
# Macroeconomic Interdependence under Collective Wage Bargaining

by

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# Macroeconomic interdependence under collective wage bargaining*

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**Abstract**

This paper uses a two-country, sticky-price model with non-atomistic wage setters to study the role of collective wage bargaining in the propagation of monetary shocks. I find that the welfare transmissions of a monetary expansion are reinforced by different labor market structures. Non-atomistic domestic unions anticipate that their wage demands raise real labor income through a movement of the terms of trade. This leads to an additional channel of transmission of monetary policy that goes through aggregate supply. Yet, workers benefit more from a monetary expansion when the exchange rate pass-through is not limited and the elasticity of substitution across traded goods is sizable. It follows that wage mark-ups charged by unions endogenously vary with those structural parameters. In particular, labor and product market distortions are strategic substitute in affecting the perceived labor demand elasticity.

**Keywords:** non-atomistic agents, interdependence, exchange rate fluctuation, wage setting

**JEL:** F41, F42, J5

# 1 Introduction

Wage setting reflects the particularity of the industrial relations system and the type of labor regulation a country traditionally subscribes to. However, its potential implications concern not only wage compensation but also economic well-being. Indicators of collective bargaining coverage, defined as the proportion of wage workers under a collective agreement, show

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considerable variations across countries (see Table 1). "In most countries in the OECD, the majority of workers have their wages set by collective bargaining between employers and trade unions at the plant, firm, industry or aggregate level" (Nickell et al., 2005, p. 6). Typically, more centralized systems, where collective agreements are signed at national or sectoral level, lead to a higher coverage of collective bargaining. Therefore, it is interesting to ask whether and how the impact of monetary policy on welfare is affected by different labor market structures.

The existing literature on micro-founded general equilibrium models of open economy, sparked by Obstfeld and Rogoff (1995), ignores wage bargaining systems as a channel affecting the propagation of monetary policies across countries and over time. These studies do not address the issue because either they adopt a Yeoman-Farmer framework (e.g. Obstfeld and Rogoff, 1995; Tille, 2001; Canzoneri et al., 2005) or they assume atomistic wage setting (e.g. Benigno, 2002; Corsetti and Pesenti, 2001; Obstfeld and Rogoff, 2000).[1] This paper uses a two-country, sticky-price model with non-atomistic wage setters to study the role of collective wage bargaining in the propagation of monetary shocks.[2] The analytical framework nests new open economy macroeconomics models with atomistic wage setters as particular cases.

In a recent article, Tille (2008) assesses the role of international financial integration in affecting the international transmission of monetary shocks. In the same vein, but with a different focus, this paper analyzes how the international transmission of monetary shocks is affected by different collective bargaining systems and how structural features of the model interact with a non-atomistic wage setting. I extend earlier contributions (Obstfeld and Rogoff, 1995; Tille, 2001) by encompassing varying degrees of price flexibility, openness, collective bargaining coverage, and exchange rate pass-through.

I find that a collective wage bargaining system plays a crucial role for the international transmission of monetary policy. Models that rely on the atomistic wage-setting assumption disregard the consequences of wage bargaining institutions on the overall level of wages and the macroeconomic performance of labor market. Large domestic unions in fact anticipate that their wage demands will increase real labor incomes relative to foreign unions through two channels. First, when the degree of exchange rate pass-through is complete, a depreciation of the exchange rate leads to a worsening in the terms of trade. Since prices do not adjust in the short run, there is one-to-one relationship between the terms of trade and exchange rate movements. Domestic wages claims are perceived to raise real domestic incomes by worsening the terms of trade and hence increasing relative output through the consumption switching towards home goods. Second, when the degree of exchange rate pass-through is zero, a depreciation of the exchange rate entails improving the terms of trade, without affecting cross-country output demands. In this case, wage pressures are perceived to raise workers' real incomes and hence domestic consumption relative to the foreign one through an improvement in the terms of trade.

[1] For some surveys on the new open economy macroeconomics literature, see Sarno (2001), Bowman and Doyle (2003), and Lane (2001).

[2] See Calmfors (2001) and Cukierman (2004) for extensive surveys of the non-atomistic wage setting literature.

These effects hold only when unions have a positive mass and are reinforced by a higher rate of collective bargaining coverage, since labor unions internalize the effects of their wage claims on aggregate variables to a larger extent.

The impact of wage claims on workers' welfare however depends on the ability of wage setters to affect workers' income, consumption and effort. In particular, workers benefit more from a collective wage bargaining system when the exchange rate pass-through is not limited and the elasticity of substitution across traded goods is large enough to entail a significant increase in their income in the wake of a depreciation of exchange rate. Intuitively, when the elasticity of substitution is relatively low, non-atomistic wage setters anticipate that the worsening in terms of trade caused by wage hikes is not offset by the increase in domestic demand. This leads to wage restraints and lower labor income. Conversely, a lower exchange rate pass-through induces more wage aggressiveness through the perceived improvement in the terms of trade, but reduces the role of labor institutions in affecting welfare *per se*. Output demand, in this case, is less responsive to monetary policy and terms-of-trade movements.

Since unions' mark-ups are endogenous to structural parameters, such as the elasticity of substitution across goods and labor types, the model shows a strategic interaction between labor and product market distortions. Specifically, labor and product market distortions are strategic substitute in affecting the labor demand elasticity under collective bargaining systems. Moreover, the impact of non-atomistic wage setting on welfare is reinforced in more open economies exhibiting relevant price rigidities.

The paper is organized as follows. The households and firms' optimal conditions are presented in Section 2. Section 3 discusses the main elements of non-atomistic wage setting in the labor market. Section 4 presents the welfare results, illustrating them with a simple and more general equilibrium model. Section 5 concludes.

[Table 1 about here.]

# 2 Households and Firms' optimization

The economy consists of two equally-sized countries, home and foreign. Each country is populated by a continuum of agents, whose total measure is normalized to $1/2$, and $n > 1$ labor unions setting the wage that workers receive. Households work and consume different varieties of goods produced by monopolistic competitive firms.

## 2.1 Households

For simplicity, I follow the notation in Tille (2008). Preferences are identical across countries. A representative household derives utility from consumption, holdings of real balances, and

leisure as follows:

$$U_t = \sum_{s=0}^{\infty} \beta^s \left[ \frac{1}{1-\rho} (C_{t+s})^{1-\rho} + \frac{\chi}{1-\varepsilon} \left( \frac{M_{t+s}}{P_{t+s}} \right)^{1-\varepsilon} - \frac{\kappa}{1+\omega} (H_{t+s})^{1+\omega} \right]. \tag{1}$$

$C$ is a standard CES consumption aggregate of baskets of traded goods produced in the home country ($C_H$), traded goods produced in the foreign country ($C_F$), and non-traded goods produced in the home country ($C_N$):

$$C = \left[ \left( \frac{1-\gamma}{2-\gamma} \right)^{\frac{1}{\lambda}} (C_H)^{\frac{\lambda-1}{\lambda}} + \left( \frac{1-\gamma}{2-\gamma} \right)^{\frac{1}{\lambda}} (C_F)^{\frac{\lambda-1}{\lambda}} + \left( \frac{\gamma}{2-\gamma} \right)^{\frac{1}{\lambda}} (C_N)^{\frac{\lambda-1}{\lambda}} \right]^{\frac{\lambda}{\lambda-1}}, \tag{2}$$

where $\lambda \geq 1$ is the elasticity of substitution across the three sub-baskets.[3] The consumption-based price indexes as well as sub-basket expressions are presented in Table 2.

[Table 2 about here.]

