0.05, *** p<0.01.

The distribution of kitchen bins for organic waste in the Canton of Geneva increases significantly the percentage of household sorting organic waste by 28.7%, which is the main purpose of the policy. After the introduction of the policy, there is no significant difference anymore between the Canton of Geneva and the Canton of Vaud regarding the percentage of households sorting organic waste. Since the Canton of Vaud has already implemented a bag tax, the effect of both policies on organic waste sorting are thus comparable.

In addition to the direct effect of the voluntary policy, we also find a spillover effect on the other sorted categories. Indeed, the number of sorted categories increases significantly. Even when not taking into account organic waste, the number of sorted categories increases by 0.6 categories per household. These findings confirm the results of the recent literature, that apartment bins increase organic waste sorting, as well as overall sorting (Alacevich et al., 2021; Ek and Miliute-Plepiene, 2018; Metcalfe et al., 2012). However, we find no significant reduction in unsorted waste after the policy introduction. This might be due to the relative small sample, as well as a lack of precision in the data, since we deduce the amount of unsorted waste from the number of trash bags and the volume of the trash bags. We analyze again the impact of the policy on unsorted waste with the administrative data below.

Results from control variables indicate that women sort more than men, which is in line with the literature on waste (e.g. Zelezny et al. (2000)), and with the environment literature more in general, which indicate that women are more concerned and more willing to take actions for the environment (Dietz et al., 2002)

Being member of an environmental association tends to increase organic waste sorting, which confirms that households concerned about the environment tend to sort more than others (Hage et al., 2009).

More educated households tend to sort less categories of waste, but not less organic waste, which is the target of the policy. Even if pro-environmental behaviors are often positively associated with education (e.g. Jenkins et al. (2003)), this finding can be explained by the fact that more educated households have in general also higher opportunity cost of time which may decrease voluntary waste sorting.

We find that living in a house has a positive impact on the number of sorted categories, with respect to households living in an apartment. This might be due to more space and convenience to sort. Miafodzyeva and Brandt (2012) conclude from their meta-analysis that convenience is the strongest determinant in waste sorting. Furthermore, DiGiacomo et al. (2018) demonstrate that convenience increases waste sorting, but also in particular organic waste sorting.

Households living in urban areas tend to sort less categories of waste, which could be explained by lower social pressure in urban than more rural areas (Halvorsen, 2012).

4.4.2 Robustness check with administrative data

In this section, we assess the causal impact of the new organic waste policy in the Canton of Geneva on the quantity of unsorted waste and the proportions of waste sorted using administrative data. Estimates in Table 4.3 show that the policy has a statistically significant effect on both. The distribution of the kitchen bins decreases the amount of unsorted waste by around 36 kilos per inhabitant per year, which represents a decrease of about 15%. The proportion of waste sorted increases by about 6%, including or not green waste. Note that in the administrative data only the quantities of green waste are available, which includes organic and garden waste. Since organic waste represents only a small fraction of the green waste weight, the impact of the policy on organic waste specifically is difficult to assess with administrative data.

The administrative data confirm the impacts of the policy we find with the survey data, in particular the spillover effects. Even if the policy is primarily targeting organic waste sorting, we find a decrease in unsorted waste and an increase in waste sorting in general (Alacevich et al., 2021; Sintov et al., 2019; Ek and Miliute-Plepiene, 2018; Miliute-Plepiene and Plepys, 2015).

TABLE 4.3: Treatment effect on the quantity of unsorted waste and the proportions of waste sorted: administrative data

	Unsorted waste (1)	Proportion of waste sorted (2)	Proportion of waste sorted without greens (3)
Group (GE)	115.0***	-0.195***	-0.224***
	(9.608)	(0.024)	(0.022)
Year 2017	1.476	-0.026*	-0.027*
	(6.373)	(0.014)	(0.015)
Policy	-36.04***	0.062***	0.056***
	(7.551)	(0.015)	(0.017)
Constant	123.2***	0.640***	0.518***
	(7.441)	(0.02)	(0.021)
R^2	0.6320	0.4206	0.5203
N	426	425	425

Clustered standard errors in parentheses (cluster per municipality).
* p<0.1, ** p<0.05, *** p<0.01.

4.4.3 Robustness check with a different control

As an additional robustness check, we use the Canton of Zurich as control group instead of the Canton of Vaud over the same period of time. We choose the Canton of Zurich since Geneva and Zurich are the two biggest cities in Switzerland and even if both cantons do not share the same language and are not located in the same region of Switzerland, they have other important similarities. Both cantons have a high population density, almost their entire population live in an urban area and their GDP per capita is quite similar (see Table C.5 in the Appendix). Furthermore, as the bag tax was already introduced in 1993 in the Canton of Zürich, we can exclude any confounders of this policy.

This complementary analysis allows us to confirm the effect of the voluntary policy introduction in the Canton of Geneva and verify that there are no other changes that drive some of the treatment effects. Parallel trends are shown in Figure C.3 and Figure C.4 in the Appendix. As for the Canton of Vaud, we conduct some placebo tests and effects are not statistically significant. The results, shown in Table C.6 in the Appendix, confirm the spillover effects of the policy introduction and are not statistically different from those found with the Canton of Vaud as control group. We find a decrease of 28 kilos per inhabitant per year in unsorted waste and an increase of 4% to 5% in the proportion of waste sorted.

4.4.4 Comparison of the Geneva voluntary policy with a bag tax policy

In this section, we assess the impact of the bag tax implemented in 58 municipalities of the Canton of Vaud in 2014. We then compare this result with the impact of the voluntary policy introduced in the Canton of Geneva[3]. Results are displayed in Table 4.4.

The bag tax introduction decreases unsorted waste by about 65 kilos per inhabitant per year, i.e. by about 29%. This result is not statistically different from the decrease of about 80 kilos per inhabitant per year found by Carattini et al. (2018a), who analyzed the impact of the bag tax implemented in 2013 in some municipalities of the Canton of Vaud over the period 2008 to 2015. Pfister and Mathys (2022) also looked at the impact of the bag tax implemented in 2013 in the Canton of Vaud, but mainly at the district level and only as robustness check at the municipality level. Furthermore, their analysis runs over the period 2010 to 2017, which includes 4 years after the bag tax implementation and not only two as in our analysis or in the study of Carattini et al. (2018a). Pfister and Mathys (2022) found a reduction of about 47 kilos per inhabitant per year at the district level, corresponding to a 26% decrease in unsorted waste.

[3]We compare the impact of the policies on sorted and unsorted waste. We do not take into account the costs of the policies here, which include the new bins, the informational campaigns, and the organic waste collection services

This result is in line with our findings. However, the results computed with the data at the municipality level as in our analysis show a decrease of about 40 kilos per inhabitant per year, which is statistically different from the 65 kilos that we find in this chapter. This difference might be due to the fact that, as explained by Pfister and Mathys (2022), they are capturing a longer-term effect, whereas in this chapter and in Carattini et al. (2018a) we identify rather a short-term impact. The effect of the bag tax seems to be stronger in the short-term than in the long-term, which is in line with the findings of Allers and Hoeben (2010).

TABLE 4.4: Effect of the bag tax on the quantity of unsorted waste and the proportions of waste sorted: administrative data

	Unsorted waste (1)	Proportion of waste sorted (2)	Proportion of waste sorted without greens (3)
Group (treatment)	-55.87***	0.063***	0.127***
	(11.08)	(0.02)	(0.015)
Year 2017	-31.12***	0.033***	0.024***
	(2.552)	(0.005)	(0.003)
Policy	-64.93***	0.102***	0.105***
	(6.578)	(0.011)	(0.011)
Constant	279.4***	0.425***	0.250***
	(6.335)	(0.015)	(0.009)
R^2	0.4536	0.4739	0.2623
N	1030	1030	1030

Clustered standard errors in parentheses (cluster per municipality).
* p<0.1, ** p<0.05, *** p<0.01.

By comparing the impact of the voluntary policy in the Canton of Geneva (about -36 kilos corresponding to a decrease of 15%) to the impact of the bag tax in the Canton of Vaud (about -65 kilos corresponding to a decrease of 29%), we find a statistically significant difference at the 5% level. The unsorted waste reduction due to the bag tax is almost twice as large in percentage. This result is not surprising, since the primary goal of the two policies are different. The bag tax aims at reducing the quantities of waste, whereas the introduction of the kitchen bins are targeting more specifically organic waste sorting and only indirectly a reduction in the quantities of unsorted waste. The results are similar for the proportion of waste sorted. The increase in the proportion of waste sorted is about 6% for the voluntary policy and about 10% for the monetary incentive. These results are again statistically significantly different at the 5% level and not surprising, since with the voluntary policy there is no direct incentive to sort more except organic waste, whereas the bag tax targets unsorted waste and thus the number of bags. Our results thus show that the voluntary policy achieves a significant increase in organic waste sorting and half the impact of the bag tax if we consider its global impact on the quantities of waste.

Interestingly, the impact of the kitchen bins introduction in the Canton of Geneva on unsorted waste is statistically different at the 1% level from the effect of the bag tax introduced in the Canton of Vaud found by Carattini et al. (2018a), but not different from the one found by Pfister and Mathys (2022). It might thus be that the effect of the voluntary policy on unsorted waste is smaller than the short-term effect of the bag tax, but similar to its long-term effect.

Overall, we find that the implementation of the voluntary organic waste policy is less effective, at least in the short-term, than the introduction of a bag tax except on organic waste. In fact, as we show in section 4.4.1 with the survey data, we find that the introduction of the kitchen bins in the Canton of Geneva increases the percentage of households sorting organic waste to the level of the Canton of Vaud that already introduced a bag tax. Pfister and Mathys (2022) found a significant increase in organic waste after the bag tax implementation that they explain by the fact that throwing not a full bag away due to bad smell or leakage of organic waste is now more costly and there is thus an incentive to sort more organic waste.

4.5 Conclusion

We analyze the effectiveness of a voluntary environmental policy targeting organic waste sorting in the Canton of Geneva. We use a difference-in-differences approach with survey and administrative data to estimate the causal impacts of the policy. We find that the distribution of kitchen bins for organic waste together with a better collection service and an information campaign in the Canton of Geneva has a significant impact on organic waste sorting. This policy increases the percentage of households sorting organic waste by almost 29%. In addition to the direct effect of the policy on organic waste, we observe positive spillover effects on unsorted waste and on the other sorted waste categories. The quantity of unsorted waste decreases by about 15% and the quantities of waste sorted in addition to organic waste increases by about 6%. Interestingly, since the adjacent Canton of Vaud implemented an alternative bag tax policy, we can compare the impact of the voluntary environmental policy with this pricing policy. We show that the voluntary policy possesses a similar impact on organic waste. However, looking at overall household waste generation, the impact of the voluntary policy is smaller than the short-term effect of the monetary incentive policy, but similar to the long-term effect. Although we show that the voluntary policy produces positive spillovers effects, the primary target of the voluntary policy is to increase organic waste sorting and consequently increase the recycling rate. From this point of view, the goal is fulfilled. However, with a monetary incentive like a bag tax, the effect on the recycling rate would have been even more important through the larger effect on other sorted waste categories.

Voluntary policies might be as effective as monetary incentive policies on specific targets. However, voluntary policies are less stringent and thus are less effective overall, at least on the short-term. It would be interesting to study the long-term effect of the voluntary policy, especially if the effect weakened similarly to a monetary incentive policy. Nevertheless, even if voluntary policies can be effective, the principle of the polluter pays principle is not fulfilled and leads to some equity issues that need to be addressed.

Chapter 5

Conclusion

The aim of this thesis is to contribute to the improvement of environmental policy design. We focus in particular on closing the gap between efficiency and acceptability of monetary incentives and on the efficacy of non-monetary incentives. We analyze three different environmental policies in the Canton of Geneva, Switzerland.

In Chapter 2, we are concerned with the global problem of public acceptability of pricing policies and in particular congestion charges. Only a few cities in the world have implemented a congestion charge due to public opposition. We build on the existing literature to design different congestion charges that could fit the context of Geneva, a context in which policy-makers are planning to implement such a policy, but voters have the final say. We assess the acceptability of the different congestion charge designs with a large survey including a DCE and randomized informational treatments. In line with the literature on public support for environmental policies, we find that acceptability change with the policy design. The charge level plays a crucial role in public support and there is a clear preference for lower charges, although some groups of our sample tend to be much more sensitive to the level of the charge than others. In addition, households have a preference for higher exemptions, constant modulation and earmarking revenues for improvements in public transportation. Hence, our findings highlight an important trade-off between acceptability and efficiency. Finally, we show that information asymmetries contribute to lower public support. The additional information randomly provided to some groups of our sample, especially information about expected pollution reduction increases public support for more stringent policies. According to the literature, information asymmetries may in fact represent an obstacle to public support, but no causal evidence on the effect of additional information on public support for congestion charges has been provided before.

In Chapter 3, we analyze the determinants of households' municipal waste sorting behaviors and the heterogeneity in preferences for sorting infrastructures and services. We design a survey including a DCE among the population of the Canton of Geneva, the last Swiss canton without a bag tax. The results show that knowledge, guilty conscience as well as satisfaction about the existing collection scheme are important determinants of waste sorting behaviors. As in Chapter 2, we observe a preference for schemes with lower prices. Although price is a crucial component of waste management policies, households' preferences also indicate an important need for convenient infrastructures like close collection point, curb collection or even the provision of specific bins to sort organic waste. Better infrastructures are preferred, but with some thresholds, which means that improving waste collection schemes does not always imply providing more, but correctly targeting household needs. By analyzing the heterogeneity of our sample and linking personal beliefs and characteristics, we identify three different household classes sorting a similar number of categories, but with different underlying mechanisms like a lack of knowledge or a need for more convenient infrastructures and services.

To complement our analysis on non-monetary determinants of households' municipal waste sorting behavior, in Chapter 4, we assess the causal impact of a new voluntary environmental policy implemented in the Canton of Geneva. The aim of the new policy is to increase organic waste sorting and to decrease the total amount of unsorted waste. We use a difference-in-differences approach with survey and administrative data to estimate the causal impacts of the policy. We find a significant impact of the voluntary policy on organic waste sorting as well as positive spillover effects on other categories of waste sorted and on unsorted waste quantities. Interestingly, since the adjacent Canton of Vaud implemented an alternative bag tax policy, we compare the impact of the voluntary policy with the pricing policy. The effect on organic waste is similar for both policies. However, the effect of the voluntary policy on unsorted waste is smaller than the short-term effect of the bag tax, but similar to its long-term effect. Voluntary policies seem thus less effective overall but to perform similarly to pricing policies on specific targets.

We can conclude that, as a standard public choice result, the higher the price paid by the households the lower the popularity of the policy. Price has thus to be taken into account in the development of an environmental policy, but it should not be the only factor to focus on. Public support depends crucially on the design of the policy. Even more stringent policies can be acceptable if carefully designed. In particular, we show that key factors in acceptability are convenience and information. People should understand the policy, how it works and which impacts, in particular environmental, it could have. The impact of non-monetary incentives should not be minimized by policy makers. With voluntary policies, households carry out environmental measures by their own interest and commitment. It might thus also lead to positive spillover effects by influencing behaviors in other environmental domains. Finally, heterogeneity and norms should be considered in all environmental policy designs.

Policy makers should consider about adapting policies or related information to different populations.

This thesis contribute to solutions to limit traffic congestion and identify several congestion charge design that reach majority support despite land-use planning and constraints, that was the big issue of the Canton of Geneva. In addition, we show that waste policy objectives can be achieved even without a pricing policy like a bag tax introduction, as wanted by the Canton of Geneva. Voluntary environmental policies can be effective. We base our analysis on the case of the Canton of Geneva and Switzerland, but all municipalities around the world are concerned with these issues when developing environmental policies. We look at the impact, preferences and acceptability of environmental public policies, but we mainly focus on the households and the efficacy of the policies. We did not investigate the costs of the different policies and did not compare monetary and non-monetary incentives from an efficiency point of view. Moreover, monetary incentives are known to weaken with the time. Future work could thus also look at the evolution of non-monetary incentives over a longer period of time and compare the long-term effect of a voluntary and a pricing policy.

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Appendix A

Appendix to Chapter 2

A.1 Questionnaire

General information

Mobility demand in Geneva has been sharply increasing for decades. In the center of the agglomeration, around 1.5 millions trips per day are undertaken by around 520'000 vehicles.

A congestion charge aims at reducing traffic jams and traffic-related pollution by charging motorized vehicles circulating in a defined perimeter. The introduction of a congestion charge would encourage more efficient modes of transportation, reduce commuting times and air pollution, leading to a better use of the infrastructure. Coupled with other traffic management measures, the charge would allow to meet the goals of the law aiming for a coherent and balanced mobility, accepted by a large majority of Geneva's voters in June 2016.

A congestion charge can be designed in different ways (perimeter, charge rate, use of revenues, exemptions etc.). The impacts on traffic, the environment, people's purchasing power, and the revenues generated will depend on the specific design of the implemented congestion charge.

