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A Case for Intermediate Exchange-Rate Regimes

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NON-TECHNICAL SUMMARY

Despite increasing capital mobility and the subsequent difficulty in controlling exchange rates, intermediate exchange-rate regimes have remained widespread, especially in emerging and developing economies. This piece of evidence hardly fits the "impossible Trinity" theory arguing that it becomes difficult to control the exchange rate without a "hard" device when capital flows are freed. Calvo and Reinhart (2000) have suggested several explanations for such "fear of floating": exchange rate pass-through, liability dollarization, dollar invoicing of domestic and external transactions, and an underdeveloped market for currency hedging make it more desirable to stabilize the nominal exchange rate.

However, the New-Keynesian model, which has become the main workhorse for studying exchange-rate regime choice since the 1990s, typically opposes fixed nominal pegs to free-floating regime, without considering intermediate regimes. We intend to fill this gap here by comparing the performance of "extreme" regimes to that of an intermediate regime where monetary authorities care both about inflation and about nominal exchange-rate deviations from the steady state, when a small economy is hit by several types of shocks. Without nominal wage rigidities, our results are in line with the New-Keynesian literature arguing in favor of inflation-targeting regimes. However, when nominal wage rigidities are taken into account, we find the intermediate regime to be appropriate for an economy that is mainly hit by productivity and foreign-interest shocks, which is often the case in emerging and developing economies. The free-floating regime (with inflation targeting) seems more adequate if the economy experiences mostly demand shocks and foreign prices shock. Finally, the fixed peg regime is always dominated by either the free-floating or the intermediate regime.

A fully-fledged analysis of intermediate regimes should of course account for the fear-of-floating-type advantages of such regimes, as well as for their shortcomings in terms of costly reserve-accumulation and/or recurrent crises. Our results however suggest that, by concentrating on two extreme regimes (fixed nominal pegs and free floats), by neglecting wage rigidities and/or by assuming that floating countries can engineer an "optimal" interest-rate feedback rule, the existing New-Keynesian literature may have exaggerated the merits of free-floating regimes to the detriment of "soft" pegs.

ABSTRACT

Despite increasing capital mobility and the subsequent difficulty in controlling exchange rates, intermediate exchange-rate regimes have remained widespread, especially in emerging and developing economies. However, the New-Keynesian model, which has become the main work-horse for studying exchange-rate regime choice since the 1990s, typically opposes fixed nominal pegs to free floats, without considering intermediate regimes. We intend to fill this gap by comparing the performance of "extreme" regimes to that of an intermediate regime whereby monetary authorities care both about inflation and about nominal exchange-rate deviations from the steady state, when a small economy is hit by several types of shocks. Without nominal wages rigidities, our results are in line with the New-Keynesian literature arguing in favor of floating regimes. However, when nominal wage rigidities are taken into account, we find the intermediate regime to be more appropriate for an economy that is mainly hit by productivity and foreign-interest shocks, which is often the case in emerging and developing economies. The free-floating regime (with inflation targeting) seems more adequate if the economy experiences mostly demand shocks and foreign-price shocks. Finally, the fixed peg regime is always dominated by either the free-floating or the intermediate regime.

JEL Classification: F33, F41

Keywords: Exchange-rate regime, DSGE model.

UN ARGUMENT EN FAVEUR DES RÉGIMES DE CHANGE INTERMÉDIAIRES

RÉSUME NON TECHNIQUE

Les régimes de change intermédiaires demeurent très répandus dans le monde et notamment dans les pays émergents ou en développement, et ce malgré la mobilité croissante des capitaux qui rend difficile tout contrôle des taux de changes. Ce constat contredit largement le "triangle d'impossibilité" de Mundell selon lequel, lorsque les capitaux sont mobiles, un taux de change fixe est difficilement tenable sans un ancrage "dur" supprimant toute autonomie de la politique monétaire. Calvo et Reinhart (2000) ont proposé plusieurs explications à la réticence des pays à laisser flotter leur monnaie : les pratiques de tarification au marché, un endettement en monnaie étrangère, des transactions, y compris domestiques, effectuées en devises, ou des marchés financiers trop peu développés pour permettre une bonne couverture du risque de change.

Couramment utilisés pour étudier les régimes de change depuis les années 1990, les modèles de la nouvelle économie keynésienne opposent traditionnellement les changes fixes aux changes flexibles, négligeant les régimes intermédiaires. On cherche ici à combler ce manque en comparant les performances des régimes "en coin" (complètement fixes ou complètement flottants) à celles d'un régime intermédiaire où les autorités chercheraient à limiter à la fois l'inflation et les écarts du taux de change nominal par rapport à son niveau d'équilibre stationnaire, quand une petite économie est frappée par différents types de chocs. Lorsqu'aucune friction n'entrave l'ajustement des salaires, nos résultats sont en ligne avec la littérature de la nouvelle économie keynésienne, plaidant en faveur des régimes de change flexible. En revanche, lorsque les rigidités nominales pesant sur les salaires sont prises en compte, le régime intermédiaire devient préférable pour une économie subissant essentiellement des chocs de productivité et des chocs de taux d'intérêt étranger. C'est généralement le cas dans les pays émergents et en développement. Le régime de change flottant (avec ciblage de l'inflation) est plus adapté si l'économie doit fréquemment faire face à des chocs de demande étrangère et de prix étrangers. Le régime de change fixe est toujours dominé, en termes de bien-être, par l'un ou l'autre des deux autres régimes.

Une analyse exhaustive de régimes de changes intermédiaires nécessiterait la prise en compte de leurs avantages liés à la "peur du flottement", mais aussi de leurs limites, notamment l'accumulation coûteuse de réserves de changes qu'ils nécessitent et/ou leur faible résilience face aux attaques spéculatives. Nos résultats montrent cependant qu'en se focalisant sur les régimes "en coin", les modèles de la nouvelle économie keynésienne ont probablement surestimé les mérites des régimes de changes flottants par rapport à des régimes visant une certaine stabilité du change. Ils n'ont en effet généralement pas pris en compte les rigidités nominales liées aux salaires et ont considéré que les pays en régimes de changes flexibles pouvaient effectivement mettre en œuvre des politiques monétaires optimales.

RÉSUMÉ COURT

Les régimes de change intermédiaires demeurent très répandus dans le monde et notamment dans les pays émergents ou en développement, et ce malgré la mobilité croissante des capitaux qui rend difficile tout contrôle des taux de change. Couramment utilisés pour étudier les régimes de change depuis les années 1990, les modèles de la nouvelle économie keynésienne opposent traditionnellement les changes fixes aux changes flexibles, négligeant les régimes intermédiaires. On cherche ici à combler ce manque en comparant les performances des régimes "en coin" (complètement fixes ou complètement flexibles) à celles d'un régime intermédiaire où les autorités chercheraient à limiter à la fois l'inflation et les écarts du taux de change nominal par rapport à son niveau d'équilibre stationnaire, quand une petite économie est frappée par différents types de chocs. Lorsqu'aucune friction n'entrave l'ajustement des salaires, nos résultats sont en ligne avec la littérature de la nouvelle économie keynésienne, plaidant en faveur des régimes de change flexible. En revanche, lorsque les rigidités nominales pesant sur les salaires sont prises en compte, le régime intermédiaire devient préférable pour une économie subissant essentiellement des chocs de productivité et des chocs de taux d'intérêt étranger. C'est généralement le cas dans les pays émergents et en développement. Le régime de change flottant (avec ciblage de l'inflation) est plus adapté si l'économie doit fréquemment faire face à des chocs de demande étrangère et de prix étrangers. Le régime de change fixe est toujours dominé, en termes de bien-être, par l'un ou l'autre des deux autres régimes.

Classification JEL : F33, F41

Mots clés : Régime de change, modèle d'équilibre général dynamique stochastique.

A CASE FOR INTERMEDIATE EXCHANGE-RATE REGIMES

Véronique Salins* and Agnès Bénassy-Quéré†

1. INTRODUCTION

Since the European crisis of 1992-93 and the Asian crisis of 1997-98, the conventional wisdom of international policymaking has been that economies open to international capital flows should not try to fix their nominal exchange rate, unless they adopt a currency board or they move to full dollarization, "euroization" or currency union (Eichengreen, 1999; Fischer, 2001). However empirical evidence on a "hollowing out" of intermediate exchange-rate regimes has been relatively weak. Among advanced economies, Euro-area countries do have moved from conventionally fixed exchange rates (the European exchange-rate mechanism) to a monetary union, translating into a net increase in the proportion of hard peggers. In developing and emerging countries, however, intermediate regimes have remained widespread (see Calvo and Reinhart, 2002; Levy-Yeyati and Sturzenegger, 2005; Masson, 2001; Bénassy-Quéré, Coeuré and Mignon, 2006; Eichengreen and Razo-Garcia, 2006). Figure 1 illustrates the resilience of intermediate exchange-rate regimes since the 1980s, even when managed floating regimes are classified as floats. This piece of evidence hardly fits the "impossible Trinity": the steady increase in capital mobility in both advanced and developing economies since the 1980s (see Figure 2) has not been accompanied by a move towards extreme exchange-rate regimes at the expense of intermediate ones.

Calvo and Reinhart (2002) have suggested several explanations for such "fear of floating": exchange rate pass-through, liability dollarization, dollar invoicing of domestic and external transactions, and an underdeveloped market for currency hedging are as many reasons to try to stabilize the nominal exchange rate. However no existing theoretical model produces hard pegs or free floats as optimal solutions of a welfare-maximizing exercise where the full range of exchange rate regimes would be available as policy options. In fact, the bulk of the literature on optimal exchange-rate regimes has been carried out within the New-Keynesian framework where the fixed exchange rate regime is contrasted with the free floating one (see Clarida, Galí, Gertler, 2001), while disregarding intermediate regimes.

In this paper, we intend to fill this gap by studying the rationale for an intermediate regime within a standard, small-economy, New-Keynesian model with price and wage rigidities. We define the intermediate regime as a regime where monetary authorities intend to stabilize the inflation rate while limiting the deviations of the nominal exchange rate from its steady-state

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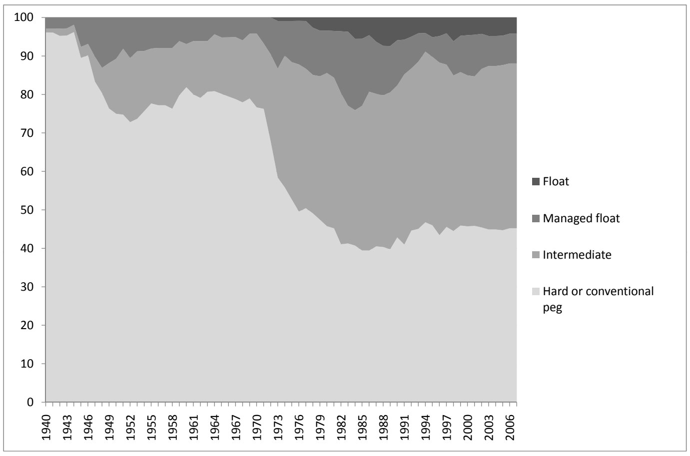
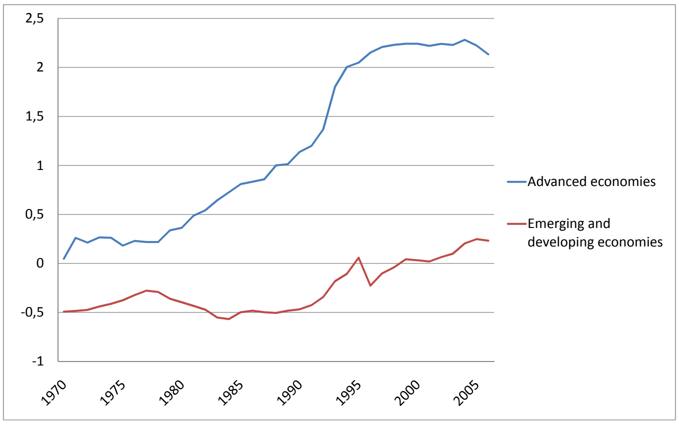
Figure 1 – Hard pegs, floats and intermediate regimes, 1940-2007, % of countries in each regime



Source: Ilzetski, Reinhart and Rogoff database.

