Essays in Open Economy Macroeconomics

by

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Abstract

This thesis consists of three essays. The first paper examines the choice of exchange rate regime in partially dollarized developing economies. The second paper explores stability consequences of various combinations of alternative monetary and fiscal policy rules for the new European Union (EU) countries in the process of their accession to the Euro zone. Building on the results of the second paper, the third essay computes optimal monetary and fiscal policy rules for these countries.

The *first essay* examines the choice of exchange rate regime in partially dollarized developing economies. The study constructs and solves a two-country dynamic stochastic general equilibrium model. In contrast to the existing literature, the paper allows for asymmetric monetary rules and households' preferences across the countries, and assesses welfare implications of the currency substitution. Series of ordered logit regressions show that the model predictions largely match the observed data for a panel of 21 developing countries. The main findings and policy implications are as follows. First, in highly dollarized economies, the fixed exchange arrangement results in considerably smaller welfare losses than the flexible regime and hence, is to be preferred. Second, as the degree of dollarization decreases, the relative gain of the fixed vis-à-vis the floating regime diminishes. Third, decline in the home consumption bias coupled with the currency substitution entails greater welfare losses, which, again, calls for a more vigorous exchange rate stabilization.

The *second essay* explores stability consequences of various combinations of different monetary and fiscal policy rules for the new EU countries on their road to the Euro zone. The analysis is undertaken in a two-sector small open economy framework with permanent sector specific shocks. I consider a variety of monetary rules that are compatible with Exchange Rate

Mechanism-II: inflation targeting, inflation targeting with managed float and fixed exchange rate regimes. The paper considers fiscal rules that are based on the Stability and Growth Pact (SGP) fiscal criteria: sixty percent debt-to-GDP ratio, three percent budget deficit and the composite, which is the combination of the previous two. Further, I introduce distortionary taxes on consumption and labor income that are used by the fiscal authority to meet the SGP targets.

The main findings and policy implications can be summarized as follows. First, unlike simple theoretical structures, e.g. Leeper (1991), rational expectation equilibrium can be consistent with both active monetary and active fiscal policies as well as passive monetary and passive fiscal policies. This result holds true for all monetary regimes and any of the three fiscal regimes. Second, if the fiscal authorities in the European Monetary Union (EMU) candidate countries follow the rule based on the SGP debt criterion they should not be very harsh on the debt requirement, since it may lead to the indeterminate equilibrium. Third, in contrast to the fiscal policy based on the debt criterion, in order to ensure unique equilibrium it is desirable to be quite aggressive in meeting the SGP deficit requirement. Fourth, if the fiscal authorities attempt to match both fiscal criteria they have to be harsh on both debt and deficit components under any monetary regime.

The *third essay* builds on the results of the second paper and computes optimal monetary and fiscal policy rules for the EMU candidate countries and tests whether or not the Maastricht nominal exchange rate and inflation criteria are violated. The main findings and policy implications are as follows. First, under inflation targeting and inflation targeting with managed float, it is optimal that the central bank aggressively fights inflation regardless of the fiscal rule employed by the government. Second, under the assumption that nominal exchange rate is close to its long run equilibrium, the exchange rate stabilization should be achieved more as an endogenous equilibrium outcome rather than through active monetary policy. Third, it is desirable that the government tries to achieve both SGP fiscal targets but with a bit more emphasis on the debt criterion since it entails lower welfare costs. Finally, there is no threat to violating the Maastricht's nominal exchange rate and inflation criteria under all monetary and fiscal policy mixes. However, under inflation targeting there is a possibility of violation of the nominal exchange rate requirement, which might call for some moderate interventions on the foreign exchange markets.

Chapter 1

Choice of Exchange Rate Regime for Partially Dollarized Developing Economies

1.1 Introduction

Choice of appropriate exchange rate regime has been a long-debated topic. Proponents of a flexible regime argue that it allows a country to pursue monetary policy independently from foreign monetary policy, thus preventing the transmission of foreign monetary policy shocks. Moreover, when goods prices are sticky, a floating regime acts as a ‘shock absorber’ by allowing relative prices to adjust in response to country specific real shocks. This helps to stabilize the domestic economy in the face of adverse domestic and external shocks. Arguments in favor of a fixed exchange regime include lower transaction costs and exchange rate risk exposure. The latter is especially relevant for countries with underdeveloped financial sectors that do not allow them to hedge against long-term currency risks. Furthermore, countries with weak institutions can ‘import’ monetary credibility by pegging their currencies to a currency with a credible central bank.[1]

Exchange rate arrangements have also a bearing on aggregate demand through balance sheet effects on borrowing and investment expenditures. In most of developing and emerging economies, external liabilities are denominated in foreign currencies. Exchange rate depreciation might reduce net worth of domestic firms through increased expenditures on servicing of

[1] Pure flexible and fixed exchange regimes are not only two monetary arrangements a country can choose. There are, of course, many intermediate regimes. See, for instance, Edwards and Savastano (1999) for a detailed discussion of advantages and disadvantages of alternative exchange rate regimes.

external debt and reduced revenues in terms of foreign currency.[2] However, results of some theoretical studies suggest that, even in the presence of balance sheet effects, following a negative external shock flexible exchange regime stabilizes economy better than fixed exchange rate arrangement.[3]

Despite the above-listed theoretical arguments in favor of floating exchange rate regime, not only developing but also developed economies continue to intervene on the foreign exchange markets to smooth out exchange rate fluctuations. This phenomenon is termed as the “fear of floating” by Calvo and Reinhart (2000). Recent research by Calvo and Reinhart (2000), Hausman, Panizza and Stein (2000), and Levy-Yeyati and Sturzenegger (1999) find that countries, which *de jure* have switched to floating exchange rates, are *de facto* still pegging. Among the factors that potentially explain the “fear of floating” are large unhedged foreign currency denominated debt and the corresponding high exchange rate risk exposure. Balino, Bennet, and Borensztein (1999) stress unofficial dollarization.

Dollarization (euroization) is a common phenomenon in most developing and transition economies. Dollarization can take two forms: currency and asset substitution. The latter refers to the situation when domestic residents hold foreign currency deposits at either domestic banks or banks located abroad (cross border deposits). The former is present when domestic residents use foreign currency for transactions, for example, to buy imports and domestic products. Although one can get information on the degree of asset substitution from the statistics published by Bank for International Settlements and International Financial Statistics of IMF, unfortunately, no

[2] Domestic firms typically earn their revenues in domestic currency. The reduction in the firms’ net worth causes increase in the risk premium, which in turn, depresses investments and negatively affects aggregate demand.

[3]For instance, see Gertler et al. (2003) and Cespedes et al. (2004). They argue that under the fixed regime, following the foreign interest rate increase, domestic central bank has to raise interest rate to match the rise. This increase leads to a decrease in a firm’s net worth since future revenues are worth less in current value terms. As a result, the risk premium rises. Alternatively, under floating regime, depreciation makes domestic goods cheaper and boosts exports. If this positive effect dominates increased debt service payments, there would be an increase in net worth and the overall effect would be positive.

statistics exists for foreign currency in circulation. However, we can use foreign currency deposits to broad money (FCD/BM) ratio as a proxy for the degree of dollarization in a particular country.[4] In 1995, as Table A.1 in Appendix A illustrates, the average of FCD/BM ratio was 45.5% in highly dollarized and 16.4% in moderately dollarized developing and transition economies.[5] Clearly, high levels of dollarization in developing economies need to be factored into the analysis of alternative monetary policy rules and exchange rate regimes.

The recent years have seen an explosion in the literature assessing welfare implications of alternative monetary policies using dynamic stochastic general equilibrium (DSGE) models of open economies. This strand of the literature is often referred to as “New Open Economy Macroeconomics” (NOEM).[6] Due to its microeconomic foundations, NOEM approach gained popularity in studying normative issues related to the conduct of alternative monetary and fiscal rules. It is argued that choice of exchange rate regime depends on the nature of shocks that economy faces. Under a real shock, such as technology shock, flexible exchange rate is more preferable than fixed. Conversely, if economy is hit by a nominal shock, such as monetary shock, fixed exchange rate is argued to stabilize economy better than flexible.

Within this strand of literature, some studies examine how price setting behavior and expenditure switching affects the stabilizing properties of different exchange rate regimes. Devereux and Engel (2000) show that, in the absence of dollarization, the choice of an optimal exchange rate regime may depend on whether prices are set in the currency of producers (PCP) or the currency of consumers (LCP). They argue that in an environment of uncertainty created by

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[4] Clearly, domestic foreign currency deposits at domestic banks also include short-term foreign currency deposits, which can be easily withdrawn and used for transaction purposes. Conversely, foreign currency proceeds from commercial activities are deposited back to foreign currency accounts.
[5] IMF Classification is based on observations for 1995. Economies with FCD/BM greater than 30% are considered to be highly dollarized.
[6] See Lane (2001), Sarno (2001), Ganelli and Lane (2002) and Bowman and Doyle (2003) for surveys.

monetary shocks and under the PCP there is a tradeoff between the fixed and flexible exchange rate regimes. Senay and Sutherland (2003) argue that if the expenditure switching effect is low, then flexible exchange rate regime is preferred to the fixed one, but in the case of the strong expenditure switching effect the fixed regime is superior to the floating regime.

The existing literature on the choice of monetary regimes either completely overlooks the role of partial dollarization and welfare effects of the currency substitution in developing economies or focuses only on the extreme case of full dollarization – official adoption of the foreign currency as a legal tender – and compares it with other monetary environments.[7] Majority of small open economy and two-country models of exchange rate determination do not allow for partial dollarization, they hinge upon the assumptions of no currency substitution and symmetric monetary rules and households' preferences.[8]

Most of the existing studies on the currency substitution starting from the seminal paper by Sargent and Wallace (1981) mainly focused on the (in)determinacy issues under currency substitution.[9] Rogers (1990) studies the transmission of foreign inflation shocks to a small open economy model under currency substitution. He shows that the flexible exchange regime can behave similarly to the fixed exchange rate arrangement in absorbing foreign inflationary shocks under certain conditions. Berg and Borensztein (2000) develop a model of currency substitution and argue for a more rigid exchange rate regime in highly dollarized economies. However, they consider a simplified model, and do not evaluate welfare outcomes under the two alternative regimes.

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[7] Schmitt-Grohé and Uribe (2001) and Ghironi and Rebucci (2002) are examples of full dollarization studies.
[8] See, for example, Gali and Monacelli (2005), Bergin and Tchakarov (2003) and Kollmann (2002).
[9] Dupor (2001) shows how perfect substitutability between currencies may result in nominal exchange rate indeterminacy in the context of the fiscal theory of the price level. Airaudo (2004) studies the performance of a simple interest rule in a dollarized developing economy and derives conditions necessary for local equilibrium determinacy.

This paper attempts to fill the above cited gaps in the existing literature. The Chapter studies the stabilization properties of flexible and fixed exchange rate regimes in a partially dollarized developing economy. It quantifies and compares the welfare outcomes under the two alternative monetary regimes. The model deals with the currency substitution case.[10] The analysis is carried out within a two-country dynamic stochastic general equilibrium model with sticky prices, capital adjustment costs and monopolistic competition.[11] I follow a vertical production structure similar to Bergin (2004) and Bergin and Tchakarov (2003). To account for the well-documented fact that there is a "disconnect" between exchange rate and real economic variables, I also allow for home bias in the production of final goods.[12]

Another key distinctive feature of the paper is that there is an asymmetry in the preferences of domestic and foreign households. Consumers in the developing economy also value foreign currency for transaction or store of value purposes, whereas foreign consumers value only their own currency.[13] Moreover, monetary rules in two countries are not symmetric. In contrast to many other papers, this paper calculates conditional welfare, which is a more appropriate measure for evaluating of alternative policy regimes.[14] The algorithm recently proposed by Schmitt-Grohé and Uribe (2004) makes such an analysis possible. This algorithm

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[10] Terms currency substitution and dollarization will be used interchangeably throughout the paper.

[11] An easier alternative would be to analyze welfare effects of currency substitution in a small open economy framework. However, explicitly modeling foreign country allows for richer dynamics.

[12] For instance, see Flood and Rose (1995), Obstfeld and Rogoff (2000), and Duarte and Stockman (2005).

[13] Thus, the currency substitution is introduced exogenously. Of course, this is a simple way to introduce multiple currencies into a model. However, it would be of both theoretical and practical interest to examine the performance of alternative exchange rate regimes in endogenously dollarized economies. However, this task is beyond the scope of this paper and left for future research.

[14] Kollmann (2002) computes optimal monetary rules in the framework of a small open economy with no dollarization. Bergin and Tchakarov (2003) compute welfare losses arising from the risk under flexible and fixed exchange rate regimes.

allows for a second order approximation to the equilibrium conditions of a wide range of stochastic models.[15]

The major findings of the paper are as follows. First, in highly dollarized economies, welfare losses under fixed exchange arrangement are substantially smaller than under the flexible regime. However, as the degree of dollarization decreases, the relative merit of the fixed vis-à-vis the floating regime diminishes. These results hold for both PCP and LCP cases. Like in Bergin and Tchakarov (2003), I find that welfare losses under LCP are smaller than under PCP, though quantitatively the difference is trivial. Results are also robust under preferences with habits persistence.

Second, the paper shows that as the degree of substitution between domestic and foreign currencies increases, dollarized economies become more vulnerable to unexpected foreign shocks, such as foreign inflation hikes. Not only could such shocks bring the economy off its stationary equilibrium, but also render the latter locally indeterminate. Such an exposure may entail substantial welfare losses under the floating regime, even when the two currencies are not perfect substitutes.

Third, the study also analyzes the effects of the home consumption bias on welfare. The main finding is that decline in the home consumption bias coupled with currency substitution results in a greater welfare loss. Again, this calls for more vigorous exchange rate stabilization policy by the monetary authority.

Finally, I test empirically the predictions of the model. A series of ordered logit regressions for a panel of 21 developing countries largely support the model's main prediction – more dollarized economies tend to choose more rigid exchange rate regimes.

[15] Similar algorithms have been proposed by Sims (2000), Collard and Julliard (2001) and Kim et al. (2003).

The Chapter is organized as follows. Section 2 describes the model. Section 3 discusses the solution method, the computation of the welfare measure and provides details on the parameterization. The results are presented in Section 4. The next section provides the results of the regression analyses. Section 6 concludes.

1.2 Two country model

The world consists of two countries, home and foreign. Home is a small developing market. Foreign is a big economy, which is also a host of the reserve currency held by consumers in the home country. The population of the home country is fraction *n* of the world total. There are two sectors of production in both countries: final and intermediate goods. Each country specializes in the production of one final good, which is not internationally tradable and is manufactured from internationally traded intermediate composites. In both countries, monopolistically competitive firms produce intermediate goods. Households in home (foreign) country own home (foreign) firms and home (foreign) capital, which they rent to home (foreign) producers. They also supply labor. Labor and capital markets in both countries are competitive. It is assumed that there are no barriers for trade and no transportation costs. In what follows, the utility function of a foreign representative consumer and foreign variables are identified with an asterisk.

1.2.1 Final goods market

Final good (G) is produced according to the following CES production technology:

$$G_t = \left(a^{\frac{1}{\omega}} G_{h,t}^{\frac{\omega-1}{\omega}} + (1-a)^{\frac{1}{\omega}} G_{f,t}^{\frac{\omega-1}{\omega}} \right)^{\frac{\omega-1}{\omega}}, \tag{1.1}$$

where ω is the elasticity of substitution between the home and foreign intermediate goods composites. *a* is the weight of the home intermediate goods composite in the production of the final consumption good. If *a*>1/2, we say that consumption is biased towards the home goods.

$G_{h,t}$ and $G_{f,t}$ are aggregates of the home intermediate and the imported foreign intermediate goods, respectively:

$$G_{h,t} = \left(\int_0^1 g_{h,t}(z)^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1.2}$$

$$G_{f,t} = \left(\int_0^1 g_{f,t}(z)^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1.3}$$

where $g_{h,t}(z)$ and $g_{f,t}(z)$ represent outputs of individual home and foreign firms, respectively. Symmetrically, the production function of the foreign final good is

$$G_t^* = \left(a^{\frac{1}{\omega}} G_{f,t}^{*\,\frac{\omega-1}{\omega}} + (1-a)^{\frac{1}{\omega}} G_{h,t}^{*\,\frac{\omega-1}{\omega}} \right)^{\frac{\omega-1}{\omega}}. \tag{1.4}$$

Due to the symmetry in the goods market structure, in this section I will focus only on the home country.

Final goods market is perfectly competitive and producers maximize profits each period:

$$\pi_{h,t} = \left(P_t G_t - P_{h,t} G_{h,t} - P_{f,t} G_{f,t} \right), \tag{1.5}$$

where P is an overall price index, P_h and P_f are price indexes of the home and foreign goods, all denominated in local currency, and are given as

$$P_t = \left(a P_{h,t}^{\ 1-\omega} + (1-a) P_{f,t}^{\ 1-\omega} \right)^{\frac{1}{1-\omega}}, \tag{1.6}$$

$$P_{h,t} = \left(\int_0^1 p_{h,t}(z)^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}, \tag{1.7}$$

$$P_{f,t} = \left(\int_0^1 p_{f,t}(z)^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}. \tag{1.8}$$

Given equation (1.5) it is easy to derive demand functions for home and foreign goods composites:

$$G_{h,t} = a\left(\frac{P_{h,t}}{P_t} \right)^{-\omega} G_t, \tag{1.9}$$

$$G_{f,t} = (1-a)\left(\frac{P_{f,t}}{P_t} \right)^{-\omega} G_t. \tag{1.10}$$

Individual goods demand functions are

$$g_{h,t}(z) = \left(\frac{p_{h,t}(z)}{P_{h,t}} \right)^{-\varepsilon} G_{h,t}, \tag{1.11}$$

$$g_{f,t}(z) = \left(\frac{p_{f,t}(z)}{P_{f,t}} \right)^{-\varepsilon} G_{f,t}. \tag{1.12}$$

1.2.2 Intermediate goods market

The production function of the home firm that produces a variety *z* of home intermediate good is

$$Y_t(z) = \zeta_t K_t(z)^{\alpha} L_t(z)^{1-\alpha}, \tag{1.13}$$

where $0<\alpha<1$. $K_t(z)$ and $L_t(z)$ amount of labor and capital used by the firm *z* at time *t*. ζ_t is an exogenous productivity parameter subject to shocks and is common for all domestic producers.

In the benchmark case, I assume that the prices are set in the currency of the producer both for domestic and sales abroad, i.e. producer currency pricing (PCP). Price stickiness is introduced in the form of quadratic price adjustment cost function.

The representative home firm maximizes:

$$E_0 \sum_{t=0}^{\infty} \sigma_{t,t+n} \pi_{H,t}(z), \tag{1.14}$$

where $\sigma_{t,t+n}$ is a pricing kernel (to value date *t* and *t+n* payoffs), since firms are assumed to be owned by households, and it is equal the household's marginal rate of substitution between consumption at *t* and *t+n:* $\sigma_{t,t+n} = \beta^n \frac{U'_{C,t+n}}{P_{t+n}} \frac{P_t}{U'_{C,t}}$.

Each period profit function is

$$\pi_{h,t}(z) = \left(p_{H,t}(z) - MC_t(z) - AC_t(z) \right) g_{H,t}(z). \tag{1.15}$$

MC_t is a marginal cost function. $AC_t(z)$ is a quadratic price adjustment function and is given by

$$AC_{p,t}(z) = \frac{\mu}{2} \frac{\left(p_{H,t}(z) - p_{H,t-1}(z) \right)^2}{p_{H,t-1}(z)}. \tag{1.16}$$

Minimization of the cost function (for simplicity firm subscript is omitted)

$\frac{W_t L_t}{P_t} + K_t r_t$ subject to production technology $Y_t = \zeta_t K_t^{\alpha} L_t^{1-\alpha}$ yields $\lambda = \frac{W_t^{1-\alpha} r_t^{\alpha} P_t^{\alpha-1}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}\zeta_t}$,

where λ is the real marginal cost (Lagrange multiplier). Therefore, the nominal marginal cost is $MC_t = \frac{W_t^{1-\alpha} r_t^{\alpha} P_t^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}\zeta_t}$. Since all firms are assumed to have the same production technology, the MC will be the same across producers as well as the capital-labor tradeoff equation, which is given below.

$$P_t r_r K_t(z) = \frac{\alpha}{1-\alpha} W_t L_t(z) \,. \tag{1.17}$$

Substituting equation (1.15) into profit function (1.14) with the expressions for *MC*, *AC* and $g_{h,t}(z)$ from equation (1.11) and taking derivative with respect to $p_{H,t}(z)$, one can get a price-setting expression similar to that in Bergin and Tchakarov (2003):

$$\begin{aligned} p_{H,t}(z) = {} & \frac{\varepsilon}{\varepsilon-1}(MC_{H,t} + AC_{H,t}) + \frac{\mu}{\varepsilon-1} p_{H,t}(z)\left(1 - \frac{p_{H,t}(z)}{p_{H,t-1}(z)}\right) + \\ & + \frac{1}{2}\frac{\mu}{\varepsilon-1} p_{H,t}(z) E_t\left(\frac{\sigma_{t,t+n+1}}{\sigma_{t,t+n}}\left(1 - \frac{p_{H,t+1}^2(z)}{p_{H,t}^2(z)}\right)\frac{g_{H,t+1}(z)}{g_{H,t}(z)}\right). \end{aligned} \tag{1.18}$$

Unlike the standard case with no price adjustment costs, where the price is a markup over marginal cost, here we have some additional terms. Now, in equation (1.18) we also have: (i) price adjustment costs included into the calculation of the final price of good; (ii) the bracketed term in the middle, which is a backward looking component that indicates firm's reluctance to make large changes in price due to the presence of marginal adjustment costs, and (iii) the final term, forward looking part meaning that firms would increase prices by more today if they expect their rise in the future.

The optimal price for the foreign market is

$$p_{h,t}^* = p_{h,t} / e_t \,. \tag{1.19}$$

The similar price setting equations are derived for the foreign country.