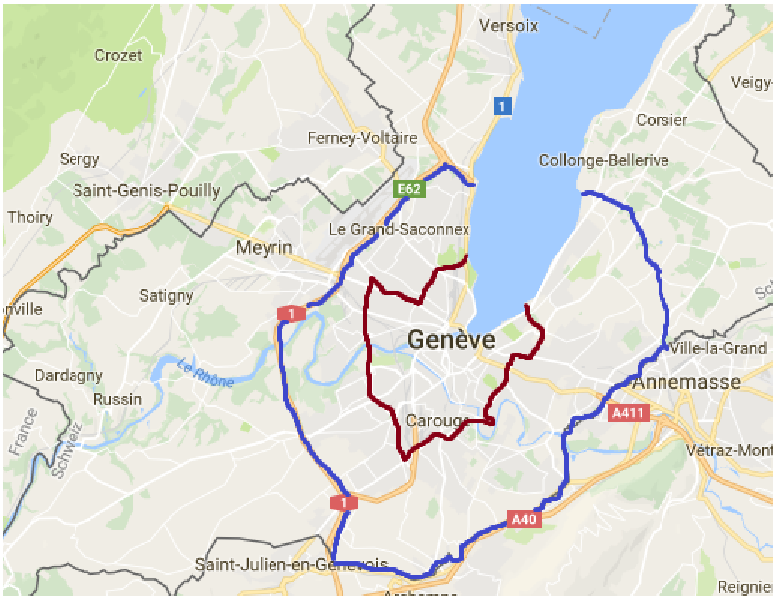
Several scenarios are currently under consideration. You have here the chance to express your preferences. Your responses will contribute to determine the interest in the introduction of a congestion charge in Geneva and under which conditions. In your answers, we will ask you to take into account all impacts of a possible congestion charge, which could be environmental, economic or social.

To facilitate your understanding, you will find in the next page a description of the possible characteristics of a congestion charge.

Main characteristics of a congestion charge

- **Perimeter**: As shown by the following map, the charging area could correspond either to the red perimeter (center) or the blue one (until the highway non included). Traffic on the federal highways is not affected by the congestion charge.

FIGURE A.1: Perimeters



- **Charge level**: It would lie between a minimum of CHF 0.2 per passage through the cordon defining the perimeter and a maximum of CHF 5.-. The price would be charged both when entering and exiting the zone according to the modulation and exemptions.

- **Modulation**: The charge would be effective from Monday to Friday (6am-7pm), except on bank holidays. The price could vary in presence of pollution peaks (CHF 1.- top-up), according to the time of the day (CHF 1.50 top-up at peak-hours, 6:30am-9am and 4pm-7pm) or depending on the kilometers driven inside the perimeter (CHF 0.20 per kilometer driven). Alternatively, the charge could be effective only during peak hours (6:30am-9am and 4pm-7pm).

- **Use of revenues**: According to the first estimations, the congestion charge could generate revenues reaching CHF 50-100 million per year depending on the congestion charge characteristics. These revenues could be used in different ways: to finance public transportation in the Canton of Geneva (more frequency, enhanced quality, line extensions, lower off-peak fares), to finance a bridge or a tunnel to cross the Lake of Geneva, to adjust the vehicle registration fee in the Canton of Geneva, and to finance measures to reduce air and noise pollution.

- **Exemptions**: Emergency vehicles and those driven by disabled would not be subject to the congestion charge. Different exemption levels could be given to residents of the perimeter, scooters/motorbikes, electric vehicles, business deliveries, and frequent commuters (in the latter case, buying 200 passages would give a rebate on the following 200 passages).

Instructions

Congestion treatment
We would like to remind you that the goal of the congestion charge is to reduce congestion. In London and Milan, congestion decreased by 30 % and 25 %, respectively, following the implementation of a congestion charge. In Stockholm, traffic was reduced by more than 20 %. We expect similar effects in Geneva.

Pollution treatment
We would like to remind you that the goal of the congestion charge is to reduce pollution and noise due to traffic. In London and Stockholm, small particles decreased by 10 to 15 % and carbon dioxide by 13 to 16 % following the implementation of a congestion charge. The decline in pollution has had a positive impact on public health. In addition to improvements in air quality, the level of noise declined as well. We expect similar effects in Geneva.

Common information
In what follows, you will vote 10 times on a congestion charge design. In each ballot, you have to choose among three alternatives: two scenarios with different congestion charges and the current situation without a congestion charge. During the vote, you will have access to further information in tooltips.
Please evaluate all proposition as if they would have been proposed by the local government and vote for your preferred option. There is no good or bad response.
Before the ballots, you will face an introductory question.

Introductory question

Which mode of transportation do you use most frequently (at least 4 times a week)?

☐ Car

☐ Bus,tramway

☐ Train

☐ Motorbike

☐ Bicycle

☐ Walking

Vote

If you would have to vote between these alternatives, which one would you prefer?
Click on the underlined elements to get more information.

	Attributes					
	Perimeter	Charge rate	Modulation	Exemption	Beneficiaries	Revenues
Levels	Center Ring	0.2 1 2 3 4 5	Constant Peak hours only Peak hours top-up Pollution top-up Distance top-up	0 % 25 % 50 % 75 % 100 %	Residents Motorbikes Business deliveries Electric vehicles Frequent commuters	Public transportation Transport infrastructure Pollution reduction Tunnel or bridge Vehicle registration fee

Tooltips content

Perimeter: The map in Figure A.1 appears.

Charge rate: Drivers are charged both when entering and exiting the perimeter.

Peak hours only: Drivers are charged only during peak hours (6.30 am to 9 am and 4 pm to 7 pm).

Peak hours top-up: Drivers are charged from 6 am to 7 pm and there is a surcharge during peak hours (from 6.30 am to 9 am and from 4 pm to 7 pm).

Distance top-up: Drivers are charged from 6 am to 7 pm and there is a surcharge of CHF 0.20 per kilometer driven within the perimeter.

Pollution top-up: Drivers are charged from 6 am to 7 pm and there is a surcharge of CHF 1 when pollution is high.

Constant: Drivers are charged from 6 am to 7 pm at a constant rate.

Frequent commuters: The prepayment of 200 passages across the perimeter provides a discount on the following 200 passages.

Business deliveries: Businesses with an economic activity within the perimeter can benefit from an exemption.

No exemption: No exemption is granted, except for emergency vehicles and disabled individuals.

Public transportation: Revenues earmarked for public transportation in the Canton of Geneva (*Transports Publics Genevois*) with the objective to improve quality, frequency, and coverage, as well as to lead to lower fares during off-peak times.

Tunnel or bridge: Revenues earmarked for a tunnel or bridge crossing the Lake Geneva

(*Grande Traversée du Lac*) as well as for accompanying measures to manage road traffic in the center of the agglomeration.

Transport infrastructure: Revenues earmarked for improvements in transport supply such as the road network and the cycling lanes.

Pollution: Revenues earmarked for measures abating air and noise pollution such as sound-absorbing coating.

Vehicle registration fee: Revenues redistributed to the population of the Canton of Geneva via a reduction in the annual vehicle registration fee.

Mobility equipment

Here, we ask you some questions about your equipment in transportation passes and in cars.

1. Do you have a driving license allowing you to drive a car?
   ☐ Yes
   ☐ No

2. How many cars do you have in your household? Take also into account company cars that are always at your disposal.
   _ Car(s)

3. Do you have the possibility to borrow a car from a relative or your family?
   ☐ Yes
   ☐ No

4. Do you have a monthly or annual pass for the Swiss public transportation system (except the Half Fare Travelcard) or the local mass transit system (TPG, Unireso, etc)?
   ☐ Yes
   ☐ No

Your trips to Geneva

To better know your mobility habits we ask you some questions about your trips to and from the center of Geneva.

1. What is your municipality of residence?

2. What is your current activity?
   ☐ Student
   ☐ At home

☐ Full-time or part-time worker
☐ Job seeking
☐ Retiree

3. In which municipality do you work/study?

4. Which mode of transportation do you mainly use to commute to your working or studying place? Only one response possible. If you use several transportation modes for this journey, indicate the one that you use on the last part of the trip.

   ☐ Car
   ☐ Mass transit (bus/tramway)
   ☐ Train
   ☐ Motorbike
   ☐ Bicycle
   ☐ Walking

5. What is the average duration of your trip from home to your working place or from home to your studying place (one-way) in minutes?
   _ minutes

6. At what time do you leave your residency in general for this trip?

7. When commuting to your working or studying place, do you cross the municipalities of Geneva, Lancy or Carouge ?

   ☐ Yes
   ☐ No

8. Are you sometimes commuting to your working place with another mode of transportation?

   ☐ Yes
   ☐ No

9. If yes, which one? Only one response possible. If you use several transportation modes for this journey, indicate the one that you use on the last part of the trip.

   ☐ Car
   ☐ Mass transit
   ☐ Train
   ☐ Motorbikes
   ☐ Bicycle
   ☐ Walking

10. What is the average length of this trip? (in minutes)

11. At what time do you leave in general your residency for this trip?

12. Is it possible for you to commute by mass transit to your working place?

    ☐ Yes
    ☐ No

13. What is the average duration of this trip by mass transit? (in minutes)
    _ minutes

14. Do you sometimes, during the week (Monday to Friday), cross the municipalities of Geneva, Carouge or Lancy by car for shopping or leisure activities (visiting friends or family, restaurants, sport, etc.)?

    ☐ Yes
    ☐ No

15. Do you sometimes leave your municipality of residence by car for shopping or leisure activities (visiting friends or family, restaurants,sport, etc) during the week (Monday to Friday)?

    ☐ Yes
    ☐ No

16. Could you indicate the destination of the most recent trip that you undertook by car for shopping or leisure activities?

17. How long was this trip? (in minutes)
    _ minutes

18. At what time did you leave your residence for this trip?

Respondent profile

1. Are you?

   ☐ A female
   ☐ A male

2. How old are you?
   _ years old

3. How many people usually live in your household, included you? (Include your family, but also any person living at least 4 days a week in your household)
   _ Adults _ Children (0-18 years)

4. What is the last diploma that you obtained?

   ☐ Compulsory school certificate, no diploma, primary school certificate
   ☐ Apprenticeship
   ☐ Post-compulsory school : secondary level, high school
   ☐ Diploma of higher education (DEUG, DUT, BTS)
   ☐ University degree (undergraduate, master, PhD) : university, institute of technology, and university of applied sciences.

5. What is the total monthly gross income (including benefits and other subsidies) of your household, taking into account the income of all the members of the household? (In Euros/CHF)

   ☐ Less than 900
   ☐ From 901 to 1 500
   ☐ From 1 501 to 2 000
   ☐ From 2 001 to 3 000
   ☐ From 3 001 to 4 000
   ☐ From 4 001 to 5 000
   ☐ From 5 001 to 6 000
   ☐ From 6 001 to 7 000
   ☐ From 7 001 to 8 000
   ☐ From 8 001 to 9 000
   ☐ From 9 001 to 10 000
   ☐ From 10 001 to 11 000
   ☐ From 11 001 to 12 000
   ☐ More than 12 000
   ☐ I do not want to answer.

A.2 Tables

TABLE A.1: Summary information available at any time to respondents

Variable	**Description**
Perimeter	The map in Figure A.1 appears
Charge rate	Drivers are charged both when entering and exiting the perimeter
Peak hours only	Drivers are charged only during peak hours (6.30 am to 9 am and 4 pm to 7 pm).
Peak hours top-up	Drivers are charged from 6 am to 7 pm and there is a surcharge during peak hours (from 6.30 am to 9 am and from 4 pm to 7 pm).
Distance top-up	Drivers are charged from 6 am to 7 pm and there is a surcharge of CHF 0.20 per kilometer driven within the perimeter.
Pollution top-up	Drivers are charged from 6 am to 7 pm and there is a surcharge of CHF 1 when pollution is high.
Constant	Drivers are charged from 6 am to 7 pm at a constant rate.
Frequent commuters	The prepayment of 200 passages across the perimeter provides a discount on the following 200 passages.
Business deliveries	Businesses with an economic activity within the perimeter can benefit from an exemption.
No exemption	No exemption is granted, except for emergency vehicles and disabled individuals.
Public transportation	Revenues earmarked for public transportation in the Canton of Geneva (*Transports Publics Genevois*) with the objective of improving quality, frequency, and coverage, as well as to lead to lower fares during off-peak times.
Tunnel or bridge	Revenues earmarked for a tunnel or bridge crossing the Lake Geneva (*Grande Traversée du Lac*) as well as for accompanying measures to manage road traffic in the center of the agglomeration.
Transport infrastructure	Revenues earmarked for improvements in transport infrastructure such as the road network and cycling lanes.
Pollution	Revenues earmarked for measures abating air and noise pollution such as sound-absorbing coating.
Vehicle registration fee	Revenues redistributed to the population of the Canton of Geneva via a reduction in the annual vehicle registration fee.

A.2.1 Sample characteristics and representativity

TABLE A.2: Sample composition

Variable	Mean	Std. Dev.	Min.	Max.	N
Gender (female)	0.512	0.500	0	1	1414
Age	41.789	13.738	18	77	1414
Household size	2.252	1.677	0	10	1414
Number of cars in household	1.405	0.752	0	5	1171
Public transportation pass holder	0.500	0.500	0	1	1222
Household monthly income					
< CHF 900	0.023	0.151	0	1	995
CHF 901 - CHF 1’500	0.021	0.144	0	1	995
CHF 1’501 - CHF 2’000	0.02	0.139	0	1	995
CHF 2’001 - CHF 3’000	0.037	0.188	0	1	995
CHF 3’001 - CHF 4’000	0.062	0.242	0	1	995
CHF 4’001 - CHF 5’000	0.070	0.255	0	1	995
CHF 5’001 - CHF 6’000	0.079	0.269	0	1	995
CHF 6’001 - CHF 7’000	0.062	0.240	0	1	995
CHF 7’001 - CHF 8’000	0.050	0.219	0	1	995
CHF 8’001 - CHF 9’000	0.057	0.231	0	1	995
CHF 9’001 - CHF 10’000	0.053	0.224	0	1	995
CHF 10’001 - CHF 11’000	0.039	0.193	0	1	995
CHF 11’001 - CHF 12’000	0.033	0.178	0	1	995
> CHF 12’000	0.099	0.299	0	1	995
Education level					
Compulsory schooling	0.065	0.247	0	1	1398
Apprenticeship	0.199	0.4	0	1	1398
Post-compulsory school	0.255	0.436	0	1	1398
Superior first cycle degree	0.107	0.309	0	1	1398
Superior second cycle degree	0.362	0.481	0	1	1398
Residence area					
Switzerland	0.714	0.452	0	1	1414
Canton of Geneva	0.553	0.497	0	1	1414
Canton of Vaud	0.161	0.367	0	1	1414
France	0.286	0.452	0	1	1414
Genevois	0.039	0.193	0	1	1414
Gex	0.127	0.333	0	1	1414
Haute-Savoie	0.031	0.174	0	1	1414
Annemasse agglomeration	0.089	0.285	0	1	1414
Commuting					
Car	0.466	0.499	0	1	999
Bus and tramway	0.246	0.431	0	1	999
Train	0.091	0.288	0	1	999
Motorcycle	0.079	0.270	0	1	999
Bicycle	0.050	0.218	0	1	999
Walking	0.067	0.250	0	1	999

TABLE A.3: Balance of covariates

	Congestion			Pollution			Control				
Variable	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Min.	Max.
Gender (female)	0.52	0.50	454	0.54**	0.50	478	0.47	0.50	482	0	1
Age	41.13	13.67	454	41.86	14.30	478	42.34	13.19	482	18	77
Household size	2.29	1.62	454	2.28	1.70	478	2.19	1.70	482	0	10
Number of cars in household	1.39	0.69	374	1.38	0.75	392	1.44	0.80	405	0	5
Public transportation pass holder	0.48	0.50	389	0.49	0.50	407	0.53	0.50	426	0	1
Household monthly income											
< CHF 900	0.03	0.17	454	0.02	0.13	478	0.02	0.16	482	0	1
CHF 901 - CHF 1'500	0.02	0.15	454	0.02	0.15	478	0.02	0.14	482	0	1
CHF 1'501 - CHF 2'000	0.02	0.13	454	0.02	0.14	478	0.02	0.15	482	0	1
CHF 2'001 - CHF 3'000	0.02*	0.15	454	0.05	0.22	478	0.04	0.19	482	0	1
CHF 3'001 - CHF 4'000	0.07	0.25	454	0.05	0.21	478	0.07	0.26	482	0	1
CHF 4'001 - CHF 5'000	0.07	0.25	454	0.08	0.27	478	0.06	0.24	482	0	1
CHF 5'001 - CHF 6'000	0.09	0.29	454	0.06	0.24	478	0.08	0.27	482	0	1
CHF 6'001 - CHF 7'000	0.05	0.22	454	0.06	0.24	478	0.07	0.25	482	0	1
CHF 7'001 - CHF 8'000	0.05	0.22	454	0.05	0.22	478	0.05	0.22	482	0	1
CHF 8'001 - CHF 9'000	0.05	0.21	454	0.06	0.25	478	0.06	0.23	482	0	1
CHF 9'001 - CHF 10'000	0.05	0.22	454	0.04**	0.20	478	0.07	0.25	482	0	1
CHF 10'001 - CHF 11'000	0.05	0.21	454	0.03	0.16	478	0.04	0.20	482	0	1
CHF 11'001 - CHF 12'000	0.03	0.17	454	0.03	0.17	478	0.04	0.18	482	0	1
> CHF 12'000	0.12	0.32	454	0.09	0.29	478	0.09	0.28	482	0	1
Education level											
Compulsory schooling	0.05*	0.21	454	0.06	0.24	478	0.08	0.28	482	0	1
Apprenticeship	0.19	0.39	454	0.20	0.40	478	0.21	0.40	482	0	1

Table A.3 (continued)

	Congestion			Pollution			Control				
Variable	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Min.	Max.
Post-compulsory school	0.26	0.44	454	0.28*	0.45	478	0.23	0.42	482	0	1
Superior first cycle degree	0.10	0.30	454	0.09	0.29	478	0.12	0.33	482	0	1
Superior second cycle degree	0.39	0.49	454	0.34	0.47	478	0.35	0.48	482	0	1
Residence area											
Switzerland	0.71	0.45	454	0.72	0.45	478	0.71	0.45	482	0	1
Canton of Geneva	0.55	0.50	454	0.55	0.50	478	0.56	0.50	482	0	1
Canton of Vaud	0.17	0.37	454	0.17	0.37	478	0.15	0.36	482	0	1
France	0.29	0.45	454	0.28	0.45	478	0.29	0.45	482	0	1
Genevois	0.03	0.17	454	0.04	0.20	478	0.05	0.21	482	0	1
Gex	0.13	0.34	454	0.13	0.34	478	0.12	0.33	482	0	1
Haute-Savoie	0.04	0.20	454	0.02	0.14	478	0.03	0.18	482	0	1
Annemasse agglomeration	0.09	0.28	454	0.09	0.29	478	0.09	0.29	482	0	1
Commuting											
Car	0.51	0.50	319	0.43	0.50	337	0.46	0.50	343	0	1
Bus and tramway	0.22	0.41	319	0.28	0.45	337	0.24	0.43	343	0	1
Train	0.09	0.28	319	0.10	0.30	337	0.09	0.28	343	0	1
Motorcycle	0.08	0.27	319	0.06	0.24	337	0.09	0.29	343	0	1
Bicycle	0.04	0.20	319	0.05	0.22	337	0.06	0.23	343	0	1
Walking	0.06	0.24	319	0.08	0.27	337	0.06	0.24	343	0	1

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

TABLE A.4: Socioeconomic characteristics of the underlying population - Geneva

Variable	Geneva Mean	Sample Mean
Gender (female)	0.515	0.567
Number of cars per inhabitant	0.448	0.635
Education level		
Compulsory schooling	0.286	0.31
Secondary education	0.326	0.353
Tertiary education	0.388	0.326
Commuting		
Car and motorcycle	0.45	0.434

Source: All variables come from the Cantonal Office of Statistics.