Notice that consumption indexes $C_H$, $C_F$, and $C_N$, are defined over consumption of all the varieties of each good, where $\theta > 1$ is the elasticity of substitution across brands in a given country. I assume that the elasticity of substitution across brands is at least as large as the elasticity of substitution across goods: $\theta \geq \lambda$. $H$ represents total hours worked by domestic households. $M/P$ denotes real money balances, where $M$ are nominal balances and $P$ is the home country CPI defined as follows:

$$P = \left[ \frac{1-\gamma}{2-\gamma} (P_H)^{1-\lambda} + \frac{1-\gamma}{2-\gamma} (P_F)^{1-\lambda} + \frac{\gamma}{2-\gamma} (P_N)^{1-\lambda} \right]^{1/(1-\lambda)}, \tag{3}$$

where $P_H$ and $P_F$ indicate, respectively, the home-currency price of one unit of the composite good of all home and foreign traded varieties, while $P_N$ is the price of one unit of the composite good of non-traded varieties defined in Table 2.

## 2.2 Budget constraint and intertemporal optimization

Home households supply labor services to firms, receiving wages $W$ and dividends $D$ on their ownership of domestic firms. The home households' budget constraint in period $t$ is:

$$P_t C_t + M_t + B_{t+1} = W_t H_t + M_{t-1} + T_t + D_t + (1+i_t) B_t, \tag{4}$$

where $B_{t+1}$ denotes the quantity of home-currency bond purchased by the households at the end of the period. There is free trade between countries in such a nominal bond. Each unit of the home currency bond pays a return of $1+i_t$. $T$ denotes a lump-sum transfer.

[3] For simplicity, I abstract from the case where $\lambda < 1$. The case of $\lambda > 0$ is investigated in Tille (2001).

The representative home household maximizes utility subject to (4) choosing sequences of consumption, bond and money holdings. This leads to the following first-order conditions:

$$\left(\frac{M_t}{P_t}\right)^{\varepsilon} = \chi C_t^{\rho} \frac{1+i_{t+1}}{i_{t+1}}, \tag{5}$$

$$C_{t+1}^{\rho} = \beta(1+i_{t+1})\frac{P_t}{P_{t+1}} C_t^{\rho}, \tag{6}$$

where eqs. (5) and (6) are respectively the money demand and the Euler relation. The labor supply will be derived below solving the union's problem. Labor unions are in fact in charge of wage setting decisions, while households supply whatever quantity of labor is required to clear the market for a given wage.

Bonds traded internationally are in zero net supply[4]

$$B_t + B_t^* = 0. \tag{7}$$

I abstract from government spending and assume that in each country the seigniorage income is repaid to domestic households through a lump-sum transfer

$$T_t = M_t - M_{t-1}. \tag{8}$$

Combining budget constraints (4) and (8) lead to the following current account in the home country:

$$P_t C_t + B_{t+1} = REV_t + (1+i_t)B_t, \tag{9}$$

where $REV \equiv D + WH$ denotes the sales revenues of all firms as the sum of their dividend and wage income.

## 2.3 Firms

In the domestic goods market, there is a continuum of monopolistically competitive firms, each producing a particular brand $z$. Production by these firms is a linear function of hours. Aggregating consumption demands from the home and foreign households yields the demands faced by home firms in the traded and non-traded sectors:

$$Y_{Tt}(z) = \frac{1}{2-\gamma}\left\{\left[\frac{P_{Ht}(z)}{P_{Ht}}\right]^{-\theta}\left[\frac{P_{Ht}}{P_t}\right]^{-\lambda} C_t + \left[\frac{P_{Ht}^*(z)}{P_{Ht}^*}\right]^{-\theta}\left[\frac{P_{Ht}^*}{P_t^*}\right]^{-\lambda} C_t^*\right\}, \tag{10}$$

$$Y_{Nt}(z) = \frac{1}{2-\gamma}\left[\frac{P_{Nt}(z)}{P_{Nt}}\right]^{-\theta}\left[\frac{P_{Nt}}{P_t}\right]^{-\lambda} C_t, \tag{11}$$

[4] I employ the convention of denoting the corresponding foreign variables by *.

where $P_{Ht}(z)$ is the price, in home currency, charged to home households for the brand $z$ in the traded sector, $P^*_{Ht}(z)$ is the price, in foreign currency, charged to foreign households, and $P_{Nt}(z)$ is the price, in home currency, charged to home households for the brand sold in the non-traded sector. $P_{Ht}$ and $P_t$ are the home-currency price indexes faced by the home household, as presented in Table 2, while $P^*_{Ht}$ and $P^*_t$ are the corresponding isomorphic price indexes, in foreign currency, faced by the foreign household.

Profits of domestic firms producing a traded brand $z$ are given by

$$D_{Tt}(z) = \frac{P_{Ht}(z) - W_t}{2-\gamma}\left[\frac{P_{Ht}(z)}{P_{Ht}}\right]^{-\theta}\left[\frac{P_{Ht}}{P_t}\right]^{-\lambda} C_t + \frac{S_t P^*_{Ht}(z) - W_t}{2-\gamma}\left[\frac{P^*_{Ht}(z)}{P^*_{Ht}}\right]^{-\theta}\left[\frac{P^*_{Ht}}{P^*_t}\right]^{-\lambda} C^*_t, \tag{12}$$

where $S$ is the exchange rate defined in terms of units of home currency per unit of foreign currency. I assume that profits are entirely distributed as dividends.

When firms can adjust their prices, they charge a mark-up over the wage cost as follows:

$$P_{Ht}(z) = S_t P^*_{Ht}(z) = P_{Nt}(z) = \frac{\theta}{\theta - 1} W_t \qquad \forall z, \tag{13}$$

$$P^*_{Ft}(z) = S_t^{-1} P_{Ft}(z) = P^*_{Nt}(z) = \frac{\theta}{\theta - 1} W^*_t \qquad \forall z. \tag{14}$$

This is a standard result due to the assumption of monopolistic competition.

In the short-run, only an exogenous fraction $\tau \in [0,1]$ of prices can be adjusted. Specifically, prices are completely rigid when $\tau = 0$ and fully flexible when $\tau = 1$. Moreover, following Corsetti and Pesenti (2005), an exogenous fraction $\eta \in [0,1]$ of exchange rate movements is passed through to prices in the foreign market, with the case of complete and zero exchange rate pass-through corresponding to $\eta = 1$ and $\eta = 0$ respectively.

# 3 Labor market

This section analyzes how non-atomistic labor unions optimally set their wage anticipating the impact of their wage demands on aggregate variables. In order to disentangle the key mechanisms, I focus on a baseline utility with all goods traded ($\gamma = 0$), log utility of consumption and real balances ($\rho = \varepsilon = 1$), and preset prices ($\tau = 0$). Let the aggregate measure of hours in the home country be defined as

$$H = \left[\int_0^1 (H(j))^{\frac{\sigma-1}{\sigma}} \mathrm{d}j\right]^{\frac{\sigma}{\sigma-1}} \qquad \sigma > 1, \tag{15}$$

where $\sigma$ is the elasticity of substitution across the various categories of labor. From cost minimization, demand by home firms for a particular type of labor $j$ is given by:

$$H_t(j) = \left[\frac{W_t(j)}{W_t}\right]^{-\sigma} H_t, \tag{16}$$

where $W(j)$ indicates the nominal wage of labor type $j$ and $W$ is the following nominal wage index:

$$W_t = \left[\int_0^1 (W_t(j))^{1-\sigma} \mathrm{d}j\right]^{\frac{1}{1-\sigma}}. \tag{17}$$

## 3.1 The impact of nominal wage rises on aggregate variables

In each country workers are organized in $n > 1$ labor unions. I assume that all types of labor are unionized and equally distributed among unions. Therefore $1/n$ indicates both the representative union's mass and the fraction of workers covered by a collective agreement, i.e. the fraction of workers whose pay have been negotiated through collective bargaining. This framework captures the fact that more centralized systems, whereby collective agreements are signed at national or sectoral level, typically have a higher coverage of collective bargaining. Since the representative union $x$ has a positive mass, it will anticipate that

$$\frac{\partial W}{\partial W(x)} = \frac{1}{n}\left(\frac{W(x)}{W}\right)^{-\sigma}, \tag{18}$$

i.e., the higher its mass the more the $x$-th union internalizes the impact of its wage settlement on aggregate wage (see e.g. Bratsiotis and Martin, 1999; Soskice and Iversen, 2000; Lippi, 2003). Eq. (18) is derived in Appendix A and is key to the model results.