1.2.3 Home household problem

The representative household lives infinitely many periods. At any time *t*, the representative home consumer maximizes her inter-temporal utility function:

$$U_t = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\rho}}{1-\rho} + \frac{1}{1-\eta} \chi_t \left(\frac{M_t^{\ A}}{P_t} \right)^{1-\eta} - \frac{(L_t)^{1+\psi}}{1+\psi} \right\}. \tag{1.20}$$

The second term in the objective function reflects the utility derived from holding real balances, for instance, as a means of facilitating transactions and is given as a CES aggregator over nominal domestic and foreign money: $M_t^{\ A} = \left(\phi^{\frac{1}{\gamma}} M_t^{\frac{\gamma-1}{\gamma}} + (1-\phi)^{\frac{1}{\gamma}} (e_t M_{f,t})^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}$. Domestic and foreign currencies provide utility in a non-separable way. $1-\phi$ can be thought of as the "degree of currency substitution". Lower ϕ indicates the higher importance of foreign currency for home residents. γ is the elasticity of substitution between home and foreign currency and e_t is nominal exchange rate. χ_t is an exogenously given money demand shock. Finally, the third term is the disutility from work.

Consumers receive income from providing labor at the nominal wage rate (*W*), renting out capital to firms at the real rental rate (*r*), receiving real profits from home firms (π), and from government transfers (*T*). In addition to money, home consumers can lend and borrow only in non-contingent foreign currency denominated nominal bonds that pay interest rate i^*. Consumer owns capital (*K*) which depreciates at a constant rate (δ), and whose adjustment incurs costs that are represented by quadratic adjustment cost function depending on parameter χ_c. Households also incur bond adjustment costs which depend on parameter χ_B. Capital adjustment costs are in changes and incorporated to prevent excessive capital volatility. The foreign bond adjustment costs are in the form of deviation from steady state level. They serve two purposes: to ensure that the bond holdings and consumption are stationary, and to indicate the fact that domestic households usually incur some adjustments costs on their foreign currency bond holdings.[16]

The budget constraint of the home household is

$$P_tC_t + P_t(K_{t+1} - (1-\delta)K_t) + \frac{1}{2}\chi_c P_t \frac{(K_{t+1} - K_t)^2}{K_t} + e_t B_{F,t} + \frac{1}{2}\chi_B \frac{\left(e_t\left(B_{F,t} - \bar{B}_F\right)\right)^2}{P_t} + M_t + e_t M_{F,t} =$$

$$= e_t(1+i^*_{t-1})B_{F,t-1} + M_{t-1} + e_t M_{F,t-1} + P_t r_t K_t + W_t L_t + \int_0^1 \pi_{h,t}(z)dz + P_t T_t \, . \tag{1.21}$$

Consumers maximize equation (1.20) subject to the budget constraint (1.21). Optimization yields the following first order conditions.

1. Home money demand equation:

$$\chi_t C_t^{\rho}\left(\frac{M_t}{P_t}\right)^{\frac{-1}{\gamma}} \phi^{\frac{1}{\gamma}} \left(\phi^{\frac{1}{\gamma}}\left(\frac{M_t}{P_t}\right)^{\frac{\gamma-1}{\gamma}} + (1-\phi)^{\frac{1}{\gamma}}\left(\frac{e_t M_{F,t}}{P_t}\right)^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma(1-\eta)}{\gamma-1}-1} = 1 - \beta E_t\left(\frac{C_t^{\rho}}{C_{t+1}^{\rho}}\frac{P_t}{P_{t+1}}\right). \tag{1.22}$$

2. Foreign money demand equation:

$$C_t^{\rho}\left(\frac{e_t M_{F,t}}{P_t}\right)^{\frac{-1}{\gamma}} \chi_t (1-\phi)^{\frac{1}{\gamma}} \left(\phi^{\frac{1}{\gamma}}\left(\frac{M_t}{P_t}\right)^{\frac{\gamma-1}{\gamma}} + (1-\phi)^{\frac{1}{\gamma}}\left(\frac{e_t M_{F,t}}{P_t}\right)^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma(1-\eta)}{\gamma-1}-1} = 1 - \beta E_t\left(\frac{C_t^{\rho}}{C_{t+1}^{\rho}}\frac{e_{t+1}P_t}{e_t P_{t+1}}\right). \tag{1.23}$$

3. Consumption Euler equation:

$$1 + \frac{\chi_B\left(B_{F,t} - \overline{B}_F\right)}{P_t} = \beta E_t\left(\frac{C_{t+1}^{-\rho}}{C_t^{-\rho}}\frac{e_{t+1}P_t(1+i_t^*)}{e_t P_{t+1}}\right). \tag{1.24}$$

[16] See Schmitt-Grohé and Uribe (2003) for a more detailed discussion. There is no role for home currency denominated bonds. It is assumed that foreign consumers do not want to hold them. Hence, home households cannot trade them since they are assumed to be identical as well as intermediate firms since they do not face idiosyncratic technology shocks.

4. Consumption-leisure tradeoff:

$$-L_t^{\psi} + \frac{W_t}{P_t C_t^{\rho}} = 0\,. \tag{1.25}$$

5. Capital accumulation equation:

$$1 + \chi_c \frac{K_{t+1} - K_t}{K_t} = \beta E_t \left[\left(\frac{C_t}{C_{t+1}} \right)^{\rho} \left(r_{t+1} + 1 - \delta + \frac{1}{2} \chi_c \left(\frac{K_{t+2}^2 - K_{t+1}^2}{K_{t+1}^2} \right) \right) \right]. \tag{1.26}$$

1.2.4 Foreign household problem

Foreign consumers maximize:

$$U_t^* = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(C_t^*\right)^{1-\rho}}{1-\rho} + \frac{\chi_t^*}{1-\eta} \left(\frac{M_{F,t}^{\ *}}{P_t^*} \right)^{1-\eta} - \frac{(L_t^*)^{1+\psi}}{1+\psi} \right\} \tag{1.27}$$

.

Unlike home consumers, their foreign counterparts do not derive utility from holding home country currency. Moreover, they do not face bond adjustment costs. Therefore, the budget constraint of the foreign representative consumer may be written as

$$\begin{aligned} P_t^* C^*_{\ t} + P_t^* (K^*_{\ t+1} - (1-\delta) K^*_{\ t}) + \frac{1}{2} \chi_c^* \frac{(K^*_{\ t+1} - K^*_{\ t})^2}{K_t^*} + B_{F,t}^* + M_{F,t}^* = (1 + i_{t-1}^{f*}) B_{F,t-1}^* + M_{F,t-1}^* + \\ + P_t^* r_t^* K_t^* + W_t^* L_t^* + \int_0^1 \pi^*_{f,t}(z) dz + P_t^* T_t^*. \end{aligned} \tag{1.28}$$

The associated first order conditions of the foreign representative household's optimization problem are similar to those of the home consumer with the exception of the money demand and consumption Euler equations:

$$\chi_t^* C_t^{*\rho} \left(\frac{M_{F,t}^*}{P_t^*} \right)^{-\eta} = 1 - \beta E_t \left(\frac{C_t^{*\rho}}{C_{t+1}^{*\rho}} \frac{P_t^*}{P_{t+1}^*} \right), \tag{1.29}$$

$$1-\beta E_t\left(\frac{C_{t+1}^{*\ -\rho}}{C_t^{*-\rho}}\frac{P_t^*(1+i_t^*)}{P_{t+1}^*}\right)=0\ . \tag{1.30}$$

1.2.5 Monetary and fiscal policy rules

Foreign Rules

It is assumed that the foreign monetary authority follows a constant money growth rule. The foreign country does not have to worry about maintaining some nominal exchange rate with the home country, which is a small open economy. The monetary rule is

$$M_t^* = (1+g)M_{t-1}^* . \tag{1.31}$$

For simplicity, I assume that the government's budget is balanced each period and there is no government spending and all seignorage revenues are returned to the public in the form of transfers. The foreign government's budget constraint is

$$T_t^* = \frac{M_t^* - M_{t-1}^*}{P_t^*} . \tag{1.32}$$

At this point, it is worthwhile noting that foreign transfers exceed the amount of foreign currency held by foreign consumers by the amount of foreign currency held by the home country. That is, the foreign economy, being the host of reserve currency, receives additional seignorage revenues from the home country.

Home Rules

I follow Obstfeld and Rogoff (2000), Devereux and Engel (2000), Bacchetta and Van Wincoop (2000), and Bergin and Tchakarov (2003) in setting up a money growth rule:

$$\ln(M_t) = \ln(M_{t-1}) + \lambda_e(\ln(e_t) - \ln(\overline{e})) . \tag{1.33}$$

A large negative value of λ_e corresponds to the case of a fixed exchange rate regime. However, for the flexible exchange regime I make some minor modification:

$$\ln(M_t) = \ln(M_{t-1}) + \ln(1+g) + \lambda_e(\ln(e_t) - \ln(\overline{e})) . \tag{1.34}$$

To ensure stationarity of nominal exchange rate, λ_e is set to a very small negative value close to zero. When this parameter is zero, the home monetary rule collapses to a constant money growth rule. *ln(1+g)* is included into the rule to pin down the steady state value of nominal exchange rate. Otherwise, nominal exchange rate and hence real variables, such as consumption, will be indeterminate.

The home government's budget constraint is similar to the foreign budget constraint:

$$T_t = \frac{M_t - M_{t-1}}{P_t} . \tag{1.35}$$

1.2.6 Market clearing and equilibrium

Goods market clearing conditions are

$$nY_{h,t} = nG_{h,t} + (1-n)G^*_{h,t} , \tag{1.36}$$

$$(1-n)Y^*_{f,t} = nG_{f,t} + (1-n)G^*_{f,t} . \tag{1.37}$$

Bonds clearing condition implies

$$nB_{F,t} + (1-n)B^*_{F,t} = 0 . \tag{1.38}$$

The home balance of payments equation is

$$P_tC_t + P_t(K_{t+1} - (1-\delta)K_t) + e_tB_{f,t} + e_tM_{f,t} = e_t(1+i^*_{t-1})B_{F,t-1} + e_tM_{F,t-1} + \\ + P_{H,t}\left(\frac{P_{H,t}}{P_t}\right)^{-\omega} G_t + \frac{1-n}{n} P_{H,t}\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\omega} G^*_t . \tag{1.39}$$

The home resource constraint may be written as

$$G_t = C_t + (K_{t+1} - (1-\delta)K_t) + \frac{1}{2}\chi_c \frac{(K_{t+1}-K_t)^2}{K_t} + \frac{1}{2}\chi_B \frac{\left(e_t\left(B_{f,t} - \bar{B}_f\right)\right)^2}{P_t^2} + e_t \frac{M_{f,t} - M_{f,t-1}}{P_t} + \frac{1}{P_t}\int_0^1 AC_{p,t}(z)dz. \qquad (1.40)$$

The foreign balance of payments condition is

$$P_t^* C_t^* + P_t^*(K_{t+1}^* - (1-\delta)K_t^*) + B_{F,t}^* = (1+i_{t-1}^*)B_{F,t-1}^* + G_t^*\left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\omega} P_{F,t}^* + \frac{n}{1-n}G_t\left(\frac{P_{F,t}}{P_t}\right)^{-\omega} P_{F,t}^* + \frac{n}{1-n}\frac{M_{F,t} - M_{F,t-1}}{P_t^*}. \qquad (1.41)$$

Note that the last term on the right hand side in the foreign balance of payments equation represents seignorage revenues that the foreign country collects from the home country by the virtue of being the host of the reserve currency. Foreign resource constraint may be defined as

$$G_t^* = C_t^* + (K_{t+1}^* - (1-\delta)K_t^*) + \frac{1}{2}\chi_c \frac{(K_{t+1}^* - K_t^*)^2}{K_t^*} + \frac{1}{P_t^*}\int_0^1 AC_{p,t}^*(z)dz. \qquad (1.42)$$

At the symmetric equilibrium, we have $p_{H,t}(z) = P_{H,t}$ and $p_{F,t}(z) = P_{F,t}$. The same applies to their foreign counterparts.

Stochastic Processes

Money demand and technology shocks are log-normally distributed and uncorrelated with each other:

$$\ln(\frac{\zeta_t}{\bar{\zeta}}) = \rho_1 \ln(\frac{\zeta_{t-1}}{\bar{\zeta}}) + \varepsilon_{1t}, \qquad (1.43)$$

$$\ln(\frac{\zeta_t^*}{\bar{\zeta}^*}) = \rho_1^* \ln(\frac{\zeta_{t-1}^*}{\bar{\zeta}^*}) + \varepsilon_{1t}^*, \qquad (1.44)$$

$$\ln(\frac{\chi_t}{\bar{\chi}}) = \rho_2 \ln(\frac{\chi_{t-1}}{\bar{\chi}}) + \varepsilon_{2t}, \qquad (1.45)$$

$$\ln(\frac{\chi_t^*}{\bar{\chi}^*}) = \rho_2^* \ln(\frac{\chi_{t-1}^*}{\bar{\chi}^*}) + \varepsilon_{2t}^*. \qquad (1.46)$$

1.3. Solution algorithm, welfare measure and calibration

1.3.1 Solution method, conditional and unconditional welfare

Most of research dealing with the evaluation of alternative monetary and fiscal policies rests on the log-linear approximation of the equilibrium conditions – the policy functions - and consequent second order approximation of the welfare function. The choice of unconditional expectation is mostly due to its advantages of computational simplicity. This approach may yield accurate results under certain simplifying assumptions, such as restrictive preferences specifications and access to government subsidies. In general, for such an approach to give correct results up to the second order, it is required that the solution to the equilibrium conditions be also accurate up to the second order. In this paper, I compute second order approximations to the policy functions and the welfare using the algorithm recently developed by Schmitt-Grohé and Uribe (2004). I follow them and assume that in initial state all state variables are in their deterministic steady states and alternative exchange rate regimes are evaluated by the conditional expectation of the discounted life time utility.

It is a common practice to exclude real monetary balances from the utility function in the welfare computation. In accordance with this practice, the conditional expectation of lifetime utility at time *t* can be written as

$$V_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} u(C_s, L_s) . \tag{1.47}$$

Instead of plugging the second order approximations of C_s and L_s in the above equation to determine the second order approximation of V_t, we can introduce a new control variable - V_t. Its law of motion can be written as

$V_t - \beta E_t(V_{t+1}) = u(C_t, L_t)$.

Most of the recent literature on monetary policy uses unconditional welfare index. However, it neglects the quantitative relevance of transitional dynamics. By now, it is well known that unconditional welfare index may produce incorrect rankings across alternative policies, since it omits the transition costs of moving from the deterministic to the stochastic steady states.[17]

1.3.2 Computation of the welfare measure

It is assumed that economy begins at time zero, at which all variables of the system are equal to their respective steady state values. Furthermore, the economy begins from the same state, which is a non-stochastic steady state and is the same under the two alternative monetary regimes. For each of the two exchange rate regimes, I compute the conditional expectation of lifetime utility as of time *t*. Let V_t^{flex} and V_t^{fix} be the conditional welfare outcomes as of time *t* under flexible fixed exchange rate regime, respectively.

Following the welfare loss measure introduced by Lucas (1987), let λ^{flex} (λ^{fix}) be the fraction of the nonstochastic steady state consumption level that consumers are willing to give up in order to avoid risk and be as well-off under the stochastic flexible (fixed) exchange rate regime environment.

Then the loss from uncertainty under flexible regime can be written as

$$\lambda^{flex} = \left(1 - \left(\frac{(V^{flex} - V)(1-\beta)(1-\rho)}{\bar{C}^{1-\rho}} + 1 \right)^{\frac{1}{1-\rho}} \right) \times 100 ,$$

[17] See Kim and Kim (2003) for a more detailed discussion.

where $\bar{C}$ is a steady state consumption level, which is the same under both flexible and fixed regimes.

Similarly, the loss under the fixed regime is given by

$$\lambda^{fix} = \left(1 - \left(\frac{(V^{fix} - V)(1-\beta)(1-\rho)}{\bar{C}^{1-\rho}} + 1 \right)^{\frac{1}{1-\rho}} \right) \times 100 .$$

Then, the gain (loss) of the fixed over the flexible regime is[18]

$\lambda = \lambda^{fix} - \lambda^{flex}$.

I also decompose conditional welfare costs under both fixed and flexible regimes. Let us denote by λ_{mean}^{fix} (λ_{mean}^{flex}) welfare costs due to changes in means and $\lambda_{\mathrm{var}}^{fix}$ ($\lambda_{\mathrm{var}}^{flex}$) costs due to variance effect under fixed (flexible) exchange rate regime. Given the second order approximation to the utility function and steady state levels of consumption, $\bar{C}$, and labor, $\bar{L}$, one can decompose λ^{fix} as follows:

$$u([1-\lambda^{fix}]\bar{C},\ \bar{L}) \approx u(\bar{C},\ \bar{L}) + (1-\beta)\sum_{t=0}^{\infty}\beta^t \left\{ E(\bar{C}^{1-\rho}\hat{C}_t - \bar{L}^{1+\psi}\hat{L}_t) - \frac{1}{2}\rho\bar{C}^{1-\rho}\ \mathrm{var}(\hat{C}_t) - \frac{1}{2}\psi\bar{L}^{1+\psi}\ \mathrm{var}(\hat{L}_t) \right\},$$

where hats over variables represent log-deviations from the deterministic steady states. The change in mean consumption, λ_{mean}^{fix}, is computed from the following expression:

$$u([1-\lambda_{mean}^{fix}]\bar{C},\ \bar{L}) = u(\bar{C},\ \bar{L}) + (1-\beta)\sum_{t=0}^{\infty}\beta^t \left\{ E(\bar{C}^{1-\rho}\hat{C}_t - \bar{L}^{1+\psi}\hat{L}_t) \right\}. \tag{1.48}$$

The change in conditional variance of consumption is given by

$$u([1-\lambda_{\mathrm{var}}^{fix}]\bar{C},\ \bar{L}) = u(\bar{C},\ \bar{L}) - (1-\beta)\sum_{t=0}^{\infty}\beta^t \left\{ \frac{1}{2}\rho\bar{C}^{1-\rho}\ \mathrm{var}(\hat{C}_t) + \frac{1}{2}\psi\bar{L}^{1+\psi}\ \mathrm{var}(\hat{L}_t) \right\}. \tag{1.49}$$

[18] When $\rho = 1$, we can derive a direct formula calculating welfare loss of the flexible vis-à-vis the fixed regime: $\lambda = \left(1 - e^{(1-\beta)(V^{flex} - V^{fix})}\right) \times 100$.

It can be easily shown that the following relation holds:

$$(1-\lambda^{fix})^{1-\rho} = (1-\lambda^{fix}_{mean})^{1-\rho} + (1-\lambda^{fix}_{\text{var}})^{1-\rho} - 1. \tag{1.50}$$

As there are no closed-form solutions to (1.48) and (1.49), I simulate the conditional moments for 2000 periods and compute the discounted sum. I calculate $\lambda^{fix}_{\text{var}}$ from (1.49) and λ^{fix}_{mean} is computed using (1.50).The analytical formulas for the computation of conditional moments are derived and provided in Paustian (2003) and Marzo, Strid and Zagaglia (2006). Similarly, one can decompose the welfare cost for the flexible exchange rate regime.

To facilitate the comparison with the literature, I also calculate unconditional welfare costs. Following Bergin and Tchakarov (2003) and Straub and Tchakarov (2004) I decompose unconditional welfare cost under the fixed exchange rate regime into mean and variance components:

$$u([1-\lambda^{fix,u}_{mean}]\bar{C},\ \bar{L}) = u(\bar{C},\ \bar{L}) + \bar{C}^{1-\rho}E(\hat{C}_t) - \bar{L}^{1+\psi}E(\hat{L}_t),$$

$$u([(1-\lambda^{fix,u}_{\text{var}})\bar{C},\ \bar{L}) = u(\bar{C},\ \bar{L}) - \frac{1}{2}\rho\bar{C}^{1-\rho}\ \text{var}(\hat{C}_t) - \frac{1}{2}\psi\bar{L}^{1+\psi}\ \text{var}(\hat{L}_t).$$

Rearranging these equations, one can get the expressions for the unconditional mean and variance components:

$$\lambda^{fix,u}_{mean} = 1 - \left\{1 + (1-\rho)E(\hat{C}_t) - \frac{(1-\rho)}{\bar{C}^{1-\rho}}\bar{L}^{1+\psi}E(\hat{L}_t)\right\}^{1/(1-\rho)},$$

$$\lambda^{fix,u}_{\text{var}} = 1 - \left\{1 - \frac{1}{2}\rho(1-\rho)\,\text{var}(\hat{C}_t) - \frac{1}{2}\frac{(1-\rho)}{\bar{C}^{1-\rho}}\psi\bar{L}^{1+\psi}\ \text{var}(\hat{L}_t)\right\}^{1/(1-\rho)}.$$

The decomposition of the unconditional welfare cost under the flexible exchange rate regime is undertaken in the same way.

1.3.3 Parameterization

The calibrated parameters used for the base model are provided in Table 1.1. The time period in the model is one quarter. Therefore, I set β=0.99 and choose δ=0.025 for the depreciation rate. Capital share in the production is set to 0.36. I follow Bergin and Feenstra (2001) in choosing a value of 0.25 for the interest elasticity of real money balances ($1/\eta$). ρ is set to 4 in line with the empirical findings that the income elasticity of real money demand (ρ/η) is about unity. I follow Harrigan (1993) and Trefler and Lai (1999) and Bergin and Tchakarov (2003) by setting the value of elasticity of substitution between foreign and home goods, ω, to 5. Rotemberg and Woodford (1998) set the degree of monopolistic competition ε to be 7.66, which implies an average price mark-up of 15%, and I follow this parameterization. The size of the home country is set to 0.15 for the base model computations. I follow Christiano et al. (1997) and set ψ=1, which is the inverse of labor supply elasticity. Following Bergin and Tchakarov (2003), the price adjustment cost is set at μ =50 for both countries, which implies that 95% of the price has adjusted 4 periods after a monetary shock. As in Bergin and Tchakarov (2003) investment adjustment cost in the foreign country is set at χ_c =4, meaning that investment is about three times more volatile than output. I use the same value for the home country's capital adjustment cost parameter in view of the problem related to capital measurement in developing countries. Introducing bond adjustment costs and assigning a small value to it, χ_B =0.0004, is necessary to ensure the stationarity in the net foreign assets position.