TABLE A.5: Socioeconomic characteristics of the underlying population - entire metropolitan area ("Grand-Genève")

Variable	Grand-Genève Mean	Sample Mean
Gender (female)	0.513	0.512
Number of cars per inhabitant	0.533	0.687
Education level		
Compulsory schooling	0.205	0.265
Secondary education	0.349	0.362
Tertiary education	0.439	0.362
Residence area		
Switzerland	0.65	0.714
France	0.35	0.286
Commuting		
Car and motorcycle	0.57	0.545

Source: All variables come from the Cross-Border Observatory for Statistics and the Swiss Federal Office of Statistics.

A.2.2 Additional empirical results

TABLE A.6: Estimates from conditional logit: residents of the perimeter, living in the Canton of Geneva but outside the perimeters, not living in the Canton of Geneva

	(1) Residents		(2) Living in the Canton of Geneva but outside the perimeters		(3) Not living in the Canton of Geneva	
Charge rate						
CHF 0 (reference)						
CHF 0.2	-0.053*	(0.028)	-0.088**	(0.042)	-0.034	(0.025)
CHF 1	-0.072**	(0.029)	-0.150***	(0.039)	-0.119***	(0.025)
CHF 2	-0.144***	(0.029)	-0.231***	(0.039)	-0.220***	(0.024)
CHF 3	-0.215***	(0.028)	-0.264***	(0.038)	-0.296***	(0.025)
CHF 4	-0.210***	(0.029)	-0.302***	(0.038)	-0.340***	(0.024)
CHF 5	-0.268***	(0.029)	-0.336***	(0.038)	-0.375***	(0.025)
Perimeter						
Center (reference)						
Ring	-0.005	(0.012)	-0.008	(0.021)	-0.02*	(0.011)
Modulation						
Constant (reference)						
Peak hours only	-0.002	(0.014)	0.034	(0.024)	0.029**	(0.014)
Peak hours top-up	-0.018	(0.014)	0.041*	(0.022)	0.017	(0.014)
Distance top-up	-0.081***	(0.016)	-0.056**	(0.024)	-0.009	(0.015)
Pollution top-up	-0.036**	(0.014)	0.032	(0.022)	0.001	(0.014)
Beneficiaries						
Business deliveries (reference)						
Residents	0.068***	(0.016)	0.045*	(0.024)	-0.014	(0.014)
Motorbikes	-0.006	(0.016)	0.010	(0.024)	-0.035**	(0.015)
Frequent commuters	0.021	(0.016)	0.027	(0.024)	0.006	(0.014)
Electric vehicles	0.012	(0.015)	-0.037	(0.026)	-0.05***	(0.016)
Exemption level						
0% (reference)						
25%	0.01	(0.016)	-0.020	(0.021)	0.004	(0.014)
50%	0.039***	(0.015)	0.029	(0.022)	0.036**	(0.014)
75%	0.039**	(0.016)	0.048**	(0.021)	0.049***	(0.014)
100%	0.054***	(0.016)	0.026	(0.023)	0.098***	(0.015)
Use of revenue						
Vehicle registration fee (reference)						
Public transportation	0.087***	(0.016)	0.079***	(0.025)	0.080***	(0.015)
Transport infrastructure	0.058***	(0.015)	0.052**	(0.023)	0.044***	(0.015)
Pollution reduction	0.066***	(0.016)	0.053**	(0.024)	0.039**	(0.016)
Tunnel or bridge	0.020	(0.016)	0.038	(0.027)	0.050***	(0.016)
Number of respondents	547		235		632	
Number of observations	16’407		7’047		18’954	
Pseudo R^2	0.0456		0.0775		0.1148	

Estimates report average marginal effects from conditional logit.
Heteroskedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.17.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.7: Estimates from conditional logit by commuting mode

	(1) Car and motorbike		(2) Public transportation, cycling and walking	
Charge rate				
CHF 0 (reference)				
CHF 0.2	-0.043	(0.027)	-0.056**	(0.022)
CHF 1	-0.140***	(0.027)	-0.086***	(0.022)
CHF 2	-0.248***	(0.026)	-0.159***	(0.022)
CHF 3	-0.321***	(0.026)	-0.224***	(0.022)
CHF 4	-0.328***	(0.026)	-0.252***	(0.022)
CHF 5	-0.388***	(0.027)	-0.292***	(0.022)
Perimeter				
Center (reference)				
Ring	-0.018	(0.012)	-0.004	(0.009)
Modulation				
Constant (reference)				
Peak hours only	0.031**	(0.015)	0.010	(0.011)
Peak hours top-up	0.014	(0.015)	0.004	(0.012)
Distance top-up	-0.012	(0.016)	-0.063***	(0.012)
Pollution top-up	0.004	(0.015)	-0.017	(0.011)
Beneficiaries				
Business deliveries (reference)				
Residents	-0.006	(0.016)	0.047***	(0.012)
Motorbikes	-0.016	(0.016)	-0.017	(0.013)
Frequent commuters	0.009	(0.015)	0.018	(0.012)
Electric vehicles	-0.067***	(0.018)	0.002	(0.012)
Exemption level				
0% (reference)				
25%	0.020	(0.015)	-0.007	(0.012)
50%	0.045***	(0.015)	0.031***	(0.012)
75%	0.061***	(0.015)	0.036***	(0.012)
100%	0.096***	(0.016)	0.054***	(0.013)
Use of revenue				
Vehicle registration fee (reference)				
Public transportation	0.061***	(0.016)	0.093***	(0.013)
Transport infrastructure	0.033**	(0.015)	0.062***	(0.012)
Pollution reduction	0.051***	(0.015)	0.052***	(0.013)
Tunnel or bridge	0.05***	(0.016)	0.027**	(0.013)
Number of respondents	544		870	
Number of observations	16’314		26’094	
Pseudo R^2	0.1206		0.0552	

Estimates report average marginal effects from conditional logit.
Heteroscedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.18.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.8: Estimates from conditional logit by commuting frequency

	(1) Inhabitants of the Canton of Geneva		(2) 6-7 trips/week to Geneva		(3) 1-5 trips/week to Geneva	
Charge rate						
CHF 0 (reference)						
CHF 0.2	-0.046	(0.029)	-0.103***	(0.036)	-0.03	(0.026)
CHF 1	-0.0742***	(0.029)	-0.151***	(0.037)	-0.119***	(0.026)
CHF 2	-0.151***	(0.029)	-0.255***	(0.036)	-0.201***	(0.026)
CHF 3	-0.214***	(0.029)	-0.288***	(0.034)	-0.290***	(0.026)
CHF 4	-0.205***	(0.029)	-0.322***	(0.034)	-0.335***	(0.026)
CHF 5	-0.266***	(0.028)	-0.340***	(0.036)	-0.383***	(0.026)
Perimeter						
Center (reference)						
Ring	0.002	(0.012)	0.006	(0.015)	-0.026**	(0.011)
Modulation						
Constant (reference)						
Peak hours only	-0.008	(0.014)	0.038**	(0.019)	0.031**	(0.014)
Peak hours top-up	-0.01	(0.015)	0.017	(0.019)	0.02	(0.014)
Distance top-up	-0.084***	(0.016)	-0.055***	(0.020)	-0.004	(0.016)
Pollution top-up	-0.024*	(0.015)	-0.019	(0.021)	0.013	(0.014)
Beneficiaries						
Business deliveries (reference)						
Residents	0.053***	(0.016)	0.031	(0.02)	0.003	(0.015)
Motorbikes	-0.009	(0.017)	0.013	(0.021)	-0.04**	(0.016)
Frequent commuters	0.021	(0.016)	0.041**	(0.021)	-0.003	(0.015)
Electric vehicles	-0.011	(0.016)	-0.007	(0.020)	-0.043**	(0.017)
Exemption level						
0% (reference)						
25%	-0.001	(0.015)	-0.0002	(0.020)	0.007	(0.015)
50%	0.025	(0.015)	0.042**	(0.018)	0.043***	(0.016)
75%	0.026	(0.016)	0.065***	(0.021)	0.050***	(0.014)
100%	0.041**	(0.016)	0.045**	(0.021)	0.107***	(0.015)
Use of revenue						
Vehicle registration fee (reference)						
Public transportation	0.076***	(0.016)	0.106***	(0.022)	0.075***	(0.016)
Transport infrastructure	0.045***	(0.015)	0.060***	(0.022)	0.051***	(0.015)
Pollution reduction	0.054***	(0.016)	0.062***	(0.022)	0.044***	(0.016)
Tunnel or bridge	0.007	(0.016)	0.054**	(0.023)	0.052***	(0.017)
Number of respondents	515		314		585	
Number of observations	15’444		9’414		17’550	
Pseudo R^2	0.0531		0.0735		0.1057	

Estimates report average marginal effects from conditional logit.
Heteroscedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.19.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.9: Estimates from conditional logit: cars vs. motorbikes

	(1) Car		(2) Motorbike	
Charge rate				
CHF 0 (reference)				
CHF 0.2	-0.022	(0.029)	-0.159**	(0.069)
CHF 1	-0.124***	(0.028)	-0.234***	(0.072)
CHF 2	-0.233***	(0.028)	-0.334***	(0.065)
CHF 3	-0.319***	(0.028)	-0.343***	(0.069)
CHF 4	-0.321***	(0.029)	-0.376***	(0.064)
CHF 5	-0.375***	(0.029)	-0.454***	(0.068)
Perimeter				
Center (reference)				
Ring	-0.02	(0.013)	-0.008	(0.032)
Modulation				
Constant (reference)				
Peak hours only	0.029*	(0.016)	0.05	(0.037)
Peak hours top-up	0.013	(0.016)	0.028	(0.039)
Distance top-up	-0.013	(0.018)	0.008	(0.039)
Pollution top-up	0.004	(0.016)	0.013	(0.039)
Beneficiaries				
Business deliveries (reference)				
Resident	-0.004	(0.017)	-0.008	(0.035)
Motorbikes	-0.048***	(0.017)	0.147***	(0.037)
Frequent commuters	0.013	(0.017)	-0.019	(0.038)
Electric vehicles	-0.073***	(0.02)	-0.026	(0.04)
Exemption level				
0% (reference)				
25%	0.011	(0.017)	0.071*	(0.04)
50%	0.037**	(0.017)	0.081**	(0.04)
75%	0.052***	(0.017)	0.098***	(0.034)
100%	0.092***	(0.017)	0.117***	(0.038)
Use of revenue				
Vehicle registration fee (reference)				
Public transportation	0.053***	(0.017)	0.101***	(0.038)
Transport infrastructure	0.036**	(0.017)	0.009	(0.042)
Pollution reduction	0.054***	(0.016)	0.029	(0.041)
Tunnel or bridge	0.045**	(0.018)	0.085**	(0.043)
Number of respondents	465		79	
Number of observations	13’944		2’370	
Pseudo R^2	0.1285		0.1066	

Estimates report average marginal effects from conditional logit.
Heteroscedasticity-robust standard errors in parentheses.
Continuous p-values are provided in Table A.20.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.2.3 Tables displaying coefficients for control variables

TABLE A.10: The impact of informational treatments on public support, for each charge rate

	(1)	(2)	(3)	(4)	(5)	(6)
	CHF 0.2	CHF 1	CHF 2	CHF 3	CHF 4	CHF 5
Treatments						
Control (reference)						
Congestion	0.015	0.022	-0.001	0.006	0.003	0.016
	(0.017)	(0.017)	(0.016)	(0.015)	(0.015)	(0.014)
Pollution	0.006	0.016	0.039**	0.036**	0.043***	0.037***
	(0.017)	(0.017)	(0.016)	(0.014)	(0.014)	(0.013)
Control variables						
Gender (female)	-0.004	0.011	-0.004	0.014	-0.006	-0.004
	(0.015)	(0.015)	(0.014)	(0.013)	(0.012)	(0.011)
Age	-0.003***	-0.002***	-0.002***	-0.001	-0.002***	-0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0005)	(0.000)
Household size	0.011**	0.016***	0.012***	0.010***	0.008**	0.012***
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.003)
Number of cars in household						
No car (reference)						
1 car	-0.023	0.008	-0.023	0.035	0.009	0.007
	(0.031)	(0.031)	(0.027)	(0.026)	(0.024)	(0.023)
2 cars	-0.026	0.018	-0.030	0.021	-0.005	-0.009
	(0.033)	(0.033)	(0.030)	(0.028)	(0.027)	(0.025)
3 cars	0.122**	0.015	-0.029	0.025	-0.041	-0.099**
	(0.047)	(0.046)	(0.043)	(0.041)	(0.041)	(0.042)
4 cars	-0.154	0.034	-0.070	-0.005	-0.049	0.102*
	(0.095)	(0.087)	(0.084)	(0.077)	(0.079)	(0.054)
5 cars	-0.174	-0.090	-0.210	-0.064	-0.054	0.000
	(0.187)	(0.184)	(0.205)	(0.171)	(0.163)	(.)
No answer	-0.079*	-0.064	-0.017	0.038	-0.009	-0.003
	(0.047)	(0.047)	(0.042)	(0.038)	(0.038)	(0.036)
Public transportation pass holder						
No (reference)						
Yes	0.090***	0.068***	0.046***	0.045***	0.076***	0.034**
	(0.018)	(0.018)	(0.016)	(0.015)	(0.015)	(0.014)
No answer	0.098**	0.092**	0.016	0.022	0.070*	0.049
	(0.046)	(0.046)	(0.041)	(0.037)	(0.038)	(0.036)
Household monthly income:						
< CHF 900 (reference)						
CHF 901 - CHF 1'500	0.058	-0.102	-0.026	0.046	-0.023	-0.169***
	(0.067)	(0.069)	(0.063)	(0.054)	(0.057)	(0.056)

Table A.10 (continued)

	(1) CHF 0.2	(2) CHF 1	(3) CHF 2	(4) CHF 3	(5) CHF 4	(6) CHF 5
CHF 1’501 - CHF 2’000	0.128*	0.047	0.043	0.083	0.053	-0.019
	(0.067)	(0.065)	(0.061)	(0.053)	(0.053)	(0.042)
CHF 2’001 - CHF 3’000	0.078	0.119**	0.109**	0.047	0.064	-0.054
	(0.060)	(0.057)	(0.052)	(0.046)	(0.046)	(0.039)
CHF 3’001 - CHF 4’000	0.102*	0.062	-0.008	0.003	-0.013	-0.064*
	(0.056)	(0.053)	(0.050)	(0.044)	(0.044)	(0.036)
CHF 4’001 - CHF 5’000	0.108*	0.048	-0.004	-0.019	-0.029	-0.112***
	(0.055)	(0.053)	(0.049)	(0.043)	(0.043)	(0.036)
CHF 5’001 - CHF 6’000	0.124**	0.025	0.012	-0.051	-0.040	-0.187***
	(0.054)	(0.052)	(0.048)	(0.043)	(0.042)	(0.037)
CHF 6’001 - CHF 7’000	0.087	-0.002	0.016	-0.022	-0.011	-0.088**
	(0.056)	(0.054)	(0.050)	(0.044)	(0.043)	(0.036)
CHF 7’001 - CHF 8’000	0.119**	0.030	0.039	0.002	0.004	-0.099***
	(0.057)	(0.055)	(0.051)	(0.045)	(0.044)	(0.037)
CHF 8’001 - CHF 9’000	0.051	-0.060	-0.032	-0.012	-0.009	-0.101***
	(0.058)	(0.056)	(0.051)	(0.044)	(0.044)	(0.037)
CHF 9’001 - CHF 10’000	0.096*	0.053	0.036	-0.004	0.025	-0.137***
	(0.058)	(0.055)	(0.051)	(0.044)	(0.044)	(0.038)
CHF 10’001 - CHF 11’000	0.056	-0.013	0.012	-0.036	0.001	-0.120***
	(0.061)	(0.059)	(0.054)	(0.048)	(0.047)	(0.041)
CHF 11’001 - CHF 12’000	0.073	-0.076	-0.034	-0.045	-0.042	-0.143***
	(0.063)	(0.063)	(0.058)	(0.051)	(0.050)	(0.042)
> CHF 12’000	0.154***	0.018	-0.009	-0.034	-0.016	-0.133***
	(0.054)	(0.052)	(0.049)	(0.043)	(0.042)	(0.035)
No answer	0.110**	0.010	-0.005	-0.075*	-0.028	-0.134***
	(0.050)	(0.047)	(0.044)	(0.039)	(0.038)	(0.031)
Education level						
Compulsory schooling (reference)						
Apprenticeship	0.005	0.013	-0.023	-0.014	-0.060**	-0.018
	(0.032)	(0.032)	(0.029)	(0.028)	(0.026)	(0.024)
Post-compulsory school	0.054*	0.014	0.000	-0.009	-0.059**	-0.006
	(0.030)	(0.030)	(0.028)	(0.027)	(0.024)	(0.023)
Superior first cycle degree	0.031	0.003	0.008	-0.012	-0.062**	0.001
	(0.035)	(0.035)	(0.032)	(0.031)	(0.029)	(0.027)
Superior second cycle degree	0.002	-0.007	-0.014	0.012	-0.040*	0.015
	(0.030)	(0.030)	(0.028)	(0.026)	(0.024)	(0.023)
No answer	-0.406***	-0.255***	-0.090	0.057	0.057	0.084*
	(0.114)	(0.095)	(0.072)	(0.055)	(0.050)	(0.050)
Residence area						
Canton of Geneva (reference)						
Canton of Vaud	-0.104***	-0.068***	-0.009	0.015	-0.018	0.012