Wages are flexible[5] and set under discretion, namely taking past and future variables as given.[6] When prices are preset, the main channel through which non-atomistic unions (i.e. $n$ finite) may affect aggregate variables is the exchange rate and hence the terms of trade. Specifically, Appendix B shows that, combining the Euler equations, money demands (5), output demands (10)-(11), current account (9), optimal price-setting relations (13)-(14), and eq. (18),

**Result 1** *In a symmetric equilibrium ($W(x) = W$), a wage rise in the home country is perceived to lead to a depreciation of the exchange rate*

$$\frac{\partial \log S}{\partial \log W(x)} = \frac{\theta - 1}{\theta(1-\eta) + \eta\lambda}\frac{1}{n} > 0. \tag{19}$$

*This effect is smaller the higher the elasticity of substitution across goods $\lambda$ and the lower the degree of exchange rate pass-through $\eta$.*

[5] Wage stickiness does not qualitatively alter the main results of the paper.

[6] Following the literature on non-atomistic wage setting, I assume that unions take the impact of their wages on profits and fiscal policy as given (e.g. Guzzo and Velasco, 1999; Lippi, 2003; Gnocchi, 2006).

An intuitive account of the mechanism through which domestic wage pressures are expected to depreciate the exchange rate is as follows: since wages are bargained simultaneously in an uncoordinated manner, domestic unions perceive that an increase in their wages raises their (real) labor income relative to foreign unions' one. This arises from the anticipated impact of wage hikes on the terms of trade and hence on the exchange rate. Since prices do not adjust in the short run, there is in fact a one-to-one relationship between the terms of trade and exchange rate movements. Specifically, when the degree of exchange rate pass-through is complete ($\eta = 1$), domestic wages claims are expected to raise real domestic incomes by increasing relative output through a worsening in the terms of trade (i.e. through a depreciation of the exchange rate). This effect reduces the relative price of goods produced in the home country and induces households to switch their purchases towards home-produced goods, thereby boosting output in the home country. When the degree of exchange rate pass-through is zero ($\eta = 0$), instead, domestic wage claims are expected to raise domestic workers' income through an improvement in the terms of trade (i.e. through a depreciation of the exchange rate) since relative output demands are not affected. The responsiveness of aggregate demand to the exchange rate is in fact larger the higher the degree of exchange rate pass-through and the elasticity of substitution across goods $\lambda$. This explains why the sensitivity of the exchange rate movements to wage is proportional to the degree of exchange rate pass-through $\eta$, and inversely related to the elasticity of substitution across goods $\lambda$. Key to the above result is that unions have positive mass (i.e. $1/n > 0$). In this way they internalize, at least partially, the effects of wage claims on aggregate variables.

**Result 2** *An increase in domestic wages is perceived to reduce aggregate output if the degree of exchange rate pass-through is small, $\eta < 1/\lambda$. Conversely, it raises output if the degree of pass-through is large, $\eta > 1/\lambda$:*

$$\frac{\partial \log Y}{\partial \log W(x)} = \frac{(\theta - 1)(\eta\lambda - 1)}{2[\theta(1-\eta) + \eta\lambda]} \frac{1}{n}. \tag{20}$$

As noted by Corsetti and Pesenti (2001), in the case of $\lambda = \eta = 1$ the ratio of Home and Foreign consumption is constant in equilibrium. Therefore, with some degree of exchange rate pass-through, a rise in domestic wages is perceived to entail a relative increase in nominal incomes but also a proportional decline in purchasing power through the worsening in the terms of trade so that *real* incomes remain unchanged. When $\lambda > 1$, instead, the real incomes of Home workers increase relative to Foreign workers.

In presence of collective wage bargaining, a rise in $W(x)$ has hence two opposite effects on domestic output depending on the degree of exchange rate pass-through. With zero pass-through, a wage hike depreciates the exchange rate (see Result 1) and leads to an improvement in the terms of trade, i.e. it reduces the relative price of goods produced in the foreign country. This outcome induces domestic agents to switch their purchases towards foreign-produced

goods so as to boost their consumption, thereby decreasing output in the home country (see Appendix C for details). Conversely, with a sufficiently high degree of exchange rate pass-through, $\eta > 1/\lambda$, the terms of trade worsens in the wake of an exchange rate depreciation, diminishing the relative price of goods produced in the home country. As a result, consumption of domestic goods stemming from domestic (and foreign) agents rises.

## 3.2 Unions' optimization

Each union plays a Nash game with other unions: they simultaneously set nominal wages, taking the other unions' nominal wage as given. In doing that, the $x$-th labor unions sets the nominal wage $W(x)$ on behalf of its members maximizing their lifetime utility function (1), disregarding liquidity effects, subject to the budget constraint (4) and labor demand (16) for all members $j \in x$.[7] The solution to the union's problem is[8]

$$W_t(x) = W_t = \frac{\delta}{\delta - 1} \kappa P_t C_t H_t^{\omega}, \tag{21}$$

where $\delta \equiv \frac{\Sigma_h}{1-\Sigma_p}$ is the elasticity of labor demand to real wage perceived by the $u$-th union for each of its members:

$$\Sigma_h \equiv -\frac{\partial \log H(x)}{\partial \log W(x)} = \sigma\left(1 - \frac{1}{n}\right) - \frac{\partial \log H_t}{\partial \log W_t}\frac{1}{n} = \sigma\left(1 - \frac{1}{n}\right) + \frac{(\theta - 1)(1 - \eta\lambda)}{2(\theta - \eta\theta + \eta\lambda)}\frac{1}{n}, \tag{22}$$

$$\Sigma_p \equiv \frac{\partial \log P}{\partial \log W(x)} = \frac{\eta(\theta - 1)}{2(\theta - \eta\theta + \eta\lambda)}\frac{1}{n}. \tag{23}$$

Eq. (22) defines the elasticity of domestic labor demand as a weighted average (with weights respectively $1 - 1/n$ and $1/n$) of the elasticity of substitution across labor types $\sigma$ and of the elasticity of domestic aggregate labor demand (20).[9] Notice that it nests the standard case of a labor demand elasticity equal to $\sigma$ as a special case (i.e. atomistic wage setters, $n \to \infty$). With large unions, the mark-up $\delta/(\delta - 1)$ depends on the response of aggregate variables to wage demands as assessed above.

**Result 3** *A higher degree of exchange rate pass-through raises the mark-up set by unions when labor market distortions are sizeable* $\sigma < \frac{1+\theta(2n(\lambda-1)-1)+2n\lambda}{2(n-1)\theta}$. *Conversely, it reduces the mark-up when labor market distortions are relatively small* $\sigma > \frac{1+\theta(2n(\lambda-1)-1)+2n\lambda}{2(n-1)\theta}$.

Intuitively, a higher degree of exchange rate pass-through has two opposite effects on $\delta$. First, an increase in the $x$-th union's wage raises its real wage inducing firms to substitute labor

[7] The benevolent union hypothesis is consistent with the traditional labor union theory (e.g. Oswald, 1985).

[8] More general first-order condition and mark-up charged by the $x$-th union are derived in Appendix C and D.