It is assumed that the foreign central bank is increasing nominal money at a rate of 5% per annum, which is equivalent to setting g=0.012272. The home monetary policy reaction parameter, λ_e, is set at -10^{-6} and -10^{3}, for flexible and fixed exchange regimes, respectively. It is difficult to estimate the elasticity of substitution between domestic and foreign money, γ, therefore the parameter is set to 1, which implies Cobb-Douglas monetary aggregate. Foreign and domestic money do not enter monetary aggregate as perfect substitutes, since I assume that there are some legal restrictions over the use of foreign money in the home country. The elasticity of substitution between the currencies will turn out to be an important parameter for the purposes of welfare evaluation across alternative exchange rate regimes. Later, I will relax the assumption of no perfect substitutability and will vary γ bringing it closer to the case of perfect currency substitution. I use the following numerical values for the degree of dollarization, ϕ={3/5, 4/5, 17/20, 9/10}. These values respectively correspond to FCD/BM={0.4, 0.2, 0.15,0.1}.[19].

For the variance and persistence of technology shocks, I use common values employed in the real business cycle literature and also used in Bergin and Tchakarov (2003), $var(\varepsilon_1)=var(\varepsilon^*_1)=0.01^2$ and $\rho_1=\rho_1^*=0.9$. I use $var(\varepsilon_2)=var(\varepsilon^*_2)=0.05^2$ and $\rho_2=\rho_2^*=0.9$ for monetary shocks persistence and variance. To simplify analysis, it is assumed that shocks are uncorrelated with each other.

[19] The value for ϕ is chosen such that at the steady state: $\frac{eM_f}{eM_f+M}=\frac{FCD}{BM}$ reported in Table A.1.

Table 1.1. Calibrated parameters

Parameter	Value	Description
β	0.99	Quarterly subjective discount rate
δ	0.025	Quarterly depreciation rate
α	0.36	Cost share of capital, $Y=\zeta K^{\alpha}L^{1-\alpha}$
$1/\eta$	1/4	Interest elasticity of real money balances
ρ	4	Risk aversion parameter, $U=\frac{C^{1-\rho}}{1-\rho}+\frac{1}{1-\eta}\chi\left(\frac{M^{A}}{P}\right)^{1-\eta}-\frac{(L)^{1+\psi}}{1+\psi}$
ω	5	Elasticity of substitution between home and foreign intermediate goods in the production of final good, $G=\left(a^{\frac{1}{\omega}}G^{\frac{\omega-1}{\omega}}+(1-a)^{\frac{1}{\omega}}G^{\frac{\omega-1}{\omega}}\right)^{\frac{\omega-1}{\omega}}$
n	0.15	Relative size of the home country
ε	7.66	Degree of monopolistic competition in the intermediate goods market
μ	50	Coefficient in price adjustment costs, $\frac{\mu}{2}\frac{\left(p_t-p_{t-1}\right)^2}{p_{t-1}}$
χ_c	4	Coefficient in investment adjustment costs, $\frac{1}{2}\chi_c\frac{(K_{t+1}-K_t)^2}{K_t}$
χ_B	0.0004	Coefficient in bond adjustment costs, $\frac{1}{2}\chi_B\frac{\left(e_t\left(B_{f,t}-\bar{B}_f\right)\right)^2}{P_t^2}$ [20]
$1/\psi$	1	Labor supply elasticity
γ	1	Elasticity of substitution between domestic and foreign money
g	0.012272	Quarterly nominal money growth rate in the foreign money rule
ρ_1	0.9	First-order serial correlation of technology shock
ρ_2	0.9	First-order serial correlation of monetary shock

[20] $\overline{B}_f$ is the steady state value of nominal foreign currency denominated bonds, whose real value is calculated jointly with the steady state values of other real variables.

1.4 Results

1.4.1 Benchmark and related cases

Summary of results of the benchmark model, which is PCP case with Cobb-Douglas monetary aggregator in the utility function of the home consumer, are presented in Table 1.2.[21] First column of the table represents the degree of dollarization in the home country. Parameter ϕ is set to such a level that at the steady state ratio of foreign money held by the home consumer and the sum of the foreign and home currency holdings in the home country is equal to the observed data on FCD/BM ratio reported in Table A.1.

Table 1.2. Summary of welfare effects under producer currency pricing

	Welfare Loss Relative to Steady State (%)		Welfare Loss (Gain) of Flexible relative to Fixed (%)
	Flexible Regime	Fixed Regime	"+ " - loss, "-" - gain
Import Share=0.2	Both shocks	Both shocks	
Degree of Dollarization			
Φ=3/5 (40%)	0.256	0.140	0.116
Φ=4/5 (20%)	0.140	0.068	0.072
Φ=17/20 (15%)	0.117	0.061	0.056
Φ=9/10 (10%)	0.100	0.058	0.042
Φ=1 (0%)	0.072	0.068	0.004
Import Share=0.4			
Degree of Dollarization			
Φ=3/5 (40%)	0.600	0.314	0.286
Φ=4/5 (20%)	0.238	0.132	0.106
Φ=17/20 (15%)	0.177	0.101	0.076
Φ=9/10 (10%)	0.131	0.081	0.050
Φ=1 (0%)	0.081	0.082	-0.001

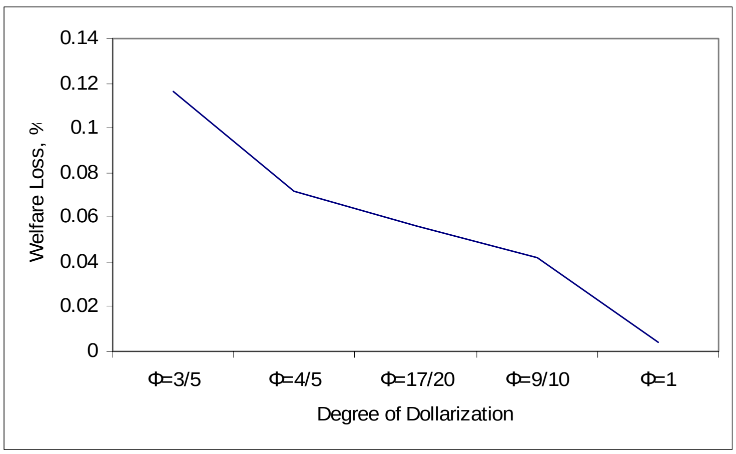
Notes. The welfare loss is computed as the percentage steady state consumption loss. Numbers in the brackets indicate the degree of dollarization.

Table 1.2 shows that for dollarized economies welfare loss under flexible exchange arrangement is higher than under the fixed one. For instance, for 40% dollarization case the welfare loss relative to the steady state under the flexible regime is 0.256%, whereas under the

[21] More detailed breakdown of welfare losses discussed in this section, which are due to monetary and productivity shocks can be found in Appendix A.

fixed it is 0.14%. Though, the gain of the fixed over the flexible of 0.116% may not seem substantial, below I will present cases where the loss under the flexible regime can be substantial. One can also observe that with the decline in the degree of dollarization, the relative loss of the flexible compared to the fixed regime diminishes. Basically, currency substitution tends to increase exchange rate volatility (see Table A.6). In the case of no dollarization, the loss of the flexible in terms of fixed regime becomes trivial. This trend is reflected in Figure 1.1 below.

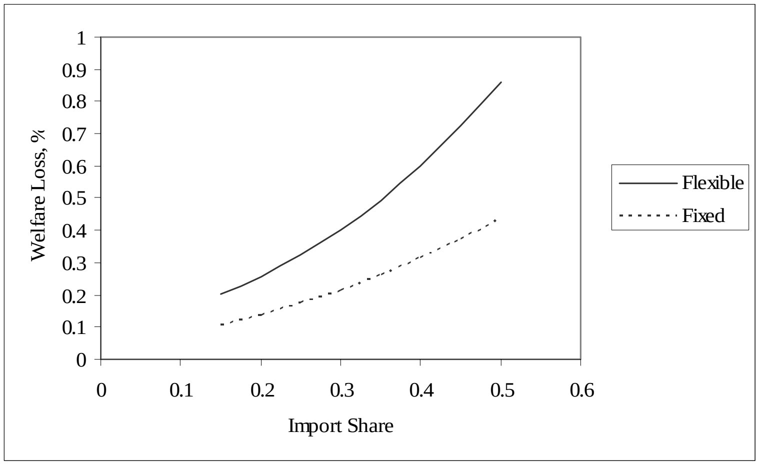
Figure 1.1. Welfare loss of flexible relative to fixed regime: PCP, import share=20%



Let us now look at the lower part of Table 1.2. One can see that decreasing home bias in the production of the final good, i.e., setting import share to 40%, results in the increased loss under both regimes. In this case and under 40% dollarization, the loss under the flexible regime relative to the steady state increases to 0.6%, while under the fixed it goes up to 0.31%, and, in turn, the loss of the flexible relative to the fixed regime rises to 0.29%. It is more than twice higher than under the 20% import share case. However, in the case of no dollarization, decreasing home bias has a negligible effect on welfare.

The intuition for this finding may be as follows. The demand for foreign money depends on the foreign CPI inflation. As the share of imported goods increases, the CPI inflation becomes more volatile due to the volatility of nominal exchange rate. These fluctuations cause higher volatility of the foreign money demand by home consumers and this, in turn, results in more volatile home aggregate demand and increased welfare loss. This can be seen in Figure 1.2 below. The graph shows welfare loss under alternative regimes as a function of import share.

Figure 1.2. Welfare loss as a function of import share: ϕ=3/5 (40% dollarization)



Hence, given high degree of dollarization and lower home bias, it is more desirable to stabilize exchange rate fluctuations.

Another useful exercise is to compare welfare outcomes when prices are set in the local currency of the buyer (LCP). Table 1.3 presents summary of results under the LCP pricing. One can observe that welfare losses under the flexible are higher than under the fixed exchange rate regime. Welfare outcomes have not changed much for both exchange rate regimes, though welfare loss is slightly smaller under the LCP than under the PCP case at all levels of dollarization and both monetary regimes.

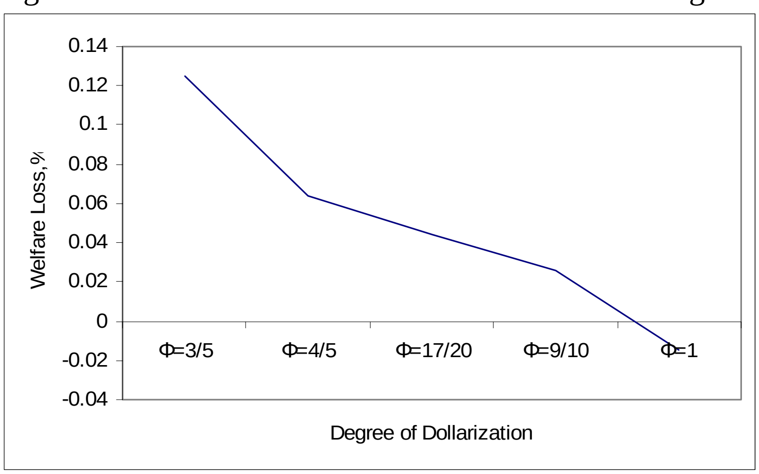
Table 1.3. Summary of welfare effects under local currency pricing

	Welfare Loss Relative to Steady State (%)		Welfare Loss (Gain) of Flexible relative to Fixed (%):
	Flexible Regime	Fixed Regime	"+ " - loss, "-" - gain
Import Share=0.2	Both shocks	Both shocks	
Degree of Dollarization			
Φ=3/5 (40%)	0.216	0.091	0.125
Φ=4/5 (20%)	0.096	0.032	0.064
Φ=17/20 (15%)	0.074	0.030	0.044
Φ=9/10 (10%)	0.058	0.032	0.026
Φ=1 (0%)	0.041	0.056	-0.015
Import Share=0.4			
Degree of Dollarization			
Φ=3/5 (40%)	0.590	0.200	0.390
Φ=4/5 (20%)	0.210	0.057	0.153
Φ=17/20 (15%)	0.140	0.038	0.102
Φ=9/10 (10%)	0.090	0.031	0.059
Φ=1 (0%)	0.030	0.059	-0.029

Notes. The welfare loss is computed as the percentage steady state consumption loss. Numbers in the brackets indicate the degree of dollarization.

Again, one can observe that the relative gain of the fixed regime declines with the decrease in the degree of dollarization as depicted in Figure 1.3.

Figure 1.3. Welfare loss of flexible relative to fixed regime: LCP, import share=20%



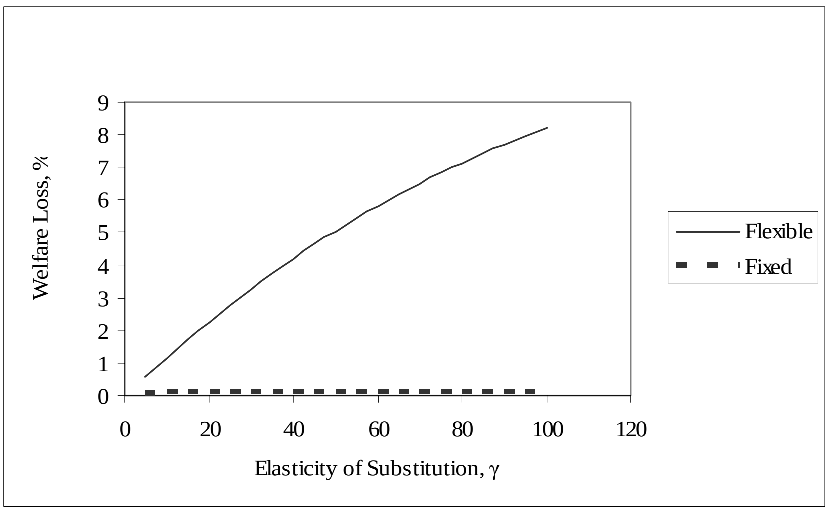
Theoretically, the choice of price-setting mechanism is deemed to affect the choice of exchange regime. However, I find that quantitatively the results do not differ much under both pricing mechanisms --when prices are set in the currency of the producer and when prices are set in the local currency of the buyer. Similar finding was obtained by Bergin and Tchakarov (2003).

The above results have been obtained for the case of Cobb-Douglas monetary aggregator, that is, domestic and foreign currencies are not perfect substitutes. So far, the results suggest that if the home bias is high and the two currencies do not enter the home utility function as perfect substitutes then, quantitatively, the relative gain of the fixed versus the flexible is not very significant.

Now, let us examine what happens to the welfare when we increase parameter γ, the elasticity of substitution between the two currencies. Setting γ to infinity would be the case of perfect substitutability between the domestic and foreign currencies. Obstfeld and Rogoff (1996, pp 551-53) present a simple model of currency substitution. They argue that when purchasing power parity (PPP) holds, and there are no legal restrictions (no foreign currency transaction costs) over the use of the foreign currency, and two currencies are perfect substitutes; then there may be considerable instability in domestic prices and exchange rates.

Although, the PPP does not hold, and the two currencies are not perfect substitutes in this model, results presented below support Obstfeld and Rogoff's (1996) finding. Figure 1.4 plots the welfare loss as a function of the elasticity of substitution between the home and foreign currencies. In this experiment, I increase the elasticity of substitution between domestic and foreign currencies from 1 (Cobb-Douglas monetary aggregator case) to 100 and calculate the associated welfare losses. I consider monetary shocks and 40 percent degree of dollarization. One can see that increasing γ results in the increased welfare loss under the flexible exchange rate regime .Now, welfare loss under the flexible regime is substantial, and is well above one percentage point.[22] This stems from significant exchange rate fluctuations and huge currency swings, which, in turn, cause substantial aggregate fluctuations in the home country. However, under the fixed exchange regime, increasing γ has almost no effect on the welfare; the welfare loss is almost unchanged and remains almost the same under the Cobb-Douglas case considered above. Thus, in highly dollarized developing economies where the elasticity of substitution between domestic and foreign currencies is high, there is a greater need for a fixed exchange regime.

Figure 1.4. Welfare loss and the elasticity of substitution between currencies: import share=40% and ϕ=3/5



Another useful experiment is to calculate welfare under the higher risk aversion parameter, ρ. Table 1.4 reports results for ρ=30. From the table, it can be seen that the welfare losses for both flexible and fixed regimes have risen; however, these changes are not substantially different from the results of the benchmark case reported in Table 1.2. Again, we can observe that with the decline in the level of dollarization, the relative gain of the fixed over the flexible regime diminishes.

[22] Similar experiment has been done for the case of productivity shocks. Qualitatively results were similar; however, quantitatively the welfare losses under flexible exchange regime were not that high like in the case of monetary shocks.

Table 1.4. Summary of welfare effects under producer currency pricing: higher risk aversion (ρ=30)

	Welfare Loss Relative to Steady State (%)		Welfare Loss (Gain) of Flexible relative to Fixed (%):
	Flexible Regime	Fixed Regime	"+ " - loss, "-" - gain
Import Share=0.2	Both shocks	Both shocks	
Degree of Dollarization			
Φ=3/5 (40%)	0.354	0.177	0.177
Φ=4/5 (20%)	0.188	0.087	0.101
Φ=17/20 (15%)	0.159	0.077	0.082
Φ=9/10 (10%)	0.137	0.071	0.066
Φ=1 (0%)	0.110	0.089	0.021

Notes. The welfare loss is computed as the percentage steady state consumption loss. Numbers in the brackets indicate the degree of dollarization.

1.4.2 Conditional *vs* unconditional welfare

Table 1.5 presents results of conditional and conditional welfare costs mean-variance decompositions as well as unconditional welfare costs for fixed and flexible exchange rate regimes. Unconditional welfare losses are presented in columns 5 and 11. Quick look at the table shows that as in the case of conditional welfare index, unconditional welfare losses under floating regime diminishes as the degree of dollarization decreases under both PCP and LCP cases.

Another observation is that unconditional welfare index underestimates unconditional costs. As argued before, it ignores the costs associated with the transition from the deterministic to stochastic steady states. For instance, the unconditional welfare loss under flexible regime with 40% dollarization is 0.186%, whereas its conditional counterpart is 0.256%. Moreover, one can observe welfare ranking reversals under LCP case when one uses unconditional measures. For instance, under LCP case with degrees of dollarization lower than 20% unconditional welfare losses are smaller than under fixed regime. Further, unconditional measures suggest that under fixed exchange rate with LCP the lowest welfare loss is when the degree of dollarization is

40%. And, as the degree of dollarization decreases, the unconditional welfare losses increase. This result is completely contrary to the corresponding results when conditional measures are used.

Table 1.5. Mean-variance decomposition of conditional and unconditional welfare measures

	Flexible ER						Fixed ER					
	Conditional Measures			Unconditional Measures			Conditional Measures			Unconditional Measures		
	λ^c	λ^c_{mean}	λ^c_{var}	λ^u	λ^u_{mean}	λ^u_{var}	λ^c	λ^c_{mean}	λ^c_{var}	λ^u	λ^u_{mean}	λ^u_{var}
PCP, Import Share=0.2												
Φ=3/5 (40%)	0.256	0.245	0.011	0.186	0.099	0.087	0.140	0.124	0.013	0.050	-0.034	0.085
Φ=4/5 (20%)	0.140	0.131	0.061	0.091	0.033	0.058	0.068	0.062	0.007	0.026	-0.029	0.054
Φ=17/20 (15%)	0.117	0.112	0.005	0.075	0.023	0.052	0.061	0.055	0.006	0.027	-0.021	0.048
Φ=9/10 (10%)	0.100	0.096	0.004	0.061	0.015	0.046	0.058	0.053	0.005	0.033	-0.010	0.043
Φ=1 (0%)	0.072	0.068	0.003	0.045	0.008	0.036	0.068	0.065	0.004	0.054	0.016	0.039
LCP, Import Share=0.2												
Φ=3/5 (40%)	0.216	0.215	0.002	0.022	0.003	0.020	0.091	0.089	0.002	0.011	-0.011	0.022
Φ=4/5 (20%)	0.096	0.094	0.001	0.012	-0.005	0.017	0.032	0.031	0.001	0.018	-0.000	0.019
Φ=17/20 (15%)	0.074	0.073	0.001	0.010	-0.007	0.017	0.030	0.028	0.001	0.023	0.004	0.018
Φ=9/10 (10%)	0.058	0.057	0.001	0.009	-0.008	0.017	0.032	0.031	0.001	0.028	0.009	0.019
Φ=1 (0%)	0.041	0.039	0.001	0.017	-0.002	0.019	0.056	0.055	0.001	0.042	0.017	0.024

Notes. The welfare loss is computed as the percentage steady state consumption loss. Numbers in the brackets indicate the degree of dollarization.