Figure 2 – Index of financial openness, 1970-2006



Source: Chinn and Ito (2008).

level. We compare this regime with both a fixed nominal peg and a free-floating regime. Departing from the optimal-rule literature, we assume that under the latter regime, monetary policy follows an inflation-targeting rule. Indeed, inflation targeting has arisen as the most popular substitute for exchange-rate pegs since the 1990s, both in advanced and in emerging countries.

We find that, when wages are sticky, the intermediate regime dominates both the free floating and the fixed peg regimes when the economy is mainly hit by productivity and foreign interest-rate shocks. In contrast, a fixed nominal peg never performs better than either the floating or the intermediate regime, whatever the shocks hitting the economy. We conclude that, by disregarding the possibility of soft pegs, the New-Keynesian literature has maybe put too much emphasis on the superiority of floating regimes. Such result is especially striking in that it does not rely on fear-of-floating arguments that are deliberately left aside from the exercise.

The paper is organized as follows. In Section 2, we briefly review the relevant literature. Section 3 presents the model and its calibration. Section 4 comments the impulse-response functions. Section 5 presents the welfare analysis. In Section 6, some robustness checks are performed. Section 7 concludes.

2. Literature review

Dellas and Tavlas (2009) note that the theoretical literature on exchange-rate regime choice has experienced a revival since the early 1990s through the use of the New-Keynesian framework to analyze the optimality of monetary-policy rules when an open economy is hit by shocks. The basic result is that, in the presence of nominal rigidities, pegging the exchange rate reduces welfare compared to a free-floating regime since in precludes immediate adjustment of the real exchange rate (see Kollmann, 2002).

More generally, as noted by Calvo and Mishkin (2003), the main disadvantage of a fixed exchange-rate regime is that it narrows the scope of domestic monetary policy, whereas in a flexible regime, monetary policy can be used fully to stabilize the economy. For instance, Clarida, Galí and Gertler (2001) show the superiority of an interest-rate feedback rule over a fixed exchange rate when an economy is hit by demand or supply shocks. The parameters of the interest-rate rule are set at their optimal level, whereas there is only one way to define a fixed nominal peg, which is unlikely to be optimal.

To depart from such common wisdom, it is then necessary to introduce specific features such as pricing-to-market (see Devereux and Engel, 2003; Duarte, 2003; Corsetti and Pesenti, 2005), liability dollarization (Elekdağ and Tchakarov, 2007), and/or balance-sheet effects with (Céspedes, Chang and Velasco, 2004, Gertler, Gilchrist and Natalucci, 2007).

Calvo and Mishkin further argue that emerging countries may not have the adequate institutions to handle optimal monetary policy, which raises the case for a fixed exchange rate. Since the 1990s, however, central banks in emerging countries have become increasingly independent[1] and they have often been able to run inflation-targeting strategies.[2] Still, exchange-rate stabilization has remained a widespread strategy, as evidenced in Figure 1.

The case for intermediate exchange-rate regimes has rarely been studied in the theoretical literature. An exception is Aizenman and Frenkel (1985) who study the joint determination of the optimal degree of wage indexation and of foreign-exchange intervention. Another exception is Lahiri and Végh (2001) who model the trade-off between the output cost of exchange-rate volatility and the social cost of foreign-exchange intervention. They first compare the performance of four exchange-rate regimes (nominal exchange rate peg, pure floating, dirty floating, and sterilized intervention). Then, they show that monetary authorities should try to stabilize the exchange rate only when the economy is hit by large shocks, which resembles a band-regime.

Within the New-Keynesian strand of the literature, though, little attention has been devoted to intermediate exchange-rate regimes, perhaps because these regimes are difficult to define in a non-ad hoc way. One exception is De Paoli (2009b) who shows that when home and foreign goods are close substitutes, the optimal policy rule involves lower real exchange-rate volatility than an inflation-targeting regime under complete markets. Under incomplete markets the opposite holds: nominal exchange rate stabilization is appropriate when the elasticity of substitution between goods is low. But according to De Paoli, there are few cases when a currency peg can outperform an inflation-targeting regime.

Campolmi (2009) provides a recent, new insight on monetary regime choice by incorporating staggered wage contracts in the analysis. In this case, CPI inflation targeting displays better performance in terms of welfare than PPI targeting, which can be viewed a reason why stabilizing the nominal exchange rate. However the paper does not analyze the case for a currency peg nor intermediate regimes.

In this paper, we aim at studying the case for an intermediate exchange-rate regime within a standard, New-Keynesian framework including staggered wage contracts, and to compare this regime with both a fixed nominal peg and a free-floating regime with inflation targeting. We depart from the literature by not studying the optimal monetary rule, since most central banks tend to adopt rather simple rules. Consistently, we assume that, under a flexible exchange-rate regime, the central bank follows an inflation-targeting rule, whereas under a peg, the nominal exchange rate stays constant. As for the intermediate regime, it is defined through an interest-rate feedback rule where the authorities care about both inflation and nominal exchange-rate deviations from steady-state. Hence, the intermediate regime lies in-between the two extreme regimes, and the latter regimes can be recovered by setting the parameters of the intermediate regime at extreme values.

[1]See Crow and Meade, 2008.
[2]See Mishkin and Schmidt-Hebbel (2007).

3. THE MODEL

Like Galí and Monacelli (2005) and De Paoli (2009a), we consider a model of a small economy with imperfect competition and price rigidities, which we extend to include wage rigidities. Households consume a domestic good and a foreign good that are imperfect substitutes. Like in De Paoli (2009b), capital markets are assumed incomplete, so households have access to only two types of riskless bonds: domestic and foreign bonds, only the latter being traded internationally.

Production takes place in two stages. The final good is a composite of differentiated goods produced by a continuum of firms producing intermediate goods. While the market for final goods is assumed perfectly competitive, that for intermediate goods operates under monopolistic competition, with staggered nominal prices *à la* Calvo (1983).

We successively consider the case of perfect wage flexibility and of staggered wage contracts. Christiano, Eichenbaum and Evans (2005), and Smets and Wouters (2003) argue that the introduction of staggered wage contracts improve the ability of DGSE models to replicate dynamic responses of an economy to shocks.

3.1. Consumption and demand

The representative household is assumed to maximize her expected inter-temporal utility which positively depends on consumption C_t and negatively depends on hours worked N_t:

$$\max W = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{{C_t}^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} \right] \tag{1}$$

with $\sigma, \phi > 0$. The volume of consumption by the representative consumer at time t, C_t, is defined as follows, where C_t^h, C_t^f denote the consumption of the home and of the foreign good, respectively:

$$C_t \equiv [(1-\gamma)^{\frac{1}{\eta}}(C_t^h)^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}}(C_t^f)^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} \tag{2}$$

where $\eta > 0$ is the elasticity of substitution between domestic and foreign goods and γ ($0 < \gamma < 1$) represents the preference of the home consumer for the foreign good. The corresponding price index is:

$$P_t \equiv [(1-\gamma)(P_t^h)^{1-\eta} + \gamma(P_t^f)^{1-\eta}]^{\frac{1}{1-\eta}} \tag{3}$$

where P_t^h, P_t^f denote the home price of the domestic and of the foreign good, respectively. The first-order conditions are detailed in Appendix A. We assume no pricing-to-market for both the home and the foreign good. Due to the home bias of consumption, the real exchange rate RER_t may nevertheless vary:

$$RER_t = \frac{S_t P_t^*}{P_t} \tag{4}$$

with S_t the nominal exchange rate (the price of the foreign currency in terms of the domestic one), and P_t^* the foreign consumer price index, defined in a similar way as in Equation (3).

Foreign households follow a similar decision-making process as in the home country. For simplicity, the same parameters are assumed to apply in the foreign country. However, we consider the foreign economy as large enough for foreign consumption of the home good to be negligible in the foreign consumption basket (although this consumption is not negligible for the home economy). Hence, we can consider foreign consumption, C_t^*, as exogenous. Furthermore, we assume that, contrasting with the home economy, there is no public spending in the foreign economy. The demand-side of the model is detailed in Appendix A.

3.2. Asset markets

Incomplete asset markets have been pointed as a key feature of emerging countries that can heavily contribute to the pattern of their capital flows and exchange-rate regimes. Here we follow De Paoli (2009b) in assuming that households can only trade two types of nominal riskless bonds, one denominated in the home currency and the other one in the foreign currency. Both have a one-period maturity, but only the latter is traded internationally. As in Benigno (2009), the model is closed through a convex intermediation cost of deviating from the steady-state real value of the foreign asset position, $\bar{b}$. As evidenced by Schmitt-Grohé and Uribe (2003), this feature ensures the stationarity of the model. The household's budget constraint writes:

$$\begin{aligned} & P_t C_t + \frac{B_t^h}{1+i_t} + \frac{S_t B_t^f}{1+i_t^*} \\ & \leq B_{t-1}^h + B_{t-1}^f - \frac{\chi}{2(1+i_t^*)} \left(\frac{S_t B_t^f}{P_t} - \bar{b} \right)^2 + (1-\tau_w) W_t N_t + \Gamma_t - T_t \end{aligned} \tag{5}$$

where Γ_t is the lump-sum profit accruing from ownership of intermediate goods firms, B_t^h and B_t^f represent the value of domestic and foreign bonds at the end of period t,[3] i_t and i_t^* are

[3]Because domestic bonds are not traded internationally, we have $B_t^h = 0$.

the corresponding nominal interest rates. The intermediation cost is scaled by a non-negative parameter χ and, for analytical convenience, by $1/2(1+i_t)$. Following the literature, we assume that labor income $W_t N_t$ is taxed at rate $\tau_w > 0$ to compensate for the markup the workers are able to reap on the labor market (see the determination of wages). We can now derive the Euler conditions:

$$(1+i_t)\beta E_t\left[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}}\frac{P_t}{P_{t+1}}\right]=1 \tag{6}$$

$$(1+i_t^*)\beta E_t\left[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}}\frac{P_t}{P_{t+1}}\frac{S_{t+1}}{S_t}\right]=1+\chi\left(\frac{S_t B_t^f}{P_t}-\bar{b}\right) \tag{7}$$

Equation (6) represents the optimal consumption path in the home country. As for Equation (7), it arises from the trade-off between home and foreign-currency bond holdings. With $\chi = 0$, this equation, together with (6) implies the uncovered interest parity. However with $\chi > 0$, raising foreign bond holdings above the steady-state is consistent with an increase in present consumption compared to future consumption, other things being equal, because of the cost of holding more bonds to consume later on.

3.3. Wages

We assume that each household h supplies a differentiated labor service to the production sector. He maximizes his wage $W_t(h)$ subject to the labor demand function and the budget constraint. Aggregate labor demand writes:

$$N_t=\left[\int_0^1 N_t(h)^{\frac{1-\kappa}{\kappa}}dh\right]^{\frac{\kappa}{\kappa-1}} \tag{8}$$

where $N_t(h)$ is the demand addressed to each household h, and $\kappa > 1$ is the elasticity of substitution between workers.

Following Erceg, Henderson and Levine (2000), we assume that a representative labor aggregator minimizes the aggregate cost of labor, taking as given the nominal wage of each household. This yields the following demand for each household's labor:

$$N_t(h)=\left(\frac{W_t(h)}{W_t}\right)^{-\kappa}N_t \tag{9}$$

where W_t is the aggregate wage index, given by $W_t \equiv \left[\int_0^1 W_t(h)^{1-\kappa}dh\right]^{\frac{1}{1-\kappa}}$. In each period, however, a fraction θ_w of randomly-chosen households are unable to reset their wages, θ_w being i.i.d. These households simply receive the same nominal wage as in the previous period. Those who can reset their wages maximize their utility with respect to the wage rate $W_t(h)$ under (5) and (9) taking into account the probability of not being able to re-optimize in the future. This yields the following first-order condition :

$$E_t \sum_{j=0}^{\infty} (\beta\theta_w)^j \left[P_{t+j}^{-1} C_{t+j}^{-\sigma} W_t(h)(1-\tau_w)\frac{\kappa-1}{\kappa} - N_{t+j}^{\phi}(h) \right] N_{t+j} = 0 \tag{10}$$

τ_w will be calibrated so as to fully eliminate monopolistic competition distortions on the labor market in the steady state, i.e. $\tau_w = \frac{1}{1-\kappa}$. In other terms, τ_w is designed so as to eliminate the markup. Since all households that are able to reset their wages in a given period t will choose the same solution, we have $W_t(h) = W_t$ and $N_t(h) = N_t$.