[9] This result is in contrast with the U-shaped relation predicted in Calmfors and Driffill (1988) between centralization of wage bargaining and economic performance, which in this case depends on the union's mark-up. The main reason is that the competition level in this model is not proportional to the degree of decentralization of wage bargaining as in Calmfors and Driffill (1988). See Guzzo and Velasco (1999) for a discussion of this issue.

types $j \in x$ with other more competitive labor types $j \notin x$. This substitution effect depends on $\sigma$ and is reinforced by the degree of exchange pass-through which leads to an increase in CPI, thereby reducing other unions' real wage to a larger extent. As a result, wage claims are dampened through this channel. Each union in fact anticipates that, for a given reduction in employment, the real wage increase will be smaller the higher $\eta$. Second, an increase in exchange rate pass-through leads to a greater consumers' switch from foreign to domestic output, thereby encouraging wage hikes. Since $\delta$ is a combination of these two effects, it will rise in the wake of a higher degree of exchange rate pass-through when the first effect prevails, namely when the degree of substitution across labor types is sufficiently large $\sigma > \frac{1+\theta(2n(\lambda-1)-1)+2n\lambda}{2(n-1)\theta}$.[10]

**Result 4** *Product and labor market distortions are strategic substitute in the perceived elasticity of labor demand by non-atomistic unions in presence of non zero exchange rate pass-through:*

$$Sign\left[\frac{\partial^2\delta}{\partial\lambda\partial\sigma}\right] = Sign\left[-\frac{2(n-1)\eta^2(\theta-1)}{(\eta(\theta-1+2n\theta-2n\lambda)-2n\theta)^2}\right] < 0.$$

Consider the case of a positive relationship between the elasticity of substitution across goods $\lambda$ and labor market elasticity $\delta$.[11] Result 4 states that a reduction in the monopolistic power in the products market stemming from a larger $\lambda$ abates the mark-up set by large unions to a larger extent when labor market distortions are sizeable (i.e. $\sigma$ small). In other words, the presence of the elasticity of substitution across goods $\lambda$ in the labor market elasticity $\delta$ indicates an interaction between labor and goods market distortions. Intuitively, when labor market distortions are relatively low, the increase in competitiveness between foreign and domestic goods has a smaller impact on the unions' mark-up which is already close to the efficient level.

Assuming that both $\lambda$ and $\sigma$ are negatively related to the degree of regulation,[12] respectively in the product and labor market, Result 4 is in line with recent empirical evidence (e.g. Fiori et al., 2008), whereby the impact of product market deregulation on employment is larger when labor market regulations are more stringent. Notice that, differently from Blanchard and Giavazzi (2003), the combination of labor *and* product market regulations affects real variables in the short run. Moreover, an increase in the elasticity of substitution across goods not necessarily reduces the real wages (see discussion above).

[10] Cuciniello (2009) focuses on the strategic effects arising in a similar labor market structure but under international time-consistent monetary policies.

[11] In general the impact of $\lambda$ on $\delta$ depends on $\text{Sign}[\eta(\theta-1+2\sigma)-2n(1+(1-\eta)\theta+\eta\sigma)]$.

[12] The cross-country substitutability $\lambda$, for example, may be assumed to be a function of the number of firms (e.g. Blanchard and Giavazzi, 2003) which in turn depends on legal barriers restricting access to markets and other barriers to entry related to market or industry structure (e.g. market dominance and vertical integration in network industries.). Similarly, one can imagine that employment protection legislation tends to raise labor adjustment costs, thereby reducing the elasticity of substitution across labor services $\sigma$.

# 4 The welfare impact of monetary shocks

This section presents how the international transmission of monetary shocks on welfare is affected by collective wage bargaining systems. I describes the solution method and focus on the impact of consumption and effort disregarding real balances. Next, main results are derived in a more general setup by a numerical illustration.

## 4.1 A symmetric steady state

In an initial symmetric steady state households do not hold any net claims on each other, namely no cross-country bond holdings $B_0 = B_0^* = 0$. All prices in the same currency are identical

$$P_0 = S_0 P_0^* = \frac{\theta}{\theta - 1} W_0 = \frac{\theta}{\theta - 1} S_0 W_0^*, \tag{24}$$

i.e. the purchasing power parity condition holds. From the above expression it turns out that the exchange rate in the steady state is given by the relative wages ratio

$$S_0 = P_0 / P_0^* = W_0 / W_0^* = M_0 / M_0^*. \tag{25}$$

The Euler condition (6) and the corresponding foreign one pin down the steady-state real interest rate

$$i_0 = i_0^* = \frac{1 - \beta}{\beta}. \tag{26}$$

All agents in a country are symmetric, which from eq. (9) implies that $P_0 C_0 = D_0 + W_0 Y_0 = P_0 Y_0$. Finally, using the unions' first order conditions yields

$$\frac{D_0}{P_0 C_0} = \frac{D_0^*}{P_0^* C_0^*} = \frac{1}{\theta}, \tag{27}$$

$$C_0 = C_0^* = Y_0 = Y_0^* = \left[ \frac{\theta - 1}{\kappa \theta} \frac{\delta - 1}{\delta} \right]^{\frac{1}{\rho + \omega}}. \tag{28}$$

## 4.2 Solution method

The economy is initially at a symmetric steady state. At period $t$ an unforeseen permanent monetary shock occurs and information about future shocks is revealed (perfect foresight equilibrium). From period $t$ to $t+1$ (i.e. the short run), I allow for nominal rigidities in prices. As illustrated above, only an exogenous fraction $\tau$ of all prices can adjust in the short run. Wages, instead, are completely flexible in the short run. Next, at period $t+1$ (i.e. the long run) prices and wages fully adjust. From then on the economy is in a long-run steady state, with variables denoted by an upper bar.

Recall that the law of one price holds in the short run only for firms that can reset their

prices. Instead, the other firms in the traded sector that cannot reset prices may engage in pricing-to-market across countries. In such a case, an exogenous fraction $\eta$ of the price charged to consumer abroad moves with the exchange rate, spanning the case of producer currency pricing ($\eta = 1$) and local currency pricing ($\eta = 0$).

I will express the various relations in terms of log deviations from the symmetric steady state denoting these deviations by Sans-Serif fonts: $\mathsf{v} = \log V - \log V_0 = (V - V_0)/V_0$.

Following Obstfeld and Rogoff (1995), I abstract from the direct welfare impact of real balances and focus on consumption and effort. Thus, in studying the international transmission of a monetary shock, I will look at the welfare implications in the limiting case as $\chi \to 0$ in eq. (1). Home households' utility is hence rewritten as:

$$\mathsf{u} = \mathsf{c} - \frac{\theta - 1}{\theta}\frac{\delta - 1}{\delta}\mathsf{y} + \frac{\beta}{1-\beta}\left[\bar{\mathsf{c}} - \frac{\theta - 1}{\theta}\frac{\delta - 1}{\delta}\bar{\mathsf{y}}\right]. \tag{29}$$

## 4.3 Baseline specification

To obtain tractable analytical solutions, I consider a baseline setup with linear effort ($\omega = 0$), elasticity of substitution across brands equals to the elasticity of substitution across different types of goods ($\theta = \lambda$), only traded goods ($\gamma = 0$), log utility of consumption ($\rho = 1$), and log real money balances ($\varepsilon = 1$). I discuss the implication of more general preferences by numerical exercise.

Henceforth, for sake of conciseness, I illustrate the welfare impact of a permanent home monetary shock occurring in period $t$ (i.e. $\mathsf{m}_{t+s} = \bar{\mathsf{m}}$, $\forall s \geq 0$) assuming foreign monetary stance be constant (i.e. $\mathsf{m}^* = \bar{\mathsf{m}}^* = 0$). It can be shown that, under this parametrization, a monetary shock yields a depreciation of the home currency:

$$\mathsf{s} = \frac{1 + \beta(\lambda - 1)}{1 + \eta(\lambda - 1) + \beta(1 - \eta)(\lambda - 1)}\bar{\mathsf{m}}, \tag{30}$$

where $\mathsf{s}/\bar{\mathsf{m}} > 0$.

### 4.3.1 Nominal rigidities and complete exchange rate pass-through

I start with the case where prices are preset ($\tau = 0$) in the short run and there is full exchange rate pass-through ($\eta = 1$). When prices cannot adjust, aggregate labor demand elasticity to wages, $\Sigma_h$, is given by eq. (22).