1.4.3 Adding consumption habits

In this subsection, I test whether the results obtained above are sensitive to the model setup. Specifically, I modify instantaneous utility function in equation (1.20) to incorporate habit persistence:

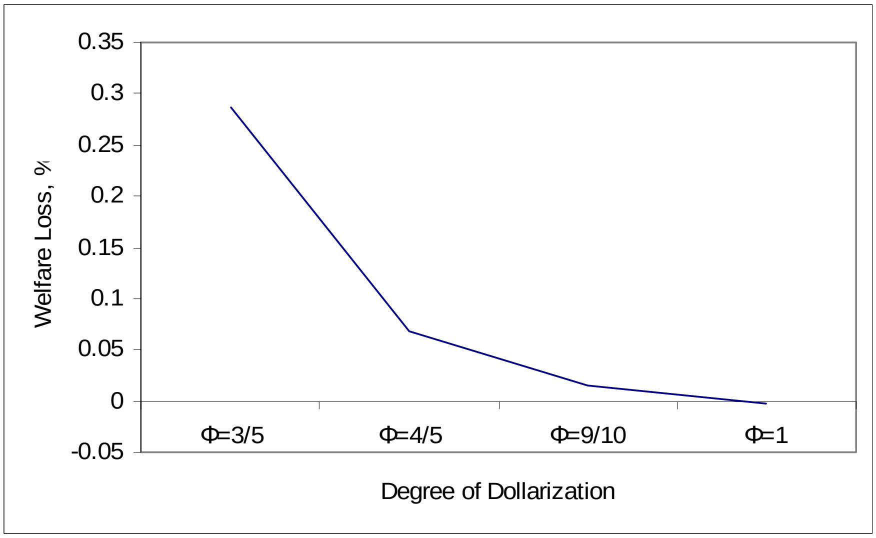
$$U_t = \frac{(C_t - \gamma_c C_{t-1})^{1-\rho}}{1-\rho} + \frac{1}{1-\eta}\chi_t \left(\frac{M_t^{\ A}}{P_t}\right)^{1-\eta} - \frac{(L_t)^{1+\psi}}{1+\psi}. \tag{1.51}$$

In this new period utility function, when γ_c goes to unity, households try to smooth changes in consumption rather than levels of consumption. Deaton (1987) and Constantinides (1990) find that setting $\gamma_c = 0.8$ can help to explain consumption smoothness and the equity premium puzzle. I follow them in calibrating habit persistence parameter at $\gamma_c = 0.8$. In order to prevent deviation of consumption from falling too low, I follow Bergin and Tchakarov (2003) and augment bond adjustment costs, which can now be written as:

$$AC_{b,t} = \frac{1}{2}\chi_B \frac{\left(e_t\left(B_{f,t} - \bar{B}_f\right)\right)^2}{P_t} + \frac{1}{2}\chi_{B2}\frac{\left(e_t\left(B_{f,t} - B_{f,t-1}\right)\right)^2}{P_t}.$$

Parameter χ_{B2} is calibrated at 0.0004. Results are reported in Table A.5. Compared with the benchmark case, at high levels of dollarization welfare losses under both regimes are higher. Surprisingly, at moderate and lower levels of dollarization, welfare losses under habits persistence become lower than under the benchmark case. In contrast to recent studies of incomplete symmetric assets market cases, where introduction of habits persistence generally results in higher welfare losses than under the standard utility function without habits, I find that habits persistence in asymmetric assets market environment delivers lower welfare loss than under the standard symmetric case. This makes a combination of habit persistence and asymmetric assets markets a more interesting case to investigate. Again, the welfare loss under the fixed is lower than under the flexible arrangement and the relative gain of the former over the latter declines with the degree of dollarization (see Figure 1.5).

Figure 1.5. Welfare loss of flexible relative to fixed regime: habits persistence, import share=20%



Results presented in this section suggest that fixed exchange rate regime outperforms flexible exchange rate regime based on money growth rule in dollarized economies. However, it would be interesting to see whether or not the results would carry over to the case when central bank employs floating exchange rate regime based on a standard inflation targeting interest rate rule.

1.5 Empirical Investigation[23]

In this section, I use an ordered logit model for the *de facto* exchange rate classifications to examine whether or not partial dollarization has influenced the choice of exchange rate regimes in developing economies. The results of the regression suggest that (i) more dollarized economies have a tendency to use more rigid exchange regimes, though the estimated coefficient on dollarization is marginally significant. This is in line with the predictions of the theoretical model developed in the previous section; (ii) developing countries that are more open to trade

[23] The purpose of this exercise is not to conduct a full-fledged econometric analysis, but rather to establish some stylized facts.

tend to choose more rigid exchange rate regimes. Above, it is shown that currency substitution combined with higher import shares entails higher welfare losses and therefore more rigid exchange rate regimes are desirable; (iii) developing countries that have experienced high inflation also tend to adopt more fixed regimes, and (iv) countries with sound fiscal policies tend to have more rigid exchange arrangements.

1.5.1 Theoretical determinants of exchange rate arrangements and data description

According to the theoretical literature, determinants of exchange regime can be grouped into four broad categories: (i) the optimum currency areas (OCA) fundamentals, (ii) the stabilization considerations, (iii) the currency crises factors, and (iv) political and institutional features. In present paper, I focus on the former three groups of determinants.[24] The OCA explanatory variables are trade openness (ratio of trade to GDP), country size (proxied by log of GDP). The second group – stabilization considerations – includes inflation (consumer price index) and budget deficit to GDP ratio.[25] The last group comprises ratio of non-gold reserves to broad money and ratio of current account to GDP. I also include the ratio of broad money to GDP as a proxy for the level of financial development. In addition to the above determinants, I include foreign currency deposits to broad money ratio as a proxy for the currency substitution.

The panel consists of 21 developing countries observed for the period 1993-1995.[26] The *de facto* exchange regime classifications are obtained from Reinhart and Rogoff (2001). A slight modification to Reinhart-Rogoff‘s classification has been made by merging original 14 into 4

[24] The choice of specific determinants has been dictated by data availability.
[25] Instead of CPI index, I use CPI/(CPI+1) measure in order to account for countries with hyper inflationary episodes.
[26] The panel contains 63 observations. List of countries include Argentina, Bolivia, Costa Rica, Nicaragua, Peru, Turkey, Uruguay, Bulgaria, Egypt, El Salvador, Estonia, Honduras, Hungary, Jordan, Mexico, Philippines, Poland, Romania, Sierra Leone, Trinidad and Tobago, Uganda. The data come mainly from IFS statistics of the International Monetary Fund.

categories to reduce the number of thresholds to be evaluated. In order to reduce endogeneity problem, all explanatory variables are lagged one period.

1.5.2 Baseline model of exchange rate regime choice

I describe the choice of exchange rate regimes using a discrete variable, $y_{i,t}$. This variable can take on one of the four values:[27]

$y_{i,t} = 0$, if a currency board or hard peg regime is adopted by the country *i* in year *t*,

$y_{i,t} = 1$, if a soft peg regime is used by the country *i* in year *t*,

$y_{i,t} = 2$, if the country *i* in year *t* chooses the intermediate regime,

$y_{i,t} = 3$, if a flexible regime is chosen by the country *i* in year *t*,

with probabilities p_i, where *i*=0,1,2,3. The choice is based on the continuous latent variable $y^*_{i,t}$, which represents attractiveness of flexible exchange regime, and is, in turn, a linear function of explanatory variables discussed previously:

$y^*_{i,t} = X_{i,t}\beta + u_{i,t}$, for *i*=1,2,…,N and *t*=1,…,T.

The probabilities of $y_{i,t}$ are given by:

$\Pr(y_{i,t} = 0) = F(c_1 - X_{i,t}\beta)$,

$\Pr(y_{i,t} = 1) = F(c_2 - X_{i,t}\beta) - F(c_1 - X_{i,t}\beta)$,

[27] The original 14 categories are no separate legal tender; pre announced peg or currency board arrangement; pre announced horizontal band that is narrower than or equal to +/- 2%; de facto peg; pre announced crawling peg; pre announced crawling band that is narrower than or equal to +/- 2%; de facto crawling peg; de facto crawling band that is narrower than or equal to +/- 2%; pre announced crawling band that is wide than or equal to +/- 2%; de facto crawling band that is narrower than or equal to +/- 5%; moving band that is narrower than or equal to +/- 2%; managed floating; freely floating, and freely falling. The first two regimes are merged into the first category. Third to seventh constitute second group. Eights to twelfths are included into the third category. Finally, freely floating and freely falling represent the last group. Around 14% of observations fall into the currency board or hard peg category, 46% into second, 19% into third, and 21% of observations constitute flexible regime.

$$\Pr(y_{i,t} = 2) = F(c_3 - X_{i,t}\beta) - F(c_2 - X_{i,t}\beta)\,,$$

$$\Pr(y_{i,t} = 3) = 1 - F(c_3 - X_{i,t}\beta)\,,$$

where F(·) is the cumulative probability distribution of the error term. Although, the country specific fixed effects model would be of interest, it is not feasible to estimate them. The maximum likelihood estimator will be inconsistent since, given fixed *T*, increasing sample size *N* will increase the number of fixed effects to be estimated. In the linear fixed effects models, one can obtain consistent estimates by removing fixed effects from the estimated model using the *Within* transformation. This is no longer the case for qualitative limited dependent variable models with fixed *T* (Chamberlain, 1980). Therefore, I pool all country-year observations to run an ordered logit regression.

1.5.3 Regression results

Table 1.6 below presents the results of logit regression of the de facto exchange rate regimes.[28] A negative sign of a coefficient means that an increase in the associated variable raises the probability of adopting a hard peg. One can observe that model predicts correctly 70 percent of the *de facto* exchange rate regimes. The results suggest that four out of eight explanatory variables play a role in choosing the exchange rate regime. The main explanatory variable of interest – degree of dollarization – has expected sign and is significant at 10 percent significance level, meaning that more dollarized economies tend to choose more rigid regimes. More specifically, a one percentage point increase in the degree of dollarization increases the probability of choosing a hard peg by 0.0004, holding all other explanatory variables at their means. More open economies also have a tendency to choose more rigid regimes as well as the

[28] Ordered probit regression delivers similar results.

countries with high inflation rates. Provided that other explanatory variables are kept at their means, one percentage point increase in the openness increases the probability of choosing a hard peg by 0.0012, whereas for the inflation rate the increase in the probability is 0.0043.

Table 1.6. Determinants of *de facto* exchange rate regimes

Variable	Coefficient	z-statistic	Changes in probabilities			
			y=0	y=1	y=2	y=3
DOLLARIZATION	-2.450086	-1.782579*	-0.0004	-0.0058	0.0040	0.0022
COUNTRY SIZE	-0.312695	-1.353680				
RESERVES	-0.357604	-0.629137				
OPENNESS	-6.526787	-2.645275**	-0.0012	-0.0151	0.0106	0.0057
INFLATION	-23.65593	-4.474483**	-0.0043	-0.0547	0.0383	0.0207
FINDEV	-0.406815	-0.302978				
BUDGET DEFICIT	-0.363974	-2.912364**	-0.0001	-0.0008	0.0006	0.0003
CURRENT ACCOUNT	-2.806769	-0.745394				
Predictive power[1]	70%					

Notes: * z statistics is significant at 10%; ** z statistics is significant at 1%; [1] - since R^2 is meaningless in the ordered logit, I report the appropriate measure of goodness of fit. This measure computes the share of correctly predicted regimes.

1.6 Conclusion

The paper explores the welfare effects of currency substitution in a partially dollarized developing economy in a two country framework. Unlike the previous studies, the model allows for asymmetric households preferences and asymmetric monetary rules. The main findings are threefold.

First, the fixed exchange regime is superior to the flexible in highly dollarized economies since it results in smaller welfare losses. As the degree of dollarization decreases, the relative gain of the fixed over the flexible regime abates. The results hold true under both producer and local currency pricing mechanisms and consumer preferences with habits persistence.

Second, the decline in the home consumption bias coupled with the currency substitution entails greater welfare losses. Hence, the fixed exchange rate is to be preferred to the flexible.

Finally, the paper shows that under the flexible regime dollarized countries with high elasticity of substitution between domestic and foreign currencies are highly vulnerable to foreign shocks. Even when two currencies are not perfect substitutes, exposure to foreign shocks may entail very substantial welfare costs. Therefore, in order to reduce welfare costs, monetary authority should follow a more vigorous exchange rate stabilization policy.

Chapter 2

Fiscal and Monetary Policy Rules for New EU Member Countries on Their Road to Euro: Stability Analysis

2.1 Introduction

New European Union (EU) member countries in the process of their accession to the European Monetary Union (EMU) have to comply with the Maastricht admission criteria. Before adopting the euro, new EU members have to spend two years in the Exchange Rate Mechanism II (ERM-II) and meet nominal exchange rate and inflation requirements. Namely, the annual inflation rate in these countries should not exceed by more than 1.5 percent the average of three best performing inflation countries in the euro zone. Nominal exchange rate should not deviate more than 15% around the central parity. On the fiscal side, the EMU candidates have to adhere with the Stability and Growth Pact (SGP) requirements. Under these criteria budget deficit should not be higher than 3% of GDP and debt-to-GDP ratio should not exceed 60%.

As most of the new EU countries are expected to experience or have already experienced real exchange rate appreciation, it becomes difficult to meet both Maastricht nominal exchange rate and inflation criteria. The real exchange rate appreciation is caused by the excessive productivity growth in the tradable sector (the so-called Balassa-Samuelson effect). Therefore, policy makers in these countries face the problem of choosing the right monetary and fiscal policy mix that would allow them to meet the Maastricht inflation and nominal exchange rate as well as the fiscal criteria.

Since the seminal paper by Sargent and Wallace (1981), there has been a revival in the literature of monetary economics that studies links between monetary and fiscal policies.[29] Most of the existing papers on the design of optimal monetary policies usually ignore the fiscal side. Fiscal policy is thought to be of little consequence as far as inflation is concerned. This is based on the following ground. It is believed by some that inflation is a purely monetary phenomenon. Hence, fiscal policy is not important for inflation determination, at least in the developed countries.[30] However, the recent findings in the field suggest that fiscal policy have an effect on the price level.[31] Woodford (2001) shows that in 'non-Ricardian' regimes fiscal policy affects private sector budget constraints and as a consequence aggregate demand and inflation.[32] Moreover, he shows that non-Ricardian policies may be consistent with the existence of rational expectations equilibrium (REE). There are also fiscal effects of monetary policy. Monetary policy affects the price level, which in turn affects the real value of outstanding public debt and the real debt service, provided that monetary policy can affect real and nominal interest rates.[33] This channel is usually overlooked on the grounds that seignorage revenues in industrialized countries constitute a small fraction of total government revenues.

When modeling monetary and fiscal policy interactions, it is well known that given monetary policy, the determinacy properties of REE crucially depends on the nature of fiscal policy. Leeper (1991) defines active and passive fiscal and monetary policies. By active monetary policy he means strong reaction by the Central Bank (CB) to inflation. In the case of

[29] See, for instance, Leeper (1991), Sims (1994), Cochrane (1999),
[30] In less developed countries, it might be the case that monetary policy is subordinated to fiscal policy, i.e. regime of 'fiscal dominance', and is given directives to generate certain amounts of seignorage revenues to finance government budget deficit.
[31] See, for example, Woodford (1994, 1995, 1996, 1998)
[32] By 'non-Ricardian' Woodford (1995, 1996) calls regimes under which the government does not have to subsequently adjust its budget, in present value, in order to neutralize the effects of fiscal disturbances upon private sector budget constraints.
[33] See Loyo (1999) for a discussion when inflation explodes because of the fiscal effects of monetary policy.

Taylor rule, this corresponds to high values of inflation coefficient, usually greater than unity, which is in line with the Taylor principle. In contrast, passive fiscal policy is associated with high values of fiscal policy coefficient, which relates taxes to deficit or debt, whereas under active fiscal policy the coefficient is relatively low. In other words, active fiscal policy is such that it is not constrained by budgetary conditions, whereas under passive fiscal policy it has to generate sufficient tax revenues to balance budget. In this paper, I follow Leeper (1991) in defining active and passive monetary and fiscal policies.

Leeper (1991) studies the stability properties of monetary and fiscal policies in a closed economy framework with flexible prices. In a simple theoretical setting, he shows that active monetary policy together with active fiscal policy results in explosive solution. He further argues that in order to have unique stationary REE one policy should be passive, while the other should be active. Passive monetary and passive fiscal policies do not deliver stable determinate equilibrium. Leith and Wren-Lewis (2000) study determinacy properties of monetary and fiscal rules in the framework of overlapping generations. Their findings suggest that both monetary and fiscal policy should be jointly either active or passive to deliver unique REE. The above two papers considered fiscal regimes based on liability rules with non-distortionary tax instruments - lump sum taxes. In a more complex theoretical setting with distortionary tax instruments and government liability based fiscal rule, Schmitt-Grohe and Uribe (2007a) show that combination of active monetary and active fiscal policies results in unique REE, which is not possible in Leeper (1991).

The existing research on determinacy analysis of fiscal and monetary policies has been mainly conducted in a closed economy environments. Moreover, in the context of the euro zone accession of new EU member countries, the literature paid little attention to examining determinacy properties of fiscal regimes dictated by the SGP and different monetary regimes that are compatible with ERM-II.[34] Therefore, this paper tries to fill this gap by studying determinacy properties of various combinations of different monetary and fiscal policy rules for new EU member countries. Namely, I consider three monetary regimes: inflation targeting, inflation targeting with managed float (hereinafter also referred to as managed exchange rate regime) and fixed exchange rate regime. On the fiscal side, I explicitly model fiscal policy based on the following SGP criteria: 3% budget deficit, 60% debt-to-GDP ratio, and a composite rule based on the previous two. I introduce distortionary taxes on consumption and labor income that are used by fiscal authority as instruments to satisfy government budget deficit and government liabilities requirements. For each of the above fiscal regimes, one tax instrument is used, while the other is kept at the steady state level. All together, I investigate 18 scenarios: three fiscal regimes with two different distortionary tax instruments for each of three monetary regimes.

To investigate stabilizing properties of various monetary and fiscal policy mixes, I build a two-sector small open economy model. The model features sticky prices and monopolistic competition in both tradable and nontradable sectors, which gives a wider scope for monetary policy. To account for high productivity growth rates enjoyed by some of the new EU member countries, I allow for permanent sector-specific productivity shocks, which enables a proper simulation of the Balassa-Samuelson effect, that is, as an equilibrium driving process. It is especially relevant for some of the new EU countries being transition economies. In such economies, high productivity gains (at least initially) tend to be concentrated in the tradable sector. This fact should not be overlooked when studying monetary and fiscal policy interactions

[34] In a closed economy framework, Railavo (2004). studies determinacy properties of inflation targeting and its combination with one of the fiscal rules based on the SGP: 3% budget deficit, 60% debt-to-GDP ratio and the mixed rule based on deficit and debt.

in the new EU countries.[35] Apart from productivity shocks, there are four additional shocks: government expenditure, foreign interest rate, foreign inflation, foreign import demand and foreign interest rate shocks.

The main findings of the paper are as follows. Under inflation targeting and the debt rule, unique REE can also be consistent with active monetary and active fiscal policies as well as passive monetary and passive fiscal policies. However, it is undesirable that the fiscal authority takes a very strong stance on the SGP debt criterion since it may bring the economy into indeterminate equilibrium. This holds true for both consumption and labor income taxes. When inflation targeting is combined with the deficit rule, in order to have unique equilibrium, fiscal policy has to be harsh on the SGP deficit requirement compared to the debt rule, whereas the CB can follow either active or passive policy. Under both active and passive monetary policies based on inflation targeting, the composite rule produces a determinate solution for a wide range of positive fiscal policy coefficients, which are consistent with both active and passive fiscal policy.

Similar to inflation targeting, under inflation targeting with managed exchange rate regime and the fixed exchange rate regime, unique equilibrium can be consistent with (i) both active and passive fiscal policies under the debt rule, (ii) more passive fiscal policies under the deficit rule compared to the debt rule. Combination of managed or fixed exchange arrangements with either active or passive composite fiscal rules also delivers unique REE.

The rest of the Chapter is organized as follows. Section 2 sets up the model and goes through the optimization problems of households and firms. In this section, I also describe alternative monetary and fiscal regimes. The next section describes the solution algorithm and

[35] One could argue that exclusion of nonstationary productivity processes would not alter determinacy properties of the model. However, it is important to keep this structure if one is to compute optimal monetary and fiscal policy mix and undertake some further analysis relevant for new EU countries.

provides details on the calibration. The determinacy results of various combinations of different monetary and fiscal policy rules are presented in Section 4. Section 5 draws conclusions.

2.2 The model

The model economy has the following structure. There are two countries, home and foreign. The latter is also referred to as the rest of the world. The foreign country is not modeled explicitly in the sense that equations describing the foreign economy mainly enter the model in terms of the exogenously given stationary AR (1) processes. In home country, households maximize expected lifetime utility, taking prices and wages as given. The production process in the home country consists of two stages. In the first step, home firms produce intermediate tradable and nontradable goods in a monopolistically competitive environment. The prices in both tradable and nontradable intermediate goods sectors are sticky. The capital in both sectors is assumed to be fixed and there is no investment. Therefore, the production technology in these sectors is assumed to feature decreasing returns to scale in labor.

In the second stage, the economy produces final good from domestic nontradable, domestic tradable and foreign intermediate goods composites. Final good is produced in a perfectly competitive environment, which is then used for private and government consumption. Money is introduced into the model by assuming that firms' wage payments are subject to a cash-in-advance constraint (CIA) that requires that a certain fraction of the wage bill should be backed with monetary assets.[36] This is necessary to allow the government to extract seignorage revenues. Though seignorage revenues constitute a small fraction of total government revenues in industrialized countries, one should not neglect it, especially, if one studies interactions

[36] An alternative would be to (i) make real monetary balances enter utility function of households; (ii) impose a CIA constraint on the households' consumption, and (iii) impose CIA constraints both on the wage bill and private consumption.

between monetary and fiscal policies. Since the monetary policy have effects upon the real value of outstanding government debt (provided that much public debt is nominal), through its effects on the price level, and upon the real debt service (Woodford, 2001).

2.2.1 Demand side of the economy

The representative household lives infinitely many periods and maximizes expected lifetime utility:

$$\max\ \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{(C_t)^{1-\rho}}{1-\rho} - \frac{H_t^{1+\psi}}{1+\psi} \right\},$$

subject to a flow budget constraint:

$$P_t C_t (1+\tau_t^c) + e_t B_{F,t} + B_{H,t} = e_t (1+i_{F,t-1}) B_{F,t-1} + (1+i_{t-1}) B_{H,t-1} + (1-\tau_t^l)(W_{H,t} H_{H,t} + W_{N,t} H_{N,t}) + \Pi_t, \qquad (2.1)$$

and

$$H_t = H_{H,t} + H_{N,t}. \qquad (2.2)$$

It is assumed that capital is fixed and there is no capital accumulation. Households receive labor income subject to the average tax rate, τ^l, from supplying labor to tradable and nontradable sectors in line with (2.2). There is also a tax on consumption, τ^c. Households receive profits, Π, from firms that produce intermediate goods. It is assumed that these firms are owned by consumers. Corporate taxation is not considered in this model since it is most relevant for the evolution of investment, which is absent in the model. B_H are domestic currency denominated government bonds held by consumers. Households also have an access to foreign currency denominated bonds, B_F. e is a nominal exchange rate expressed as the number of units of local currency required to purchase one unit of foreign currency.