3.4. Production

The final good is produced using a continuum of intermediate goods following a CES technology:

$$Y_t = \left(\int_0^1 Y_t(k)^{\frac{\xi-1}{\xi}} dk \right)^{\frac{\xi}{\xi-1}} \tag{11}$$

where Y_t denotes the output of final good, $Y_t(k)$ is the input of intermediate good k, and $\xi > 0$ is the elasticity of substitution between intermediate goods. Both Y_t and $Y_t(k)$ are expressed in per capita terms. In turn, the production of intermediate good depends on employment N_t and on an exogenous, stochastic productivity factor A_t:

$$Y_t(k) = A_t N_t(k) \tag{12}$$

As detailed in Appendix A, this specification yields the following expression for the supply of final goods:

$$Y_t = \frac{A_t N_t}{M_t} \tag{13}$$

with

$$M_t \equiv \int_0^1 \left(\frac{P_t(k)}{P_t^h} \right)^{-\xi} dk \tag{14}$$

M_t is an increasing function of price dispersion across the firms producing intermediate goods. Such dispersion arises due to the inability of some firms to adjust their price at each period (see Appendix A). This introduces an inefficiency that lowers the level of output, other things equal.

3.5. Monetary policy

To close the model we need to express the monetary policy rules in both the home and the foreign country. Like De Paoli (2009b), we assume that the rest of the world follows a policy of strict inflation targeting, maintaining its producer price index at a predetermined level. As for the home country, we successively consider four regimes:

- a flexible exchange rate cum producer-price inflation targeting (a constant PPI inflation rate, equal to its steady-state value);
- a flexible exchange rate cum consumer-price inflation targeting (a constant CPI inflation rate, equal to its steady-state value);
- a fixed, nominal exchange rate (constant nominal exchange rate, equal to its steady-state value);
- an intermediate exchange-rate regime whereby the central bank smooths both nominal exchange-rate deviations from steady-state and consumer-price inflation based on the following feed-back rule:

$$(i_t + 1) = (i + 1) \left(\frac{S_t}{S}\right)^a \left(\frac{P_t}{P_{t-1}}\right)^b \tag{15}$$

where i, S, P denote the nominal interest rate, nominal exchange rate and consumer price index in the steady state, respectively, and a, b are positive parameters. Note that the intermediate regimes reduces to a fixed regime if a does to infinity, and to a flexible one if b goes to infinity.[4]

3.6. Welfare

The model is solved numerically up to second-order approximations[5] using DYNARE.[6] The welfare cost associated to a particular monetary regime is measured as the consumption-equivalent of the utility deviation to its steady-state value:

$$\Delta c = (W_S - W)\, C^{\sigma-1} \tag{16}$$

where W and C denote the welfare and consumption levels in the steady state (absent shocks) and W_S represents the welfare level when the economy is hit by a shock, welfare being defined as in Equation (1). This consumption gain or loss following a shock will differ across monetary

[4]The calibration of a and b of course will be ad hoc, since there is a continuum of intermediate regimes. This may explain why the theoretical literature so far has tended to neglect these regimes. In Section 6, we provide sensitivity analysis relative to the calibration of a and b.

[5]See Kim and Kim (2003) on the necessity to use second-order approximations rather than first-order ones.

[6]On DYNARE, see Collard and Juillard (2003).

regimes. Note that, due to the non-linearities of the model, positive and negative shocks do not have symmetric effects on welfare. Stochastic shocks generally impact negatively on welfare, although this is not always the case (see Kollmann, 2002).

3.7. Shocks

We successively consider five perturbations:

- a domestic demand shock (a shock on G_t);
- a productivity shock (on A_t);
- a foreign interest rate shock (on i_t^*);
- a foreign price shock (on P_t^*);
- a foreign demand shock (on C_t^*).

All these shocks are defined as exogenous AR(1) processes as follows:

$$X_t = (1 - \rho_X)X + \rho_X X_{t-1} + \varpi_{Xt} \tag{17}$$

where X_t represents the shocked variable ($X = G, A, i^*, P^*, C^*$), X its steady-state value, ρ_X is the coefficient of auto-regression of the shock, and ϖ_{Xt} is the shock itself (a white noise).

3.8. Calibration

The calibration of the model is detailed in Appendix B. It largely relies on the literature. In the calibration of the intermediate regime, we set a smaller weight on the exchange rate than on inflation ($a = 1$, $b = 5$), mirroring the larger volatility of the former compared to the latter. Section 6 reports sensitivity analysis performed on the key parameters of the model.

4. IMPULSE-RESPONSE FUNCTIONS

In this section, we successively study the impact of the five shocks on the economy, under the four different monetary regimes: (i) a floating exchange rate with producer-price inflation targeting ('PPI' regime), (ii) a floating exchange rate with consumer-price inflation targeting ('CPI'), (iii) a fixed exchange-rate regime ('FIX') and (iv) an intermediate regime ('INT'). The impulse-response functions are reported in Appendix C for the flexible-wage case ($\theta_w = 0$) and in Appendix D for the model with wage rigidity ($\theta_w > 0$).[7]

[7]Note that the model cannot be solved with constant producer price *and* wage rigidity, for in this case the real wage is rigid in the short run, which prevents labor market clearance (the model does not allow for unemployment). Hence the PPI regime is dropped when staggered wage contracts are considered.

4.1. Domestic demand shock

As a first exercise, we consider a temporary increase in domestic demand (a temporary rise in government demand). The impulse-response functions are reported in panels C.1 (flexible wages) and D.1 (staggered wage contracts). The shock produces a temporary increase in production and employment. The labor market clears through an increase in the real wage.[8]

The domestic goods market clears through the fall in domestic consumption and exports. The fall in exports derives from the real exchange-rate appreciation. Domestic holdings of foreign bonds decline accordingly, which reduces intertemporal wealth. Additionally, domestic households suffer a rise in lump-sum taxes. Consequently, their consumption falls as a result of the shock.

The real interest rate falls in all cases except under the PPI regime. In the latter case, the nominal exchange-rate appreciation reduces the consumption price index in the short run, which makes the real interest rate increase. Conversely, in both the INT and the FIX cases, CPI inflation increases and the real interest rate falls following the shock, which is consistent with the real exchange rate going on appreciating during several periods before reversing towards its baseline level.

The way the real exchange-rate appreciation is achieved depends on the monetary regime. Under a flexible exchange-rate regime, the nominal exchange rate appreciates. This is especially the case in the PPI regime where the consumption price falls (which tends to depreciate the real exchange rate). In the FIX regime, the nominal exchange rate stays constant, so the adjustment is achieved through an increase in the consumer-price index. Due to nominal rigidities, this regime produces less real exchange-rate appreciation in the short run than when the nominal exchange rate is allowed to adjust. In the INT regime, finally, the real exchange rate follows a similar path as in the FIX regime but with milder variation in the consumption price index combined with limited nominal exchange-rate appreciation. In the following periods, further real appreciation must take place. This is consistent with a sharp fall in the real interest rate in the FIX and INT regimes, which reduces the extent of the drop in consumption.

Following a temporary increase in domestic demand, the rise in employment is highest under the FIX and INT regimes, but these regimes tend to stabilize private consumption. Conversely, the rise in employment is lowest with the PPI regime and, to a lesser extent, the CPI one, but these regimes produce a larger drop in private consumption.

Introducing wage rigidities increases the reaction of employment to the shock while reducing that of consumption, compared to the flexible-wage case. There is now more contrast between the floating regime and the other two: wage rigidity translates into very small price variations in the short run, hence the real exchange rate varies much more under the CPI regime than under a FIX or an INT regime. There is more trade deficit in the former regime, hence the wealth effect

[8] The IRF for the real wage is not presented in the panels to save space.

is more pronounced, as is the fall in consumption.

4.2. Productivity shock

We now consider a temporary increase in the productivity level of firms producing intermediate goods (Panels C.2 and D.2). This positive supply shock raises the level of production and, through a permanent income effect, increases the level of consumption.

The domestic good market clears through a real exchange-rate depreciation. The current account increases, which triggers foreign bond accumulation. How the real depreciation is achieved again depends on the monetary regime.

Under flexible regimes, the nominal exchange rate depreciates in the short run. Since the nominal exchange rate appreciates between the short run and the long run, the nominal interest rate falls in the short run. Under the PPI regime, CPI inflation increases (due to the nominal exchange-rate depreciation): the real interest rate falls, which further encourages consumption. In this regime, both employment and the real wage increase in the short run. The fall in the real interest rate is much more limited under the CPI regime since CPI inflation by construction does not increase. Hence the incentive to consume is more limited than under the PPI regime. Employment and the real wage now fall following the shock.

Under a FIX, the depreciation of the real exchange rate is obtained through deflation. Because the nominal exchange rate is fixed, the nominal interest rate stays constant. Hence, the real interest rate increases, which discourages consumption. In this regime, consumption increases less and employment falls more than under the CPI regime.

Finally, under the INT regime, the real exchange-rate depreciation comes from both nominal exchange rate depreciation and deflation. The extent of deflation is smaller than under a FIX but higher than under a flexible regime. The outcome in terms of consumption and employment is thus intermediate between fixed and flexible exchange-rate regimes.

With wage rigidities, the marginal production cost falls in the short run as a result of the productivity hike. Whatever the monetary regime, employment increases following the shock, and consumption increases to a larger extent than when wages are flexible. This is especially the case under the CPI regime where the large real exchange-rate depreciation triggers both higher foreign demand (through a competitiveness effect) and higher domestic consumption (due to the wealth effect from accumulated foreign bonds). In the FIX and INT regimes, the more limited increase in foreign demand (since there is less real exchange-rate depreciation) reduces the reaction of employment and consumption to the shock. Interestingly, the INT regime entails more employment and consumption than the FIX one in the very short run, but it is more stabilizing after a few periods, because the real exchange rate adjusts more quickly to its baseline level.

Wage rigidity induces wrong price signals following a productivity shock: because wages fail to adjust, there is a large drop in the marginal cost of production. In such situation, a large exchange-rate depreciation adds to price distortions since it boosts demand: employment and production increase more than with flexible wages. To the extent that households accumulate foreign bonds, this short-run rigidity has a lasting effect on consumption and employment. Conversely, fixed exchange rates have a stabilizing effect on employment, production and consumption.

4.3. Foreign interest-rate shock

A temporary increase in the foreign, nominal interest rate raises domestic demand for foreign bonds (Panels C.3 and D.3). The real exchange rate depreciates, raising the trade balance. Domestic consumption falls since households substitute future for present consumption. This is consistent with the increase in the domestic, real interest rate (although the domestic real rate increases less than the foreign one, consistent with a real exchange-rate appreciation from the short run to the long run).

Under inflation-targeting regimes, the short-run real exchange-rate depreciation is achieved through the nominal exchange rate. Such flexibility allows for a large depreciation in real terms, which boosts foreign demand. This is especially the case under the PPI regime where monetary authorities do not care about higher consumer-price inflation (itself triggered by the nominal depreciation). Under PPI, production and employment increase following the shock, while under CPI, production and employment slightly decrease before increasing. Conversely, under a FIX, the real exchange rate depreciates less (due to nominal rigidities). This combines with a large increase in the real interest rate to produce a large fall in production and employment. Finally, the INT regime produces a reaction of employment that lies in-between PPI and CPI.