**Result 5** *Under preset prices ($\tau = 0$) and complete exchange rate pass-through ($\eta = 1$), the welfare gain of the Home country following a monetary expansion is*

$$\mathsf{u} = \frac{1}{\theta}\left[1 + \frac{2(\theta - 1)(1 + (2n - 1)\theta)}{2(n-1)\theta\sigma - (\theta - 1)^2}\right]\bar{\mathsf{m}},$$

*where*

$$\frac{\mathsf{u}}{\bar{\mathsf{m}}} > 0,$$

$$\frac{\partial}{\partial n}\left\{\frac{\mathsf{u}}{\bar{\mathsf{m}}}\right\} < 0.$$

In presence of large unions the mark-up $\delta(\delta-1)^{-1}$ depends positively on the elasticity of substitution across goods $\lambda$.[13] When the baskets of goods produced by the home and foreign countries are close substitute ($\lambda > 1$ ), each union anticipates that its wage claim will trigger an increase in real labor income proportional to $\lambda$ (see Section 3). This clearly raises wage pressures through the unions' mark-up so that the additional effort required to produce output in the wake of a monetary expansion is relatively small. It turns out that the worsening in the terms of trade associated with a depreciation of the exchange rate will enhance real sales revenues and hence consumption, more than compensating the effort cost.[14] Evidently, this effect is reinforced by the unions' capacity for internalizing the impact of their wage demands on the exchange rate: the higher the degree of collective bargaining coverage ($1/n$), the higher will be the mark-up set by the unions.

The impact on domestic welfare of a one per cent permanent monetary expansion in the home country is illustrated through a numerical example in Table 3 so as to complement the analytical results. I focus on three alternative rates of collective bargaining coverage. Under a high rate, I assume that $(1/n =)70$ per cent of the workers is covered by collective bargaining agreements (namely wage determination), while under a medium and low rate respectively 50 and 10 per cent. Two values for the elasticity across goods types $\lambda$ are assumed: low ($\lambda = 2.5$) and high ($\lambda = 7$).[15] The elasticity of labor types $\sigma$ is set at 11, while the elasticity of brand types $\theta$ is set at 7. The discount rate $\beta$ is equal to 0.96.

Table 3 summarizes the welfare effect of a monetary expansion under different levels of collective wage bargaining (namely high, medium and low) and under competitive labor markets (namely when the real wage is equal to marginal rate of substitution between consumption and leisure, $\delta \to \infty$). Welfare is sensitive to the system of wage determination. The top panel of Table 3 displays the case of a high elasticity of goods types, $\lambda = 7$. In this case the positive impact of a monetary expansion on welfare with a high rate of wage-bargaining coverage is roughly three times as large as with a low rate ($\mathsf{u} = 0.47$ vs. $\mathsf{u} = 0.16$). As underlined above, a high degree of internalization leads unions to anticipate the repercussions of their wage demands on aggregate variables to a larger extent. In particular, when the elasticity of substitution across

[13]Notice that, in order to have a mark-up $\frac{\delta}{\delta-1} > 1$, the following condition has to hold $\sigma > \frac{1+(\theta-1)^2+(2n-1)\theta}{2(n-1)\theta}$. This implies a negative relationship between $\lambda$ and labor market elasticity $\delta$ (see footnote 11), and $\frac{\mathsf{u}}{\bar{\mathsf{m}}} > 0$.

[14]In cross-country differential $\mathsf{u} - \mathsf{u}^* > 0$. This result is in contrast with Obstfeld and Rogoff (1995) where $\mathsf{u} - \mathsf{u}^* = 0$. The main reason is due to the fact that they abstract from labor market frictions (their model corresponds to $\delta \to \infty$).

[15]Imbs and Méjean's (2009) estimates suggest that, when all elasticities are forced to be equal across sectors, the aggregate substitutability $\lambda$ in the US is between 2.5 and 3; while allowing for heterogeneity across sectors, this aggregate elasticity is between 6 and 7.

goods types is sizable, the currency depreciation in the wake of wage demands will raise domestic aggregate demand to a larger extent, thereby boosting wage mark-ups. The competitiveness gain for domestic agents then leads to such a large consumption switching towards domestic goods that their income increases by enough to expand consumption despite the higher cost of in terms of leisure.

In the case of a low elasticity of substitution across goods types $\lambda = 2.5$ (the bottom part of Table 3), moving from a low to a high rate of collective bargaining coverage is not welfare improving anymore. Intuitively, a reduction in $\lambda$ boosts the aggregate labor demand elasticity, thereby lowering the mark-up associated with the aggregate component. It turns out that a lower rate of collective bargaining entails attaching a higher weight to the monopolistic distortion stemming from $\sigma$ in eq. (22) with a welfare gain of 100 per cent ($\mathsf{u} = 0.01$ vs. $\mathsf{u} = 0.02$). Notice that in this case a monetary expansion has still a positive welfare effect: it boosts employment but allows domestic agents to purchase enough additional consumption to offset the cost of their effort.

[Table 3 about here.]

#### 4.3.2 Nominal rigidities and zero exchange rate pass-through

**Result 6** *Under preset prices ($\tau = 0$) and zero exchange rate pass-through ($\eta = 0$), the welfare gain of the home country following a monetary expansion is*

$$\mathsf{u} = \left[1 + \frac{1}{\theta} + \frac{2n(\theta - 1)}{\theta - 1 + 2(n-1)\theta\sigma}\right] \bar{\mathsf{m}},$$

*where*

$$\frac{\mathsf{u}}{\bar{\mathsf{m}}} > 0,$$

$$\frac{\partial}{\partial n}\left\{\frac{\mathsf{u}}{\bar{\mathsf{m}}}\right\} < 0.$$

When there is zero exchange rate pass-through ($\eta = 0$) and prices are preset, relative prices faced by consumers are not affected by the exchange depreciation in either country. The impact of a monetary expansion in the short run affects demand by one half per cent $\mathsf{y} = 1/2\bar{\mathsf{m}}$, while raising consumption by one per cent $\mathsf{c} = \bar{\mathsf{m}}$. Under this parametrization, long-run consumption and output are instead not affected by a monetary shock. It turns out that the impact on the utility is always positive since, with import prices set in the customers' currency, the currency depreciation associated with a monetary expansion enlarges agents' export revenues (see Betts and Devereux, 2000).

Result 6 highlights how the impact of a monetary shock on welfare is positively affected by collective wage setting. Intuitively, a large union anticipates higher revenues attached to the depreciation of the exchange rate (see Section 3), thereby boosting its wage demand. However,

the welfare gains of moving from a low to a high rate of collective bargaining coverage are now 13 per cent ($u = 0.69$ vs. $u = 0.61$). This indicates that a zero exchange rate pass-through reduces the role of collective wage bargaining system in shaping welfare effects, compared to the case of complete exchange rate pass-through. Intuitively, when import prices are insulated from exchange rate movements in the short run ($\eta = 0$), the exchange rate depreciation caused by a monetary expansion does not affect the consumption switch from foreign to domestic traded goods as in the case of complete pass-through, thereby reducing its impact on aggregate demand ($y$). But the effect of wage setting on utility operates through the output demand, i.e. how employment responds to a monetary shock. Moreover, Table 3 illustrates that welfare is unaffected by the elasticity of substitution across goods types with zero pass-through. This reflects the fact that a zero exchange rate pass-through leads to $y - y^* = 0$, ruling out the channel through which the elasticity of substitution $\lambda$ influences output differential.

## 4.4 General specification

In this subsection I consider a more general specification of the utility function: $\rho = 4$, $\varepsilon = 2$, $\omega = 1$, $\gamma = 0.75$. The main results are robust to the inclusion of a richer utility and the presence of non-traded goods. Table 4 shows that welfare gains from a home monetary shock are substantial with complete exchange rate pass-through. Specifically, comparing high and low collective wage bargaining levels in the top and bottom panels of Table 4, a high collective wage bargaining system generates welfare advantages under complete exchange rate pass-through amounting to 123 per cent ($u = 0.29$ vs. $u = 0.13$) and 133 per cent ($u = 0.14$ vs. $u = 0.06$), respectively under high and low elasticity of substitution across goods.

[Table 4 about here.]