Let us introduce new notation: CPI inflation, $\pi_{t+1} = P_{t+1} / P_t$; tradable and nontradable goods sectors' inflation, $\pi_{i,t+1} = P_{i,t+1} / P_{i,t}$ for $i=\{N,H\}$; real wage, $w_t = W_t / P_t$, where $W_t = W_{H,t} = W_{N,t}$. The last equality comes from the household's optimization problem, since the labor is mobile across sectors.

Then, the household's optimization gives the following FOCs written in real terms.

Euler equation:

$$\beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \frac{1}{\pi_{t+1}} (1+i_t) \right] = 1 \ . \tag{2.3}$$

UIP equation under C-CAPM :

$$\beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \frac{1}{\pi_{t+1}} \frac{e_{t+1}}{e_t} (1+i_{F,t}) \right] = 1 \ . \tag{2.4}$$

Labor supply equation:

$$C_t^{-\rho} \omega_t \frac{1-\tau_t^l}{1+\tau_t^c} - H_t^{\psi} = 0 \, , \ i = \{N, H\} \, . \tag{2.5}$$

2.2.2 Production side of the economy

Domestic economy produces one final good, which is not internationally tradable and is manufactured from nontradable intermediate goods composite and intermediate tradable goods composite. Final good is then split between private and government consumption. Individual tradable and nontradable intermediate goods are produced in monopolistically competitive environment. Final good market is assumed to be perfectly competitive. It is assumed that there are neither barriers for trade nor transportation costs. Labor market is also assumed to be perfectly competitive.

2.2.2.1 Final good market

Economy produces final good, Y, using the following Cobb-Douglas production technology:

$$Y = \frac{Y_N^{\gamma} Y_T^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} \quad ,$$

where Y_N is an aggregate of domestically produced intermediate goods, which is given by:

$$Y_N = \left[\int_0^1 y_N(i)^{\frac{\omega-1}{\omega}} di\right]^{\frac{\omega}{\omega-1}}.$$

y_N is an output of individual firm producing intermediate nontradable good. Y_T is a composite index consisting of both domestic and foreign intermediate tradable goods aggregates and is given by:

$$Y_T = \frac{Y_H^{\varepsilon} Y_F^{1-\varepsilon}}{\varepsilon^{\varepsilon}(1-\varepsilon)^{1-\varepsilon}} \quad .$$

Domestic and foreign intermediate tradable aggregates, in turn, are:

$Y_H = \left[\int_0^1 y_H(i)^{\frac{\eta-1}{\eta}} di\right]^{\frac{\eta}{\eta-1}}$, and $Y_F = \left[\int_1^2 y_F(i)^{\frac{\mu-1}{\mu}} di\right]^{\frac{\mu}{\mu-1}}$, respectively.

y_H and y_F represent outputs of individual domestic tradable and foreign tradable goods firms, respectively. In line with the above definitions of final good, nontradable and tradable intermediate goods aggregates, let us define their respective price indexes.

The aggregate price index (CPI):

$$P = P_N^{\gamma} P_T^{1-\gamma} \quad .$$

Tradable price index:

$$P_T = P_H^{\varepsilon} P_F^{1-\varepsilon} \quad ,$$

where $P_H = \left[\int_0^1 p_H(i)^{1-\eta} di \right]^{\frac{1}{1-\eta}}$ and $P_F = \left[\int_1^2 p_F(i)^{1-\mu} di \right]^{\frac{1}{1-\mu}}$.

Nontradable price index:

$$P_N = \left[\int_0^1 p_N(i)^{1-\omega} di \right]^{\frac{1}{1-\omega}}.$$

Under the assumption of perfect competition in the final good market, it is easy to derive the following demand functions.

Demand for individual tradable and nontradable intermediate goods:

$$y_H(i) = \left[\frac{P_H(i)}{P_H} \right]^{-\eta} Y_H,$$

$$y_F(i) = \left[\frac{P_F(i)}{P_F} \right]^{-\mu} Y_F \quad ,$$

$$y_N(i) = \left[\frac{P_N(i)}{P_N} \right]^{-\omega} Y_N \quad .$$

Demand for tradable and nontradable composites:

$$Y_H = \varepsilon \left[\frac{P_H}{P_T} \right]^{-1} Y_T,$$

$$Y_F = (1-\varepsilon) \left[\frac{P_F}{P_T} \right]^{-1} Y_T,$$

$$Y_T = (1-\gamma) \left[\frac{P_T}{P} \right]^{-1} Y,$$

$$Y_N = \gamma \left[\frac{P_N}{P} \right]^{-1} Y.$$

2.2.2.2 Intermediate goods producers

Every variety of tradable and nontradable goods is produced by a single firm in a monopolistically competitive environment. Firm $i \in [0,1]$ produces good $y_t(i)$ using labor, $H_t(i)$. Each variety is then used in the production of the final good. The production function of a representative firm in both tradable and nontradable sectors exhibits decreasing returns to scale (DRS) in labor and is subject to permanent productivity shocks:

$Y_{j,t}(i) = A_{j,t} H_{j,t}(i)^{\alpha_j}$, $0<\alpha_j<1$, and $j=\{H, N\}$.

$A_{j,t}$ is an exogenous productivity parameter subject to shocks and is common for all producers in sector *j*. Since the production function is a DRS in labor, the labor earns a quasi-rent which adds to the income of households enabling a wedge between labor income and consumption tax.

The log of technology parameter follows an AR(2) process with a unit root:

$$\ln(A_{j,t}) = (1-\varphi)\ln A + (1+\varphi)\ln(A_{j,t-1}) - \varphi \ln(A_{j,t-2}) + \varsigma_{j,t}, \tag{2.6}$$

where $j=\{H, N\}$, ς is a zero mean i.i.d. productivity shock and $0 \le \varphi < 1$. Such a specification allows to properly model a permanent productivity increase. Productivity shock at time *t* cumulates to the level of productivity also in the future until it gradually reaches new steady state. Unlike widely employed assumption of perfect competition in the tradable sector, I allow for monopolistic competition and price stickiness in both tradable and nontradable sectors. This gives a wider scope for monetary policy.

Following Schmitt-Grohe and Uribe (2007a), I introduce money in the model by assuming that wage payments in both sectors are subject to the following cash-in-advance constraint (for simplicity, sector and firm subscripts are omitted):

$$M_t \ge \nu W_t H_t, \tag{2.7}$$

where M_t denotes the demand for nominal money balances by a firm in period t and $\nu \geq 0$ is a fraction of the wage bill that should be backed with monetary assets.

Price Setting in Nontradable Sector

Prices are assumed to be sticky a la Calvo (1983) and Yun (1996) in both tradable and nontradable sectors. Each period a fraction $\theta \in [0,1)$ of randomly chosen firms is not allowed to change the nominal price of the good that it manufactures. The remaining $(1-\theta)$ firms set prices optimally. In the calibration procedure θ is assumed to be the same for both sectors. However, it can easily be made different across sectors and will not affect qualitative nature of results. Let us suppose that firm *i* gets to choose price $\tilde{P}_{N,t}$. Let us also drop, for simplicity, index *i*. Then, the firm's profit maximization problem can be written:

$$\max_{\tilde{P}_{N,t}} \sum_{s=t}^{\infty} \theta^{s-t} \sigma_{t,s} \Pi_{N,s} ,$$

where $\sigma_{t,s}$ is a pricing kernel, which is assumed to be equal to the household's intertemporal marginal rate of substitution in consumption. Firm's profits are given as:

$$\Pi_{N,s} = \tilde{P}_{N,s} a_{N,s} - W_t H_{N,t} - (1-(1+i_t)^{-1}) M_{N,t} ,$$

where $a_{N,s}$ is a domestic absorption of domestically produced nontradable goods, which is defined below. In the derivation of the last expression I use the following assumptions. Let us assume that firms in both sectors also have a choice of holding bonds denoted $B_{firm,t}$ (again, I drop firm and sector subscripts). Then, a period-by-period budget constraint of a firm can be written as:

$$M_t + B_{firm,t} = P_t a_t - W_t H_t + M_{t-1} + (1+i_{t-1}) B_{firm,t-1} .$$

Following Schmitt-Grohe and Uribe (2007a), I assume that the firm's initial wealth is nil. That is, $M_{-1}+(1+i_{-1})B_{firm,-1}=0$. Moreover, I assume that firms hold no financial wealth at the beginning of any period, or $M_t+(1+i_t)B_{firm,t}=0$ for all *t*. These assumptions along with the firm's budget constraint imply the firm's profit function given above.

From the cost minimization problem of the firm one can get an expression for marginal cost in the nontradable sector, which is identical across the firms in the nontradable sector since they face the same factor price, have access to the same production technology and do not face idiosyncratic productivity shocks:

$$MC_N=\frac{W(1+\nu\frac{i}{i+1})}{\alpha A_N H_N^{\alpha-1}}. \tag{2.8}$$

Then, the firm's optimization with respect to $\tilde{P}_{N,t}$ gives the following FOC:

$$\mathrm{E}_t\sum_{s=t}^{\infty}\theta^{s-t}\sigma_{t,s}\left(\frac{\tilde{P}_{N,t}}{P_{N,s}}\right)^{-\omega-1}a_{N,s}\left\{\frac{1-\omega}{\omega}\frac{\tilde{P}_{N,t}}{P_{N,s}}+\frac{MC_{N,s}}{P_{N,s}}\right\}=0. \tag{2.9}$$

We limit our attention to a symmetric equilibrium at which all firms that happen to change their price in each period choose the same price. Therefore, one can use the definition of the nontradable price index to obtain:

$$\theta\pi_{N,t}^{\omega-1}+(1-\theta)\hat{\tilde{P}}_{N,t}^{1-\omega}=1, \tag{2.10}$$

where $\hat{\tilde{P}}_N=\tilde{P}_N/P_N$ is the relative price of any nontradable good whose price was changed in period *t* relative to the composite nontradable good. The standard practice in the neo-Keynesian literature is then to log-linearize equations (2.9) and (2.10) to derive the standard (linear) New Keynesian Phillips curve that involves inflation and marginal costs. However, since the economy is on the balanced growth path and the long run inflation is not zero I follow a different approach proposed in Schmitt-Grohe and Uribe (2007a).[37]

We can define two new auxiliary variables x_t^1 and x_t^2 to get rid of the infinite sum in (2.9) and keep the nonlinear structure. Further, the problem can be cast in a recursive way.

Let

$$x_t^1 = E_t \sum_{s=t}^{\infty} \theta^{s-t} \sigma_{t,s} \left(\frac{\tilde{P}_{N,t}}{P_{N,s}} \right)^{-\omega-1} a_{N,s} \frac{MC_{N,s}}{P_{N,s}} = \left(\frac{\tilde{P}_{N,t}}{P_{N,t}} \right)^{-\omega-1} a_{N,t} \frac{MC_{N,t}}{P_{N,t}} + E_t \sum_{s=t+1}^{\infty} \theta^{s-t} \sigma_{t,s} \left(\frac{\tilde{P}_{N,t}}{P_{N,s}} \right)^{-\omega-1} a_{N,s} \frac{MC_{N,s}}{P_{N,s}}$$

$$= \left(\frac{\tilde{P}_{N,t}}{P_{N,s}} \right)^{-\omega-1} a_{N,t} \frac{MC_{N,t}}{P_{N,t}} + \theta E_t \sigma_{t,t+1} \left(\frac{\tilde{P}_{N,t}}{P_{N,t+1}} \right)^{-\omega-1} E_{t+1} \sum_{s=t+1}^{\infty} \theta^{s-t-1} \sigma_{t+1,s} \left(\frac{\tilde{P}_{N,t+1}}{P_{N,s}} \right)^{-\omega-1} a_{N,s} \frac{MC_{N,t}}{P_{N,t}}$$

$$= \hat{\tilde{P}}_{N,t}^{-\omega-1} a_{N,t} \frac{MC_{N,t}}{P_{N,t}} + \theta E_t \sigma_{t,t+1} \left(\frac{\hat{\tilde{P}}_{N,t}}{\hat{\tilde{P}}_{N,t+1}} \frac{1}{\pi_{N,t+1}} \right)^{-\omega-1} x_{t+1}^1 . \tag{2.11}$$

Similarly, let

$$x_t^2 = E_t \sum_{s=t}^{\infty} \theta^{s-t} \sigma_{t,s} \hat{\tilde{P}}_{N,t}^{-\omega} a_{N,s} = \hat{\tilde{P}}_{N,t}^{-\omega} a_{N,t} + \theta E_t \sigma_{t,t+1} \left(\frac{\hat{\tilde{P}}_{N,t}}{\hat{\tilde{P}}_{N,t+1}} \frac{1}{\pi_{N,t+1}} \right)^{-\omega} x_{t+1}^2 . \tag{2.12}$$

Using these two auxiliary variables, we can write (2.9) as:

$$x_t^1 \frac{\omega}{\omega-1} = x_t^2 . \tag{2.13}$$

At equilibrium, domestic absorption is given by: $a_N = Y_N$.

Integrating over all firms, one can obtain:

[37] Another shortcoming of the approach that involves log-linearization is the necessity to make additional assumptions if one is to accurately calculate welfare from first order approximation to the equilibrium conditions. The steady state in this model is distorted with the distortions coming from monopolistic competition. Therefore, in order to undo the distortions one has assume the existence of factor-input subsidies financed by lump sum taxes that would ensure the competitive long run employment level.

$$A_{N,t} {H_{N,t}}^{\alpha_N} = Y_N \int_0^1 \left(\frac{P_{N,t}(i)}{P_{N,t}} \right)^{-\omega} di .$$

Following Schmitt-Grohe and Uribe (2007a), let us introduce new variable $s_{N,t} = \int_0^1 \left(\frac{P_{N,t}(i)}{P_{N,t}} \right)^{-\omega} di$.

Then one can derive the law of motion for $s_{N,t}$:

$$s_{N,t} = \int_0^1 \left(\frac{P_{N,t}(i)}{P_{N,t}} \right)^{-\omega} di = (1-\theta)\left(\frac{\tilde{P}_{N,t}}{P_{N,t}} \right) + (1-\theta)\theta \left(\frac{\tilde{P}_{N,t-1}}{P_{N,t}} \right) + (1-\theta)\theta^2 \left(\frac{\tilde{P}_{N,t-2}}{P_{N,t}} \right) + \ldots$$

$$= (1-\theta)\sum_{j=0}^{\infty} \theta^j \left(\frac{\tilde{P}_{N,t-j}}{P_{N,t}} \right)^{-\omega} = (1-\theta)\hat{\tilde{P}}^{-\omega} + \theta \pi^{\omega}_{N,t} s_{N,t-1} . \quad (2.14)$$

The state variable $s_{N,t}$ represents the resource costs induced by the presence of price dispersion.[38] Therefore, the resource constraint in the nontradable sector is given by:

$$Y_{N,t} = A_{N,t} H^{\alpha}_{N,t} / s_{N,t} . \quad (2.15)$$

Price Setting in Tradable Sector

Analogously, firm's minimization problem gives a similar expression for the marginal cost in the tradable sector:

$$MC_H = \frac{W(1+\nu \frac{i}{i+1})}{\alpha A_H H_H^{\alpha-1}} . \quad (2.16)$$

Using the definition of the intermediate tradable domestic goods index one obtains:

$$\theta \pi^{\eta-1}_{H,t} + (1-\theta)\hat{\tilde{P}}^{1-\eta}_{H,t} = 1 , \quad (2.17)$$

[38] See Schmitt-Grohe and Uribe (2007a) for a more detailed discussion of $s_{N,t}$.

where $\hat{\tilde{P}}_H = \tilde{P}_H / P_H$ is the relative price of any domestically produced tradable good whose price was changed in period *t* relative to the aggregate tradable index.

We can follow the same steps that were used for the nontradable sector to obtain the following equations that characterize price setting in the tradable sector.

$$x_t^3 = E_t \sum_{s=t}^{\infty} \theta^{s-t} \sigma_{t,s} \left(\frac{\tilde{P}_{H,t}}{P_{H,t}} \right)^{-\eta-1} a_{H,s} \frac{MC_{H,t}}{P_{H,t}} = \hat{\tilde{P}}_{H,t}^{-\eta-1} a_{H,t} \frac{MC_{H,t}}{P_{H,t}} + \theta E_t \sigma_{t,t+1} \left(\frac{\hat{\tilde{P}}_{H,t}}{\hat{\tilde{P}}_{H,t+1}} \frac{1}{\pi_{H,t+1}} \right)^{-\eta-1} x_{t+1}^3 \quad . \tag{2.18}$$

As before:

$$x_t^4 = E_t \sum_{s=t}^{\infty} \theta^{s-t} \sigma_{t,s} \hat{\tilde{P}}_{H,t}^{-\eta} a_{H,s} = \hat{\tilde{P}}_{H,t}^{-\eta} a_{H,t} + \theta E_t \sigma_{t,t+1} \left(\frac{\hat{\tilde{P}}_{H,t}}{\hat{\tilde{P}}_{H,t+1}} \frac{1}{\pi_{H,t+1}} \right)^{-\eta} x_{t+1}^4 , \tag{2.19}$$

$$x_t^3 \frac{\eta}{\eta - 1} = x_t^4 . \tag{2.20}$$

Absorption of tradable goods is given by $a_H = Y_H + C_H^*$. Where the last term, C_H^*, represents consumption of domestically produced tradable home goods by the foreign country. In what follows, the starred variables correspond to the foreign country.

Let us make some assumptions about the foreign country. Foreign demand for traded home variety *i* is given by $C_H^*(i) = \varepsilon^* \left[\frac{P_H(i)}{P_H} \right]^{-\eta^*} \left[\frac{P_H}{e_t P_t^*} \right]^{-1} C^*$. Where ε^* is a share of home goods in foreign consumption. I assume producer currency pricing, that is, producers cannot price discriminate between markets. Since home is a small open economy, we can do the following simplifications: $C_t^* = Y_t^*$, $P_{F,t}^* = P_t^*$. Then, $C_{H,t}^* = \varepsilon^* \left[\frac{P_{H,t}}{e_t P_t^*} \right]^{-1} C_t^* = \varepsilon^* \left[\frac{P_{H,t}}{e_t P_{F,t}^*} \right]^{-1} Y_t^*$.

Similar to the nontradable sector equilibrium, equations describing equilibrium in the home tradable sector are:

$$Y_{H,t} + C^{*}_{H,t} = A_{H,t} H^{\alpha}_{H,t} / s_{H,t}\,, \tag{2.21}$$

$$s_{H,t} = (1-\theta)\hat{\tilde{P}}^{-\eta} + \theta \pi^{\eta}_{H,t} s_{H,t-1}\,, \tag{2.22}$$

where $s_{H,t} = \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\eta}$. The state variable $s_{H,t}$ represents the resource costs in the tradable sector arising from the presence of price dispersion.

2.2.3 Inducing stationarity

There are two permanent productivity shocks in the economy. Therefore, some variables such as final good, consumption, and the real wage will not be stationary along the balanced growth path. The complete set of transformations and definitions of detrended variables are provided in Appendix. Here, I will briefly outline the transformation procedure. Some of the variables pertaining to the nontradable sector, such as x^1_t, x^2_t, are cointegrated with $A_{N,t}$. Similarly, in the tradable sector, variables x^3_t, x^4_t are cointegrated with $A_{H,t}$. Variables related to the aggregate economy level, such as $Y_t, C_t, G_t, m_t, w_t, b_{H,t}, d_t$, are cointegrated with Z_t. Where $Z_t = A^{\gamma}_{N,t} A^{\varepsilon(1-\gamma)}_{H,t}$ can be thought of as an aggregate stochastic growth factor; $m_t = M_t / P_t$ is the real money holdings; $d_t = e_t B_{F,t} / P_t$ is the real foreign currency denominated bond holdings; $b_{H,t} = B_{H,t} / P_t$ is the real value of domestic government bonds, and G_t is the government consumption.

The nonstationary variables are divided by the appropriate cointegrating factors. The list of variables that do not need to be detrended include i_t, π_t, $\pi_{H,t}$, $\pi_{N,t}$, τ^j_t, *j*={*c*,*l*}, e_t, $i_{f,t}$, H_t, $\hat{\tilde{P}}_N$, $\hat{\tilde{P}}_H$, $s_{N,t}$, $s_{H,t}$, i^*_t, π^*_t. I further assume that scaling (productivity growth) variables for home variables are expressed in terms of deviations from the foreign counterparts, that is, we do not have to explicitly detrend appropriate foreign variables.[39] Thus some foreign variables, such as Y_t^*, need not be transformed. In what follows, the variables with hats correspond to detrended variables unless otherwise stated.[40] Some detrended variables are without hats.

2.2.4 Closing small open economy and equilibrium conditions

To ensure stationarity in the net foreign assets position of home households the interest rate at which a home household can borrow (lend) in foreign currency $i_{F,t}$ is set to equal the foreign interest rate plus a premium, which is an increasing function of the country's real foreign debt (see Schmitt-Grohe and Uribe (2003)): $i_{F,t} = i_t^* + \Upsilon\left[\exp(\hat{d}_t - \hat{d}) - 1\right]$, where $\Upsilon > 0$ and $\hat{d}_t$ is a detrended holdings of real foreign currency denominated bonds at time *t*, and $\hat{d}$ is a detrended steady state level of debt (see Appendix B for the definitions of detrended foreign currency denominated debt).

The aggregate resource constraint is:

$$Y_t = C_t + G_t\,. \tag{2.23}$$

The balance of payments equation can be written as:

$$e_t B_{F,t} = (1 + i_{F,t-1}) e_t B_{F,t-1} + C_{H,t}^* P_{H,t} - P_t Y_t\,. \tag{2.24}$$

[39] If we were to explicitly model permanent productivity shocks in the foreign country, the aggregate detrending factor Z_t would have taken the following form: $Z_t = A_{N,t}^{\gamma} A_{H,t}^{\varepsilon(1-\gamma)} A_{H,t}^{*(1-\varepsilon)(1-\gamma)}$, where $A_{H,t}^*$ is the productivity process in the foreign tradable sector. However, for the sake of simplicity and since the purpose of this paper is not to examine the effect of foreign productivity shocks on the home economy, it is not modeled explicitly in the paper.