On the whole, a shock on the foreign interest rate produces a similar fall in consumption in the four monetary regimes, but the CPI regime is more stabilizing for employment.

In the case of wage rigidities, the fall in consumption induces a larger drop in production and employment, because the real wage fails to fall in the short run. One outcome of the lack of wage decrease is that the producer price also fails to adjust downward. Thus under CPI, the stabilization of the consumer price index no longer requires a depreciation of the nominal exchange rate. So, the real exchange-rate depreciation is reduced under both CPI and FIX. In contrast, the INT regime allows for variations of both the consumer price index and the nominal exchange rate, which results in a larger depreciation in real terms than under the two other regimes. This larger reaction of the real exchange rate in an INT regime stabilizes employment and consumption.

It should be stressed here that the lack of real exchange-rate adjustment under a CPI is related to the combination of wage-and-price rigidity (which eliminates domestic deflation) and the fact that the central bank targets CPI inflation: with no deflationary pressure, there is no need for an exchange-rate depreciation (which would trigger imported inflation), hence the nominal interest rate adjusts upwards to the foreign level, like in a FIX regime. The INT regime involves more flexibility in this specific case.

4.4. Foreign price shock

We now turn to the impact of a shock on the price of foreign goods (Panels C.4 and D.4). The terms-of-trade deterioration triggers a fall in consumption. In all regimes but the FIX, monetary authorities react to imported inflation through rising the nominal interest rate. Under floating regimes (either CPI or PPI), the nominal exchange rate appreciates, which reduces the extent of real exchange-rate depreciation. The rise in foreign demand compensates for the fall in domestic consumption (which is accentuated by the rise in the real interest rate), so the shock has little impact on both employment and production.

Conversely, under a FIX regime, the nominal exchange rate does not appreciate, so the short-term real depreciation is maximum. There is now large imported inflation and a large increase in foreign demand that exceeds the fall in domestic demand: production and employment increase by a large extent, although the fall in domestic consumption is milder than under floating regimes due to the large fall in the real interest rate.

Finally, under the INT regime, the nominal exchange rate appreciates slightly while there is also some CPI inflation. The results in terms of both consumption and employment lie in between the FIX and the floating regimes.

The results are somewhat different when wage rigidities are introduced. In this case, there is less inflation, so the real exchange rate depreciates by more and there is a larger increase in foreign demand, especially in the FIX case. Due to net foreign asset accumulation, there is a wealth effect that sustains consumption in this regime. Because there is very little inflation, the INT regime very much resembles the FIX one when wage rigidities are accounted for.

4.5. Foreign demand shock

Finally, we consider a temporary increase in the foreign demand for home goods (Panels C.5 and D.5). Domestic production and employment increase. The shock is accommodated through real exchange-rate appreciation and an increase in real wages. Due to nominal rigidities, the real exchange-rate appreciates more under a floating regime than under a FIX or an INT. It also appreciates more under PPI than under CPI, because in the latter case the interest rate increases more (to fight PPI inflation which is larger than CPI inflation, the latter being dampened by the appreciation of the nominal exchange rate). Thus, the reaction of production and employment is limited in the PPI case; it is larger in the CPI case and even more in the INT and FIX cases. The ranking of the regimes is reversed for domestic consumption, because it is in the PPI regime where the real interest rate increases most (triggering an intertemporal substitution effect) and where foreign assets increase less (limiting the wealth effect): the fall in consumption is maximum in the PPI regime, it is less in the CPI one and even less in the INT and FIX regimes.

When wages are rigid in the short run, the nominal exchange rate appreciates during several periods leading to a drop, instead of a rise, in the nominal interest rate. The real interest rate now falls after the shock under all regimes. This explains why consumption increases instead of falling as it is the case when wages were fully flexible.

5. WELFARE ANALYSIS

We now turn to the welfare implications of stochastic shocks under the different monetary regimes. Table 1 reports the impact of the different stochastic shocks and of their combination[9] on the consumption-equivalent of welfare changes. The table also reports the average impact of the combination of all shocks on selected variables. Note that, due to the non-linearities of the model, our zero-average shocks do have an impact, either positive or negative, on average variables. In what follows, we measure the performance of each regime in terms of welfare maximization.

In the first four columns of Table 1, wages are assumed to be fully flexible ($\theta_w = 0$). In this case, the PPI regime clearly outperforms all other regimes for each shock as for their combination. The second-best regime is the CPI regime, except for foreign interest-rate shocks where it is the INT regime. Conversely, the FIX regime always produces the worst results. In brief, floating regimes isolate better the real economy from foreign shocks. Additionally, relying on the nominal exchange rate for adjusting the economy avoids having to suffer long transitions with price dispersion that is detrimental to production. These findings are consistent with the literature highlighting the ability of an inflation-targeting regime (with a flexible exchange rate) to stabilize shocks.[10]

When wages are sticky, however, the PPI is no longer an option. The last three columns of Table 1 show that the INT regime becomes the best performer in the face of productivity or foreign interest-rate shocks. The CPI regime remains best for the other shocks, but the large welfare cost associated to productivity shocks under this regime makes it less appropriate than the intermediate one when all shocks are accounted for. The FIX regime never shows up as the best one.

Our results suggest that there is a case for selecting the intermediate regime against both extreme regimes in countries experimenting mostly productivity and foreign interest-rate shocks. This is likely to be the case in a number of developing and emerging countries, which typically suffer from structural changes (internal migration, privatization,...) and large capital inflows and outflows. In turn, the fixed exchange-rate regime is always dominated by either the flexible

[9]Assuming independence across the different types of shocks.
[10]See for instance, Clarida, Galí and Gertler (2001), De Paoli (2009ab), Batani, Levine Pearlman (2009) and the literature on optimum currency areas (Mundell, 1961; Ricci, 2008).

or the intermediate one. Finally, flexible regimes are to be preferred by countries facing mostly home demand, foreign demand and price shocks.

Table 1 – Impact of shocks, depending on the monetary regime, baseline results

	Flexible wages				Staggered wages		
	CPI	PPI	INT	FIX	CPI	INT	FIX
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Shock by shock: impact on welfare (% of steady-state consumption)							
Productivity	-2.47	-1.78	-2.90	-4.37	-141.94	-21.40	-26.56
Domestic demand	-1.23	-1.08	-1.32	-1.64	-3.49	-4.50	-4.64
Foreign int. rate	1.22	1.46	1.32	0.69	0.50	0.72	0.42
Foreign price	0.15	0.23	-0.1	-1.80	-0.23	-6.43	-12.21
Foreign demand	-0.20	0.01	-0.29	-0.63	-1.09	-1.20	-1.31
All shocks: impact on welfare (% of steady sate consumption)							
	-2.53	-1.16	-3.30	-7.74	-146.24	-32.82	-44.30
All shocks: impact on average variables (deviations from steady state in %)							
C	-0.015	0.086	-0.043	-0.089	-0.290	0.581	-0.488
N	-0.001	-0.025	-0.012	-0.025	0.018	0.558	-0.279
Yh	-0.055	-0.049	0.103	-0.084	-0.066	0.736	-0.346
E	0.003	-0.017	-0.006	0.000	-0.068	-0.019	0.000
RER	-0.010	-0.009	-0.014	-0.007	-0.042	0.044	-0.050
pi	0.000	0.000	0.000	0.001	0.000	0.000	0.000
pih	0.000	0.000	0.000	0.002	0.000	0.000	0.000
Bf	0.298	3.267	-0.245	-0.222	-6.437	7.421	-4.418

Source: own calculations.

6. SENSITIVITY ANALYSIS

In this section, we report on several sensitivity exercises. We start with the flexible-wage model, by lowering the elasticity of substitution between domestic and foreign goods (η set to 0.8 instead of 3 in the baseline calibration), varying the degree of openness (γ set to 0.2 or 0.6 instead of 0.4), increasing the degree of relative risk aversion from 1 to 5, decreasing the elasticity of labor supply (ϕ) from 4 to 0.47, fixing a negative level of steady-state foreign debt: whatever the calibration change, the ranking of the monetary regimes in terms of welfare stays unaffected, the PPI regime still performing better than any other regime.[11]

Moving to the model with staggered wage contracts, we first check for the degree of wage rigidity, letting θ_w take the value of 0.5 or 0.3 (instead of 0.75 in the baseline calibration). The results are displayed in Appendix E, Table E.1. Raising the degree of wage flexibility always increases welfare but the ranking of the monetary regimes stays unaffected. The intermediate regime still performs better than the CPI even with a low value of θ_w.

[11] The results are available from the authors.

As evidenced in Table 1, the poor performance of the CPI regime in the presence of wage rigidities is mainly due to the impact of productivity shocks. Hence, we test for alternative calibrations of this shock that have been used in the literature: Faia and Monacelli (2007), FM hereafter, set ρ_A at 0.95 and σ_A at 0.0056; Galí and Monacelli (2005), GM, set ρ_A at 0.66 and σ_A at 0.0071; Elekdağ and Tchakarov, ET, set ρ_A at 0.8 and σ_A at 0.2 using emerging countries data. The results with these different calibrations are reported in Appendix E, Table E.2. Whatever the specification, the CPI regime is the more costly in terms of welfare when the economy is hit by productivity shocks. However, since the negative impact of the shock increases sharply with its persistence under CPI, this regime becomes the preferred one when all shocks are taken into account under the GM calibration (where the autocorrelation of the shock is limited). The standard deviation of the shock seems to have more limited influence on the performance of the CPI regime.

Finally we test the sensitivity of our results to the calibration of the intermediate regime by making a and b take the values of 1, 5 and 10, successively. The results in terms of welfare loss when the economy faces the whole set of shocks are displayed in table E.3. As expected, when wages are flexible, the lowest welfare loss is obtained with $a = 1$ and $b = 10$, i.e. when the intermediate regime is close to the CPI regime. In contrast, with wage rigidity, the lowest welfare loss is obtained with $a = b = 1$, i.e. when the exchange rate and the inflation rate are weighted equally in the interest-rate rule. In the latter case, whatever the weights chosen, the intermediate regime is the one producing the lowest welfare loss when all shocks are accounted for.

7. Conclusion

Despite increasing capital mobility and the subsequent difficulty in controlling exchange rates, intermediate exchange-rate regimes have remained widespread, especially in emerging and developing economies. This piece of evidence hardly fits the "impossible Trinity" theory arguing that it becomes difficult to control the exchange rate without a "hard" device when capital flows are freed. Calvo and Reinhart (2000) have suggested several explanations for such "fear of floating": exchange rate pass-through, liability dollarization, dollar invoicing of domestic and external transactions, and an underdeveloped market for currency hedging make it more desirable to stabilize the nominal exchange rate.

However, the New-Keynesian model, which has become the main workhorse for studying exchange-rate regime choice since the 1990s, typically opposes fixed nominal pegs to free-floating regime, without considering intermediate regimes. We intend to fill this gap here by comparing the performance of "extreme" regimes to that of an intermediate regime where monetary authorities care both about inflation and about nominal exchange-rate deviations from the steady state, when a small economy is hit by several types of shocks. Without nominal wage rigidities, our results are in line with the New-Keynesian literature arguing in favor of inflation-targeting regimes. However, when nominal wage rigidities are taken into account, we find the intermediate regime to be appropriate for an economy that is mainly hit by productivity and foreign-interest shocks, which is often the case in emerging and developing economies. The free-floating regime (with inflation targeting) seems more adequate if the economy experiences mostly demand shocks and foreign prices shock. Finally, the fixed peg regime is always dominated by either the free-floating or the intermediate regime.

A fully-fledged analysis of intermediate regimes should of course account for the fear-of-floating-type advantages of such regimes, as well as for their shortcomings in terms of costly reserve-accumulation and/or recurrent crises. Our results however suggest that, by concentrating on two extreme regimes (fixed nominal pegs and free floats), by neglecting wage rigidities and/or by assuming that floating countries can engineer an "optimal" interest-rate feedback rule, the existing New-Keynesian literature may have exaggerated the merits of free-floating regimes to the detriment of "soft" pegs.