In the case of zero exchange rate pass-through, instead, welfare gains are roughly 4 per cent in either panel of Table 4. In line with the previous section results, a zero exchange rate pass-through mutes the role of collective wage bargaining system in the monetary policy transmission channel since the exchange rate depreciation, caused by a monetary expansion, does not lead to a consumption switch from foreign to domestic traded goods (as in the case of complete pass-through) and reduces its impact on aggregate demand. Thus, the strategic mechanism whereby large unions internalize that wage pressures affect aggregate demand via movements of the terms of trade is now less relevant to the international transmission channel of monetary policy.

How do openness and price stickiness influence domestic utility?

[Figure 1 about here.]

Figure 1 illustrates, for a given number of unions ($n = 3$) and goods elasticity ($\lambda = 7$), the welfare transmission of a one per cent monetary expansion under different degrees of openness

and price stickiness in presence of zero pass-through. In welfare terms, a domestic monetary expansion leads to a substantial gain for the home country when the economy is more open and prices stickier. Clearly, monetary policy can have real effects in this model as long as prices do not fully adjust. In presence of flexible prices, in fact, a monetary expansion in the home country leads to a proportional depreciation of the home currency and to an increase in all nominal variables.

Interestingly, for a given degree of price stickiness $\tau$, the welfare effect of a monetary expansion is increasing in the degree of openness. The key reason is that, in a more open economy, the impact of the terms of trade on consumption is larger. In particular, since a depreciation of the exchange rate in the wake of a monetary expansion (see eq. (30)) causes an improvement in the terms of trade under a zero pass-through only when some goods are traded, consumption rises via the increase in consumption of foreign produced traded goods. Moreover, as noted above, output is less responsive to monetary expansion under zero pass-through. Thus, a monetary expansion leads to larger welfare improvement in more open economies.

# 5 Concluding remarks

This paper studied the role of collective agreement mechanisms in the labor market in a standard open-economy model considering the impact of a monetary expansion on welfare. The level at which collective bargaining takes place is usually considered important in determining wage levels and differs greatly across countries. The results show that models that disregard collective wage bargaining, e.g. by assuming atomistic wage setting, can yield substantial errors in the valuation of the welfare gain from the depreciation of the home currency.

In presence of collective bargaining coverage, wages are determined, among others, by the degree of exchange rate pass-through and the elasticity of substitution across goods. When exchange rate fluctuations affect the price of imported goods, a monetary expansion in the home country can magnify its welfare effect depending on the rate of collective bargaining coverage. Non-atomistic wage setters in fact anticipate a rise in their real income in the wake of their wage demands through two mechanisms depending on the degree of exchange rate pass-through. First, when there is some degree of exchange rate pass-through, wage setters raise real labor income and consumption via a worsening in the terms of trade. This makes all home goods more competitive vis-à-vis foreign ones, thereby boosting domestic output and generating an increase in consumption of home-produced traded goods. Second, when the degree of exchange rate pass-through is zero, large unions perceive to raise workers' income through an improvement in terms of trade in the wake of their wage demand, letting workers consume more foreign-produced traded goods.

When prices are not affected by the exchange rate in the short run, namely with zero exchange rate pass-through, the impact of a monetary expansion on welfare is less responsive to labor institutions. This is mainly due to the fact that labor demand is more insulated from

exchange rate movements and is perceived as being more elastic by non-atomistic wage setters. Both effects entail wage bargaining systems having a lower impact on labor income, since workers do not benefit as much from the depreciation of the exchange rate in the wake of a monetary expansion.

The model shows that large welfare gains arising from centralization of wage bargaining depend on the interaction between labor and product markets. Product and labor market distortions are strategic substitute for unions: when labor market distortions are sizeable, the increase in competitiveness between foreign and domestic goods has a more relevant impact on wage determination. Moreover, for a given collective bargaining system, the welfare results are more sensitive to the degree of openness and price stickiness.

A possible extension of this analysis is to include alternative shocks, such as government spending and productivity shocks, and studying endogenous monetary policy. I plan to pursue these extensions in future works.

# Appendix

## A Impact of union's wage on aggregate wage

From the wage index (17), we obtain

$$\begin{aligned}\frac{\partial W_t}{\partial W_t(x)} &= \frac{\partial}{\partial W_t(x)}\left[\int_0^1 W_t(j)^{1-\sigma}\mathrm{d}j\right]^{\frac{1}{1-\sigma}} \\ &= \frac{\partial}{\partial W_t(x)}\left[\int_{j\in x} W_t(j)^{1-\sigma}\mathrm{d}j+\int_{j\notin x} W_t(j)^{1-\sigma}\mathrm{d}j\right]^{\frac{1}{1-\sigma}} \\ &= \frac{1}{n}\left[\frac{W_t(x)}{W_t}\right]^{-\sigma}=\frac{1}{n}, \end{aligned} \tag{31}$$

where the last equality holds in a symmetric equilibrium, i.e. when $W(x)=W$.

## B Exchange rate elasticity to union's wage

In order to assess how trade unions internalize the impact of their wage settlement on the exchange rate, it is convenient to log-linearize key equations around a steady state described in Section 4.1. Henceforth, I will denote a log-linearized variable $V$ around its steady state $V_0$ as follows: $\mathsf{v}\equiv(V-V_0)/V_0$; and its cross-country difference as $\mathsf{v}^R\equiv\mathsf{v}-\mathsf{v}^*$.

From the home country current account (9) and the corresponding foreign current account,

$$\mathsf{c}_t^R+\mathsf{p}_t^R+2\mathsf{b}_{t+1}=\frac{1}{\theta}\mathsf{d}_t^R+\frac{\theta-1}{\theta}(\mathsf{y}_t^R+\mathsf{w}_t^R)+\frac{1}{\beta}2\mathsf{b}_t. \tag{32}$$

The optimal firms' prices can be log-linearized as follows

$$\mathsf{p}_{Ht}(z) = \mathsf{p}_{Nt}(z) = \tau \mathsf{w}_t \qquad \mathsf{p}^*_{Ht} = \tau(\mathsf{w}_t - \mathsf{s}_t) - \mathsf{s}_t \eta(1-\tau),$$

$$\mathsf{p}^*_{Ft}(z) = \mathsf{p}^*_{Nt}(z) = \tau \mathsf{w}^*_t \qquad \mathsf{p}_{Ft} = \tau(\mathsf{w}^*_t + \mathsf{s}_t) + \mathsf{s}_t \eta(1-\tau).$$

Using the above expressions, difference between the home CPI (3) and the corresponding for the foreign country turns out to be

$$\mathsf{p}^R_t = \frac{2\mathsf{s}_t(1-\gamma)(\eta(1-\tau)+\tau) + \mathsf{w}^R_t \gamma \tau}{2-\gamma}. \tag{33}$$

Similarly, from the aggregate output demands and revenues

$$\mathsf{y}^R_t = \frac{\mathsf{c}^R_t \gamma + \lambda(\mathsf{p}^R_t \gamma - \mathsf{w}^R_t(2-\gamma)\tau + 2\mathsf{s}_t(1-\gamma)(\eta + (1-\eta)\tau))}{2-\gamma}, \tag{34}$$

$$\frac{\mathsf{d}^R_t}{\theta} = \frac{2\mathsf{s}_t(1-\gamma)(1-\eta)(1-\tau)}{2-\gamma} + \frac{\mathsf{w}^R_t(1-\theta(1-\tau))}{\theta} + \frac{\mathsf{y}^R_t}{\theta}. \tag{35}$$

Next the Euler equations and money demands respectively yield

$$\beta \mathsf{i}^R_t = \mathsf{s}_{t+1} - \mathsf{s}_t, \tag{36}$$

$$\varepsilon(\mathsf{m}^R_t - \mathsf{p}^R_t) = \rho \mathsf{c}^R_t - \frac{\beta}{1-\beta}(\beta \mathsf{i}^R_t) \tag{37}$$

Finally, combining eqs. (32)-(37) and taking profits and fiscal policy as given, the elasticity of exchange rate to aggregate home wage is

$$\frac{\partial \mathsf{s}_t}{\partial \mathsf{w}_t} = \frac{2 - 2\theta(1-\tau) - 2\lambda\tau + \gamma(\theta - 1 + \tau - \theta\tau)}{\gamma(2\theta(1-\tau) - 1 - 2\eta(\theta-1)(1-\tau) + 2\tau) - 2\theta + 2(\theta-\lambda)(\eta + \tau - \eta\tau)}. \tag{38}$$

Eq. (19) is obtained by using eq. (31) and evaluating the above expression at $\tau = \gamma = 0$.