[40] Please note that $\hat{\tilde{P}}_N$, $\hat{\tilde{P}}_H$ are not detrended variables.

2.2.5 Rest of the world

In the foreign block, it is assumed that output, inflation and interest rate follow exogenous AR(1) processes:

$$\ln(\pi_t^* / \overline{\pi}^*) = \rho_\pi \ln(\pi_{t-1}^* / \overline{\pi}^*) + \varepsilon_\pi , \tag{2.25}$$

$$\ln(Y_t^* / \overline{Y}^*) = \rho_Y \ln(Y_{t-1}^* / \overline{Y}^*) + \varepsilon_Y , \tag{2.26}$$

$$\ln((1+i_t^*)/(1+\overline{i}^*)) = \rho_I \ln((1+i_{t-1}^*)/(1+\overline{i}^*)) + \varepsilon_i , \tag{2.27}$$

where ε_π, ε_i and ε_Y are i.i.d. processes and are neither correlated with each other nor with any other shocks in the model. The bar over the variable denotes the steady state value.

2.2.6 Fiscal and monetary policy rules

The consolidated government prints money, issues one-period nominally risk-free bonds, collects taxes, and faces an exogenous government expenditure stream.

$$M_t + B_{H,t} + T_t = (1+i_t)B_{H,t-1} + M_{t-1} + P_t G_t , \tag{2.28}$$

where T_t are total tax revenues and are given as: $T_t = \tau_t^c C_t P_t + \tau_t^l W_t (H_{H,t} + H_{N,t})$. Real tax collections can be written as: $\tau_t = \tau_t^c C_t + \tau_t^l (H_{H,t} + H_{N,t}) W_t / P_t$.

It is also assumed that detrended public consumption $\hat{G}_t$ follows the following AR(1) process:

$$\ln(\hat{G}_t / \overline{G}) = \rho_g \ln(\hat{G}_{t-1} / \overline{G}) + \varepsilon_{g,t} , \tag{2.29}$$

where $\overline{G}$ is a detrended steady state level of government consumption, and $0 \le \rho_g < 1$.

Real GDP is given by:

$$gdp_t = Y_t - \frac{P_{F,t}}{P_t} Y_{F,t} . \tag{2.30}$$

Fiscal rules

The fiscal authority can use three rules: budget deficit rule, debt rule and a composite rule.

Deficit rule:

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t \,. \tag{2.31}$$

That is, one of the available two distorting taxation instruments can only be used at a time, while the other is kept at its steady state value.

Debt Rule:

$$\tau_t^j = \tau^j + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t \,. \tag{2.32}$$

Composite Rule:

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t \,. \tag{2.33}$$

In all of the above three fiscal rules j={C, H}. τ^j denotes the steady state tax rate, j={C,H}.

Monetary rules

The domestic monetary authority follows an open-economy version of the Taylor rule:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t / \bar{\pi}) + \Omega_e \ln(e_t / \bar{e}\ ) \,. \tag{2.34}$$

Here, again, the bar over a variable denotes steady state. This rule can describe three monetary regimes: (i) inflation targeting when the CB adjusts interest rate in response to the deviation of inflation from the desired level. Under this rule, the coefficient on the nominal exchange rate is assigned a small positive value, $\Omega_e = 10^{-3}$, to ensure the stationarity of the nominal exchange rate; (ii) inflation targeting with managed float. Under this monetary regime, the CB changes interest rate in response to the deviations of both inflation and the nominal exchange rate from their respective targets. Thus, $\Omega_e > 0$, in the calculations I used $\Omega_e = 1$; and (iii) the fixed exchange rate regime: $\Omega_e = 10^3$ and $\Omega_\pi = 0$. In this case, the CB does not target inflation but reacts very aggressively if the nominal exchange rate deviates from the target level, $\bar{e}$.[41]

2.2.7 Competitive equilibrium

Formally, a competitive equilibrium can be defined as a set of stationary processes $\hat{C}_t, H_t, \hat{m}_t, \hat{w}_t, mc_{H,t}, \hat{Y}_t, mc_{N,t}, \hat{x}_t^1, \hat{x}_t^2, \hat{x}_t^3, \hat{x}_t^4, \hat{b}_{H,t}, \hat{d}_t, \pi_t, \pi_{H,t}, \pi_{N,t}, \hat{\tilde{P}}_{H,t}, \hat{\tilde{P}}_{N,t}, s_{H,t}, s_{N,t}, \hat{S}_t, \hat{Q}_t, e_t, i_t$ and τ_t^j for $t \geq 0$ that maximize (for the definitions of transformed variables see Appendix B):

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \left(Z_0 \prod_{s=1}^{t} Z_s^* \right)^{1-\rho} \frac{(\hat{C}_t)^{1-\rho}}{1-\rho} - \frac{H_t^{1+\psi}}{1+\psi} \right\},$$

where $Z_s^* = Z_s / Z_{s-1}$, and are subject to the competitive equilibrium conditions: (2.1), (2.3)-(2.5), (2.7), (2.8), (2.11) - (2.13), (2.15), (2.16), (2.18) - (2.21), (2.23), (2.24), (2.28), (2.30), (B.22) – (B.24) provided in Appendix, which are all written in stationary variables; (2.2), (2.10), (2.14), (2.17), (2.22); and depending on the type of fiscal policy, either (2.31), (2.32) or (2.33) written in stationary form; monetary rule (2.34); and exogenously given stochastic processes (2.6), (2.25)-(2.27) and (2.29).

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[41] Setting $\Omega_e = 1$ is arbitrary. However, it is desirable to prevent the weight of the exchange rate objective from driving monetary policy if it is assigned considerably higher value. At the same time, giving much smaller weight to the exchange rate objective would be bringing us back to the case of inflation targeting. Quantitative implications of assigning different values to Ω_e on welfare outcomes are discussed in Chapter 3. There are also qualitative implications related to the determinacy outcomes which are discussed in the following sections.

2.3 Solution algorithm, parameterization and definition of active and passive policies

2.3.1 Solution algorithm

In this section, I briefly describe the solution algorithm employed in this paper. I follow Klein's (2000) procedure to solve a multivariate linear rational expectations model.[42] The technique is based on the generalized Shur form or QZ decomposition of a matrix pencil. Alternative algorithms, among others, are Blanchard and Kahn (1980), Uhlig (1995), Sims (1996) and King and Watson (1995a,b).[43] The main advantage of Klein (2000) is that it allows static (intratemporal) equilibrium conditions to be included along with the dynamic relationships.[44]

To study the determinacy properties of the model, I undertake a grid search in the interval [0, 3] with a 0.1 step for policy parameters of interest – inflation coefficient in the augmented Taylor rule, Ω_π, and coefficients in the deficit and debt rules, Ω_1 and Ω_2. The size of this interval is somewhat arbitrary, but I feel that policy coefficients larger than 3 or negative would be difficult to communicate to the public or policymakers. For instance, if fiscal feedback coefficient is negative it would be difficult to explain why the fiscal authority would want to decrease tax rate if the debt or deficit to GDP ratio increases above the SGP targets. Most of the results that are presented in the next section, however, are robust to the expansion of the interval size. For each combination of policy parameters in the grid, I first take a first order approximation of a system of detrended market clearing and first order conditions around the steady state. The complete set of transformed first order difference equilibrium conditions are

[42] Schmitt-Grohe and Uribe (2004) uses Klein's (2000) procedure for their second order approximation technique.
[43] See Klein (2000) for a discussion of pros and cons of alternative algorithms.
[44] It is also possible in Sims (1996).

presented in Appendix. Instead of manually performing differentiation, I use matlab programs written by Klein (2000) and Schmitt-Grohe and Uribe (2004) to undertake the complex generalized Shur decomposition of the system.[45] Having implemented the decomposition, it is now simple to compare the number of stable eigenvalues with the number of the state variables (both predetermined and exogenously given) of the system. If the number of stable eigenvalues is equal to the number of states, then the system has unique solution. If the number of stable eigenvalues is less than the number of states, then the system has no stable solutions, that is, it explodes. Finally, if the number of stable eigenvalues is greater than the number of states, then the solution is indeterminate.

2.3.2 Parameterization

The calibrated parameters used in the paper are presented in Table 2.1. The time period in the model is one quarter. Therefore, I set $\beta = 0.99$. The risk aversion parameter, ρ, is set equal to 1 in order to have a valid transformation when detrending nonstationary variables (see equations (2.5) and (B.3) in Appendix B).[46] I follow Christiano et al. (1997) and set ψ=1. Following Natalucci and Ravenna (2007), the share of intermediate nontradable and tradable goods index in the production of the final good is set to be equal 0.5. The share domestic tradable intermediate goods composite in the production of the tradable index is also set equal 0.5. Following Schmitt-Grohe and Uribe (2007a), the fraction of firms that cannot change their price in any given quarter is set at 2/3 meaning that on average firms change their prices every three quarters. The degree of monopolistic competition in both tradable and nontradable sectors is

[45] The codes are available at: http://www.econ.duke.edu/~uribe/2nd_order.htm.
[46] This insures that real wage and consumption grow at the same rate.

fixed at 5 as in Schmitt-Grohe and Uribe (2007a), implying that the steady state markup of prices over marginal costs is 25 percent.

The quarterly steady state value of technological growth rate in both tradable and nontradable sectors, A, is assigned a value of 1.01, which translates into an annual economy wide growth of 3.5 percent. The fraction of the wage bill that should be backed with monetary assets is given a value of 0.6, which is similar to Schmitt-Grohe and Uribe (2007a). The parameter determining the size of an interest rate premium on foreign borrowing, Υ, is set at 0.004, which is also needed to ensure stationarity in net foreign assets position. DRS parameter in both tradable and nontradable sectors is given value of 0.8. [47]

Following Natalucci and Ravenna (2007), AR(1) coefficients in the exogenous processes describing foreign interest rate and foreign inflation are set at 0.9 and 0.25, respectively, and their corresponding standard deviations at 0.0025 and 0.0149. I follow Masten (2005) and set φ, parameter in the productivity process, and first-order serial coefficient and the foreign output processes at 0.95 and 0.7, respectively. The desired deficit-to-GDP and debt-to-GDP ratios are set in accordance with the SGP target levels at 3 and 60 percent, respectively. Steady state consumption and labor income taxes are set at 0.2 and 0.3, respectively, which are approximately the averages in Central and Eastern European countries. Following Altig et al (2005) and Schmitt-Grohe and Uribe (2007b) standard deviations of technology shocks in both tradable and nontradable sectors are set 0.0007.

[47] Lowering the value of this parameter did not change the qualitative nature of the results.

Table 2.1. Model parameterization

Parameter	Value	Description
β	0.99	Quarterly subjective discount rate
ρ	1	Risk aversion parameter, $C^{1-\rho}/(1-\rho)-H^{1+\psi}/(1+\psi)$
$1/\psi$	1	Labor supply elasticity
γ	0.5	Share of tradable and nontradable intermediate goods indexes in the production of final good, $Y=Y_N^{\gamma}Y_T^{1-\gamma}/(\gamma^{\gamma}(1-\gamma)^{1-\gamma})$
ω	5	Degree of monopolistic competition in the nontradable intermediate domestic goods market
η	5	Degree of monopolistic competition in the domestic intermediate nontradable goods market
ε	0.5	Share of tradable intermediate domestic and foreign goods in the production of the tradable index, $Y_T=Y_H^{\varepsilon}Y_F^{1-\varepsilon}/(\varepsilon^{\varepsilon}(1-\varepsilon)^{1-\varepsilon})$
α_H	0.8	DRS parameter, in the production function of domestic tradable intermediate goods, $Y=AH^{\alpha_H}$
α_N	0.8	DRS parameter, in the production function of domestic tradable intermediate goods, $Y=AH^{\alpha_N}$
τ^c	0.2	Steady state value of consumption tax
τ^l	0.3	Steady state value of labor income tax
φ	0.95	Parameter in AR(2) productivity process $\ln(A_{j,t})=(1-\varphi)\ln A+(1+\varphi)\ln(A_{j,t-1})-\varphi\ln(A_{j,t-2})+\varsigma_{j,t}$, $j=\{N, H\}$
A	1.01	Steady state value of productivity process, $\ln(A_{j,t})=(1-\varphi)\ln A+(1+\varphi)\ln(A_{j,t-1})-\varphi\ln(A_{j,t-2})+\varsigma_{j,t}$
ν	0.6	Fraction of the wage bill that should be backed with monetary assets $M\geq\nu WH$
θ	2/3	Parameter describing degree of price stickiness
ρ_π	0.25	AR(1) coefficient in foreign inflation process, $\ln(\pi_t^*/\overline{\pi}^*)=\rho_\pi\ln(\pi_{t-1}^*/\overline{\pi}^*)+\varepsilon_\pi$
ρ_Y	0.7	AR(1) coefficient in foreign output process, $\ln(Y_t^*/\overline{Y}^*)=\rho_Y\ln(Y_{t-1}^*/\overline{Y}^*)+\varepsilon_Y$
ρ_I	0.9	AR(1) coefficient in foreign interest rate process, $\ln((1+i_t^*)/(1+\overline{i}^*))=\rho_I\ln((1+i_{t-1}^*)/(1+\overline{i}^*))+\varepsilon_i$
ρ_g	0.7	AR(1) coefficient in government consumption process, $\ln(\hat{G}_t/\overline{G})=\rho_g\ln(\hat{G}_{t-1}/\overline{G})+\varepsilon_{g,t}$
κ_1	0.03	Target deficit-to-GDP ratio, $\tau_t^j=\tau^j+\Omega_1(G_t-\tau_t+i_{t-1}B_{H,t-1}/P_t-\kappa_1 gdp_t)/gdp_t$, $j=\{C,L\}$
κ_2	0.6	Target debt-to-GDP ratio, $\tau_t^j=\tau^j+\Omega_2(B_{H,t-1}/P_t+M_{t-1}/P_t-\kappa_2 gdp_t)/gdp_t$, $j=\{C,L\}$

Υ	0.004	Foreign interest rate premium parameter, $i_{F,t} = i_t^* + \Upsilon\left[\exp(\hat{d}_t - \hat{d}) - 1\right]$[48]
σ_{ς_j}	0.0007	Standard deviation technology shock
σ_G	0.007	Standard deviation of government expenditure shock
σ_{i^*}	0.0025	Standard deviation of foreign interest rate shock
σ_{Y^*}	0.001	Standard deviation of foreign output shock
σ_{π^*}	0.0149	Standard deviation of foreign inflation shock

2.3.3 Defining active and passive monetary and fiscal policies

In this paper, I will follow Leeper (1991) in defining active and passive monetary and fiscal policies. Under inflation targeting rule, an active monetary policy is the one under which the central bank sets its policy reaction parameter in the Taylor rule greater than unity. In other words, it raises interest rate more than one to one against the deviation of inflation from the desired level. Conversely, Leeper (1991) defines fiscal policy as active under which fiscal authority pays no attention to the state of government debt. Parameters associated with active fiscal policy are unresponsive to current budgetary conditions, whereas under passive behavior the fiscal authority is forced to use tax to balance the budget. To make the picture clearer and to facilitate the comparison with Leeper's (1991) categorization, below I will briefly outline the main building blocks of his model and the policy parameter space that delivers determinate equilibrium. The overview of results obtained in Leeper (1991) is followed by the discussion of definition of active and passive policies employed in this paper.

[48] $\hat{d}$ is the steady state value of foreign currency denominated debt, whose value is assigned exogenously. Otherwise, its steady state value is indeterminate. See equation (B.26).

Overview of Leeper's (1991) results and definition of active and passive policies[49]

There is a representative infinitely-lived consumer who receives some constant amount of consumption good each period. The consumer derives utility from consumption and real monetary balances, which yield no interest. The monetary authority sets the nominal interest rate as a function of the current inflation:

$$R_t = \alpha_0 + \alpha\pi_t + \theta_t ,$$

where θ_t is a shock that follows AR(1) process:

$$\theta_t = \rho_1\theta_t + \varepsilon_{1t} ,\ |\rho_1| \le 1 , \varepsilon_{1t} \sim N(0,\sigma_1^2) .$$

The fiscal authority sets direct lump-sum taxes as a function of real government debt outstanding:

$$\tau_t = \gamma_0 + \gamma b_{t-1} + \psi_t ,$$

where ψ_t is a fiscal shock that also follows AR(1) process:

$$\psi_t = \rho_2\psi_{t-1} + \varepsilon_{2t} ,\ |\rho_2| \le 1,\ \varepsilon_{2t} \sim N(0,\sigma_2^2)$$

After some simplifications and log-linearization around the deterministic steady state, he obtains a system consisting of two first order difference equations in two variables:[50]

$$E_t\tilde{\pi}_{t+1} = \alpha\beta\tilde{\pi}_t + \beta\theta_t , \tag{2.35}$$

$$\tilde{b}_t = \left(\beta^{-1} - \gamma\right)\tilde{b}_{t-1} + \varphi_1\tilde{\pi}_t + \varphi_2\tilde{\pi}_{t-1} - \psi_t + \varphi_3\theta_t + \varphi_4\theta_{t-1} , \tag{2.36}$$

where parameters φ_1, φ_2, φ_3 and φ_4 are some numbers that depend on steady state values of the system's variables and β is the subjective discount factor. Tildes over variables denote the deviations from their deterministic steady states.

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[49] Please note that notation used to describe Leeper (1991) paper is applicable only to this section.
[50] Since shocks are stationary AR(1) processes they do not have direct bearing on the determinacy properties of the model.

Expression in (2.36) states that parameter $\left(\beta^{-1}-\gamma\right)$ controls the rate of growth of total real government liabilities. Moreover, in his model this parameter also happens to be one of the roots of the system consisting of equations (2.35) and (2.36). The other root is $\alpha\beta$. For the system to have unique solution, one of the roots should be smaller than one in absolute value, while other should be greater than one in absolute value. He further defines active and passive monetary and fiscal policies as follows. Passive fiscal policy is when $\left|\beta^{-1}-\gamma\right|<1$ and active fiscal policy if $\left|\beta^{-1}-\gamma\right|>1$. That is, when γ is close to zero it is the case of active fiscal policy. It means that the fiscal authority does not pay attention to real public debt and sets its control variable as it sees fit. In this case, the central bank has to adjust initial price level to ensure the existence of stationary equilibrium. That is, the initial price level should be adjusted such that the present discounted value of future expected real government liabilities converges to zero. On the other hand, γ has to take a high positive value in order to satisfy $\left|\beta^{-1}-\gamma\right|<1$. Under this scenario, the fiscal authority reacts strongly to the real public debt in order to ensure that the government liabilities do not explode, that is, behaves in a passive way. In this case fiscal solvency is guaranteed regardless of the stance of monetary policy. Active monetary policy is associated with $|\alpha\beta|>1$. In this case the inflation feedback parameter is set greater than one meaning that the central bank takes a strong stance in fighting inflation. On the other hand, $|\alpha\beta|<1$describes passive monetary stance. One can observe that for this model to have unique saddle-path equilibrium, one of the policies should be active while the other has to be passive. When both policies are active the model results in explosive solution. On the other hand, passive monetary and passive fiscal policies result in indeterminacy.

Defining active and passive policies

Now, let us return to the model considered in this paper. The definition of active/passive monetary policy comes straight from Leeper (1991). If the monetary authority takes a strong stance on inflation by increasing interest rate by more than one to one in response to the deviation of inflation from target I would call such monetary policy as active. It requires that $\Omega_\pi > 1$, that is in line with the Taylor principle. This is similar to Leeper's (1991) definition of active monetary policy: $|\alpha\beta| > 1$. If $\Omega_\pi < 1$ then it is the case of passive monetary policy.

Unlike Leeper (1991), where he considers only lump sum taxation, which is nondistortionary, in the economy under study I consider distortionary taxation. A priory it is impossible to make a distinction of whether monetary or fiscal policy is dominant, since distortionary taxation and endogenous labor supply link parameters of monetary and fiscal policy in stability analysis. Therefore, in the economy under study analytical derivations that would explicitly define fiscal policy parameter range corresponding to active/passive regime are not an easy task and would not provide much value-added to the stability analysis of the model.[51] However, the same logic as in Leeper (1991) can be applied to define active and passive policies. In this paper, I would call fiscal policy active if it is unresponsive to current budgetary conditions. That is, the fiscal authority assigns a small positive value (close to zero) to its feedback parameter(s), Ω_1 and/or Ω_2. This is in line with Leeper's (1991) definition of active fiscal policy: if γ is close to zero then $|\beta^{-1} - \gamma| > 1$ is satisfied. It means that commitment of the government to satisfy the SGP 3% budget deficit and 60% debt to GDP ratio is not strong in the short run. On the contrary, when Ω_1 and/or Ω_2 take relatively high positive values, I would call

[51] In the case of Leeper (1991), the model easily simplifies to two first order difference equations for which the calculation of roots is pretty straightforward. Therefore, one can find parameter intervals pertaining to passive/active regimes.

such policy passive. In this case, the fiscal authority strongly increases taxes to ensure that the SGP fiscal criteria are met. Again, given a relative complexity of the model and presence of distortionary taxation, it would be a complicated exercise to calculate exact thresholds for parameters at which active fiscal policy turns into passive.

2.4 Determinacy properties of the model

2.4.1 Inflation targeting

In this section, I consider the determinacy properties of the model when inflation targeting is combined with one of the three fiscal rules based on the SGP. Inflation targeting is given by an augmented open economy version of Taylor rule:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t/\bar{\pi}) + \Omega_e \ln(e_t/\bar{e}) .$$

The monetary authority responds to the deviations of inflation from the desired inflation target level, $\bar{\pi}$, by adjusting interest rate. The degree of the adjustment is determined by the size of coefficient Ω_π. Under this regime, the CB does not react to the deviations of the nominal exchange rate regime from its desired level. However, Ω_e is set equal to 10^{-3} to ensure stationarity of nominal exchange rate. This is also needed to explicitly model nominal exchange rate instead of resorting to real exchange rate transformation and/or additional assumption of perfect risk sharing between countries.