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APPENDIX A: MODEL EQUATIONS

A.1 Consumption and demand

The optimal allocation of expenditures across the two goods implies the following demand functions:

$$C_t^h = (1-\gamma)\left(\frac{P_t^h}{P_t}\right)^{-\eta} C_t \quad (18)$$

$$C_t^f = \gamma\left(\frac{P_t^f}{P_t}\right)^{-\eta} C_t \quad (19)$$

The law of one price holds which implies:

$$P_t^h = S_t P_t^{h*} \quad (20)$$

and:

$$P_t^f = S_t P_t^{f*} \quad (21)$$

where P_t^{h*}, P_t^{f*} denote the foreign-market price of the home and of the foreign good, respectively.

Foreign consumption of the home good is assumed negilible for the foreign economy but not for the home one. Consistently, the foreign consumer price index simply writes:

$$P_t^* = P_t^f / S_t \quad (22)$$

Total demand for home goods can be expressed as follows:

$$Y_t = \left(\frac{P_t^h}{P_t}\right)^{-\eta} [(1-\gamma)C_t + \gamma RER_t^{\eta} C_t^*] + G_t \quad (23)$$

with C_t^* denoting foreign consumption, and G_t domestic government spending. The government budget is balanced through the wage tax τ_w and a lump-sum tax T_t:

$$G_t = \tau_w W_t N_t + T_t \quad (24)$$

A.2 Production

Assuming perfect competition on the final good market, profit maximization yields the demand for each intermediate good:

$$Y_t(k) = \left(\frac{P_t(k)}{P_t^h}\right)^{-\xi} Y_t \tag{25}$$

where $P_t(k)$ is the price of intermediate good k and P_t^h is the domestic producer price index:

$$P_t^h = \left(\int_0^1 P_t(k)^{1-\xi} dk\right)^{\frac{1}{1-\xi}} \tag{26}$$

Labor demand in the intermediate-good sector can be recovered by inverting the production function. Aggregating labor demand across intermediate good firms k then yields:

$$N_t = \int_0^1 N_t(k) dk = \frac{Y_t}{A_t} \int_0^1 \frac{Y_t(k)}{Y_t} dk \tag{27}$$

The production of final good is then obtained by combining this expression with the demand for each intermediate good k.

A.3 Price rigidity

Firms producing intermediate goods are assumed to set nominal prices on a staggered basis as in Calvo (1983): at each period t, a proportion θ_p of randomly-chosen firms are unable to change their prices, where θ_p is i.i.d.. At time t, firms that are unable to change their price simply adjust output to meet demand. Those that are able to change their price set a price $\tilde{P}_t(k)$ that maximizes the current value of their profit streams, accounting for the risk of not being able to change this price in the future. Rearranging the first order condition, the optimal price $\tilde{P}_t(k)$ of firm k is such that:

$$\begin{aligned} & E_t \sum_{j=0}^{\infty} (\beta\theta_p)^j (P_{t+j})^{-1} C_{t+j}^{-\sigma} Y_{t+j}(k) \tilde{P}_t(k) \\ & = \mu^p E_t \sum_{j=0}^{\infty} (\beta\theta_p)^j C_{t+j}^{-\sigma} Y_{t+j}(k) (P_{t+j})^{-1} MC_{t+j} \end{aligned} \tag{28}$$

where $\mu^p = \frac{\epsilon}{\epsilon-1}$ is the markup that a firm which is able to adjust its price at any time would charge,[12] and MC_{t+j} is the real marginal cost at time $t+j$:

$$MC_{t+j} = \frac{W_{t+j}}{A_{t+j} P^h_{t+j}} \tag{29}$$

Following the law of large numbers, the domestic price index writes:

$$P^h_t = [\theta(P^h_{t-1})^{1-\xi} + (1-\theta)(\tilde{P}^h_t)^{1-\xi}]^{1/(1-\xi)} \tag{30}$$

Appendix B: Calibration

Table B.1 lists all parameter values used in our benchmark simulations.

The quarterly discount factor β is set at 0.99, implying an annual steady-state nominal interest rate of about 4%. The risk-aversion coefficient, σ, is set at unity, which is standard in the literature (see for instance Benigno, 2009, and De Paoli, 2009a-b) and consistent with the estimation performed by Eichenbaum et al. (1988), which lies between 0.5 and 3. Given that the Frisch elasticity is usually assumed to range from 0.05 to 0.3, we use the value of 4 for ϕ, the inverse of the elasticity of labor supply (implying an elasticity of 0.2). γ, the degree of openness, is assumed to be 0.4, implying a 40% import-to-GDP ratio. Following Obsfeld and Rogoff who argue that η, the elasticity of substitution between home and foreign goods, should lie between 3 and 6, we set $\eta = 3$. The elasticity of substitution between differentiated goods is assumed to be 6, implying a steady-state mark-up of 20%, in line with Bradford and Lawrence (2003) who estimate that it should range from 15% to 20%. The elasticity of substitution between workers κ is set at 4, consistent with Erceg, Henderson and Levin (2000). To characterize an average price and wage contract length of one year, we assume $\theta_p = \theta_w = 0.75$. Furthermore, as in Kollmann (2002) and Elekdag̃ and Tchakarov (2007), the intermediation cost parameter χ is based on Lane and Milesi-Ferretti (2002) estimates and set at 0.0019.

We assume symmetric initial conditions in both countries in the steady state, i.e. $C = C^*$ and $Y = Y^*$. This implies a zero steady-state net foreign asset position, that is $B^f = 0$. G is set at zero, and the steady-state values of C^* and A are 1. We assume the producer-price inflation to be equal to one and also fix the real exchange value at unity. Our specification implies that, at the steady state $MC = \frac{1}{\mu_p}$, which corresponds to a flexible-price equilibrium.

[12]Note that when prices are fully flexible ($\theta_p = 0$), then $\tilde{P}_t(k) = \tilde{P}_t = \mu^p MC_t$. Denoting by $\tilde{MC}_t$ the real marginal cost in this specific case, we have (since $P^h_t = \tilde{P}_t$): $\tilde{MC} = \frac{1}{\mu^p}$ which is fixed. In this case, a productivity shock must be compensated by a change either in the producer price index or in the wage index (see Equation (29)).

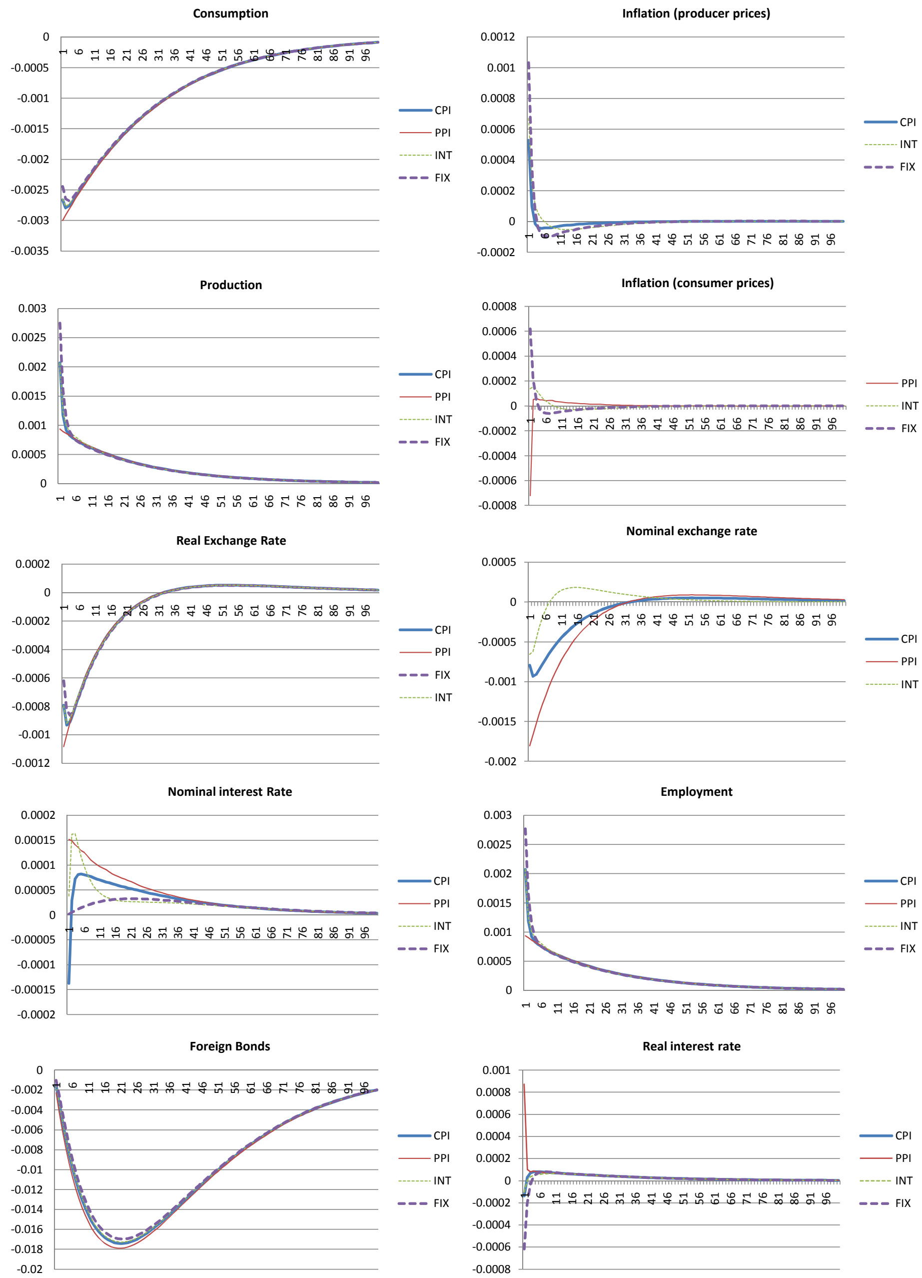
The calibration of the exogenous shocks also follows the literature. For, the productivity shock, we use $\rho_A = 0.9$ and $\sigma_A = 0.01$ as in Kollmann(2002). We also use Kollmann's calibrations for the foreign interest rate and the foreign price shocks: $\rho_{i*} = 0.65$, $\sigma_{i*} = 0.003$, $\rho_{P*} = 0.8$ and $\sigma_{P*} = 0.005$. When it comes to the demand shock, we set ρ_G at 0.94 and σ_G at 0.0062 following De Paoli (2009b) and Lubik and Schorfeide (2005). The foreign shock is parameterized as in Lubik and Schorfeide (2007) and De Paoli (2009), i.e. $\rho_{C*} = 0.65$ and $\sigma_{C*} = 0.0129$.