Table A.10 (continued)

	(1) CHF 0.2	(2) CHF 1	(3) CHF 2	(4) CHF 3	(5) CHF 4	(6) CHF 5
	(0.023)	(0.023)	(0.020)	(0.019)	(0.018)	(0.016)
Genevois	0.137***	0.062*	-0.030	-0.041	-0.102***	-0.104***
	(0.036)	(0.037)	(0.036)	(0.034)	(0.038)	(0.036)
Gex	0.069***	0.033	-0.034	-0.061***	-0.065***	-0.061***
	(0.023)	(0.023)	(0.022)	(0.022)	(0.021)	(0.020)
Haute-Savoie	0.263***	0.162***	0.009	-0.073*	-0.209***	-0.144***
	(0.041)	(0.039)	(0.040)	(0.042)	(0.057)	(0.048)
Annemasse agglomeration	0.137***	0.062**	0.009	-0.024	-0.041*	-0.036*
	(0.026)	(0.026)	(0.024)	(0.023)	(0.022)	(0.020)
Commuting						
Car (reference)						
Bus and tramway	-0.065***	0.027	0.044**	0.060***	-0.007	0.033*
	(0.024)	(0.024)	(0.021)	(0.020)	(0.019)	(0.018)
Train	0.012	0.046	0.022	0.013	-0.023	-0.007
	(0.034)	(0.034)	(0.030)	(0.028)	(0.028)	(0.025)
Motorcycle	-0.027	0.001	-0.010	0.069**	0.020	0.011
	(0.034)	(0.033)	(0.031)	(0.027)	(0.026)	(0.026)
Bicycle	-0.017	-0.048	0.065*	0.053	0.048	0.090***
	(0.038)	(0.042)	(0.037)	(0.033)	(0.031)	(0.027)
Walking	-0.072*	0.031	0.070**	0.061**	0.015	0.009
	(0.037)	(0.036)	(0.033)	(0.029)	(0.028)	(0.027)
No answer	-0.022	0.034	0.020	0.029	-0.014	-0.007
	(0.024)	(0.023)	(0.022)	(0.020)	(0.020)	(0.019)
Number of respondents	1414	1414	1414	1414	1414	1414
Number of observations	4’736	4’711	4’702	4’702	4’711	4’702
R^2	0.0432	0.0265	0.0202	0.0290	0.0412	0.0462

Estimates report average marginal effects from logit with control variables.
Heteroskedasticity-robust standard errors in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.11: The impact of informational treatments on public support, for each modulation

	(1) Constant	(2) Peak hours only	(3) Peak hours top-up	(4) Distance top-up	(5) Pollution top-up
Treatments					
Control (reference)					
Congestion	0.020	-0.005	0.005	0.026*	0.006
	(0.015)	(0.015)	(0.015)	(0.014)	(0.015)
Pollution	0.018	0.021	0.047***	0.021	0.045***
	(0.015)	(0.015)	(0.014)	(0.014)	(0.014)
Control variables					
Gender (female)	-0.012	0.014	-0.015	0.011	0.010
	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)
Age	-0.001***	-0.002***	-0.001***	-0.001**	-0.002***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Household size	0.013***	0.009**	0.014***	0.011***	0.010***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Number of cars in household					
No car (reference)					
1 car	0.007	0.024	-0.031	-0.005	0.013
	(0.026)	(0.027)	(0.026)	(0.025)	(0.026)
2 cars	-0.038	0.037	-0.030	-0.010	0.015
	(0.028)	(0.029)	(0.028)	(0.027)	(0.028)
3 cars	-0.014	-0.012	0.004	-0.004	0.038
	(0.040)	(0.041)	(0.039)	(0.038)	(0.039)
4 cars	0.022	-0.121	-0.021	0.041	-0.052
	(0.069)	(0.090)	(0.072)	(0.072)	(0.077)
5 cars	-0.006	0.107	0.000	0.000	-0.211
	(0.130)	(0.144)	(.)	(.)	(0.202)
No answer	-0.055	-0.030	-0.003	-0.029	0.001
	(0.040)	(0.041)	(0.039)	(0.037)	(0.039)
Public transportation pass holder					
No (reference)					
Yes	0.068***	0.065***	0.060***	0.047***	0.061***
	(0.015)	(0.015)	(0.016)	(0.015)	(0.015)
No answer	0.116***	0.057	0.009	0.062*	0.054
	(0.039)	(0.040)	(0.038)	(0.036)	(0.038)
Household monthly income:					
< CHF 900 (reference)	-0.046	0.060	-0.072	-0.003	-0.138**
CHF 901 - CHF 1'500	(0.055)	(0.059)	(0.059)	(0.053)	(0.061)
	0.046	0.124**	0.071	-0.009	0.027
CHF 1'501 - CHF 2'000	(0.054)	(0.058)	(0.054)	(0.052)	(0.054)
	0.048	0.147***	0.032	-0.001	0.059

Table A.11 (continued)

	(1) Constant	(2) Peak hours only	(3) Peak hours top-up	(4) Distance top-up	(5) Pollution top-up
CHF 2'001 - CHF 3'000	(0.047)	(0.051)	(0.048)	(0.045)	(0.047)
	-0.018	0.084*	-0.000	-0.033	0.008
CHF 3'001 - CHF 4'000	(0.044)	(0.049)	(0.045)	(0.043)	(0.045)
	-0.032	0.063	0.004	-0.036	-0.035
CHF 4'001 - CHF 5'000	(0.044)	(0.048)	(0.044)	(0.042)	(0.044)
	-0.060	0.063	-0.055	-0.017	-0.040
CHF 5'001 - CHF 6'000	(0.043)	(0.047)	(0.044)	(0.042)	(0.043)
	-0.066	0.104**	-0.022	-0.026	-0.036
CHF 6'001 - CHF 7'000	(0.045)	(0.048)	(0.045)	(0.043)	(0.045)
	-0.020	0.120**	0.021	-0.080*	0.010
CHF 7'001 - CHF 8'000	(0.046)	(0.049)	(0.046)	(0.045)	(0.046)
	-0.025	0.058	-0.050	-0.102**	-0.048
CHF 8'001 - CHF 9'000	(0.045)	(0.050)	(0.046)	(0.045)	(0.046)
	-0.020	0.096*	0.016	-0.063	-0.005
CHF 9'001 - CHF 10'000	(0.046)	(0.050)	(0.046)	(0.045)	(0.046)
	-0.023	0.046	-0.020	-0.061	-0.066
CHF 10'001 - CHF 11'000	(0.048)	(0.053)	(0.049)	(0.047)	(0.050)
	-0.096*	0.017	-0.048	-0.057	-0.062
CHF 11'001 - CHF 12'000	(0.052)	(0.056)	(0.052)	(0.049)	(0.051)
	-0.030	0.071	-0.018	-0.052	-0.020
> CHF 12'000	(0.043)	(0.048)	(0.044)	(0.042)	(0.044)
	-0.053	0.051	-0.047	-0.046	-0.036
No answer	(0.039)	(0.044)	(0.040)	(0.038)	(0.040)
Education level					
Compulsory schooling (reference)					
Apprenticeship	-0.004	-0.035	-0.031	-0.038	0.021
	(0.027)	(0.027)	(0.027)	(0.025)	(0.028)
Post-compulsory school	0.001	-0.020	-0.008	-0.020	0.035
	(0.026)	(0.026)	(0.026)	(0.024)	(0.026)
Superior first cycle degree	-0.032	0.006	-0.046	0.006	0.031
	(0.030)	(0.030)	(0.030)	(0.028)	(0.031)
Superior second cycle degree	-0.009	-0.028	-0.022	-0.009	0.034
	(0.026)	(0.026)	(0.026)	(0.024)	(0.026)
No answer	-0.052	-0.199**	-0.061	-0.000	-0.010
	(0.064)	(0.079)	(0.066)	(0.059)	(0.061)
Residence area					
Canton of Geneva (reference)					
Canton of Vaud	-0.067***	-0.024	-0.032	0.024	-0.048**
	(0.019)	(0.019)	(0.019)	(0.018)	(0.019)

Table A.11 (continued)

	(1) Constant	(2) Peak hours only	(3) Peak hours top-up	(4) Distance top-up	(5) Pollution top-up
Genevois	-0.033	-0.015	0.019	0.006	-0.003
	(0.034)	(0.032)	(0.032)	(0.031)	(0.032)
Gex	-0.029	-0.057***	-0.016	-0.001	0.005
	(0.021)	(0.021)	(0.020)	(0.019)	(0.020)
Haute-Savoie	0.040	0.073**	0.027	-0.003	0.017
	(0.035)	(0.034)	(0.035)	(0.034)	(0.036)
Annemasse agglomeration	0.025	0.040*	0.001	0.041**	-0.014
	(0.022)	(0.022)	(0.023)	(0.021)	(0.022)
Commuting					
Car (reference)					
Bus and tramway	0.015	0.009	0.018	0.019	0.013
	(0.020)	(0.020)	(0.021)	(0.019)	(0.020)
Train	0.055*	-0.010	0.011	-0.039	0.022
	(0.028)	(0.029)	(0.029)	(0.027)	(0.028)
Motorcycle	-0.006	0.015	-0.011	0.023	0.009
	(0.029)	(0.028)	(0.029)	(0.026)	(0.028)
Bicycle	0.068**	0.100***	0.037	-0.026	-0.010
	(0.032)	(0.032)	(0.033)	(0.034)	(0.034)
Walking	0.006	0.020	0.047	-0.009	0.029
	(0.031)	(0.031)	(0.030)	(0.030)	(0.030)
No answer	0.008	0.023	-0.001	-0.011	0.003
	(0.020)	(0.020)	(0.020)	(0.019)	(0.020)
Number of respondents	1414	1414	1414	1414	1414
Number of observations	5’638	5’678	5’638	5’651	5’651
R^2	0.0226	0.0224	0.0187	0.0131	0.0204

Estimates report average marginal effects from logit with control variables.
Heteroskedasticity-robust standard errors in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.2.4 Heterogeneity analysis results

TABLE A.12: Latent classes: estimates from conditional logit

	(1)		(2)		(3)		(4)		(5)	
	Latent class 1		Latent class 2		Latent class 3		Latent class 4		Latent class 5	
Charge rate										
CHF 0 (reference)										
CHF 0.2	0.323***	(0.012)	-0.302***	(0.041)	0.069**	(0.032)	-0.316***	(0.051)	0.472***	(0.039)
CHF 1	0.334***	(0.013)	-0.236***	(0.042)	-0.179***	(0.031)	-0.332***	(0.053)	0.354***	(0.038)
CHF 2	0.319***	(0.013)	-0.225***	(0.039)	-0.376***	(0.036)	-0.507***	(0.077)	0.058	(0.038)
CHF 3	0.307***	(0.012)	-0.299***	(0.040)	-0.456***	(0.035)	-0.382***	(0.061)	-0.126***	(0.039)
CHF 4	0.297***	(0.013)	-0.274***	(0.042)	-0.469***	(0.036)	-0.439***	(0.055)	-0.290***	(0.039)
CHF 5	0.279***	(0.013)	-0.297***	(0.043)	-0.647***	(0.051)	-0.416***	(0.066)	-0.475***	(0.041)
Perimeter										
Center (reference)										
Ring	0.0004	(0.006)	-0.062**	(0.022)	0.010	(0.015)	-0.042	(0.028)	-0.029	(0.018)
Modulation										
Constant (reference)										
Peak hours only	0.010	(0.008)	-0.013	(0.023)	0.040*	(0.023)	0.054	(0.039)	0.001	(0.027)
Peak hours top-up	0.016**	(0.007)	0.005	(0.023)	-0.017	(0.023)	0.003	(0.043)	-0.027	(0.026)
Distance top-up	-0.028***	(0.008)	-0.036	(0.026)	-0.064**	(0.026)	-0.051	(0.050)	-0.082***	(0.028)
Pollution top-up	-0.001	(0.007)	0.008	(0.024)	-0.034	(0.022)	0.034	(0.040)	-0.061**	(0.026)
Beneficiaries										
Business deliveries (reference)										
Residents	0.021***	(0.008)	0.115***	(0.028)	-0.031	(0.022)	-0.002	(0.036)	-0.014	(0.028)
Motorbikes	-0.005	(0.008)	0.04	(0.030)	-0.066**	(0.026)	-0.039	(0.04)	-0.090***	(0.026)
Frequent commuters	0.014*	(0.008)	0.066**	(0.028)	-0.039*	(0.023)	0.043	(0.034)	-0.01	(0.026)
Electric vehicles	-0.007	(0.008)	0.081***	(0.027)	-0.132***	(0.025)	-0.208**	(0.092)	-0.106***	(0.028)
Exemption level										

Table A.12 (continued)

	(1) Latent class 1		(2) Latent class 2		(3) Latent class 3		(4) Latent class 4		(5) Latent class 5	
0% (reference)										
25%	-0.005	(0.008)	0.011	(0.023)	0.043*	(0.024)	-0.116**	(0.051)	0.045*	(0.024)
50%	0.014*	(0.008)	0.047*	(0.024)	0.102***	(0.025)	-0.045	(0.037)	0.111***	(0.025)
75%	0.014*	(0.008)	0.062**	(0.025)	0.092***	(0.024)	-0.071	(0.040)	0.148***	(0.026)
100%	0.026***	(0.009)	0.092***	(0.026)	0.156***	(0.026)	-0.01	(0.033)	0.179***	(0.027)
Use of revenue										
Vehicle registration fee (reference)										
Public transportation	0.036***	(0.009)	0.247***	(0.027)	0.037	(0.023)	-0.038	(0.043)	0.038	(0.027)
Transport infrastructure	0.033***	(0.008)	0.122***	(0.029)	0.036	(0.023)	-0.012	(0.040)	0.020	(0.027)
Pollution reduction	0.021***	(0.008)	0.191***	(0.027)	-0.006	(0.022)	0.025	(0.037)	0.007	(0.027)
Tunnel or bridge	0.012	(0.008)	0.078**	(0.031)	0.030	(0.025)	-0.009	(0.038)	0.085***	(0.030)
Number of respondents	393		222		233		365		201	
Number of observations	11’784		6’660		6’990		10’947		6027	
Pseudo R^2	0.3028		0.0499		0.4381		0.9333		0.4550	

Estimates report average marginal effects from conditional logit.

Heteroscedasticity-robust standard errors in parentheses.

Continuous p-values are provided in Table A.21.

* $p < 0.01$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.13: Latent classes: membership estimates from multinomial logit

	(1)		(2)		(3)		(4)		(5)	
	Latent class 1		Latent class 2		Latent class 3		Latent class 4		Latent class 5	
<30 years old	0.029	(0.034)	-0.014	(0.029)	0.01	(0.030)	-0.06*	(0.035)	0.03	(0.027)
>65 years old	0.120	(0.208)	-2.091***	(0.157)	-2.270***	(0.161)	0.066	(0.206)	0.081	(0.129)
Gender (female)	0.016	(0.029)	0.024	(0.024)	0.003	(0.024)	-0.014	(0.028)	-0.028	(0.022)
Swiss	0.089**	(0.036)	0.034	(0.029)	0.002	(0.028)	0.067**	(0.032)	-0.171***	(0.026)
Resident of the center	0.058*	(0.034)	-0.023	(0.028)	-0.010	(0.032)	-0.048	(0.036)	0.023	(0.032)
Household size	0.016*	(0.008)	-0.002	(0.007)	-0.003	(0.007)	-0.026***	(0.009)	0.014**	(0.006)
Car and motorbike commuters	-0.059*	(0.030)	-0.072***	(0.025)	0.076***	(0.027)	0.092***	(0.03)	-0.037	(0.025)
Number of respondents	998		998		9'98		998		998	
Number of observations	29'940		29'940		29'940		29'940		29'940	
Pseudo R^2	0.0267		0.0187		0.0122		0.0265		0.0716	
Share of respondents	27.5%		16.3%		16.3%		25.7%		14.2%	

Estimates report average marginal effects.

Heteroscedasticity-robust standard errors in parentheses.