2.4.1.1 Inflation targeting and debt rule

Under a consumption (labor) tax based SGP debt rule, the government raises consumption (labor income) tax if total government liabilities exceed the SGP requirement on public debt, whereas labor income (consumption) tax is held at the steady state level, τ^l (τ^c).

$\tau_t^j = \tau^j + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t$, *j={c,l}*,

where $\kappa_2 > 0$ and can be interpreted as a target government debt-to-GDP ratio as in Woodford (2001). In accordance with the Maastricht requirement on public debt, I set $\kappa_2 = 0.6$.

Before turning to the discussion of stability implications of the debt rule under inflation targeting, let us consider the determinacy properties of inflation targeting regime in the absence of fiscal policy. The case of no fiscal policy brings us to a standard assumption in dynamic general-equilibrium models that the public budget is balanced every period. This means that the real value of public debt is constant. As a result, the government flow budget constraint drops out from the model structure. This corresponds to a different, non-nested model.[52] The results are presented in Figure B.1 in the line corresponding to $\Omega_2 = 0$ in both panels. One can note that the model is determinate and stable even for inflation coefficient being smaller than unity, which is a necessary determinacy requirement for most of simple closed economy models. This is due to the fact that the CB still reacts to the nominal exchange rate deviations, though the response is very small. Further inspection of Figure B.1 shows that the model exhibits REE for quite a wide range of positive inflation and debt coefficients. The positive values of monetary and fiscal policy parameters are reasonable. The CB raises interest rate in response to higher inflation, whereas the fiscal authority has to raise tax rate if the debt-to-GDP ratio exceeds the target ratio. Under labor income tax, any combination of $\Omega_2 \in [0,1.4]$ and $\Omega_\pi \in [0,3]$ deliver unique REE. In

[52] This also holds true for inflation targeting with managed float and fixed exchange rate regimes.

the case of consumption tax the determinate area is any combination of $\Omega_2 \in [0,1.8]$ and $\Omega_\pi \in [0,3]$. It is slightly wider than that of labor income tax and allows for higher values of debt coefficient. The fiscal policy parameter range that delivers unique REE is consistent with both active and passive fiscal stance. Fiscal policy changes from active to passive as the value of Ω_2 increases. Moreover, one can observe that REE under both tax instruments is possible under both active monetary and active fiscal policies as well as passive monetary and passive fiscal policies, which is not possible in Leeper (1991) where the condition for the existence of REE is that one of the policies should be active while the other be passive.

To gain more insights into how fiscal feedback parameters, Ω_1 and Ω_2, can influence the stability properties of the model and to draw a closer parallel with the Leeper's (1991) analysis let us do the following. One can log-linearize (detrended) government budget constraint (B.27), labor supply equation (B.3), cash-in-advance constraint (B.4) and SGP debt rule (B.31) and combine them to obtain equation describing the evolution of (detrended) debt. Let us consider labor income taxation. Under debt rule, (detrended) real debt evolves according to

$$\tilde{b}_t = \tilde{b}_{t-1} \frac{1}{\overline{Z}} \left(\frac{1+\bar{i}}{\bar{\pi}} - \Omega_2 \frac{\bar{m}}{\nu\bar{\pi}(\bar{C}+\bar{G})(\varepsilon+\gamma-\varepsilon\gamma)} \right) + rest\,, \tag{2.37}$$

where a bar over variables denotes steady state and a tilde denotes log-deviation from steady state level. $\overline{Z}_t$ represents steady state economy wide growth rate. Loosely speaking, the feedback parameter Ω_2 controls the rate of growth of (detrended) real government liabilities. Roughly speaking, if the term in the brackets is smaller than one in absolute value, then real public debt tends to grow at a rate less than economy wide growth rate. In this case fiscal solvency is guaranteed regardless of the stance of monetary policy.[53] This together with distortionary taxation and supply side channel can explain why for any $\Omega_2 \in [0,1.4]$ the model economy is determinate regardless of monetary stance. On the other hand, if the term in the brackets is greater than one in absolute value, which is the case, for instance, when Ω_2 takes a high positive value, then liabilities will tend to grow at a rate higher than economy wide growth rate. In this case, the central bank has to adjust initial price level to ensure the existence of stationary equilibrium. That is, the initial price level should be adjusted such that the present discounted value of future expected real government liabilities converges to zero. When $\Omega_2 \geq 1.9$ under labor income tax, the central bank fails to adjust the initial price level to ensure fiscal solvency and the solution is explosive. Thus, the combination of active or passive monetary policy and 'very' passive fiscal policies does not result in determinate solution. The same analysis can be carried over to the consumption tax case.

Railavo (2004) studies determinacy properties of different fiscal policies dictated by the SGP fiscal criteria and a monetary policy given by a simple Taylor rule in a closed economy framework. He argues that under the debt rule the model results in an explosive solution when the monetary policy is active. However, he considers gradualist type fiscal rules where he relates the change of the tax rate to the deviation of the deficit from the target. Moreover, he solves for steady state tax rates, whereas in this model I calibrate the equilibrium tax rates based on the data from new EU member states.

Figures B.2 and B.3 depict impulse responses of main variables to a one percent government consumption shock for different values of monetary and fiscal policy coefficients.

[53] Unlike Leeper (1991), given the model complexity the value of the term in the brackets does not necessarily coincide with one of the roots of system. Therefore, it cannot be used for calculating the threshold at which fiscal policy changes from active to passive.

As can be seen from Figure B.2, increased government consumption initially rises aggregate demand and hence production and inflation, which results in the fall of debt-to-GDP ratio from its target level. This, in turn, leads to the tax cut, which is more pronounced the higher the value of the fiscal policy coefficient is. As a result (when $\Omega_2 = 1.5$), there is even an initial rise in consumption despite the crowding out effect of government purchases. Further, it can be observed that under more active fiscal policy (low values of fiscal policy coefficient), the transition of the system to the steady state is associated with higher levels of real public debt and less volatile consumption. Under labor income tax (Figure B.3), the government shock initially crowds out consumption and entails lower inflation rate, which, in turn, results in lower interest rate. Though, such deviations are very negligible. For instance, the initial fall in the inflation rate is only 0.02 percent relative to the steady state under passive fiscal policy. We can conclude that distortionary taxation together with endogenous labor supply allows for the existence of REE when both monetary and fiscal policies are active and when they are both passive.

2.4.1.2 Inflation targeting and deficit rule

I use the accounting definition of the government budget deficit. It is defined as the difference between real total tax revenues τ_t, exogenous government spending G_t, and interest payments on the outstanding government debt $i_{t-1}B_{H,t-1}$. So, the deficit rule can be written as:

$$\tau_t^j = \tau^j + \Omega_1(G_t - \tau_t + i_{t-1}B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t,\ j=\{c, l\},$$

and where $\kappa_1 \geq 0$ is a desired target level for the deficit to GDP ratio. I set it equal 0.03. If $\kappa_1 = 0$, we have the case of a balanced budget rule.

Figure B.4 displays determinacy results for the deficit rule. One can see that there is unique REE for a wide range of positive fiscal and monetary policy coefficients. Under consumption tax, fiscal policy parameter $\Omega_1 \in [0.8, 3]$ and any $\Omega_\pi \in [0, 3]$ are consistent with the existence of REE. In the case of labor income tax the determinate area is wider relative to the consumption tax. Any $\Omega_1 \in [0.6, 3]$ combined with $\Omega_\pi \in [0, 3]$ deliver unique equilibrium. Comparing Figures B.1 and B.4, one can note that for the existence of REE, fiscal policy under the deficit rule should be more passive than under the debt rule. To better understand the stability results under the deficit rule let us consider the evolution of (detrended) government liabilities. I proceed in the same way as in the case of debt rule and consider labor income taxation. Combining log-linearized government budget constraint (B.27), labor supply equation (B.3), cash-in-advance constraint (B.4) and the deficit rule (B.30), one can obtain:

$$\tilde{b}_t = \tilde{b}_{t-1} \frac{1}{\overline{Z}} \left(\frac{1+\overline{i}}{\overline{\pi}} - \Omega_1 \frac{\overline{m}\overline{i}}{\overline{\pi}\left(\nu(\overline{C}+\overline{G})(\varepsilon+\gamma-\varepsilon\gamma)+\Omega_1\overline{m}\right)} \right) + rest \, . \tag{2.38}$$

It can be observed that parameter Ω_1 controls the rate of growth of government debt. Again, if the term in the brackets is smaller than one in absolute value then fiscal solvency is met under any monetary stance. Comparing (2.37) and (2.38) one can observe the following. The lowest possible value of Ω_1 that ensures fiscal solvency has to be considerably higher than the lowest possible value of Ω_2 which is consistent with REE. This explains why fiscal policy under the deficit rule has to be more passive compared to the debt rule.

Figures B.5 and B.6 portray impulse responses to a one percent government expenditure shock. Solid line in both figures present active monetary and passive fiscal policy case. Dotted lines show system responses under passive monetary and active fiscal stance. As expected, under aggressive monetary stance inflation is lower following the shock than under passive monetary environment under both tax instruments. Furthermore, active fiscal policy is characterized by higher levels of public debt, lower tax rates and higher consumption along the way to the new steady state.

2.4.1.3 Inflation targeting and composite fiscal rule

Under the composite SGP fiscal rule, the government adjusts taxes in response to deviations of government liabilities and budget deficit from their long run targets:

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t ,$$

To see how fiscal parameters Ω_1 and Ω_2 affect stability of the model economy, we proceed in the same way as previously and derive law of motion for government liabilities under the composite SGP rule:

$$\tilde{b}_t = \tilde{b}_{t-1} \frac{1}{\overline{Z}} \left(\frac{1+\overline{i}}{\overline{\pi}} - \frac{\overline{m}(\overline{i}\,\Omega_1 + \Omega_2)}{\overline{\pi}\left(\nu(\overline{C}+\overline{G})(\varepsilon+\gamma-\varepsilon\gamma)+\Omega_1 \overline{m}\right)} \right) + rest . \tag{2.39}$$

Figure B.7 depicts determinacy results in the case of active monetary policy, $\Omega_\pi = 3$.[54] One can note that the economy exhibits REE for almost all possible combinations of Ω_1 and Ω_2. In contrast to the pure debt rule, the fiscal authority can now very aggressively react to the debt component of the SGP rule by setting $\Omega_2 = 3$ as long as $\Omega_1 \in [1.4, 3]$. Technically, this can be seen by comparing (2.37) with (2.39). Increasing Ω_2 increases the numerator of (2.39). At the same time, increasing Ω_1 raises the value of the denominator of (2.39) and the net effect is that the bracketed parameter in (2.39) becomes smaller than one in absolute value, which guarantees fiscal solvency. Compared to the stability outcome under the pure deficit rule, now REE is also

[54] Setting inflation coefficients $\Omega_\pi = 1.5$ returned almost the same determinacy area as under $\Omega_\pi = 3$.

possible for any $\Omega_1 \in [0.1, 3]$ provided that $\Omega_2 \in [0.1, 2]$. The same logic can be used to explain this result as above.

Let us now turn to the case when monetary policy is passive. In this experiment, I set $\Omega_\pi = 0.1$. It turns out that the combination of deficit and debt coefficients that delivers unique REE is almost the same as under the case of active monetary policy (see Figure B.7). As before, the explanation for this result is that the term in the brackets in (2.39) is smaller than one in absolute and therefore the fiscal solvency is assured regardless of monetary stance.

Under the composite rule, like in the cases of deficit and debt rules, active fiscal policy is characterized by higher after shock levels of public debt and smaller after shock fall in consumption (see Figure B.8). Figure B.9 shows impulse response functions to a one percent government expenditure shock when monetary policy is passive. In this case, under active fiscal policy in comparison with passive fiscal environment, the economy initially experiences higher inflation and nominal exchange rate depreciation, smaller reduction in private consumption and higher levels of public debt.

Another useful exercise is to see what happens to the determinacy properties if the government follows an ‘active’ policy with respect to the deficit (debt) component in the mixed rule. In Figure B.10, the government sets its deficit feedback coefficient at $\Omega_1 = 0.1$. Relative to the pure debt rule (Figure B.1), one can observe that now REE are possible for a slightly wider range of positive debt rule coefficients. Figure B.11 presents the case when government fixes its debt coefficient at $\Omega_2 = 0.1$. Now the REE is consistent with any $\Omega_1 \in [0, 3]$ and $\Omega_\pi \in [0, 3]$. Comparing this case with the pure deficit rule (Figure B.4), it can be seen that now government can be ‘very’ active with respect to the deficit component, which is not consistent with the existence of REE under the pure deficit rule.

2.4.2 SGP rules under inflation targeting with managed exchange rate

In this section, I examine stabilizing properties of the model when the CB follows managed exchange rate regime and the government employs one of three SGP based fiscal rules.[55] Inflation targeting with managed exchange rate regime is described by the same equation as inflation targeting:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t / \bar{\pi}) + \Omega_e \ln(e_t / \bar{e}) .$$

Now, the response of the CB to the deviations of nominal exchange rate from the desired level is significantly higher. The value of the exchange rate coefficient Ω_e is set equal 1, which is somewhat arbitrary. However, experimenting with smaller and larger positive values did not change the determinacy region.

Determinate equilibrium under *all three SGP rules* and *managed exchange rate* turns out to be exactly the same as under the corresponding fiscal regimes and inflation targeting (see Figures B.1, B.4 and B.7). The results are pretty much intuitive. If the model is determinate for some combination of monetary and fiscal policy parameters when $\Omega_e = 10^{-3}$ then it should be determinate for the same combination of policy parameters for reasonably higher values of Ω_e. The same explanation as in the corresponding inflation targeting case for why the model is locally unique for some combinations of Ω_1 and Ω_2 for any $\Omega_\pi \in [0,3]$ under the debt and deficit rules can also be applied for managed exchange regime. Similar line of argument explaining stability results for the composite SGP rule and inflation targeting can be employed for the composite rule under managed exchange regime. I have also studied determinacy implications when the fiscal authority sets fiscal policy active either with respect to budget

[55] Managed exchange rate and inflation targeting with managed exchange rate are used interchangeably throughout the paper .

deficit ($\Omega_1 = 0.1$) or debt ($\Omega_2 = 0.1$). In these cases, REE are still similar to those under inflation targeting and the composite rule.

Figures B.12 and B.13 present impulse responses to a one percent government consumption shock. Comparing it with the inflation targeting case with similar inflation and debt coefficient values (see Figures B.2 and B.3), one can note that impulse responses are qualitatively similar. Let us now take a look at Figure B.14, which displays the economy response to a one percent permanent tradable sector productivity shock. Under both monetary regimes, the government follows a passive fiscal policy. Following the shock, the price of tradable goods falls. Under inflation targeting nominal exchange rate depreciates resulting in the positive deviation of CPI inflation from steady state despite the fall in tradable sector prices. Depreciation of nominal exchange rate boosts exports, which, in turn, increase GDP. Consequently, debt-to-GDP ratio falls below the target level requiring a tax cut. This situation is depicted by negative deviations of the tax rate from the steady state.

Thus, the fiscal and monetary policy parameter combinations that deliver unique REE under managed exchange regime are similar to those of corresponding fiscal regimes under inflation targeting. However, as we have seen above, depending on the nature of the shock, transition dynamics can be different between the two monetary regimes. Again, as in the case of inflation targeting, the existence of unique equilibrium under the debt and composite rules is also consistent with both active monetary and active fiscal policies as well as passive monetary and passive fiscal regimes. The finding that fiscal policy under the deficit rule and inflation targeting has to be more passive than under the debt rule to have determinate equilibrium also holds for the managed exchange regime.

2.4.3 SGP rules under fixed exchange rate regime

The augmented Taylor rule equation can also describe the fixed exchange rate regime. It is obtained by setting $\Omega_\pi = 0$ and $\Omega_e \to +\infty$. I set Ω_e to be equal 1000. Thus, the fixed regime is given by:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_e \ln(e_t / \bar{e}) .$$

Now the CB does not react to the deviations of inflation from the desired target but *very strongly* reacts if nominal exchange rate is different from the target level. By stabilizing exchange rate, the CB curbs CPI inflation through equation (B.24).

Determinate equilibrium for the fixed exchange rate regime and the composite rule is shown in Figure B.15. Let us consider Panel A which corresponds to the consumption tax instrument. Determinacy region pertaining to the debt rule can be found by setting $\Omega_1 = 0$. One can see that REE exist for $\Omega_2 \in [0,1.8]$, which is consistent with both passive and active fiscal policies. In the case of labor income tax and the debt rule, REE exists for $\Omega_2 \in [0,1.4]$ (Panel B). Similarly, REE under the deficit rule can be found in the line where $\Omega_2 = 0$. Under the deficit rule $\Omega_1 \in [0.8,3]$ and $\Omega_1 \in [0.6,3]$ are parameter values delivering REE for consumption and labor income taxes, respectively. Under the composite rule, REE is possible for a wide range of positive fiscal policy coefficients.

Figure B.16 plots responses to a one percent permanent tradable sector productivity shock when the government follows the *debt rule*. As expected, the economy initially experiences fall in the overall CPI index due to the decline in tradable prices and virtually fixed exchange rate. As time passes, real wages between tradable and nontradable sectors level out. This translates into higher nontradable inflation and is reflected in figure by upward adjustment of CPI inflation. Compared to a passive fiscal policy, real public debt is higher under an active fiscal policy all the way along the transition to the steady state. One can also note that consumption exhibits less volatility when fiscal policy is active.

Let us now turn to the *deficit rule*. Figure B.17 compares the response of the economy to a one percent permanent tradable sector productivity shock under fixed exchange regime and inflation targeting. Unlike the pegged exchange regime under which the nominal exchange rate remains fixed, under inflation targeting it depreciates by more than 5 percent over 40 quarters. Depreciation stimulates exports and hence raises GDP at the same time reducing public debt. As a consequence, debt-to-GDP ratio falls below the target level which results in the tax cut. The economy experiences disinflation under the fixed regime, though quantitatively the magnitude is negligible, and higher levels of real public debt and hence higher tax rates than under inflation targeting.

2.4.4 Summary of determinacy properties and policy implications

To summarize the determinacy results discussed in the previous sections, below I provide the summary of determinacy properties and attempt to derive some policy implications for the EMU candidate countries. Table 2.2 presents monetary and fiscal policy parameter combinations that deliver determinate equilibria. Let us first consider the debt rule. One can note that the fiscal parameter range under both consumption and labor income taxes and any of three monetary regimes are consistent with both active and passive fiscal policies. That is, the fiscal authority's reaction in response to the deviation of the debt from the 60% target level can be both mild and relatively aggressive. However, being very harsh on the SGP debt requirement (setting $\Omega_2 \geq 1.9$

in the case of consumption tax) is undesirable since it may bring the economy into indeterminate equilibrium.

Table 2.2. Policy parameter combinations consistent with the existence of unique REE

		Monetary Regime		
Fiscal Rules	Tax	Inflation Targeting	Managed Float	Fixed
Debt	consumption	$\Omega_2 \in [0,1.8]$ and any $\Omega_\pi \in [0,3]$	$\Omega_2 \in [0,1.8]$ and any $\Omega_\pi \in [0,3]$	$\Omega_2 \in [0,1.8]$
	labor	$\Omega_2 \in [0,1.4]$ and any $\Omega_\pi \in [0,3]$	$\Omega_2 \in [0,1.4]$ and any $\Omega_\pi \in [0,3]$	$\Omega_2 \in [0,1.4]$
Deficit	consumption	$\Omega_1 \in [0.8,3]$ and any $\Omega_\pi \in [0,3]$	$\Omega_1 \in [0.8,3]$ and any $\Omega_\pi \in [0,3]$	$\Omega_1 \in [0.8,3]$
	labor	$\Omega_1 \in [0.6,3]$ and any $\Omega_\pi \in [0,3]$	$\Omega_1 \in [0.6,3]$ and any $\Omega_\pi \in [0,3]$	$\Omega_1 \in [0.6,3]$
Composite	consumption labor	see Figure B.4	see Figure B.4	see Figure B.15

In contrast to the debt rule, if the fiscal authority is to target the deficit rule, it has to be more aggressive in fulfilling the SGP deficit criterion. Being gentle on the SGP deficit criterion (setting Ω_1 close to zero) will not generate sufficient tax revenues to guarantee the fiscal solvency. Therefore, it is recommended that new EU member states take a strong stance in meeting the Maastricht deficit requirement, no matter what monetary policy is followed by their CBs.

Finally, if the fiscal authorities would like to match both the debt and the deficit requirements at the same time, they should be harsh on both fiscal criteria. For instance, setting $\Omega_1 = 3$ and $\Omega_2 = 3$ delivers determinate equilibrium. However, it is undesirable to be harsh on the debt requirement and at the same time to be lax with respect to the deficit component, since it may render the equilibrium indeterminate. For example, $\Omega_2 = 3$ and any $\Omega_1 \in [0,1.3]$ result in indeterminacy (see Figures B.4 and B.15).

It is also worth noting, that for some fiscal policy parameter ranges (combinations) the model economy features unique REE regardless of whether the CB follows active or passive policy. Such result is not possible in Leeper (1991). For instance, in his paper when both fiscal and monetary authorities follow passive policies it results in the model indeterminacy. The possible explanation for the differences in the results obtained in his model and this paper lies in the introduction of distortionary taxation and endogenous labor supply.

2.5 Conclusion

The paper explores stability consequences of various combinations of different monetary and fiscal policy rules for new EU countries on their road to the euro zone. The analysis is undertaken in a two-sector small open economy framework with permanent sector specific shocks, sticky prices and monopolistic competition. I consider a variety of monetary rules that are compatible with ERM-II, namely, inflation targeting, inflation targeting with managed float and fixed exchange rate regimes. The paper considers fiscal rules that are based on the SGP fiscal criteria. More specifically, these are rules based on debt, deficit and the composite rule which is a combination of the previous two. Further, I introduce distortionary taxes on consumption and labor income that are used by the fiscal authority to meet the SGP targets. For each combination of monetary and fiscal policy regimes and tax instruments, I study stability properties of the model.