Table B.1: Parameter values (base case)

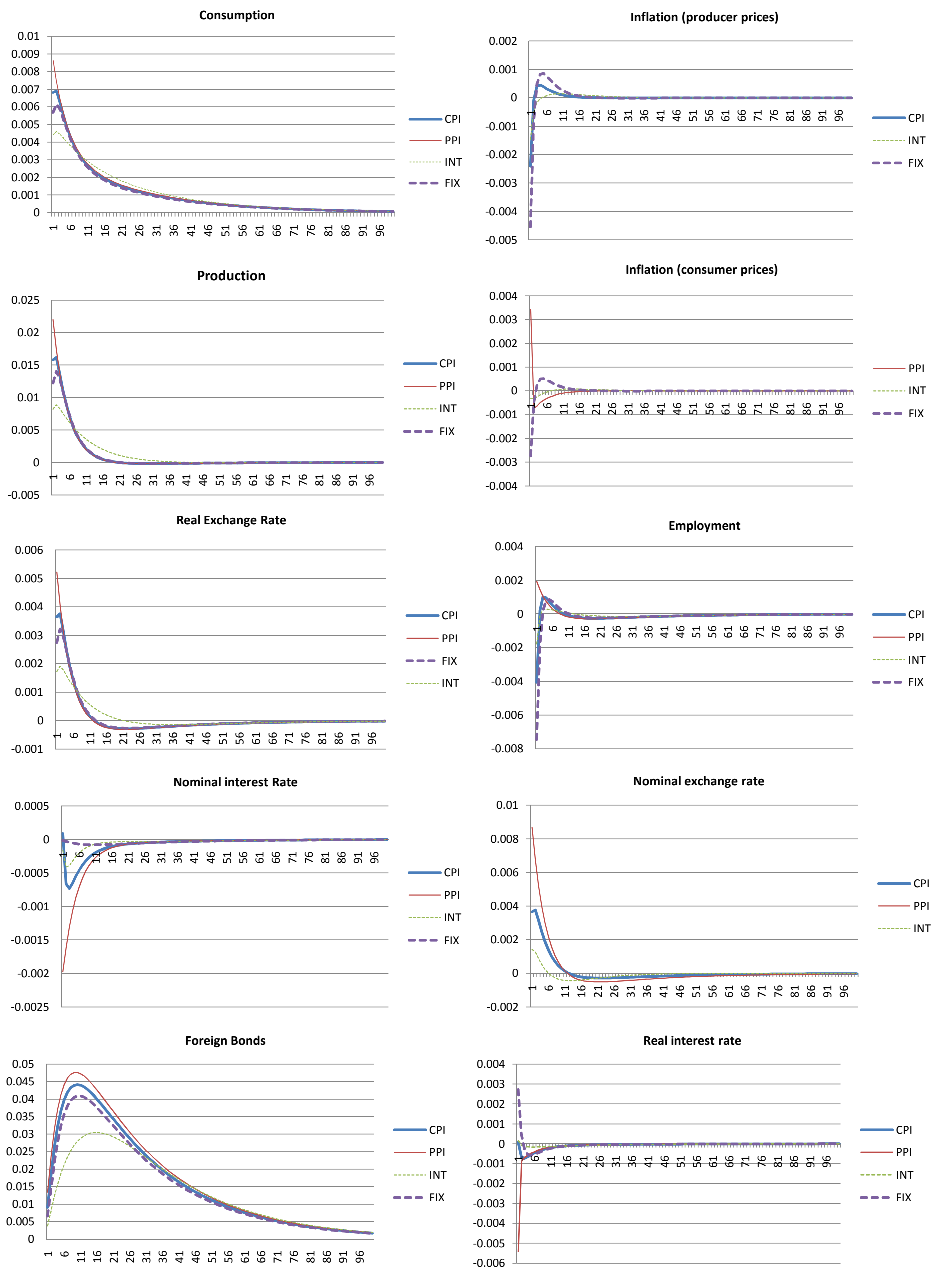
Parameter	Description	Value
β	Subjective discount factor	0.99
σ	Coefficient of relative risk aversion	1
ϕ	Elasticity of labor supply	4
ξ	Elasticity of substitution across differentiated domestic goods	6
η	Intratemporal elasticity of substitution between domestic and foreign goods	3
γ	Degree of openness	0.4
κ	Elasticity of substitution between workers	4
θ_p	Firms' probability of not being able to change their price next period	0.75
θ_w	Households' probability of not being able to reset their wage next period	0.75
χ	Foreign bond adjustment cost parameter	0.0019
μ_p	Price mark-up	1.2
ρ_A	Autocorrelation of the productivity shock	0.9
ρ_G	Autocorrelation of the demand shock	0.94
ρ_{i*}	Autocorrelation of the foreign interest rate shock	0.65
ρ_{C*}	Autocorrelation of the foreign demand shock	0.65
ρ_{P*}	Autocorrelation of the foreign-price shock	0.8
σ_A	Standard deviation of the productivity shock	0.01
σ_G	Standard deviation of the demand shock	0.0062
σ_{i*}	Standard deviation of the foreign interest rate shock	0.003
σ_{C*}	Standard deviation of the foreign demand shock	0.0129
σ_{P*}	Standard deviation of the foreign-price shock	0.005
a	Weight on nominal exchange rate, intermediate regime	1
b	Weight on inflation, intermediate regime	5