Continuous p-values are provided in Table A.22.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

A.2.5 Tables with *p*-values

TABLE A.14: Estimates from conditional logit with *p*-values

	(1) Full sample		(2) Potential voters		(3) Non-voters	
Charge rate						
CHF 0 (reference)						
CHF 0.2	-0.051***	(0.002)	-0.065***	(0.005)	-0.034	(0.167)
CHF 1	-0.109***	(0.000)	-0.099***	(0.000)	-0.119***	(0.000)
CHF 2	-0.195***	(0.000)	-0.173***	(0.000)	-0.22***	(0.000)
CHF 3	-0.262***	(0.000)	-0.232***	(0.000)	-0.296***	(0.000)
CHF 4	-0.283***	(0.000)	-0.239***	(0.000)	-0.34***	(0.000)
CHF 5	-0.33***	(0.000)	-0.291***	(0.000)	-0.375***	(0.000)
Perimeter						
Center (reference)						
Ring	-0.008	(0.263)	0.0001	(0.989)	-0.02*	(0.072)
Modulation						
Constant (reference)						
Peak hours only	0.018**	(0.042)	0.009	(0.458)	0.029**	(0.032)
Peak hours top-up	0.008	(0.395)	-0.0003	(0.983)	0.017	(0.205)
Distance top-up	-0.045***	(0.000)	-0.073***	(0.000)	-0.009	(0.542)
Pollution top-up	-0.008	(0.353)	-0.016	(0.193)	0.001	(0.945)
Exemption level						
0% (reference)						
25%	0.002	(0.839)	0.0004	(0.976)	0.004	(0.756)
50%	0.036***	(0.000)	0.036***	(0.004)	0.036 **	(0.012)
75%	0.044***	(0.000)	0.041***	(0.002)	0.049***	(0.000)
100%	0.069***	(0.000)	0.046***	(0.000)	0.098***	(0.000)
Beneficiaries						
Business deliveries (reference)						
Residents	0.029***	(0.003)	0.060***	(0.000)	-0.014	(0.315)
Motorbikes	-0.015	(0.131)	-0.001	(0.923)	-0.035**	(0.019)
Frequent commuters	0.016*	(0.097)	0.022*	(0.085)	0.006	(0.653)
Electric vehicles	-0.023**	(0.022)	-0.003	(0.834)	-0.05***	(0.002)
Use of revenue						
Vehicle registration fee(reference)						
Public transportation	0.082***	(0.000)	0.084***	(0.000)	0.080***	(0.000)
Transport infrastructure	0.050***	(0.000)	0.056***	(0.000)	0.044***	(0.003)
Pollution reduction	0.051***	(0.000)	0.062***	(0.000)	0.039**	(0.011)
Tunnel or bridge	0.035***	(0.001)	0.025*	(0.067)	0.05***	(0.001)
Number of respondents	1'414		782		632	
Number of observations	42'408		23'454		18'954	
Pseudo-R^2	0.0748		0.0523		0.1148	

Estimates report average marginal effects from conditional logit.
p-values in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.15: The impact of informational treatments on public support, for each charge rate with *p*-values

	(1) CHF 0.2	(2) CHF 1	(3) CHF 2	(4) CHF 3	(5) CHF 4	(6) CHF 5
Congestion	0.020	0.020	-0.003	0.002	-0.001	0.012
	(0.243)	(0.246)	(0.838)	(0.898)	(0.950)	(0.383)
Pollution	0.002	0.012	0.042**	0.037**	0.042***	0.038***
	(0.921)	(0.476)	(0.007)	(0.010)	(0.002)	(0.003)
Number of respondents	1414	1414	1414	1414	1414	1414
Number of observations	4’736	4’711	4’702	4’702	4’711	4’710
R^2	0.0003	0.0002	0.0019	0.0017	0.0027	0.0021

Estimates report average marginal effects from logit.
p-values in parentheses.
** $p < 0.05$, *** $p < 0.01$.

TABLE A.16: The impact of informational treatments on public support, for each modulation with *p*-values

	(1) Constant	(2) Peak hours only	(3) Peak hours top-up	(4) Distance top-up	(5) Pollution top-up
Congestion	0.019	-0.007	0.001	0.025	0.006
	(0.184)	(0.617)	(0.962)	(0.068)	(0.696)
Pollution	0.018	0.017	0.046***	0.022	0.045***
	(0.213)	(0.234)	(0.001)	(0.105)	(0.002)
Number of respondents	1414	1414	1414	1414	1414
Number of observations	5’638	5’678	5’646	5’659	5’651
R^2	0.0003	0.0004	0.002	0.0007	0.0018

Estimates report average marginal effects from logit.
p-values in parentheses.
*** $p < 0.01$.

TABLE A.17: Estimates from conditional logit with *p*-values: residents of the perimeter, living in the Canton of Geneva but outside the perimeters, not living in the Canton of Geneva

	(1) Residents		(2) Living in the Canton of Geneva but outside the perimeters		(3) Not living in the Canton of Geneva	
Charge rate						
CHF 0 (reference)						
CHF 0.2	-0.053*	(0.059)	-0.088**	(0.037)	-0.034	(0.167)
CHF 1	-0.072**	(0.012)	-0.150***	(0.000)	-0.119***	(0.000)
CHF 2	-0.144***	(0.000)	-0.231***	(0.000)	-0.220***	(0.000)
CHF 3	-0.215***	(0.000)	-0.264***	(0.000)	-0.296***	(0.000)
CHF 4	-0.210***	(0.000)	-0.302***	(0.000)	-0.340***	(0.000)
CHF 5	-0.268***	(0.000)	-0.336***	(0.000)	-0.375***	(0.000)
Perimeter						
Center (reference)						
Ring	-0.005	(0.680)	-0.008	(0.685)	-0.02*	(0.072)
Modulation						
Constant (reference)						
Peak hours only	-0.002	(0.898)	0.034	(0.156)	0.029**	(0.032)
Peak hours top-up	-0.018	(0.212)	0.041*	(0.065)	0.017	(0.205)
Distance top-up	-0.081***	(0.000)	-0.056**	(0.017)	-0.009	(0.542)
Pollution top-up	-0.036**	(0.011)	0.032	(0.140)	0.001	(0.945)
Beneficiaries						
Business deliveries (reference)						
Residents	0.068***	(0.000)	0.045*	(0.059)	-0.014	(0.315)
Motorbikes	-0.006	(0.712)	0.010	(0.676)	-0.035**	(0.019)
Frequent commuters	0.021	(0.183)	0.027	(0.272)	0.006	(0.653)
Electric vehicles	0.012	(0.453)	-0.037	(0.158)	-0.05***	(0.002)
Exemption level						
0% (reference)						
25%	0.01	(0.545)	-0.020	(0.344)	0.004	(0.756)
50%	0.039***	(0.010)	0.029	(0.184)	0.036**	(0.012)
75%	0.039**	(0.016)	0.048**	(0.021)	0.049***	(0.000)
100%	0.054***	(0.001)	0.026	(0.255)	0.098***	(0.000)
Use of revenue						
Vehicle registration fee (reference)						
Public transportation	0.087***	(0.000)	0.079***	(0.001)	0.080***	(0.000)
Transport infrastructure	0.058***	(0.000)	0.052**	(0.025)	0.044***	(0.003)
Pollution reduction	0.066***	(0.000)	0.053**	(0.026)	0.039**	(0.011)
Tunnel or bridge	0.020	(0.208)	0.038	(0.152)	0.050***	(0.001)
Number of respondents	547		235		632	
Number of observations	16’407		7’047		18’954	
Pseudo R^2	0.0456		0.0775		0.1148	

Estimates report average marginal effects from conditional logit.
p-values in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.18: Estimates from conditional logit by commuting mode with *p*-values

	(1) Car and motorbike		(2) Public transportation, cycling and walking	
Charge rate				
CHF 0 (reference)				
CHF 0.2	-0.043	(0.110)	-0.056**	(0.010)
CHF 1	-0.140***	(0.000)	-0.086***	(0.000)
CHF 2	-0.248***	(0.000)	-0.159***	(0.000)
CHF 3	-0.321***	(0.000)	-0.224***	(0.000)
CHF 4	-0.328***	(0.000)	-0.252***	(0.000)
CHF 5	-0.388***	(0.027)	-0.292***	(0.000)
Perimeter				
Center (reference)				
Ring	-0.018	(0.138)	-0.004	(0.693)
Modulation				
Constant (reference)				
Peak hours only	0.031**	(0.041)	0.010	(0.352)
Peak hours top-up	0.014	(0.346)	0.004	(0.719)
Distance top-up	-0.012	(0.456)	-0.063***	(0.000)
Pollution top-up	0.004	(0.789)	-0.017	(0.142)
Beneficiaries				
Business deliveries (reference)				
Residents	-0.006	(0.723)	0.047***	(0.000)
Motorbikes	-0.016	(0.334)	-0.017	(0.193)
Frequent commuters	0.009	(0.559)	0.018	(0.132)
Electric vehicles	-0.067***	(0.000)	0.002	(0.896)
Exemption level				
0% (reference)				
25%	0.020	(0.190)	-0.007	(0.537)
50%	0.045***	(0.004)	0.031***	(0.009)
75%	0.061***	(0.000)	0.036***	(0.003)
100%	0.096***	(0.000)	0.054***	(0.000)
Use of revenue				
Vehicle registration fee (reference)				
Public transportation	0.061***	(0.000)	0.093***	(0.000)
Transport infrastructure	0.033**	(0.035)	0.062***	(0.000)
Pollution reduction	0.051***	(0.001)	0.052***	(0.000)
Tunnel or bridge	0.05***	(0.002)	0.027**	(0.042)
Number of respondents	544		870	
Number of observations	16’314		26’094	
Pseudo R^2	0.1206		0.0552	

Estimates report average marginal effects from conditional logit.
p-values in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.19: Estimates from conditional logit by commuting frequency with p-values

	(1) Inhabitants of the Canton of Geneva		(2) 6-7 trips/week to Geneva		(3) 1-5 trips/week to Geneva	
Charge rate						
CHF 0 (reference)						
CHF 0.2	-0.046	(0.104)	-0.103***	(0.005)	-0.03	(0.246)
CHF 1	-0.0742***	(0.009)	-0.151***	(0.000)	-0.119***	(0.000)
CHF 2	-0.151***	(0.000)	-0.255***	(0.000)	-0.201***	(0.000)
CHF 3	-0.214***	(0.000)	-0.288***	(0.000)	-0.290***	(0.000)
CHF 4	-0.205***	(0.000)	-0.322***	(0.000)	-0.335***	(0.000)
CHF 5	-0.266***	(0.000)	-0.340***	(0.000)	-0.383***	(0.000)
Perimeter						
Center (reference)						
Ring	0.002	(0.861)	0.006	(0.696)	-0.026**	(0.019)
Modulation						
Constant (reference)						
Peak hours only	-0.008	(0.582)	0.038**	(0.048)	0.031**	(0.032)
Peak hours top-up	-0.01	(0.506)	0.017	(0.388)	0.02	(0.162)
Distance top-up	-0.084***	(0.000)	-0.055***	(0.008)	-0.004	(0.804)
Pollution top-up	-0.024*	(0.099)	-0.019	(0.364)	0.013	(0.331)
Beneficiaries						
Business deliveries (reference)						
Residents	0.053***	(0.001)	0.031	(0.117)	0.003	(0.820)
Motorbikes	-0.009	(0.604)	0.013	(0.533)	-0.04**	(0.010)
Frequent commuters	0.021	(0.192)	0.041**	(0.048)	-0.003	(0.826)
Electric vehicles	-0.011	(0.501)	-0.007	(0.732)	-0.043**	(0.010)
Exemption level						
0% (reference)						
25%	-0.001	(0.958)	-0.0002	(0.990)	0.007	(0.628)
50%	0.025	(0.108)	0.042**	(0.023)	0.043***	(0.005)
75%	0.026	(0.110)	0.065***	(0.002)	0.050***	(0.000)
100%	0.041**	(0.011)	0.045**	(0.030)	0.107***	(0.000)
Use of revenue						
Vehicle registration fee (reference)						
Public transportation	0.076***	(0.000)	0.106***	(0.000)	0.075***	(0.000)
Transport infrastructure	0.045***	(0.003)	0.060***	(0.007)	0.051***	(0.001)
Pollution reduction	0.054***	(0.001)	0.062***	(0.005)	0.044***	(0.007)
Tunnel or bridge	0.007	(0.688)	0.054**	(0.018)	0.052***	(0.002)
Number of respondents	515		314		585	
Number of observations	15’444		9’414		17’550	
Pseudo R^2	0.0531		0.0735		0.1057	

Estimates report average marginal effects from conditional logit.
p-values in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.20: Estimates from conditional logit with *p*-values: cars vs. motorbikes

	(1) Car		(2) Motorbike	
Charge rate				
CHF 0 (reference)				
CHF 0.2	-0.022	(0.445)	-0.159**	(0.021)
CHF 1	-0.124***	(0.000)	-0.234***	(0.001)
CHF 2	-0.233***	(0.000)	-0.334***	(0.000)
CHF 3	-0.319***	(0.000)	-0.343***	(0.000)
CHF 4	-0.321***	(0.000)	-0.376***	(0.000)
CHF 5	-0.375***	(0.000)	-0.454***	(0.000)
Perimeter				
Center (reference)				
Ring	-0.02	(0.117)	-0.008	(0.794)
Modulation				
Constant (reference)				
Peak hours only	0.029*	(0.081)	0.05	(0.174)
Peak hours top-up	0.013	(0.422)	0.028	(0.463)
Distance top-up	-0.013	(0.448)	0.008	(0.838)
Pollution top-up	0.004	(0.820)	0.013	(0.733)
Beneficiaries				
Business deliveries (reference)				
Resident	-0.004	(0.796)	-0.008	(0.808)
Motorbikes	-0.048***	(0.006)	0.147***	(0.000)
Frequent commuters	0.013	(0.446)	-0.019	(0.614)
Electric vehicles	-0.073***	(0.000)	-0.026	(0.514)
Exemption level				
0% (reference)				
25%	0.011	(0.503)	0.071*	(0.075)
50%	0.037**	(0.025)	0.081**	(0.040)
75%	0.052***	(0.002)	0.098***	(0.004)
100%	0.092***	(0.000)	0.117***	(0.002)
Use of revenue				
Vehicle registration fee (reference)				
Public transportation	0.053***	(0.002)	0.101***	(0.007)
Transport infrastructure	0.036**	(0.031)	0.009	(0.828)
Pollution reduction	0.054***	(0.001)	0.029	(0.477)
Tunnel or bridge	0.045**	(0.011)	0.085**	(0.047)
Number of respondents	465		79	
Number of observations	13’944		2’370	
pseudo R^2	0.1285		0.1066	

Estimates report average marginal effects from conditional logit.
p-values in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.21: Latent classes: estimates from conditional logit with p-values

	(1)		(2)		(3)		(4)		(5)	
	Latent class 1		Latent class 2		Latent class 3		Latent class 4		Latent class 5	
Charge rate										
CHF 0 (reference)										
CHF 0.2	0.323***	(0.000)	-0.302***	(0.000)	0.069**	(0.031)	-0.316***	(0.000)	0.472***	(0.000)
CHF 1	0.334***	(0.000)	-0.236***	(0.000)	-0.179***	(0.000)	-0.332***	(0.000)	0.354***	(0.000)
CHF 2	0.319***	(0.000)	-0.225***	(0.000)	-0.376***	(0.000)	-0.507***	(0.000)	0.058	(0.130)
CHF 3	0.307***	(0.000)	-0.299***	(0.000)	-0.456***	(0.000)	-0.382***	(0.000)	-0.126***	(0.001)
CHF 4	0.297***	(0.000)	-0.274***	(0.000)	-0.469***	(0.000)	-0.439***	(0.000)	-0.290***	(0.000)
CHF 5	0.279***	(0.000)	-0.297***	(0.000)	-0.647***	(0.000)	-0.416***	(0.000)	-0.475***	(0.000)
Perimeter										
Center (reference)										
Ring	0.0004	(0.944)	-0.062***	(0.005)	0.010	(0.499)	-0.042	(0.137)	-0.029	(0.117)
Modulation										
Constant (reference)										
Peak hours only	0.010	(0.204)	-0.013	(0.583)	0.040*	(0.084)	0.054	(0.164)	0.001	(0.976)
Peak hours top-up	0.016**	(0.031)	0.005	(0.832)	-0.017	(0.475)	0.003	(0.946)	-0.027	(0.304)
Distance top-up	-0.028***	(0.000)	-0.036	(0.163)	-0.064**	(0.013)	-0.051	(0.315)	-0.082***	(0.003)
Pollution top-up	-0.001	(0.924)	0.008	(0.750)	-0.034	(0.127)	0.034	(0.407)	-0.061**	(0.020)
Beneficiaries										
Business deliveries (reference)										
Residents	0.021***	(0.008)	0.115***	(0.000)	-0.031	(0.161)	-0.002	(0.963)	-0.014	(0.609)
Motorbikes	-0.005	(0.512)	0.04	(0.191)	-0.066**	(0.012)	-0.039	(0.322)	-0.090***	(0.001)
Frequent commuters	0.014*	(0.074)	0.066**	(0.018)	-0.039*	(0.087)	0.043	(0.208)	-0.01	(0.712)
Electric vehicles	-0.007	(0.358)	0.081***	(0.003)	-0.132***	(0.000)	-0.208**	(0.024)	-0.106***	(0.000)
Exemption level										
0% (reference)										
25%	-0.005	(0.552)	0.011	(0.627)	0.043*	(0.075)	-0.116**	(0.022)	0.045*	(0.063)
50%	0.014*	(0.075)	0.047*	(0.057)	0.102***	(0.000)	-0.045	(0.222)	0.111***	(0.000)

Table A.21 (continued)

	(1) Latent class 1		(2) Latent class 2		(3) Latent class 3		(4) Latent class 4		(5) Latent class 5	
75%	0.014*	(0.084)	0.062**	(0.014)	0.092***	(0.000)	-0.071	(0.079)	0.148***	(0.000)
100%	0.026***	(0.002)	0.092***	(0.000)	0.156***	(0.000)	-0.01	(0.763)	0.179***	(0.000)
Use of revenue										
Vehicle registration fee (reference)										
Public transportation	0.036***	(0.000)	0.247***	(0.000)	0.037	(0.105)	-0.038	(0.373)	0.038	(0.159)
Transport infrastructure	0.033***	(0.000)	0.122***	(0.000)	0.036	(0.120)	-0.012	(0.760)	0.020	(0.4537)
Pollution reduction	0.021***	(0.010)	0.191***	(0.000)	-0.006	(0.773)	0.025	(0.494)	0.007	(0.791)
Tunnel or bridge	0.012	(0.142)	0.078**	(0.012)	0.030	(0.230)	-0.009	(0.818)	0.085***	(0.005)
Number of respondents	393		222		233		365		201	
Number of observations	11’784		6’660		6’990		10’947		6027	
Pseudo R^2	0.3028		0.0499		0.4381		0.9333		0.4550	

Estimates report average marginal effects from conditional logit.

p-values in parentheses.