# C Labor demand and CPI elasticities to union's wage

The consumer price indexes (3) are log-linearized around a symmetric state (Section 4.1) as follows:

$$\mathsf{p}_t = \frac{1-\gamma}{2-\gamma}\mathsf{p}_{Ht} + \frac{1-\gamma}{2-\gamma}\mathsf{p}_{Ft} + \frac{\gamma}{2-\gamma}\mathsf{p}_{Nt}, \tag{39}$$

$$\mathsf{p}^*_t = \frac{1-\gamma}{2-\gamma}\mathsf{p}^*_{Ht} + \frac{1-\gamma}{2-\gamma}\mathsf{p}^*_{Ft} + \frac{\gamma}{2-\gamma}\mathsf{p}^*_{Nt}. \tag{40}$$

Aggregate output $Y = Y_N + Y_T$ (11) and (10), and profits $D = D_N + D_T$ (12) yield

$$y_t = \frac{2-2\gamma}{2-\gamma}\left[-\lambda\left[\frac{1}{2}(p_{Ht}-p_t)+\frac{1}{2}(p^*_{Ht}-p^*_t)\right]+\frac{1}{2}(c_t+c^*_t)\right]+\frac{\gamma}{2-\gamma}[-\lambda(p_{Nt}-p_t)+c_t] \tag{41}$$

$$y^*_t = \frac{2-2\gamma}{2-\gamma}\left[-\lambda\left[\frac{1}{2}(p_{Ft}-p_t)+\frac{1}{2}(p^*_{Ft}-p^*_t)\right]+\frac{1}{2}(c_t+c^*_t)\right]+\frac{\gamma}{2-\gamma}[-\lambda(p^*_{Nt}-p^*_t)+c^*_t] \tag{42}$$

$$d_t = \theta\left[\frac{2-2\gamma}{2-\gamma}\left[\frac{1}{2}(p_{Ht}+s_t+p^*_{Ht})\right]+\frac{\gamma}{2-\gamma}p_{Nt}\right]-(\theta-1)w_t+y_t \tag{43}$$

$$d^*_t = \theta\left[\frac{2-2\gamma}{2-\gamma}\left[\frac{1}{2}(p_{Ft}-s_t+p^*_{Ft})\right]+\frac{\gamma}{2-\gamma}p^*_{Nt}\right]-(\theta-1)w^*_t+y^*_t. \tag{44}$$

Expanding current accounts (9),

$$p_t + c_t + b_{t+1} = \frac{1}{\theta}d_t + \frac{\theta-1}{\theta}(w_t+y_t)+\frac{1}{\beta}b_t. \tag{45}$$

Similarly, money demands (5) are linearized as follows

$$\varepsilon(m_t-p_t) = \rho c_t - \beta/(1-\beta)(\beta i_{t+1}) \tag{46}$$

$$\varepsilon(m^*_t-p^*_t) = \rho c^*_t - \beta/(1-\beta)(\beta i^*_{t+1}). \tag{47}$$

Next from the two Euler equations (6)

$$\beta i_{t+1} = \rho(c_{t+1}-c_t)+p_{t+1}-p_t \tag{48}$$

$$\beta i^*_{t+1} = \rho(c^*_{t+1}-c^*_t)+p^*_{t+1}-p^*_t+s_{t+1}-s_t. \tag{49}$$

Finally, combining all the above expression and taking profits, fiscal and next period variables as given, I obtain

$$\frac{\partial p_t}{\partial w_t} = \frac{2(1-\gamma)\tau+2\gamma\tau-\frac{2(1-\gamma)(\eta(1-\tau)+\tau)(\gamma(\theta-1)(\tau-1)+2(\theta-1-\theta\tau+\lambda\tau))}{\gamma(2\eta(\theta-1)(\tau-1)-1+2\theta(1-\tau)+2\tau)+2(\theta-\lambda)(\eta+\tau-\eta\tau)}}{2(2-\gamma)-2\theta}, \tag{50}$$

$$\begin{aligned}\frac{\partial y_t}{\partial w_t} \;=\;& -\frac{\left(\gamma^2+\beta(\gamma-2)(\varepsilon-1)+2(\varepsilon+\lambda\rho)-\gamma(1+\varepsilon+2\lambda\rho)\right)\tau}{(2-\gamma)^2\rho} \\ & -\frac{(1-\gamma)(\gamma(-1+(2-\beta+(\beta-1)\varepsilon)\eta)-2(-1+(\beta-1)(\varepsilon-1)\eta+\eta\lambda\rho))}{(\gamma-2)^2\rho}\frac{\partial s_t}{\partial w_t} \\ & -\frac{(1-\gamma)(1-\eta)(\beta(\gamma-2)(\varepsilon-1)-\gamma\varepsilon+2(\gamma-1+\varepsilon-\lambda\rho))\tau}{(\gamma-2)^2\rho}\frac{\partial s_t}{\partial w_t},\end{aligned} \tag{51}$$

where $\partial \mathsf{s}_t / \partial \mathsf{w}_t$ is eq. (38). From the eqs. (16), (38), (51), and (50), define the elasticity of labor demand to real wage $\delta$ as follows

$$\delta \equiv \frac{\Sigma_h}{1-\Sigma_p}, \qquad \Sigma_h \equiv -\frac{\partial \log H(x)}{\partial \log W(x)} = \sigma\left(1-\frac{1}{n}\right) - \frac{\partial \mathsf{y}_t}{\partial \mathsf{w}_t}\frac{1}{n}, \qquad \Sigma_p \equiv \frac{\partial \log P}{\partial \log W(x)} = \frac{\partial \mathsf{p}_t}{\partial \mathsf{w}_t}\frac{1}{n}. \tag{52}$$

# D Derivation of the union's first-order condition

In order to derive the $x$-th union first-order condition, it is convenient to reproduce the Lagrangian relevant to this purpose

$$\begin{aligned}\mathscr{L}^{\mathscr{W}} \quad = \quad & \frac{C_t(x)^{1-\rho}}{1-\rho} - \frac{\kappa}{1+\omega}H_t(x)^{1+\omega} + \xi_t\left[C_t(x) + \frac{M_t(x)}{P_t} + \frac{B_{t+1}(x)}{P_t}\right. \\ & \left. - \frac{W_t(x)H_t(x)}{P_t} - \frac{M_{t-1}(x)}{P_t} - \frac{T_t(x)}{P_t} - \frac{D_t(x)}{P_t} - (1+i_t)\frac{B_t(x)}{P_t}\right], \qquad \forall x \in \{1,2,...,n\}\end{aligned} \tag{53}$$

The first-order condition with respect to $W_t(x)$ is given by

$$\begin{aligned}-\frac{\kappa}{1+\omega}\frac{\partial H_t(x)^{1+\omega}}{\partial W_t(x)} &= -\xi_t\left[\frac{H_t(x) + \frac{\partial H_t(x)}{\partial W_t(x)}W_t(x)}{P_t} - \frac{\partial P_t}{\partial W_t(x)}\frac{W_t(x)H_t(x)}{P_t^2}\right] \\ -\kappa H_t(x)^{\omega}\frac{\partial H_t(x)}{\partial W_t(x)} &= -\frac{C_t^{-\rho}(x)H_t(x)}{P_t}\left[1 + \frac{\partial H_t(x)}{\partial W_t(x)}\frac{W_t(x)}{H_t(x)} - \frac{\partial P_t}{\partial W_t(x)}\frac{W_t(x)}{P_t}\right] \\ \kappa H_t(x)^{\omega}\Sigma_h &= -\frac{C_t^{-\rho}(x)W_t(x)}{P_t}\left[1-\Sigma_h-\Sigma_p\right] \\ \Longrightarrow W_t(x) = W_t &= \frac{\delta}{\delta-1}\kappa P_t C_t^{\rho} H_t^{\omega},\end{aligned}$$

where in the last equation we have dropped the $x$ index because of the symmetry between workers in equilibrium and used the definition of $\delta$ derived in Appendix C.