APPENDIX C: IMPULSE-RESPONSE FUNCTIONS WHEN WAGES ARE FLEXIBLE

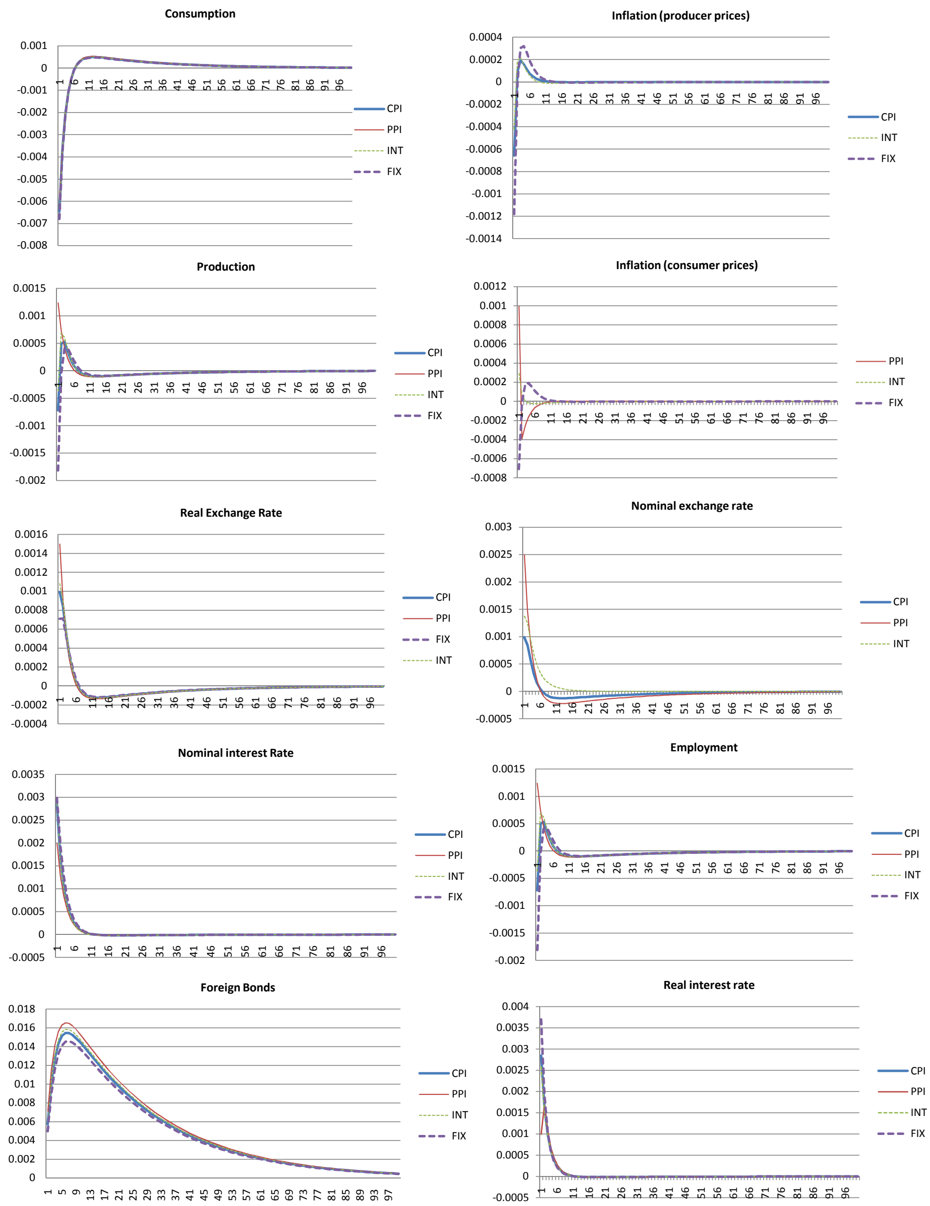
Panel C.1: Domestic demand shock



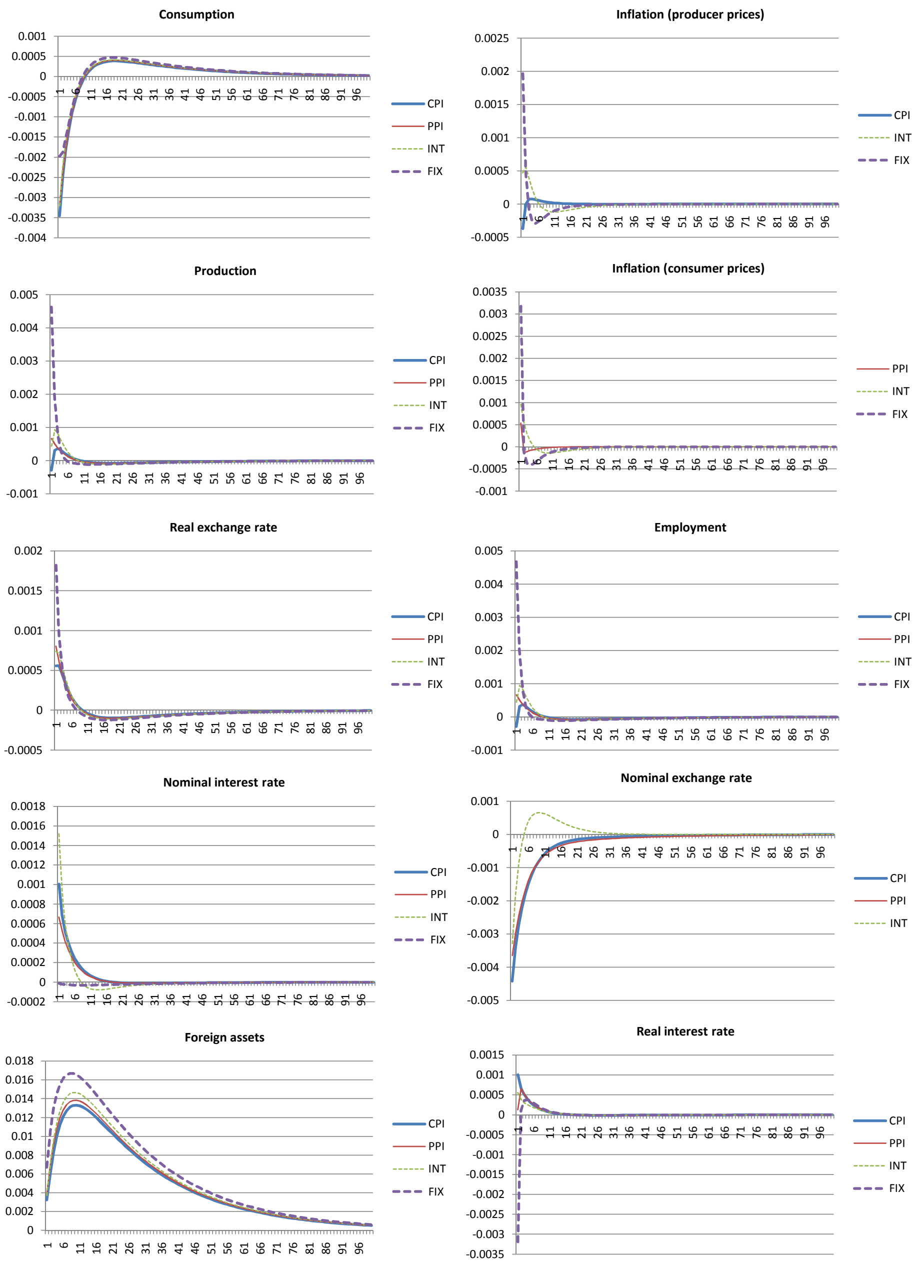
Panel C.2: Productivity shock



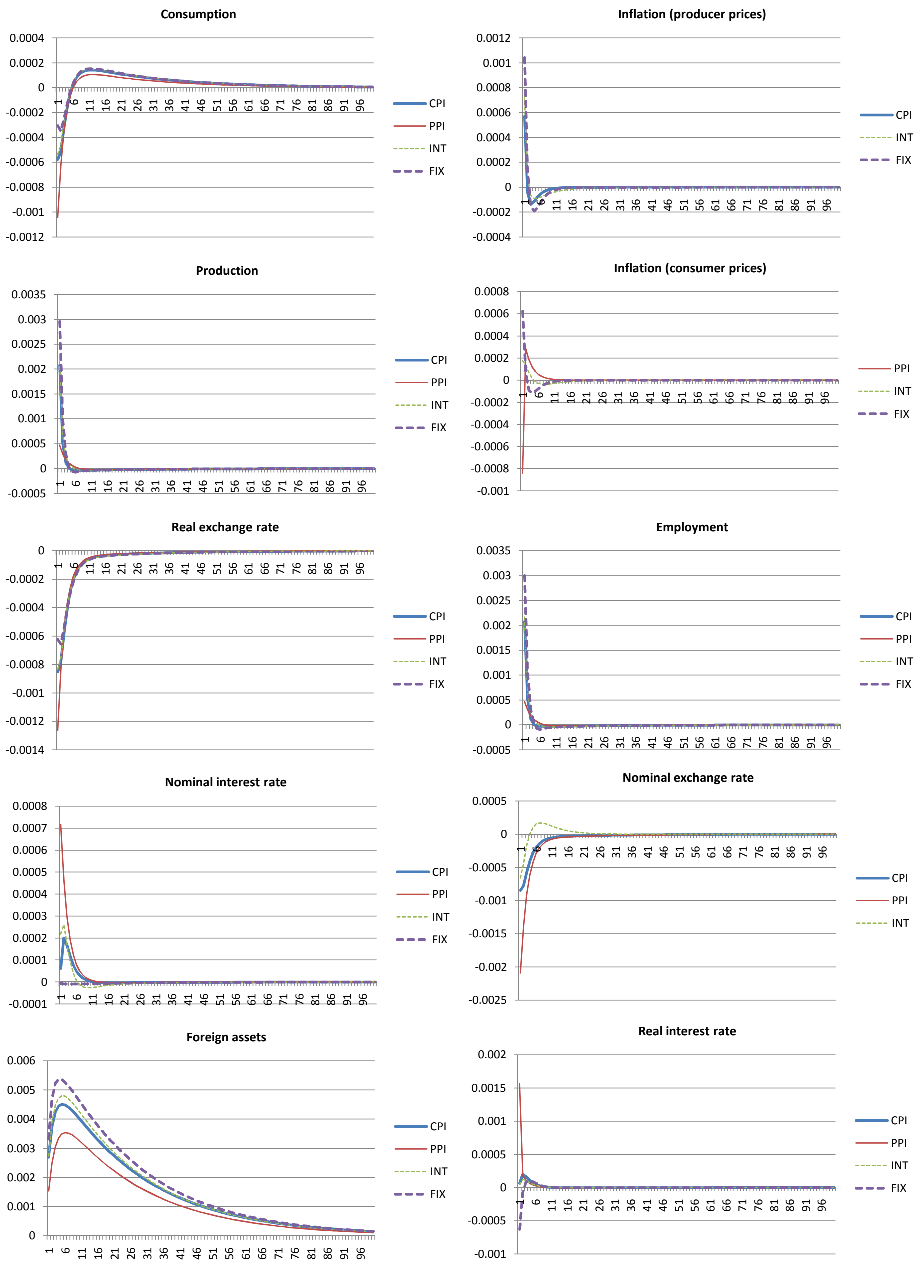
Panel C.3: Foreign interest rate shock



Panel C.4: Foreign prices shock

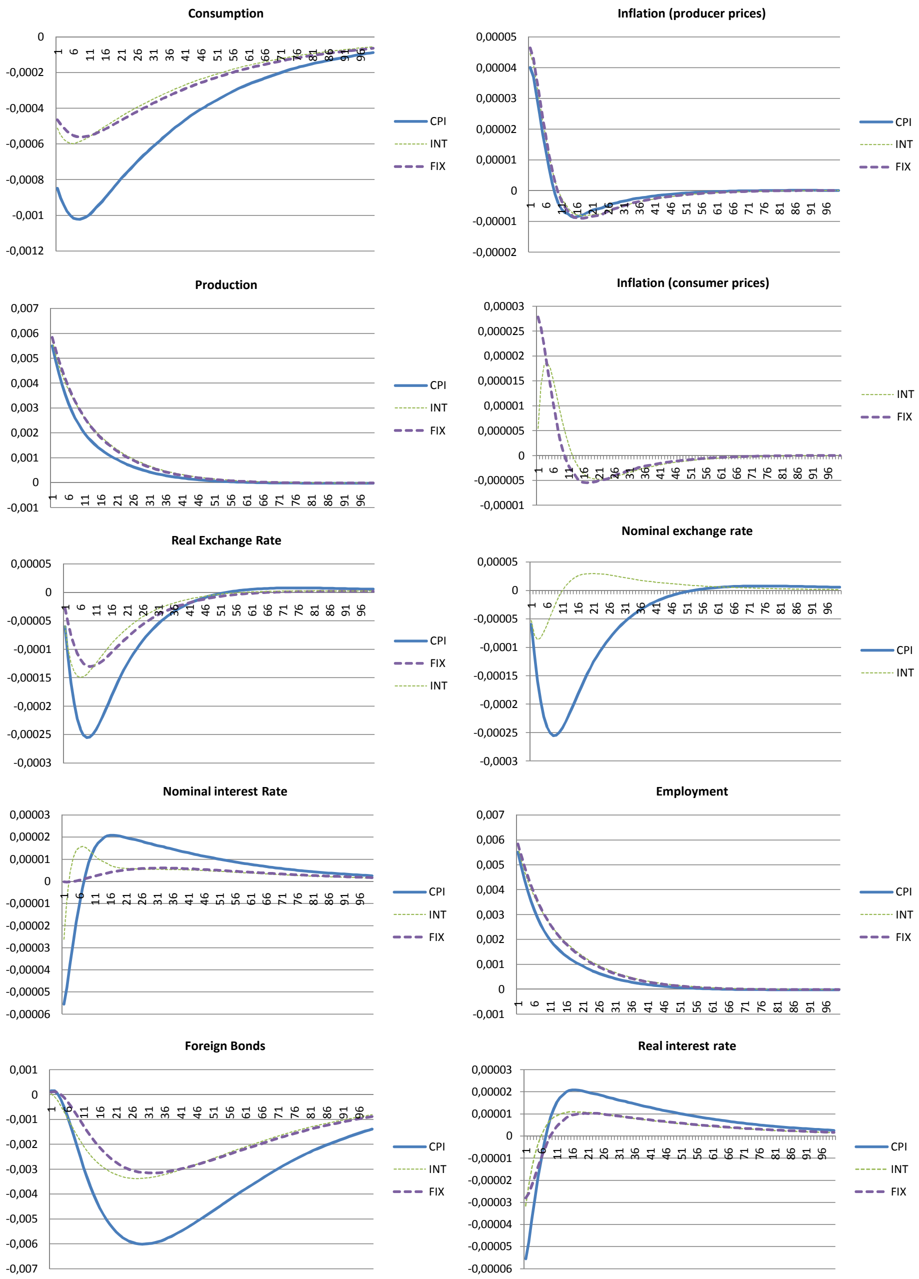


Panel C.5: Foreign demand shock

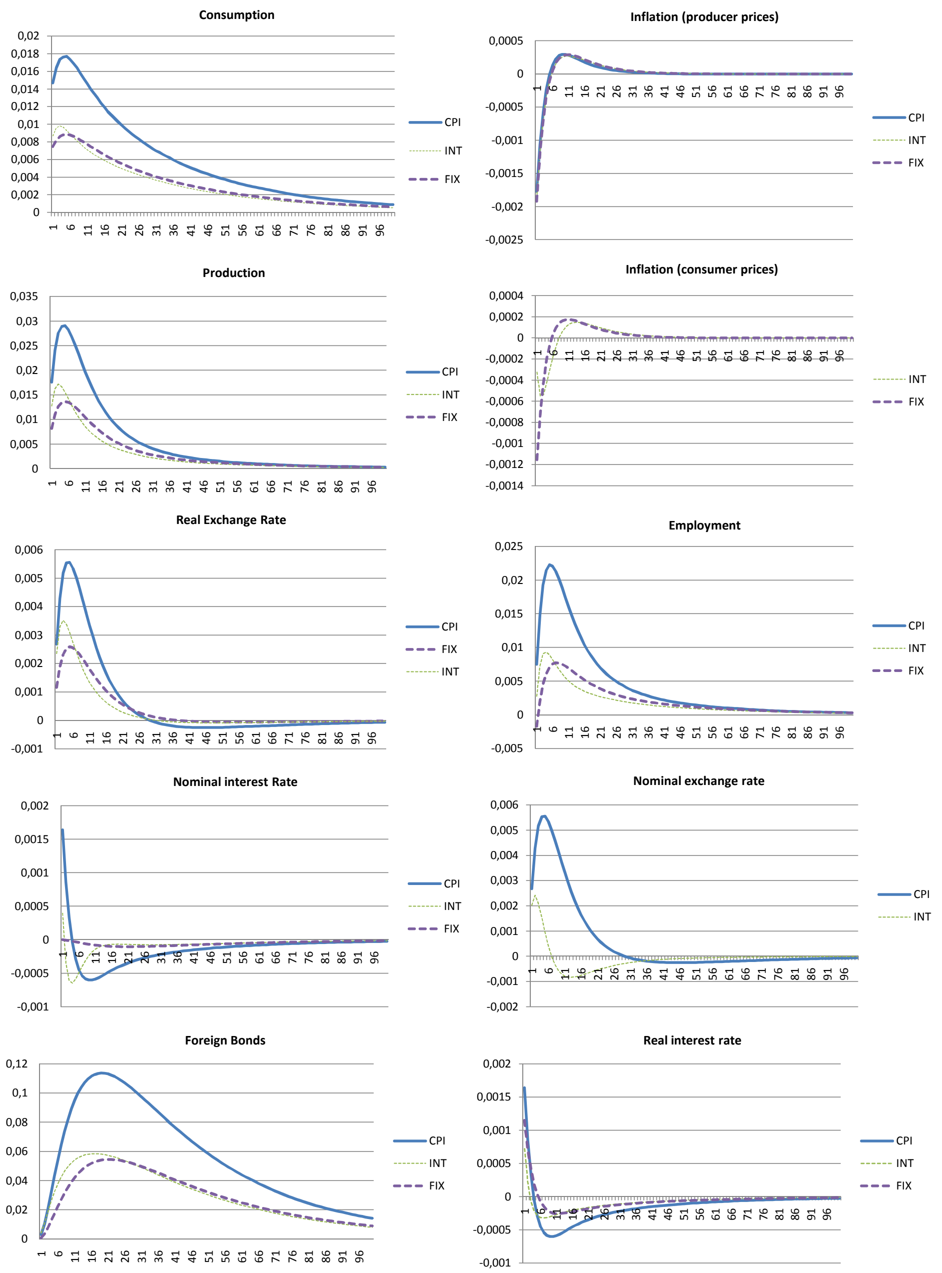


APPENDIX D: IMPULSE-RESPONSE FUNCTIONS WITH STICKY WAGES

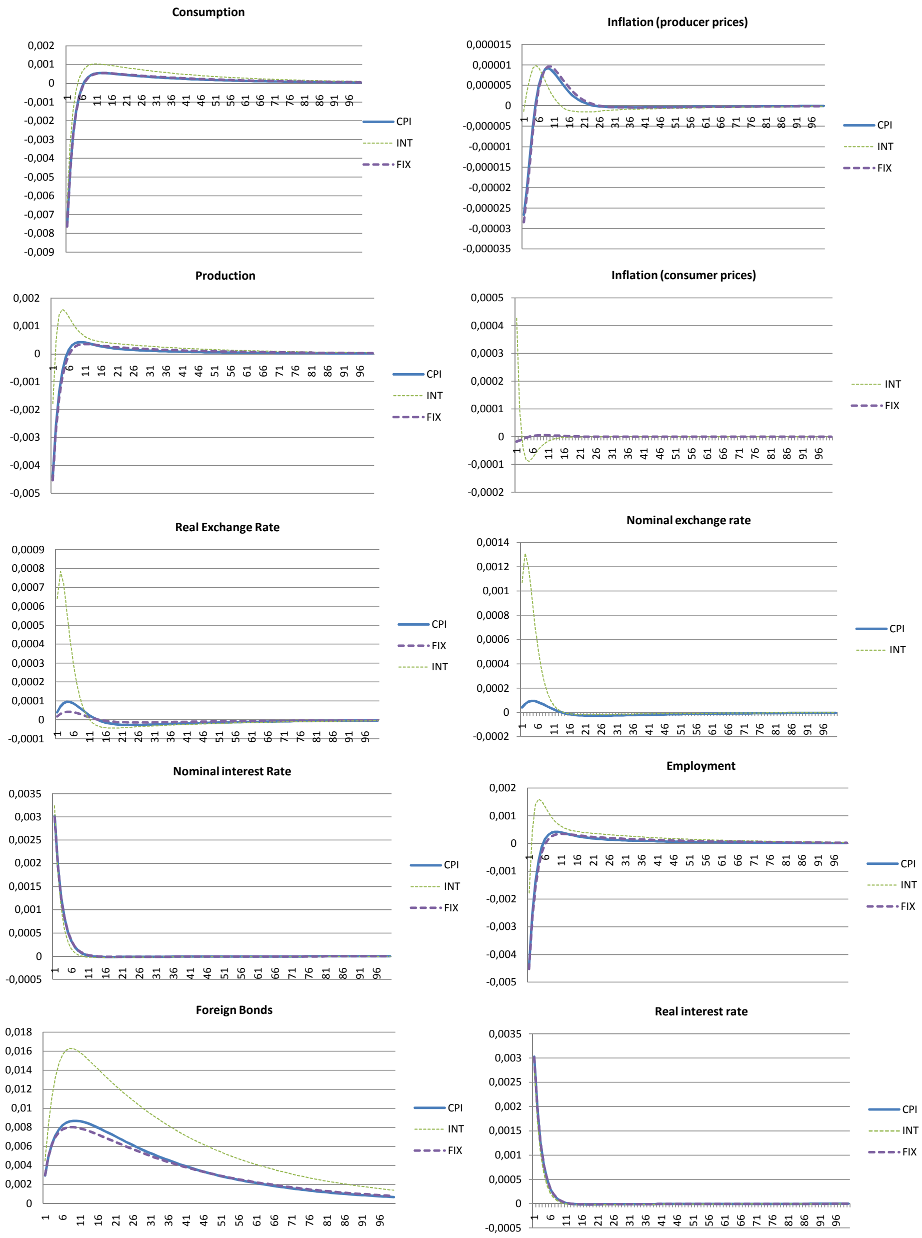
Panel D.1: Domestic demand shock



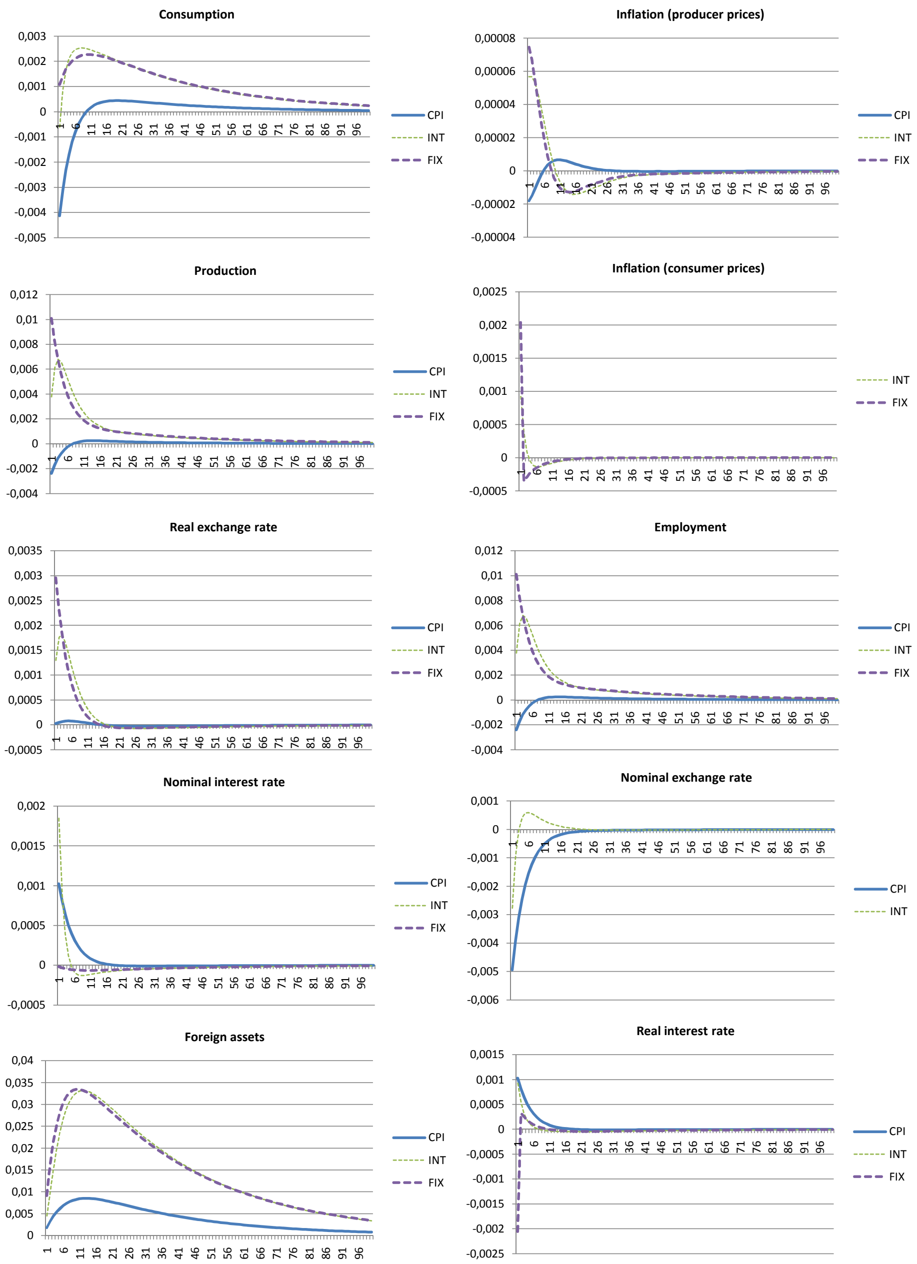
Panel D.2: Productivity shock



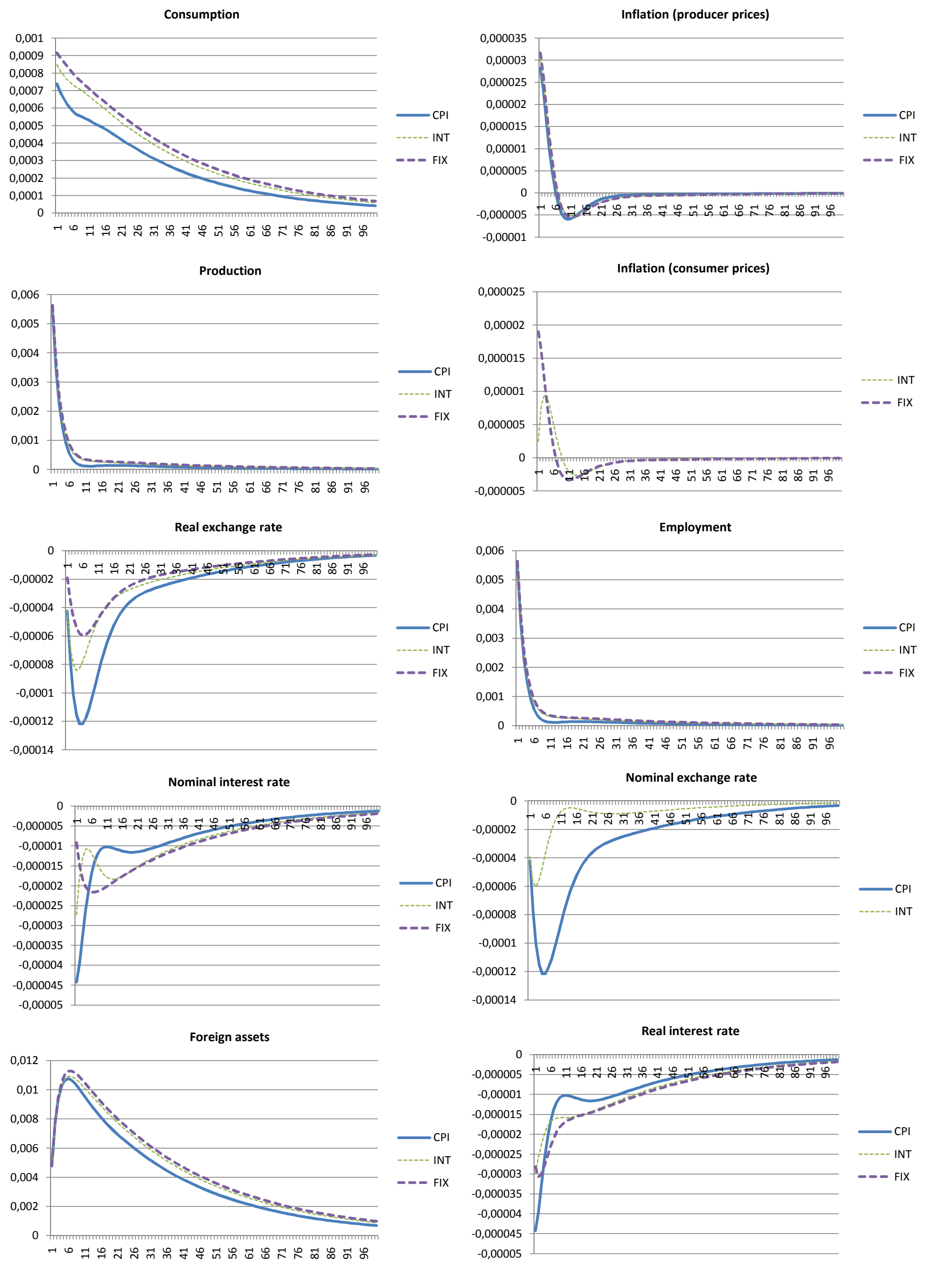
Panel D.3: Foreign interest rate shock



Panel D.4: Foreign price shock



Panel D.5: Foreign demand shock



APPENDIX E: ROBUSTNESS CHECKS

Table E.1: Impact of shocks on welfare depending on nominal wages stickiness