* $p < 0.01$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A.22: Latent classes: membership estimates from multinomial logit with p-values

	(1)		(2)		(3)		(4)		(5)	
	Latent class 1		Latent class 2		Latent class 3		Latent class 4		Latent class 5	
<30 years old	0.029	(0.404)	-0.014	(0.629)	0.014	(0.634)	-0.064*	(0.070)	0.03	(0.277)
>65 years old	0.120	(0.565)	-2.091***	(0.000)	-2.270***	(0.000)	0.066	(0.748)	0.081	(0.529)
Gender (female)	0.016	(0.579)	0.024	(0.314)	0.003	(0.896)	-0.014	(0.603)	-0.028	(0.205)
Swiss	0.089**	(0.014)	0.040	(0.178)	0.002	(0.945)	0.067**	(0.037)	-0.171***	(0.000)
Resident of the center	0.058*	(0.084)	-0.023	(0.421)	-0.010	(0.751)	-0.048	(0.182)	0.023	(0.477)
Household size	0.016*	(0.050)	-0.002	(0.753)	-0.003	(0.632)	-0.026***	(0.004)	0.014**	(0.022)
Car and motorbike commuters	-0.059*	(0.051)	-0.072***	(0.004)	0.076***	(0.004)	0.092***	(0.002)	-0.037	(0.134)
Number of respondents	998		998		9'98		998		998	
Number of observations	29'940		29'940		29'940		29'940		29'940	
Pseudo R^2	0.0267		0.0187		0.0122		0.0265		0.0716	
Share of respondents	27.5%		16.3%		16.3%		25.7%		14.2%	

Estimates report average marginal effects.
p-values in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Appendix B

Appendix to Chapter 3

B.1 Questionnaire

Sorting habits

1. Which of the following categories of waste is/are sorted by your household? *[Note: If you do not sort, it means that you are putting this type of waste in the waste bag directly for incineration or that you do not produce this type of waste]*

   ☐ Paper/cardboard

   ☐ PET bottles

   ☐ White plastic milk bottles

   ☐ Glass

   ☐ Organic waste

   ☐ Aluminum or tinplate cans

   ☐ Coffee capsules, Nespresso type

   ☐ Batteries

   ☐ Clothing or other textiles

   ☐ Electrical equipment including neon lights and long life light bulbs and LEDs

2. *[If at least one item in Q1 is not checked]* What is/are the main reason-s why you do not sort more wastes? *[Multiple answers possible]*

   ☐ I do not produce this type of waste.

- ☐ It causes me too many inconveniences (smells, dirt,...).
- ☐ The collection point is too far away or poorly located.
- ☐ There is no curb collection for these categories of wastes.
- ☐ I do not have enough space to sort more categories of waste at home.
- ☐ I do not know where to take them.
- ☐ I produce too little waste, so there is no need to sort it out.
- ☐ I do not have time to sort.
- ☐ I do not see the point of sorting.
- ☐ Other

3. Do you use the "little green bin" for your organic wastes?

   ☐ Yes ☐ No

4. How many bags of unsorted waste (black bags) do you fill in average per week?

   Number: _ or ☐ less than one

5. What is the capacity of the bag for unsorted waste you usually use? *[Note: If asked, the interviewer must say that the 35-litre bag is the most common bag]*

   ☐ 17 liters ☐ 35 liters ☐ 60 liters ☐ 110 liters

6. On a scale of 1 to 7, 1 being "strongly disagree" and 7 being "strongly agree", to what extent do you agree with the following statement: " I think that my household produces too much non-recyclable waste that goes to incineration".

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   1 = Strongly disagree
   2 = Disagree
   3 = Somewhat disagree
   4 = No opinion
   5 = Soemwhat agree
   6 = Agree
   7 = Strongly agree

7. On a scale of 1 to 7, 1 being "strongly disagree" and 7 being "strongly agree", to what extent do you agree with the following statement: " I think that my household do its best to sort its wastes".

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

8. On a scale of 1 to 7, 1 being "strongly disagree" and 7 being "strongly agree", to what extent do you agree with the following statement: "I think that my household could

reduce its wastes by being more careful when buying”.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

9. On a scale of 1 to 7, 1 being “strongly disagree” and 7 being “strongly agree”, to what extent do you agree with the following statement: “In my household, we all share the same opinion on waste sorting".

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Sorting determinants and motivation

10. Are you satisfied or not by the waste collection scheme proposed by your municipality?

    ☐ Yes ☐ No

11. *[If the answer is no]* Why are you dissatisfied with the waste collection scheme proposed by your municipality? *[Multiple answers possible]*

    ☐ The collection point is too far away.
    ☐ Curb frequency is too low.
    ☐ There are not enough waste categories collected at curb.
    ☐ There are too many waste categories to be sorted.
    ☐ Sorting containers are too often full.
    ☐ The municipality does not inform us enough about waste sorting.

12. Is it easy or not for you to sort your waste? *[Note: easy to sort according to the space available in your home, the odors, your knowledge, etc.]*.

    ☐ Yes ☐ No

Concerning waste disposal in your municipality, including curb collection, waste disposal centers and collection points, indicate on a scale of 1 to 7 if you 1 = Strongly disagree, 2 = Disagree, 3 = Somewhat disagree, 4 = No opinion, 5 = Somewhat agree, 6 = Agree, 7 = Strongly agree with the following statements:

13. I know the different waste categories to be sorted.

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

14. I know where I should bring my wastes.

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

15. I know how to sort my waste (e.g. separate organic and garden waste, do not throw paper/cardboard soiled with food with the paper/cardboard).

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

There may be a variety of reasons for sorting waste, again indicate on a scale of 1 to 7 if you 1 = Strongly disagree, 2 = Disagree, 3 = Somewhat disagree, 4 = No opinion, 5 =Somewhat agree, 6 = Agree, 7 = Strongly agree on the following statements :

16. I have bad conscience if I do not sort my wastes.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
17. I think I have to sort my wastes for the environment.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
18. I think that the majority of my acquaintances (friends, family,. . .) except me to sort my wastes.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
19. I think that the majority of my acquaintances sort their wastes.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
20. It is important to sort your wastes.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
21. It is fair to sort your wastes.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
22. Waste sorting is imposed by the municipality.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
23. Sorting my wastes saves money to my municipality.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

24. On a scale of 1 to 5, do you think that the majority of the inhabitants of your municipality sort 1 = no waste to 5 = all its waste?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Do you agree with the following statements regarding the utility of waste sorting on a scale of 1 to 7 if you 1 = Strongly disagree, 2 = Disagree, 3 = Somewhat disagree, 4=No opinion, 5 = Somewhat agree, 6 = Agree, 7 = Strongly agree?

25. Sorting is useless because all wastes are mixed and incinerated afterwards anyway.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

26. Sorting is useless because recyclable wastes are sorted again afterwards.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

27. The sorting of my household will not contribute to a better environment.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

28. Unrecycled wastes are a threat to humans and the environment.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

29. Personally, I am not interested in sorting my waste, because environmental problems concern future generations.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

30. Your municipality is improving the sorting system for households, but sorting waste is a voluntary act. Which of the following proposals do you agree with the most? *[only one answer possible]*
☐ It's good for the environment, but not for me, as I am expected to make a greater contribution.
☐ It's good for the environment and for me, because I can increase my contribution.
☐ It makes no difference to me.
☐ I don't know.

31. Here are two sentences that are often heard in discussions about the environment and economic growth. Which of the two statements is closer to your personal opinion?
☐ More importance should be attached to protecting the environment, even if it hinders economic growth and results in the loss of some jobs.
☐ Economic growth and job creation should be given the highest priority, even if the environment suffers to some extent.
☐ I do not agree with any of these statements.

Waste collection scheme preferences

[To be read by the interviewer] We will now proceed to the vote. For this part, you received in advance some material at home. The material you received contains different proposals for a waste collection scheme combining each time :

- A curb collection frequency
- The types of wastes collected at curb
- A distance to the nearest collection point in minutes by foot

- A price to be paid per person per month for a given collection scheme.

  These proposals are presented to you in pairs and you are invited to vote for the one you prefer. You will vote 8 times, but you can only choose one proposal at a time. There is no right or wrong answers.
  [For each vote, the interviewer should ask for the individual's preferred alternative: alternative 1 or alternative 2. In total there are 8 votes. If the individual does not have the material on hand or has thrown it away, then the interviewer must say that it will be sent again by email and make an appointment to complete the survey.]
  [Additional information for the interviewer:

- *Curb collection frequency (per month or per week): Number of times per month or week your garbage is collected from your home.*
- *Categories of waste collected at curb: types of waste collected at your home (on the sidewalk). The types of waste collected at curb can always be brought to the sorting center if need/desired.*
- *Distance to the nearest collection point: number of minutes from your home to the nearest collection point by foot.*
- *Price per person per month: price per person per month of the proposed collection scheme paid directly by the households or indirectly through their taxes]*

Respondent profile

32. Are you:

    ☐ A woman☐ A man

33. In which municipality do you live?

    Name of the municipality: *[SCROLLING LIST]*

34. How old are you? _

35. How many people usually live in your household, including yourself? (You must include your family, but also any other person who lives in your household for at least 4 days per week)

    _ babies (0-3 years)
    _ children (3-12 years old)
    _ youth (between 12 and 18 years old)
    _ adults (between 18 and 30 years old)
    _ adults (between 30 and 65 years old)
    _ adults (over 65 years old)

36. What is your nationality? *[several answers possible]*

    ☐ Switzerland
    ☐ Other European countries
    ☐ North America
    ☐ Central and South America
    ☐ Africa
    ☐ Asia
    ☐ Oceania

37. What is the last diploma you obtained?

    ☐ Compulsory school
    ☐ Apprenticeship
    ☐ Post-compulsory school (e.g. secondary school)
    ☐ Tertiary education (e.g. university)
    ☐ No diploma

38. What is your current main (professional) activity?

    ☐ Homemaker
    ☐ Student
    ☐ Employed or self-employed full or part time
    ☐ Unemployed
    ☐ Retired

39. You are currently living in :

    ☐ A house
    ☐ An apartment with terrace/balcony
    ☐ An apartment without terrace/balcony
    ☐ An apartment with access to the garden

40. How long have you lived in your current dwelling?

    ☐ < = 1 year
    ☐ < = 2 years
    ☐ < = 3 years
    ☐ < = 4 years
    ☐ < = 5 years
    ☐ < = 6 years
    ☐ More than 6 years

41. Do you (your household) own or rent your dwelling?

    ☐ Owner

☐ Tenant
☐ Roommate

42. Are you for or against the bag tax as practiced in the other cantons?

☐ For
☐ Against
☐ Depends on price
☐ Indifferent
☐ No opinion

43. You think that the bag tax… *[Several possible answers, there are no right answers or false]*

☐ makes it possible to charge more households that do not sort their waste.
☐ contributes to the quality of the environment.
☐ reduces waste management costs.
☐ favors the rich and therefore is antisocial.
☐ makes you pay money while you are already sorting.
☐ is not fair because you are already taxed enough.
☐ encourages people to dispose of their waste illegally.
☐ is useless, because it does not change people's behavior.

44. How far, in minutes by foot, is the closest collection point to your home?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ more than 10 minutes by foot

45. How do you get to the collection point most often?

☐ By foot
☐ By bike
☐ By car
☐ By motorcycle/scooter

46. What is the total gross monthly income of your household (with allowances, subsidies and other support). We would like to remind you that all data is treated confidentially and anonymously. *[Note: The gross monthly incomes of all household members should be summed.]*

☐ <3'000 CHF
☐ 3'000 - 5'000 CHF
☐ 5'001 - 7'000 CHF
☐ 7'001 - 9'000 CHF
☐ 9'001 - 15'000 CHF
☐ > 15'001 CHF
☐ No response *[Note: Do not offer this response spontaneously to the respondent].*

B.2 Tables

B.2.1 Sample characteristics and representativity

TABLE B.1: Sample composition

Variables	Mean	Std. dev.	Min	Max	N
Self-efficacy	6.484	0.747	1	7	591
Bad conscience	5.551	1.963	1	7	591
Maximum effort	5.814	1.299	1	7	591
System satisfaction	0.882	0.323	0	1	591
Use of the green bin	0.643	0.480	0	1	591
Environmentalist	0.766	0.423	0	1	591
Living in city	0.805	0.396	0	1	591
Years since moving-in	6.306	1.615	1	7	591
Distance to the nearest collection point	3.606	2.793	1	12	591
Number of sorted categories	8.059	1.577	1	10	591
In favor of the bag tax	0.281	0.450	0	1	591
Gender (female)	0.528	0.500	0	1	591
Age	53.406	12.834	18	74	591
Household size	2.362	1.339	1	8	591
Home property					
Owner	0.200	0.400	0	1	591
Tenant	0.799	0.401	0	1	591
Education					
Compulsory school	0.074	0.263	0	1	591
Apprenticeship	0.379	0.486	0	1	591
High school	0.164	0.371	0	1	591
University	0.365	0.482	0	1	591
No diploma	0.017	0.129	0	1	591
Gross income per month					
Less than CHF 3’000	0.074	0.263	0	1	591
CHF 3’000 to 5’000	0.193	0.395	0	1	591
CHF 5’001 to 7’000	0.140	0.348	0	1	591
CHF 7’001 to 9’000	0.159	0.366	0	1	591
CHF 9’001 to 15’000	0.242	0.429	0	1	591
More than 15’000	0.098	0.298	0	1	591
No answer	0.093	0.291	0	1	591

TABLE B.2: Socioeconomic characteristics of the underlying population - Geneva

Variables	Geneva Mean	Sample Mean
Gender (female)	0.515	0.528
Nationality (Swiss)	0.599	0.787
Owner	0.184	0.200
Tenant	0.781	0.799
Median income	8’219 - 8’904	7’001 - 9’000
Tertiary education (university)	0.388	0.366
Urban population	0.798	0.805

Source: All variables come from the Cantonal Office of Statistics

B.2.2 Descriptive statistics

TABLE B.3: Descriptive statistics: number of categories sorted

	N	Mean	Std dev.	Min.	Max
Paper	591	0.983	0.129	0	1
Glass	591	0.971	0.167	0	1
PET	591	0.963	0.189	0	1
White plastic milk bottles	591	0.418	0.494	0	1
Organic waste	591	0.807	0.395	0	1
Aluminum or tineplate cans	591	0.817	0.387	0	1
Coffee capsules, Nespresso type	591	0.453	0.498	0	1
Batteries	591	0.936	0.246	0	1
Electrical equipment	591	0.799	0.401	0	1
Clothing or other textiles	591	0.912	0.284	0	1
Number of categories sorted	591	8.059	1.577	1	10
Satisfied with sorting scheme	521	8.163	1.488	1	10
Dissatisfied with sorting scheme	70	7.286	1.972	1	10
It feels easy to sort	564	8.114	1.518	1	10
It feels not easy to sort	27	6.926	2.269	1	10
Collection point at less than 8 minutes by foot	527	8.110	1.529	1	10
Collection point at more than 8 minutes by foot	64	7.641	1.889	1	10
Sensitive to the environment	453	8.212	1.446	1	10

TABLE B.4: Descriptive statistics: proportion of households

	Proportion of households	N
Households sorting less than average	28%	591
Households sorting average	27%	591
Households sorting more than average	45%	591
Reasons for not sorting more		
I do not produce this type of waste	60%	504
It causes me too many inconveniences (smells, dirt,...)	7%	504
The collection point is too far away or poorly located	5%	504
There is no curb collection for these categories of wastes	7%	504
I do not have enough space to sort more categories of waste at home	4%	504
I do not know where to take them	14%	504
I produce too little waste, so there is no need to sort it out	11%	504
I do not have time to sort	3%	504
I do not see the point of sorting	3%	504
Other	17%	504
Households using the small green bin	64%	591
Households sorting organic waste without the small green bin	46%	211
Households satisfied with the sorting scheme	88%	591
Reason of sorting scheme dissatisfaction		
The collection point is too far away	37%	70
Curb frequency is too low	11%	70
There are not enough waste categories collected at curb	27%	70
There are too many waste categories to be sorted	1%	70
Sorting containers are too often full	13%	70
The municipality does not inform us enough about waste sorting	4%	70
Other	33%	70

B.2.3 Additional empirical results

TABLE B.5: Marginal effects of the ordered probit model for household sorting behavior

Variable	Change in probability of sorting		
	Less than average	Average	More than average
Self-efficacy	-0.076***	-0.015**	0.092***
	(0.029)	(0.006)	(0.034)
Bad conscience	-0.114***	-0.023***	0.137***
	(0.030)	(0.007)	(0.036)
Maximum effort	-0.116***	-0.024***	0.140***
	(0.029)	(0.007)	(0.036)
System satisfaction	-0.142***	-0.029***	0.170***
	(0.041)	(0.010)	(0.049)
Use of the green bin	-0.161***	-0.033***	0.194***
	(0.028)	(0.008)	(0.034)
Environmentalist	-0.093***	-0.019***	0.111***
	(0.033)	(0.007)	(0.040)
Living in a city	0.086**	0.018**	-0.104**
	(0.035)	(0.008)	(0.042)
Years since moving-in	-0.123***	-0.025***	0.149***
	(0.035)	(0.008)	(0.042)

Note: *Pseudo* $R^2 = 0.1187$, $N = 591$.
Estimates report average marginal effects from the ordered probit model.
, * indicate significance at the 95%, 99% level of confidence, respectively.