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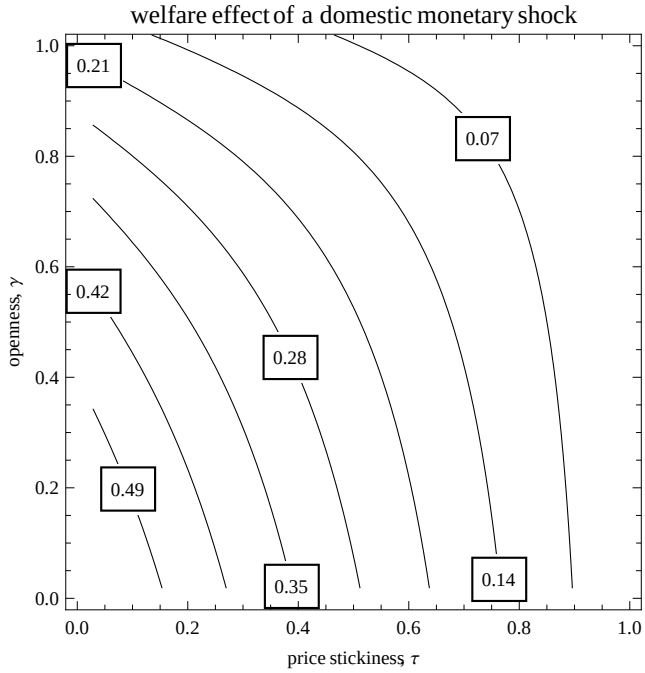


Figure 1: Degree of openness and price stickiness

Table 1: Collective bargaining coverage, 2007 or latest year[abc]

| | **Less than 15%** | **15-50%** | **51-70%** | **Higher than 70%** |
|---|---|---|---|---|
| European Union | Latvia, Lithuania | Hungary, Poland, Slovakia, United Kingdom | Czech Republic, Germany, Luxembourg | Austria, Belgium, Denmark, Finland, France, Greece, Italy, Netherlands, Portugal, Romania, Slovenia, Spain, Sweden |
| Non-EU | Serbia, Turkey | Switzerland | | Norway |
| CIS countries | | | | Belarus, Russia, Ukraine |
| North America | United States | Canada | | |
| Other developed economies | New Zealand | Australia, Japan | | |
| East Asia | Republic of Korea | | China | |
| Pacific islands | Kiribati | | | |
| South Asia | Nepal | India | | |
| South-East Asia | Indonesia, Malaysia, Philippines, Singapore, Thailand | | | |
| Central America | El Salvador, Mexico, Nicaragua | | | |
| South America | Brazil, Chile, Colombia, Peru | Venezuela | | Argentina, Bolivia, Uruguay |
| Middle East | United Arab Emirates | | | |
| North Africa | Morocco | | | Sudan |
| Sub-Saharan Africa | Burundi, Comoros, Malawi, Mauritania | South Africa, Ghana, Kenya, Swaziland, Tanzania, Togo | Guinea, Lesotho | Ethiopia, Niger, Senegal |

[a] *Source:* International Labour Office (2008) p. 38.

[b] The rate of collective bargaining is an indicator of the extent to which the terms of employment are regulated by collective agreements. It is defined as the number of employees covered by a collective agreement as a proportion of the total number of employees (i.e. wage and salary earners). This rate is an "unadjusted" one in the sense that it does not take into account the number of employees excluded from the right to bargain. Data on these excluded employees are difficult to estimate and reliable data are not readily available.

[c] The rate of collective bargaining is not necessarily the same as the union density (i.e. the ratio of the number of union members to the total number of paid employees. The main difference comes from the fact that the former reflects the presence of extension mechanisms which allow collective agreements to be applied to non-union members. Extension mechanisms have been relatively common in European countries, but are sometimes found in other regions such Africa (e.g. South Africa) and Latin America (e.g. Argentina).

Table 2: Home household's consumption baskets and price indexes

| | |
|---|---|
| $C_H = \left[\left(\frac{2}{1-\gamma}\right)^{1/\theta} \int_{\gamma/2}^{1/2} (C_H(z))^{(\theta-1)/\theta} \mathrm{d}z\right]^{\theta/(\theta-1)}$ | $P_H = \left[\frac{2}{1-\gamma} \int_{\gamma/2}^{1/2} (P_H(z))^{1-\theta} \mathrm{d}z\right]^{1/(1-\theta)}$ |
| $C_F = \left[\left(\frac{2}{1-\gamma}\right)^{1/\theta} \int_{1/2}^{1-\gamma/2} (C_F(z))^{(\theta-1)/\theta} \mathrm{d}z\right]^{\theta/(\theta-1)}$ | $P_F = \left[\frac{2}{1-\gamma} \int_{1/2}^{1-\gamma/2} (P_F(z))^{1-\theta} \mathrm{d}z\right]^{1/(1-\theta)}$ |
| $C_N = \left[\left(\frac{2}{\gamma}\right)^{1/\theta} \int_{0}^{\gamma/2} (C_N(z))^{(\theta-1)/\theta} \mathrm{d}z\right]^{\theta/(\theta-1)}$ | $P_N = \left[\frac{2}{\gamma} \int_{0}^{\gamma/2} (P_N(z))^{1-\theta} \mathrm{d}z\right]^{1/(1-\theta)}$ |

Table 3: Welfare effect of a domestic monetary expansion (Baseline specification)

| *Baseline utility with high elasticity of goods types* ($\rho = 1, \varepsilon = 1, \gamma = 0, \omega = 0, \lambda = 7$) | | | | |
|---|---|---|---|---|
| *Rate of collective bargaining coverage*: | **High** | **Medium** | **Low** | *Competitive labor markets* |
| Preset prices | | | | |
| –Complete exchange pass-through | 0.47 | 0.23 | 0.16 | 0.07 |
| –Zero exchange pass-through | 0.69 | 0.65 | 0.61 | 0.57 |
| *Baseline utility with low elasticity of goods types* ($\rho = 1, \varepsilon = 1, \gamma = 0, \omega = 0, \lambda = 2.5$) | | | | |
| *Rate of collective bargaining coverage*: | **High** | **Medium** | **Low** | *Competitive labor markets* |
| Preset prices | | | | |
| –Complete exchange pass-through | 0.01 | 0.02 | 0.02 | $-0.06$ |
| –Zero exchange pass-through | 0.69 | 0.65 | 0.61 | 0.57 |

Table 4: Welfare effect of a domestic monetary expansion (General specification)

| *General utility with high elasticity of goods types* ($\rho = 4, \varepsilon = 2, \gamma = 0.75, \omega = 1, \lambda = 7$) | | | | |
|---|---|---|---|---|
| *Rate of collective bargaining coverage*: | **High** | **Medium** | **Low** | *Competitive labor markets* |
| Preset prices | | | | |
| –Complete exchange pass-through | 0.29 | 0.19 | 0.13 | 0.08 |
| –Zero exchange pass-through | 0.25 | 0.24 | 0.24 | 0.23 |
| *General utility with low elasticity of goods types* ($\rho = 4, \varepsilon = 2, \gamma = 0.75, \omega = 1, \lambda = 2.5$) | | | | |
| *Rate of collective bargaining coverage*: | **High** | **Medium** | **Low** | *Competitive labor markets* |
| Preset prices | | | | |
| –Complete exchange pass-through | 0.14 | 0.09 | 0.06 | 0.03 |
| –Zero exchange pass-through | 0.27 | 0.27 | 0.26 | 0.26 |