	CPI	INT	FIX
Baseline: θ_w=0.75	-146.2	-32.8	-44.30
θ_w=0.5	-42.2	-16.9	-23.6
θ_w=0.3	-14.8	-8.6	-13.5

Table E.2: Impact of productivity shocks on welfare depending on its specification

	CPI	INT	FIX
Baseline ρ_A=0.9 σ_A=0.01			
All Shocks	-146.2	-32.8	-44.3
A	-141.94	-21.40	-26.56
FM ρ_A=0.95 σ_A=0.0056			
All Shocks	-129.3	-36.2	-46.7
A	-125.0	-24.8	-28.9
GM ρ_A=0.66 σ_A=0.0071			
All Shocks	-10.4	-12.5	-19.6
A	-6.1	-1.1	-1.9
ET ρ_A=0.8 σ_A=0.02			
All Shocks	-158.7	-31.5	-45.1
A	-156.3	-20.1	-30.2

Table E.3: Impact of the shocks on welfare under an intermediate regime, depending on the regime calibration

		b		
		1	5	10
		Flexible wages		
	1	-5.53	**-3.30**	-2.79
a	5	-6.83	-5.28	-4.29
	10	-7.22	-6.16	-5.28
		Staggered wages		
	1	-32.36	**-32.82**	-38.14
a	5	-35.73	-34.73	-34.26
	10	-36.35	-35.68	-35.12

In bold: baseline calibration.

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