TABLE B.6: Willingness to pay for the different waste collection scheme characteristics

Attributes of the waste collection schemes	Marginal willingness to pay
Curb collection frequency	
Once a month	-1.90
Twice a month	-1.02
Once a week	0.46
Twice a week (reference)	
Waste categories collected at curb	
General waste (reference)	
General waste and paper	0.22 (not stat. sign.)
General waste, paper and organics	0.59
General waste, paper, organics and glass	0.47
Distance to the nearest collection point	
2 minutes by foot	0.37
4 minutes by foot	0.92
6 minutes by foot	0.85
8 minutes by foot (reference)	

Note: $N = 591$. Each respondent choosing between two alternatives 8 times, we use 9’456 observations.

B.2.4 Heterogeneity analysis

TABLE B.7: Household characteristics of the different latent classes: estimates of the multinomial logistic model

Household characteristics	Class 1 "The minimalist"	Class 2 "The demanding"	Class 3 "The moderate"
Self-efficacy	-0.048*	0.054**	
	(0.025)	(0.026)	
Action efficacy		0.055***	-0.037**
		(0.014)	(0.016)
Gender (female)	-0.087**	0.096***	
	(0.039)	(0.029)	
Minors		-0.069**	
(0 - 17 years old)		(0.031)	
Young adults	-0.092*		0.123***
(18 - 30 years old)	(0.05)		(0.047)
Adults			-0.107**
(31 - 65 years old)			(0.048)
Living in city	-0.1*		
	(0.057)		
Collect system			
Both: curb and point (reference)			
Curb collection	0.016		0.054
	(0.075)		(0.480)
Collection points	0.480***		-0.502***
	(0.150)		(0.170)
Gross income per month			
Less than CHF 3'000		-0.003	
		(0.066)	
CHF 3'000 to 5'000		-0.156**	
		(0.066)	
CHF 5'001 to 7'000 (reference)			
CHF 7'001 to 9'000		0.11**	
		(0.046)	
CHF 9'001 to 15'000		0.012	
		(0.047)	
More than 15'000		0.112**	
		(0.056)	
No answer		-0.06	
		(0.068)	
Pseudo R^2	0.0627	0.1401	0.0508

Note: $N = 591$. This table reports marginal effects of the LCM and robust standard errors in parenthesis.
*, **, *** indicate significance at the 90%, 95%, 99% level of confidence, respectively.

TABLE B.8: Household characteristics of the different latent classes: estimates of the probit model

Household characteristics	Class 1 "The minimalist"	Class 2 "The demanding"	Class 3 "The moderate"
Self-efficacy	-0.048*	0.058**	
	(0.025)	(0.025)	
Action efficacy		0.053***	-0.036**
		(0.014)	(0.016)
Gender (female)	-0.087**	0.093***	
	(0.039)	(0.029)	
Minor (0 - 17 years old)		-0.069**	
		(0.030)	
Young adults (18 - 30 years old)	-0.092*		0.123***
	(0.049)		(0.047)
Adults (31 - 65 years old)			-0.109**
			(0.047)
Living in city	-0.099*		
	(0.056)		
Home property			
Owner (reference)			
Tenant	0.178***		-0.135***
	(0.054)		(0.049)
Opinion about the bag tax			
In favor (reference)			
Against	0.161***	-0.063**	-0.087*
	(0.045)	(0.031)	(0.045)
Depending on price	0.096	0.020	-0.145*
	(0.081)	(0.05)	(0.079)
Indifferent / no answer	0.100	-0.045	-0.083
	(0.08)	(0.054)	(0.080)
Collect system			
Both: curb and point (reference)			
Curb collection	0.014		0.054
	(0.075)		(0.076)
Collection points	0.465***		-0.047***
	(0.136)		(0.142)
Gross income per month			
Less than CHF 3'000		-0.006	
		(0.064)	
CHF 3'000 to 5'000		-0.146**	
		(0.060)	

Table B.8 (continued)

Household characteristics	Class 1 "The minimalist"	Class 2 "The demanding"	Class 3 "The moderate"
CHF 5'001 to 7'000 (reference)			
CHF 7'001 to 9'000		0.105**	
		(0.047)	
CHF 9'001 to 15'000		0.009	
		(0.047)	
More than 15'000		0.114**	
		(0.056)	
No answer		-0.063	
		(0.064)	
Pseudo R^2	0.0627	0.1395	0.0509

Note: $N = 591$. This table reports marginal effects of the LCM and robust standard errors in parenthesis.
*, **, *** indicate significance at the 90%, 95%, 99% level of confidence, respectively.

Appendix C

Appendix to Chapter 4

C.1 Questionnaires

C.1.1 Survey of 2016

1. Does your household sort the following materials? *[Several possible answers]*

   ☐ PET bottles
   ☐ Carton
   ☐ Paper
   ☐ Textiles
   ☐ Glass
   ☐ Cans
   ☐ Organic waste
   ☐ Batteries
   ☐ Aluminium

2. How many bags does your household fill with garbage every week?

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

3. Bags volume *[complement to previous question]*

   ☐ 17 liters
   ☐ 35 liters

4. Could you estimate the distance in minutes between your residence and the closest organic waste collection point?

5. Could you estimate the distance in meters between your residence and the closest organic waste collection point?

6. If you are sorting organic waste, what type of container do you use to do it?

   ☐ Green plastic bags
   ☐ Compastable bags
   ☐ Container without bag
   ☐ Other: _

7. How many containers does your household fill per week on average? *[complement to previous question]*

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

8. Can you estimate when you tend to empty your container? *[complement to previous question]*

   Completly empty ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completly plenty

9. If you have a garden, do you make your own compost?

   ☐ Yes ☐ No

10. If you do not sort organic waste, indicate why: *[Several possible answers]*

    ☐ Not enough space
    ☐ Bad smell
    ☐ Collection point too far away
    ☐ Not enough time
    ☐ Other: _

Respondent profile

11. In which municipality do you live?

12. Gender of the respondent:

    ☐ A woman ☐ A man

13. Year of birth: _

14. Of how many people (you included) is your household composed?

15. How many children (17 years old or younger) do you have in your household?

16. What is your nationality?

    ☐ Switzerland
    ☐ Rest of the world

17. What is the highest level of education that you attained?

    ☐ Compulsory schooling
    ☐ Apprenticeship
    ☐ Post-compulsory schooling
    ☐ Tertiary education

18. You are currently living in:

    ☐ a house.
    ☐ an apartment without terrace.
    ☐ an apartment with terrace.
    ☐ an apartment with (access to) garden.

19. Here are two sentences that are often heard in discussions about the environment and economic growth. Which of the two statements is closer to your personal opinion?

    ☐ More importance should be attached to protecting the environment, even if it hinders economic growth and results in the loss of some jobs.
    ☐ Economic growth and job creation should be given the highest priority, even if the environment suffers to some extent.
    ☐ I do not know.
    ☐ No answer.

20. Are you member of an environmental organization? (for example WWF; participating financially is a sufficient condition)

    ☐ Yes
    ☐ No

21. You think that the bag tax... *[Several possible answers]*

    ☐ allows for the application of the polluter-pays principle.
    ☐ favors the rich and therefore is antisocial.
    ☐ reduces waste management costs.
    ☐ is useless, because it does not change people's behavior.
    ☐ contributes to the quality of the environment.
    ☐ would encourage people to be more careful about the amount of waste.
    ☐ makes you pay money while you are already sorting.
    ☐ is not fair because you are already taxed enough.

22. In general, would you say that most people can be trusted or that you can never be too careful when dealing with others?

    ☐ Most people can be trusted.
    ☐ You can never be too careful when dealing with others.

23. What is the total gross annual income of your household (with allowances, subsidies and other support). We would like to remind you that all data is treated confidentially and anonymously.

    ☐ <35’000 CHF
    ☐ 35’001 - 50’000 CHF
    ☐ 50’001 - 80’000 CHF
    ☐ 80’001 - 120’000 CHF
    ☐ 120’001 - 160’000 CHF
    ☐ 160’001 - 200’000 CHF
    ☐ > 200’000 CHF
    ☐ No answer

C.1.2 Survey of 2017: Canton of Geneva

1. Does your household sort the following materials? *[Several possible answers]*

    ☐ PET bottles
    ☐ Carton
    ☐ Paper
    ☐ Textiles
    ☐ Glass
    ☐ Cans
    ☐ Organic waste
    ☐ Batteries
    ☐ Aluminium

2. How many bags does your household fill with garbage every week?

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

3. Bags volume *[complement to previous question]*

    ☐ 17 liters
    ☐ 35 liters

4. Have you moved since our last call (12 months ago)?

    ☐ Yes
    ☐ No

5. If you moved, in which municipality do you live now?

6. Could you estimate the distance in minutes between your residence and the closest organic waste collection point?

7. Could you estimate the distance in meters between your residence and the closest organic waste collection point?

8. Did you receive the kitchen bin at home to collect organic waste or did you have to pick it up at a distribution point in your municipality?

   ☐ At home *[Go to question 9]*
   ☐ Distribution point *[Go to question 10]*
   ☐ No kitchen bin *[Go to question 13]*

9. When did you receive the kitchen bin?

   ☐ September 2016
   ☐ October 2016
   ☐ November 2016
   ☐ December 2016
   ☐ January 2017
   ☐ February 2017
   ☐ March 2017
   ☐ April 2017
   ☐ May 2017
   ☐ June 2017
   ☐ July 2017
   ☐ August 2017
   ☐ September 2017
   ☐ October 2017
   ☐ November 2017

10. When did you pick up the kitchen bin at a distribution point?

   ☐ September 2016
   ☐ October 2016
   ☐ November 2016
   ☐ December 2016
   ☐ January 2017
   ☐ February 2017
   ☐ March 2017
   ☐ April 2017
   ☐ May 2017

☐ June 2017
☐ July 2017
☐ August 2017
☐ September 2017
☐ October 2017
☐ November 2017

11. Did you keep the kitchen bin?

    ☐ Yes *[Go to question 13]*
    ☐ No *[Go to question 12]*

12. Did you:

    ☐ throw or sell the kitchen bin?
    ☐ give the kitchen bin to someone living in the Canton of Geneva?
    ☐ give the kitchen bin to someone living in another canton?
    ☐ give the kitchen bin to someone living abroad (for example in neighbouring France)?

13. Do you sort your organic waste?

    ☐ Yes *[Go to question 14]*
    ☐ No *[Go to question 19]*

14. What type of container do you use to sort organic waste?

    ☐ Green plastic bags
    ☐ Compastable bags
    ☐ The kitchen bin
    ☐ Container without bag
    ☐ Other: _

15. How many containers does your household fill per week on average? *[complement to previous question]*

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

16. Can you estimate when you tend to empty your container? *[complement to previous question]*

    Completly empty ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completly plenty

17. Bag or container size to sort organic waste *[complement to previous question]*

    ☐ 5 liters
    ☐ 7 liters
    ☐ 9 liters
    ☐ Other: _

18. If you have a garden, do you make your own compost?

    ☐ Yes ☐ No

19. Indicate why you do not sort organic waste : *[Several possible answers]*

    ☐ Not enough space
    ☐ Bad smell
    ☐ Collection point too far away
    ☐ Not enough time
    ☐ Other: _

20. The kitchen bin was introduced in the Canton of Geneva to increase the recycling rate. in order to reach the same goal, other cantons have introduced a bag tax. Do you think such a measure should also be introduced in the Canton of Geneva?

    ☐ Yes
    ☐ No

21. You think that the bag tax... *[Several possible answers]*

    ☐ allows for the application of the polluter-pays principle.
    ☐ favors the rich and therefore is antisocial.
    ☐ reduces waste management costs.
    ☐ is useless, because it does not change people's behavior.
    ☐ contributes to the quality of the environment.
    ☐ would encourage people to be more careful about the amount of waste.
    ☐ makes you pay money while you are already sorting.
    ☐ is not fair because you are already taxed enough.

Household composition

22. Of how many people (you included) is your household composed?

23. How many children (17 years old or younger) do you have in your household?

C.1.3 Survey of 2017: Canton of Vaud

1. Does your household sort the following materials? *[Several possible answers]*

   ☐ PET bottles
   ☐ Carton
   ☐ Paper
   ☐ Textiles
   ☐ Glass
   ☐ Cans
   ☐ Organic waste
   ☐ Batteries
   ☐ Aluminium

2. How many bags does your household fill with garbage every week?

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

3. Bags volume *[complement to previous question]*

   ☐ 17 liters
   ☐ 35 liters

4. Have you moved since our last call (12 months ago)?

   ☐ Yes
   ☐ No

5. If you moved, in which municipality do you live now?

6. Could you estimate the distance in minutes between your residence and the closest organic waste collection point?

7. Could you estimate the distance in meters between your residence and the closest organic waste collection point?

8. Do you sort your organic waste?

   ☐ Yes *[Go to question 9]*
   ☐ No *[Go to question 14]*

9. What type of container do you use to sort organic waste?

   ☐ Green plastic bags
   ☐ Compastable bags
   ☐ Container without bag
   ☐ Other: _

10. How many containers does your household fill per week on average? *[complement to previous question]*

    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

11. Can you estimate when you tend to empty your container? *[complement to previous question]*

    ☐ 0 Completly empty ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completly plenty

12. Bag or container size to sort organic waste *[complement to previous question]*

    ☐ 5 liters
    ☐ 7 liters
    ☐ 9 liters
    ☐ Other: _

13. If you have a garden, do you make your own compost?

    ☐ Yes ☐ No

14. Indicate why you do not sort organic waste : *[Several possible answers]*

    ☐ Not enough space
    ☐ Bad smell
    ☐ Collection point too far away
    ☐ Not enough time
    ☐ Other: _

15. In the Canton of Vaud, almost all municipalities have now introduced a bag tax. The Canton of Geneva is the last canton without a bag tax or a similar instrument. If you were asked to vote now on the bag tax in your municipality, would you be in favour of:

    ☐ keeping it
    ☐ eliminating it

16. The price of a 17 liter bag is 1 CHF. Is this price correct for you and, if not, what price would you set in francs?

17. From a theoretical point of view, an instrument like the bag tax could lead to more littering or other illegal and undesirable actions. Do you think that in the Canton of Vaud these perverse effects are a problem?

    ☐ Yes
    ☐ No

18. In your opinion, is littering and other illegal and undesirable actions:

    ☐ a minor problem

☐ an important problem
☐ a very serious problem

19. You think that the bag tax... *[Several possible answers]*

    ☐ allows for the application of the polluter-pays principle.
    ☐ favors the rich and therefore is antisocial.
    ☐ reduces waste management costs.
    ☐ is useless, because it does not change people's behavior.
    ☐ contributes to the quality of the environment.
    ☐ would encourage people to be more careful about the amount of waste.
    ☐ makes you pay money while you are already sorting.
    ☐ is not fair because you are already taxed enough.

Household composition

20. Of how many people (you included) is your household composed?

21. How many children (17 years old or younger) do you have in your household?

C.2 Figures

FIGURE C.1: Parallel trends unsorted waste: treatment (VD) and control (GE) groups (2007-2014)

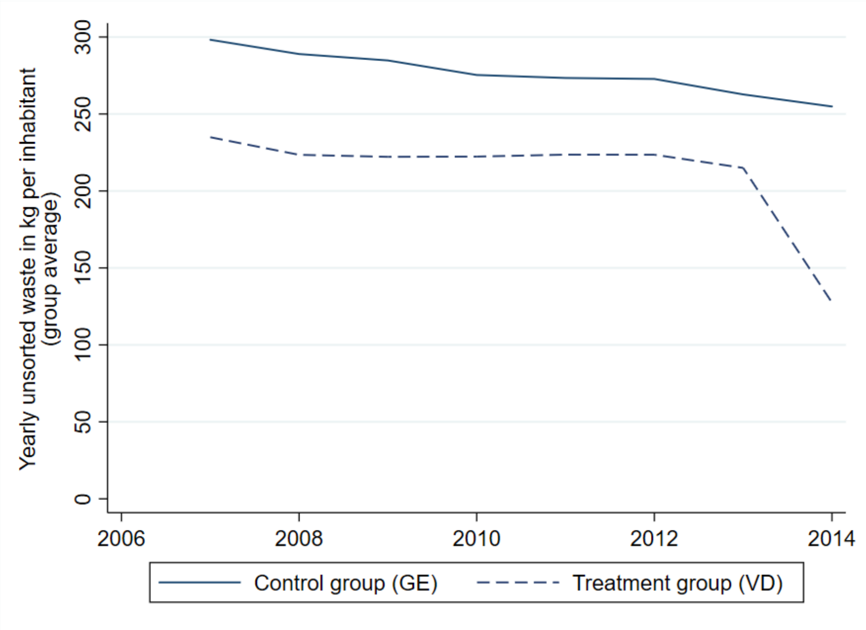


FIGURE C.2: Parallel trends sorted waste: treatment (VD) and control (GE) groups (2007-2014)

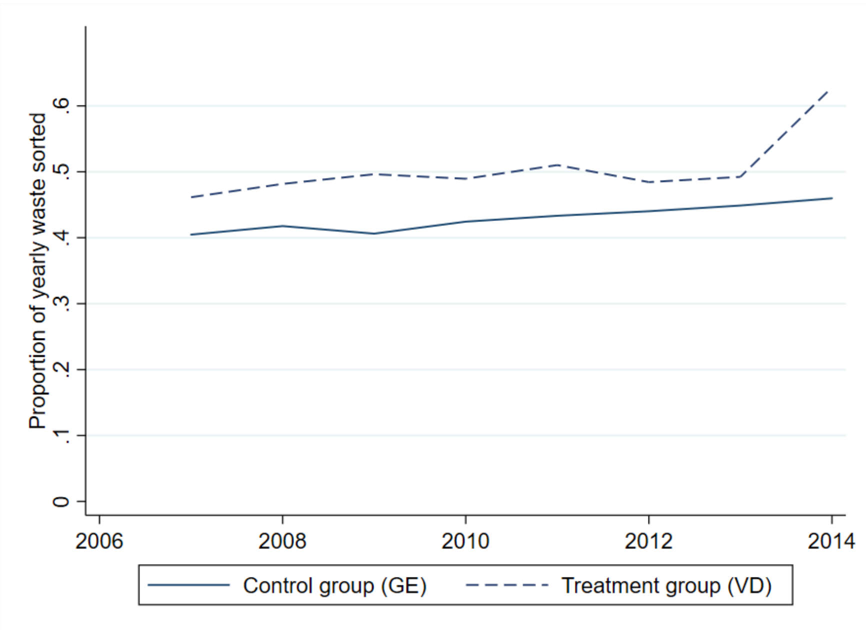


FIGURE C.3: Parallel trends unsorted waste: treatment (GE) and control (ZH) groups (2013-2017)

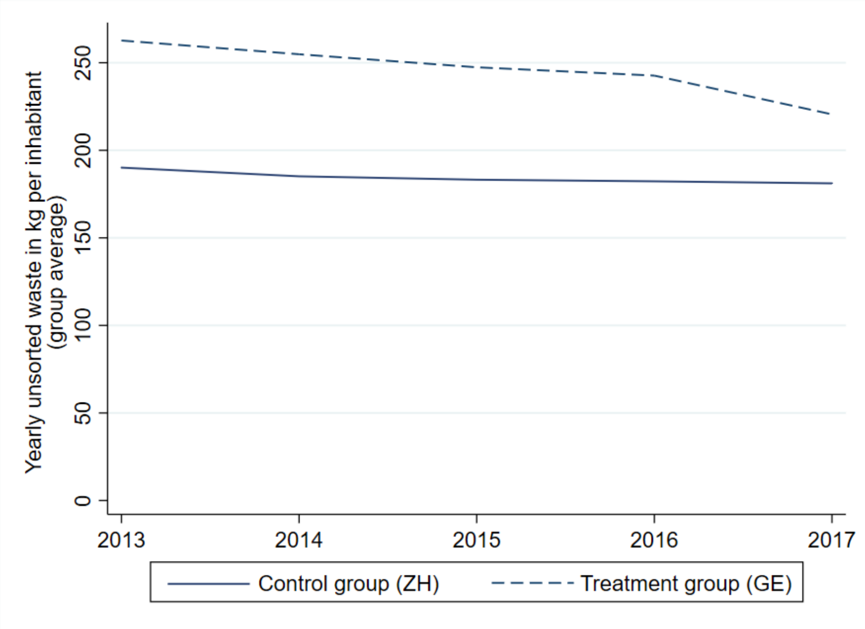
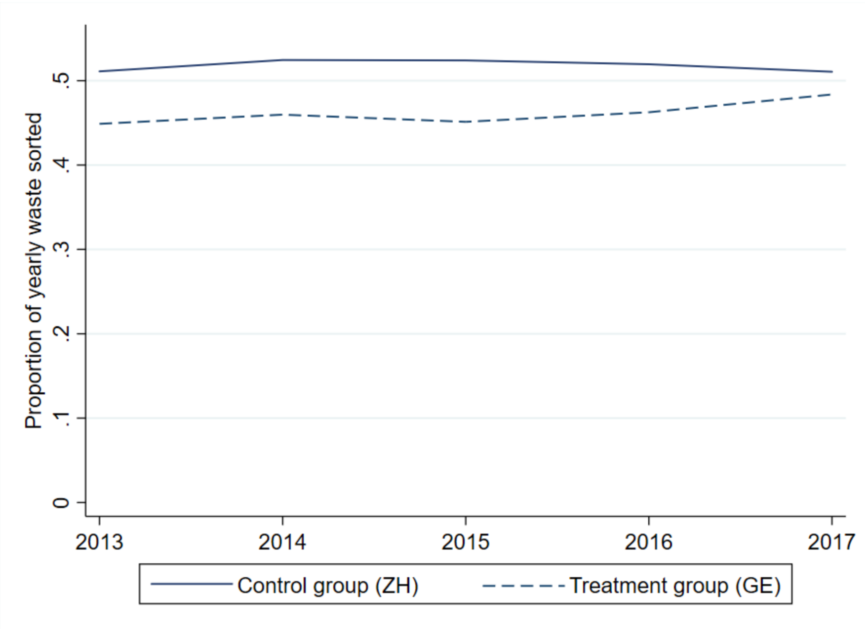


FIGURE C.4: Parallel trends sorted waste: treatment (GE) and control (ZH) groups (2013-2017)



C.3 Tables

C.3.1 Sample characteristics and representativity

TABLE C.1: Sample's socioeconomic characteristics of respondents: mean comparisons and tests with respondents of the 2016 survey only

	2016 only		Sample	
	GE	VD	GE	VD
Age	63.453	63.387	66.358	65.136
Gender (F)	0.631	0.639	0.709	0.593
Swiss	0.764	0.840	0.853**	0.860
Household size	2.084	2.148	2.285	2.135
Number of children	0.286	0.472	0.267	0.601
Compulsory schooling	0.274	0.215	0.164**	0.208
Apprenticeship	0.244	0.368	0.218	0.295
Highschool	0.208	0.174	0.309**	0.260*
University	0.250	0.208	0.285	0.202
Apartment without terrace	0.280	0.160	0.224	0.168
Apartment with terrace	0.548	0.347	0.503	0.289
Apartment with garden	0.048	0.063	0.067	0.052
House	0.119	0.431	0.200**	0.474
Income < 35'000 CHF	0.065	0.083	0.067	0.127
Income 35'001-50'000 CHF	0.143	0.243	0.133	0.156*
Income 50'001-80'000 CHF	0.065	0.153	0.170***	0.220
Income 80'001-120'000 CHF	0.054	0.097	0.103*	0.087
Income 120'001-160'000 CHF	0.030	0.035	0.036	0.029
Income 160'001-200'000 CHF	0.006	0.014	0.012	0.006
Income > 200'000 CHF	0.006	0.000	0.000	0.000
Missing value for income	0.589	0.375	0.436***	0.37
Green membership	0.077	0.042	0.152**	0.058
Priority to environmental protection	0.482	0.569	0.594**	0.445**
Priority to economic growth	0.119	0.118	0.061*	0.191*
Do not know (environmental protection or economic growth)	0.304	0.201	0.285	0.202
Missing value to environmental protection or economic growth	0.012	0.111	0.030	0.156
N	168	144	165	173
Total	312		338	

* p<0.1, ** p<0.05, *** p<0.01.

TABLE C.2: Sample's socioeconomic characteristics of respondents: mean comparisons and tests with all respondents of 2016 survey

	2016 (all)		2017 (sample)	
	GE	VD	GE	VD
Age	64.906	64.353	66.358	65.136
Gender (F)	0.67	0.614	0.709	0.593
Swiss	0.808	0.851	0.853	0.860
Household size	2.184	2.141	2.185	2.135
Number of children	0.276	0.543	0.200	0.601
Compulsory schooling diploma	0.219	0.211	0.164	0.200
Apprenticeship diploma	0.231	0.328	0.218	0.295
High school diploma	0.258	0.221	0.309	0.260
University diploma	0.267	0.205	0.285	0.202
Apartment without terrace	0.252	0.164	0.224	0.168
Apartment with terrace	0.526	0.315	0.503	0.289
Apartment with garden	0.057	0.057	0.067	0.052
House	0.159	0.454	0.200	0.474
Income < 35'000 CHF	0.066	0.107	0.067	0.127
Income 35'001-50'000 CHF	0.138	0.196	0.133	0.156
Income 50'001-80'000 CHF	0.117	0.189	0.17	0.220
Income 80'001-120'000 CHF	0.078	0.091	0.103	0.087
Income 120'001-160'000 CHF	0.033	0.032	0.036	0.029
Income 160'001-200'000 CHF	0.009	0.009	0.012	0.006
Income > 200'000 CHF	0.003	0.000	0.000	0.000
Missing value for income	0.514	0.372	0.436	0.37
Green membership	0.114	0.050	0.152	0.058
Priority to environmental protection	0.538	0.502	0.594	0.445
Priority to economic growth	0.090	0.158	0.061	0.191
Do not know (environmental protection or economic growth)	0.294	0.202	0.285	0.202
Missing value to environmental protection or economic growth	0.021	0.136	0.030	0.156
N	333	317	165	173
Total	650		338	

* p<0.1, ** p<0.05, *** p<0.01.

TABLE C.3: Sample comparison of the underlying population

	Population		2017 (sample)	
	GE	VD	GE	VD
Gender (F)	0.515	0.51	0.709***	0.593***
Swiss	0.595	0.669	0.853***	0.860***
Household size	2.18	2.26	2.285	2.135*
Number of children	1.7	1.52	1.760	2.080***
Compulsory schooling diploma	0.256	0.252	0.164***	0.200
Apprenticeship diploma	0.203	0.271	0.218	0.295
High school diploma	0.104	0.096	0.309***	0.260***
University diploma	0.437	0.380	0.285***	0.202***

Source: Swiss Federal Statistical Office and Cantonal Offices of Statistics of Geneva and Vaud

* p<0.1, ** p<0.05, *** p<0.01.

C.3.2 Additional empirical results

TABLE C.4: Treatment effect on organic waste sorting and number of sorted categories: survey data

	Organic waste		Sorted categories		Sorted categories without organic waste	
	(1)		(2)		(3)	
Group (GE)	-0.240***	(0.045)	-1.143***	(0.191)	-0.902***	(0.177)
Year 2017	-0.061**	(0.029)	-0.106	(0.136)	-0.045	(0.126)
Policy	0.287***	(0.038)	0.896***	(0.189)	0.609***	(0.184)
Age	0.001	(0.001)	0.003	(0.005)	0.00224	(0.005)
Gender (F)	0.124***	(0.0418)	0.501***	(0.142)	0.377***	(0.128)
Swiss	0.019	(0.053)	0.176	(0.159)	0.158	(0.145)
Household size	0.0165	(0.018)	0.139*	(0.084)	0.123	(0.084)
Number of children	-0.020	(0.019)	-0.098	(0.089)	-0.078	(0.092)
Compulsory schooling diploma						
Apprenticeship diploma	-0.008	(0.061)	-0.135	(0.165)	-0.127	(0.132)
High school diploma	-0.01	(0.049)	-0.583***	(0.201)	-0.573***	(0.186)
University diploma	-0.014	(0.057)	-0.373**	(0.172)	-0.359**	(0.149)
Apartment without terrace						
Apartment with terrace	0.003	(0.077)	0.142	(0.177)	0.139	(0.157)
Apartment with garden	-0.008	(0.081)	-0.418	(0.315)	-0.410	(0.313)
House	0.033	(0.085)	0.468**	(0.218)	0.435**	(0.188)
Urban areas	-0.06	(0.045)	-0.340**	(0.130)	-0.280**	(0.129)
Income < 35'000 CHF						
Income 35'001-50'000 CHF	0.016	(0.076)	-0.039	(0.334)	-0.055	(0.292)
Income 50'001-80'000 CHF	0.109	(0.076)	0.619*	(0.320)	0.510*	(0.285)
Income 80'001-120'000 CHF	0.014	(0.074)	0.083	(0.406)	0.069	(0.375)
Income 120'001-160'000 CHF	-0.04	(0.099)	0.194	(0.510)	0.234	(0.471)
Income 160'001-200'000 CHF	0.244**	(0.118)	0.735**	(0.330)	0.490*	(0.280)
Missing value for income	0.084	(0.073)	0.484	(0.315)	0.400	(0.276)
Green membership	0.138***	(0.035)	0.437**	(0.188)	0.299	(0.184)
Priority to environmental protection	0.087*	(0.046)	0.342	(0.225)	0.255	(0.215)
Priority to economic growth						
Do not know (environmental protection or economic growth)	-0.018	(0.057)	-0.125	(0.190)	-0.107	(0.181)
Missing value to environmental protection or economic growth	0.030	(0.063)	-0.038	(0.299)	-0.068	(0.290)
Constant	0.599***	(0.146)	6.998***	(0.592)	6.399***	(0.573)
R^2	0.1175		0.1780		0.1521	
N	607		607		607	

Clustered standard errors in parentheses (cluster per municipality).

* *p*<0.1, ** *p*<0.05, *** *p*<0.01.

TABLE C.5: Summary table of different characteristics of the Cantons of Geneva, Vaud and Zurich

	Geneva	Vaud	Zurich
Population	504'128	805'098	1'539'275
Size (km2)	282	3'212	1'728
Population density (inhabitants/km2)	2'051	285	927
Population living in urban area (%)	100	90	99
Foreigners rate (%)	40	33	27
GDP per capita (CHF)	109'847	74'060	104'820

Source: Swiss Federal Statistical Office, Regionalportraits 2021: Cantons

TABLE C.6: Treatment effect on incinerated waste and proportion of waste sorted: administrative data

	Incinerated waste		Proportion of waste sorted		Proportion of waste sorted without greens	
Control	VD	ZH	VD	ZH	VD	ZH
Group (GE)	115.0***	52.99***	-0.195***	-0.075***	-0.224***	-0.062***
	(9.608)	(6.532)	(0.024)	(0.015)	(0.022)	(0.009)
Year 2017	1.476	-6.254***	-0.026*	-0.007*	-0.027*	-0.023***
	(6.373)	(1.258)	(0.014)	(0.004)	(0.015)	(0.003)
Policy	-36.04***	-28.31***	0.062***	0.042***	0.056***	0.053***
	(7.551)	(4.211)	(0.015)	(0.007)	(0.017)	(0.007)
Constant	123.2***	185.2***	0.640***	0.520***	0.518***	0.356***
	(7.441)	(2.510)	(0.02)	(0.007)	(0.021)	(0.004)
R^2	0.6320	0.1869	0.4206	0.0539	0.5203	0.0855
N	426	1'322	425	1'322	425	1'322

Note: PET is not taken into account in the waste sorted here since data is not available for the Canton of Zürich.
Clustered standard errors in parentheses (cluster per municipality).
* $p<0.1$, ** $p<0.05$, *** $p<0.01$.

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Education

2018-present **PhD Program in Environmental and Civil Engineering**.
Ecole Polytechnique Fédérale de Lausanne (EPFL)
Thesis title: *Environmental policies: analysis, design and evaluation*
Thesis co-directors: Andrea Baranzini and Philippe Thalmann

2014–2016 **Master of Arts in Economics**, *Magna cum laude, Average – 5.2* .
University of Zürich
Master thesis: *Distributional impacts of a fuel tax with heterogenous regions*
Supervisors: Prof. Dr. David Hémous & Prof. Julien Daubanes
Grade: 5.75

2011–2014 **Bachelor ès Sciences in Management**, *Average – 5.1*.
University of Lausanne (HEC)
Erasmus at Mannheim University (third year)

2006–2011 **Matura in Economics and Law**, *Economic Award, UBS*.
Collège de l'Abbaye de St-Maurice

Work Experience

2017–present **HES assistant in Microeconomics**, HEG, Geneva.
Teaching and applied research
- Lectures and exams preparation
- Teaching
- Reading and reviewing scientific papers
- Survey design, data collection, statistical analysis, and results interpretation
- Writing scientific papers and reports
- Presentations at conferences

2015 **Summer Intern**, Canton du Valais, Sion.
Cantonal Financial Administration (ACF), Service of the Department for Finance and Institutions (DFI)
- Treatment and analysis of economic and financial statistics
- Participation in the completion of various works related to the budget process and the integreted multiannual planning
- Participation in the completion of mandates and projects for the head of the cantonal financial Administration

2015 **Summer Intern**, BCVs, Sion.
2013 In the credit analysis service and the payment service

- Codification and transformation of data
- Various activities related to credit monitoring
- Reporting of financial statements and computation of new ratings
- Preparation and correction of payment orders

Publications

Baranzini, A., Carattini, S., Tesauro, L. (2021). Designing Effective and Acceptable Road Pricing Schemes: Evidence from the Geneva Congestion Charge. *Environmental and Resource Economics* 79, 417–482. https://doi.org/10.1007/s10640-021-00564-y

Conferences

2021 26th annual conference of the European Association of Environmental and Resource Economists (EAERE) in Berlin (online)

9th annual conference of the Italian Association of Environmental and Resource Economists (IAERE) in Brescia (online)

8th annual conference of the French Association of Environmental and Resource Economists (FAERE) in Grenoble

27th Ulvön Conference on environmental economics (online)

9th World Sustainability Forum

2018 19th Global Conference on Environmental Taxation (GCET) in Madrid

Computer skills

MS-Office

Stata , R (basics), Sawtooth

LaTeX, LyX

Languages

French **Mothertongue**

German **Fluent (C1)**

English **Fluent (C1)**

Italian **Basic**

Interests

Sports **Skiing, climbing, hiking**
Swimming: rescue diploma and BLS-AED
Scuba diving: entry-level diving certification (CMAS One Star)

Music

Travel