The main findings are threefold. First, the paper shows that REE can be consistent with both active monetary and active fiscal policies as well as passive monetary and passive fiscal policies, not only under active monetary and passive fiscal policies or vice verse, which is the case in simple theoretical structures, e.g. Leeper (1991). This result holds true for inflation targeting and any of the three fiscal regimes. Second, under managed float and fixed exchange rate regime and any of the three fiscal rules, the government can follow either active or passive fiscal policy, which is consistent with unique determinate equilibrium. Third, under all three monetary regimes the fiscal policy under the deficit rule has to be more passive relative to the debt rule.

The preliminary policy implications emanating from this paper can be summarized as follows. If the fiscal authorities in the EMU candidate countries follow the rule based on the SGP debt criterion they should not be very harsh on the debt requirement, since it may lead to the indeterminate equilibrium. In contrast to the fiscal policy based on the debt rule, in order to ensure unique equilibrium it is desirable to be aggressive in meeting the SGP deficit requirement. Finally, if the fiscal authorities attempt to match both fiscal criteria they have to harsh on both debt and deficit components under any monetary regime.

Chapter 3

Optimal Fiscal and Monetary Policy Rules for New EU Member Countries on Their Road to Euro

3.1 Introduction

In May 2004, ten countries joined the European Union (EU).[56] Two additional countries, Romania and Bulgaria, entered the EU in 2007. The new twelve EU member states also became members of the economic and monetary union. However, the membership is not full until they enter the European Monetary Union (EMU). In order to join the EMU and adopt the euro, the new member states have to comply with the Maastricht convergence criteria. The criteria are designed in order to guarantee that new member states before joining the EMU also achieve a high degree of nominal convergence. In particular, the countries have to satisfy the following requirements before joining the Euro zone. First, an average rate of inflation observed over a period of one year before the examination should not exceed by more than 1.5 percentage points that of the three best performing Member States. Second, the countries have to comply with the nominal exchange rate criterion. For at least the last two years before the examination the countries should not devalue their currencies against the currency of any Member State and nominal exchange rate should not deviate more than 15 percent around the central parity. Third, a Member State should not run budget deficits in excess of 3 percent of GDP, and the ratio of government debt to GDP should not be higher than 60 percent.[57]

[56] The countries are the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Cyprus and Malta.
[57] There is also the long-term interest rate criterion under which a Member State for the period of one year before the examination has to have an average nominal long-term interest rate that does not exceed by more than 2 percentage

Some of the new EU members have enjoyed high productivity growth rates (see Figure C.1 in Appendix). Such productivity gains (at least initially) tend to be concentrated in the tradable sector, which is relevant for emerging market economies and transition countries. As a consequence, some of the new members have already experienced or are expected to experience real exchange rate appreciation (the so-called Balassa-Samuelson effect). These countries are likely to face a tradeoff between conforming to the inflation and the nominal exchange rate criteria. In 2007, some of the EMU candidate countries failed to meet these criteria (see Figures C.2 and C.3). Therefore, they need to be very hard on these two criteria. As for the fiscal performance, in 2007 most of the new EU member states were successful in fulfilling them (see Tables C.3 and C.4). Moreover, the new members being small open economies are also vulnerable to external shocks, such as foreign inflation and foreign interest rate shocks (see Table C.1).

Taking into account the exposure to both internal and external shocks and an obligation to fulfill the Maastricht criteria, several questions arise. First, what should the optimal monetary and fiscal policy mix be? Second, what kind of tax instruments should be used in order to satisfy the Maastricht fiscal criteria?[58] Finally, whether or not would optimized monetary and fiscal policies violate the inflation and nominal exchange rate requirements?

Recent papers by Masten (2005), Natalucci and Ravenna (2007) and Lipinska (2007), among others, compare the performance of alternative monetary rules for the EMU accession countries. They also examine the compliance of these rules with the Maastricht's limits on the nominal exchange rate and inflation. Natalucci and Ravenna (2007) develop a two-sector small

points that of the three best performing Member States. However, in this paper, I focus on the nominal exchange rate and inflation criteria on the monetary side and 3 percent budget deficit and 60 percent debt-to-GDP ratio requirements on the fiscal side.

[58] In this paper, I do not consider the ramifications of the use of alternative taxation instruments on the economic growth. I compare the effects of the use of these taxes on the welfare of private agents.

open economy (SOE) model to explore dynamic properties of the EMU candidate economy under alternative monetary rules. Their main conclusion is that the presence of the Balassa-Samuelson (BS) effect causes a high exchange rate - inflation variability trade-off. This makes it unlikely for the new member states to comply with the Maastricht criteria. However, they do not model the BS effect as an equilibrium driving process. Lipinska (2007) derives the micro-founded loss function and shows that under the chosen parameterization the optimal monetary policy violates two Maastricht inflation and the nominal interest rate criteria. Unlike the previous authors, Masten (2005) constructs real exchange rate appreciation as an equilibrium process by introducing permanent sector-specific productivity shocks. He examines the performance of inflation targeting regime in a two-sector SOE framework. Contrary to the findings of the previous authors, he shows that the BS effect need not impose considerable threats to fulfilling the inflation criterion.

To address the questions posed above, I construct a dynamic stochastic general equilibrium model (DSGE) of a two sector small open economy. In contrast to the above-listed studies, which ignore the fiscal side, I explicitly model the fiscal restrictions on the debt and the deficit set out by the Maastricht Treaty. This allows studying the interaction of alternative monetary and fiscal policy rules for the EMU candidate countries. Moreover, in contrast to Lipinska (2007) and Natalucci and Ravenna (2007), I allow for permanent sector specific shocks, which allows to construct real exchange rate appreciation as the equilibrium process.

The model I consider is the one developed in Chapter 2. Specifically, the model features two nominal frictions, sticky prices, a cash-in-advance constraint on the wage bill of firms, and imperfect competition as a source of real rigidity. Aggregate fluctuations are driven by six shocks: three internal and three external shocks. Internal disturbances comprise temporary variations in government expenditure and permanent neutral technology shocks in both tradable and nontradable sectors. The latter shocks are important for appropriately modeling the Balassa-Samuelson effect. External shocks include foreign inflation, foreign interest rate and foreign import shocks.

I consider three monetary regimes that are compatible with Exchange Rate Mechanism-II (ERM-II): inflation targeting, inflation targeting with managed exchange rate and the fixed exchange rate regimes. On the fiscal side, I explicitly model three fiscal policy regimes based on the Maastricht's Stability and Growth Pact (SGP) requirements: fiscal rule based on the 60 percent debt-to-GDP ratio requirement (hereinafter referred to as the debt rule), fiscal rule based on the 3 percent budget deficit condition, and the composite SGP rule which is the combination of the previous two. Further, I introduce two distortionary tax instruments: consumption and labor income taxes that are used by the fiscal authority as instruments to meet SGP fiscal criteria.[59]

In characterization of optimal policy regime, I depart from the widespread practice in the New Open Economy Macroeconomics literature of considering models in which steady state is undistorted. Such an approach often involves the existence of a number of subsidies to product and factor markets which undo distortions caused by monopolistic competition and bring about the efficiency of the deterministic steady state.[60] Instead, I work with the model whose steady state is distorted. I use the algorithm developed by Schmitt-Grohe and Uribe (2004) to compute second order approximations to policy functions and to calculate conditional welfare outcomes across alternative combinations of monetary and fiscal policies.

[59] Ideally, it is desirable to use lump sum taxes, since they do not cause distortions. However, in practice, these taxes are difficult to implement. Therefore, I do not consider them in this paper. In view of the absence of capital, I do not consider corporate taxation either, which is most relevant for the evolution of investment.
[60] See Schmitt-Grohe and Uribe (2007a) for a further discussion of potential shortcomings of this approach.

The main findings of the paper can be summarized as follows. Under inflation targeting and inflation targeting with managed float and under all three fiscal rules, the optimal policy picks the highest possible value for the inflation coefficient in the grid. Further, under all monetary regimes and consumption tax, the highest welfare level is achieved if the fiscal authority's stance with respect to the debt criterion is very mild, which corresponds to the active fiscal policy. In the case of labor income tax, the fiscal authority should be quite aggressive if the Maastricht fiscal indicators deviate from the targets, which is the case of passive fiscal policy.[61] Another finding is that managing exchange rate entails welfare costs under all fiscal regimes. Therefore, it is desirable that the CB does only minor interventions to stabilize the exchange rate. Under all monetary regimes, the use of labor income tax is more desirable than the use of consumption tax, since it entails smaller welfare losses. Finally, there is no threat to fulfilling the inflation criterion under all optimized monetary and fiscal policy combinations. However, under inflation targeting, the nominal exchange rate requirement might be violated.

Thus, the preliminary policy implications emanating from the analysis can be summarized as follows. First, the CBs in the EMU accession countries should be aggressive in fighting inflation. Second, if the nominal exchange rates in these countries are close to their long run equilibrium levels, their stabilization should be achieved more as an endogenous equilibrium outcome rather than through an active monetary policy. Finally, it is more desirable to use labor income than consumption tax to meet the Maastricht fiscal criteria.[62]

The rest of the Chapter 3 is organized as follows. Section 2 provides an overview of the model. The next section describes the solution algorithm, derives welfare measure and provides

[61] I follow Leeper (1991) in defining active and passive fiscal and monetary policies. For a more detailed definition of active/passive policies see Chapter 2. In short, passive fiscal policy is associated with a high value of a fiscal feedback coefficient, while active is with a low value. In contrast, active monetary policy is when the CB aggressively reacts to inflation, e.g. when the inflation coefficient in the Taylor rule is greater than unity.
[62] This result might change if the capital is added into the model.

details on the model parameterization. Section 4 presents results on optimized monetary and fiscal policy combinations and tests whether or not there is a threat to comply with the Maastricht nominal convergence criteria. Section 5 concludes.

3.2 Model overview[63]

In this section, I briefly outline main building blocks and equations of the model, which have been derived and discussed in detail in Chapter 2. The model features two countries, home and foreign. The latter is also referred to as the rest of the world. The foreign country is not modeled explicitly in the sense that equations describing the foreign economy mainly enter the model in terms of the exogenously given stationary AR (1) processes. In home country, households maximize expected lifetime utility, taking prices and wages as given. The production process in the home country consists of two stages. In the first stage, home firms produce intermediate tradable and nontradable goods in a monopolistically competitive environment. The prices in both tradable and nontradable intermediate goods sectors are sticky. The capital in both sectors is assumed to be fixed and there is no investment. Therefore, the production technology in these sectors is assumed to feature decreasing returns to scale in labor.

In the second stage, the economy produces final good from domestic nontradable, domestic tradable and foreign intermediate goods composites. Final good is produced in a perfectly competitive environment, which is then used for private and government consumption.

[63] Detailed derivation of equations and transformation of nonstationary variables are provided in Chapter 2 and Appendix B. In this chapter, I provide only main building blocks of the model.

Demand side of the economy

In the home country, there is an infinitely-lived representative consumer, who maximizes his/her expected lifetime utility

$$\max \ \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{(C_t)^{1-\rho}}{1-\rho} - \frac{H_t^{1+\psi}}{1+\psi} \right\},$$

subject to a flow budget constraint:

$$P_t C_t (1+\tau_t^c) + e_t B_{F,t} + B_{H,t} = e_t (1+i_{F,t-1}) B_{F,t-1} + (1+i_{t-1}) B_{H,t-1} + (1-\tau_t^l)(W_{H,t} H_{H,t} + W_{N,t} H_{N,t}) + \Pi_t .$$

Households receive labor income subject to the average tax rate, τ^l, from supplying labor to tradable and nontradable sectors in line with

$$H_t = H_{H,t} + H_{N,t} .$$

There is also a tax on consumption, τ^c. Households receive profits, Π, from firms that produce intermediate goods. It is assumed that these firms are owned by consumers. Corporate taxation is not considered in this model since it is most relevant for the evolution of investment, which is absent in the model. B_H are domestic currency denominated government bonds held by consumers. Households also have an access to foreign currency denominated bonds, B_F. e is a nominal exchange rate expressed as the number of units of local currency required to purchase one unit of foreign currency.

Production side of the economy

Final good market

Final good, *Y*, is manufactured according to the following Cobb-Douglas production technology:

$$Y = \frac{Y_N^{\gamma} Y_T^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} \quad ,$$

where Y_N is an aggregate of domestically produced intermediate goods, which is given by:

$$Y_N = \left[\int_0^1 y_N(i)^{\frac{\omega-1}{\omega}} di \right]^{\frac{\omega}{\omega-1}} .$$

y_N is an output of individual firm producing intermediate nontradable good. Y_T is a composite index consisting of both domestic and foreign intermediate tradable goods aggregates and is given by:

$$Y_T = \frac{Y_H^{\varepsilon} Y_F^{1-\varepsilon}}{\varepsilon^{\varepsilon}(1-\varepsilon)^{1-\varepsilon}} \quad .$$

Domestic and foreign intermediate tradable aggregates, in turn, are:

$$Y_H = \left[\int_0^1 y_H(i)^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \text{, and } Y_F = \left[\int_1^2 y_F(i)^{\frac{\mu-1}{\mu}} di \right]^{\frac{\mu}{\mu-1}} \text{, respectively.}$$

One can use the above definitions of final good, nontradable and tradable intermediate goods aggregates to define their respective price indexes.

The aggregate price index (CPI):

$$P = P_N^{\gamma} P_T^{1-\gamma} \quad .$$

Tradable price index:

$$P_T = P_H^{\varepsilon} P_F^{1-\varepsilon} \quad ,$$

where $P_H = \left[\int_0^1 p_H(i)^{1-\eta} di \right]^{\frac{1}{1-\eta}}$ and $P_F = \left[\int_1^2 p_F(i)^{1-\mu} di \right]^{\frac{1}{1-\mu}}$.

Nontradable price index:

$$P_N = \left[\int_0^1 p_N(i)^{1-\omega} di \right]^{\frac{1}{1-\omega}}.$$

Intermediate goods producers

Every variety of tradable and nontradable goods is produced by a single firm in a monopolistically competitive environment. Firm $i \in [0,1]$ produces good $y_t(i)$ using labor, $H_t(i)$. Each variety is then used in the production of the final good. The production function of a representative firm in both tradable and nontradable sectors exhibits decreasing returns to scale (DRS) in labor and is subject to permanent productivity shocks:

$Y_{j,t}(i) = A_{j,t} H_{j,t}(i)^{\alpha_j}$, $0<\alpha_j < 1$, and $j=\{H, N\}$.

$A_{j,t}$ is an exogenous productivity parameter subject to shocks and is common for all producers in sector *j*. The log of technology parameter follows an AR(2) process with a unit root:

$\ln(A_{j,t}) = (1-\varphi)\ln A + (1+\varphi)\ln(A_{j,t-1}) - \varphi \ln(A_{j,t-2}) + \varsigma_{j,t}$,

where $j=\{H, N\}$, ς is a zero mean i.i.d. productivity shock and $0 \le \varphi < 1$.

I follow Schmitt-Grohe and Uribe (2007a) and introduce money in the model by assuming that wage payments in both sectors are subject to the following cash-in-advance constraint (for simplicity, sector and firm subscripts are omitted):

$M_t \ge \nu W_t H_t$,

Moreover, I assume that prices are sticky a la Calvo (1983) and Yun (1996) in both tradable and nontradable sectors. This assumption together with the above yields the following set of equations governing the price setting in the nontradable sector:

$$\theta\pi_{N,t}^{\omega-1}+(1-\theta)\hat{\hat{P}}_{N,t}^{1-\omega}=1,$$

$$MC_N=\frac{W(1+\nu\frac{i}{i+1})}{\alpha A_N H_N{}^{\alpha-1}},$$

$$x_t^1=\hat{\hat{P}}_{N,t}^{-\omega-1}a_{N,t}\frac{MC_{N,t}}{P_{N,t}}+\theta E_t\sigma_{t,t+1}\left(\frac{\hat{\hat{P}}_{N,t}}{\hat{\hat{P}}_{N,t+1}}\frac{1}{\pi_{N,t+1}}\right)^{-\omega-1}x_{t+1}^1,$$

$$x_t^2=\hat{\hat{P}}_{N,t}^{-\omega}a_{N,t}+\theta E_t\sigma_{t,t+1}\left(\frac{\hat{\hat{P}}_{N,t}}{\hat{\hat{P}}_{N,t+1}}\frac{1}{\pi_{N,t+1}}\right)^{-\omega}x_{t+1}^2,$$

$$x_t^1\frac{\omega}{\omega-1}=x_t^2,$$

$$s_{N,t}=(1-\theta)\hat{\hat{P}}^{-\omega}+\theta\pi_{N,t}^{\omega}s_{N,t-1}.$$

π_N is the nontradable sector inflation. MC_N is the nontradable sector nominal marginal cost. $\hat{\hat{P}}_N$ is the relative price of any nontradable good whose price was changed in period *t* relative to the composite nontradable good. $a_{N,s}$ is a domestic absorption of domestically produced nontradable goods. Parameter θ represents the fraction of randomly chosen firms that is not allowed to change the nominal price of the good that it manufactures. Auxiliary variables x_t^1 and x_t^2 are introduced to get rid of the infinite sum arising from the producer maximization problem. Finally, the state variable $s_{N,t}$ represents the resource costs induced by the presence of price dispersion. Similar price setting expressions are obtained for the tradable sector.

Closing the model

The model is closed by assuming that the interest rate at which a home household can borrow (lend) in foreign currency, $i_{F,t}$, is set equal to the foreign interest rate plus a premium, which is an increasing function of the country's real foreign debt and by specifying monetary and fiscal policy rules.

The fiscal authority can employ one of the three rules based on the SGP fiscal criteria: deficit, debt or the composite SGP rule, which is the combination of the previous two:

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t \,,$$

$$\tau_t^j = \tau^j + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t \,,$$

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t \,,$$

where $j=\{C,H\}$. The government increases consumption or labor income tax rate if the deficit-to-GDP (debt-to-GDP) ratio goes above the target level κ_1 (κ_2) under the deficit (debt) rule. Under the composite SGP rule, the fiscal authority attempts to achieve simultaneously both fiscal targets.

The monetary authority can employ one of the three rules: inflation targeting, inflation targeting with managed float, and fixed exchange rate regime. All three monetary regimes can be described by an open-economy version of the Taylor rule:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t / \bar{\pi}) + \Omega_e \ln(e_t / \bar{e}) \,,$$

where bars over variables denote their steady state values. $\Omega_e = 10^{-3}$ and $\Omega_\pi \geq 0$ represents inflation targeting regime. $\Omega_e = 1$ and $\Omega_\pi \geq 0$ corresponds to inflation targeting with managed float case. $\Omega_e = 10^3$ and $\Omega_\pi = 0$ describes the fixed exchange rate regime.

Finally, in the foreign block, I assume that output, inflation and interest rate follow exogenous AR(1) processes. Domestic government consumption is also assumed to follow an exogenous AR(1) process.

3.3 Solution algorithm, parameterization and welfare measure

Most of research dealing with the evaluation of alternative monetary and fiscal policies rests on the log-linear approximation of the equilibrium conditions – the policy functions - and consequent second order approximation of the welfare function. The choice of unconditional expectation is mostly due to its advantages of computational simplicity. This approach may yield accurate results under certain simplifying assumptions, such as restrictive preferences specifications and access to government subsidies. In general, for such an approach to give correct results up to the second order, it is required that the solution to the equilibrium conditions be also accurate up to the second order. In this paper, I compute second order approximations to the policy functions and the welfare based on the system of stochastically detrended first order and equilibrium conditions. I use the algorithm recently developed by Schmitt-Grohé and Uribe (2004). I follow them and assume that in initial state all (transformed) state variables are in their deterministic steady states. Alternative policy regimes are evaluated by the conditional expectation of the discounted life time utility.

The *calibrated parameters* used in this Chapter are the same as in Chapter 2. However, it is worthwhile highlighting that the results of normative analysis crucially depend both on the chosen calibration of parameters and on the sources of shocks. Therefore, one should ensure that the selected calibration of parameters and exogenous processes is able to replicate certain features pertaining to the data of the EMU candidate countries.[64] Calibration of the most parameters and exogenous processes comes from Natalucci and Ravenna (2007) who estimate them for one of the EMU candidate countries, the Czech Republic.[65]

In choosing the optimal policy regime, denoted by *r*, the benevolent government chooses a policy regime that maximizes the expected lifetime utility of a representative household (see Appendix B for the definition of the transformed variables):

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \left(Z_0 \prod_{s=1}^{t} Z_s^* \right)^{1-\rho} \frac{(\hat{C}_t)^{1-\rho}}{1-\rho} - \frac{H_t^{1+\psi}}{1+\psi} \right\}, \text{ where } Z_s^* = Z_s / Z_{s-1}$$

We can define the welfare associated under the optimal policy regime conditional on a particular state of the economy in period 0 as:

$$V_0^r = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^r, H_t^r) .$$

Using the particular functional form for the period utility function ($\rho = 1$), we can express the above expression in terms of stationary transformation of consumption, $\hat{C}_t^r$:

$$V_0^r = E_0 \sum_{t=0}^{\infty} \beta^t \ln Z_t^* + E_0 \sum_{t=0}^{\infty} \beta^t u(\hat{C}_t^r, H_t^r) . \tag{3.1}$$

Further, let us define $\breve{V}_0^r = E_0 \sum_{t=0}^{\infty} \beta^t u(\hat{C}_t^r, H_t^r)$. Then, we can rewrite the previous expression as:

$$V_0^r = E_0 \sum_{t=0}^{\infty} \beta^t \ln Z_t^* + \breve{V}_0^r .$$

Let us denote an alternative policy regime by *a*. Similarly, the conditional welfare associated with policy regime *a* can be defined as:

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[64] For example, Coenen et al. (2008) shows that the welfare gains from monetary policy coordination rise from 0.03 to 1 percent if the share of import in GDP is increased from 10-15 to 32 percent in both regions.
[65] Ideally, all parameters and stochastic processes should be estimated from one of the EMU candidate countries. Such an exercise is left for future research.

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^a, H_t^a) .$$

This can be written in terms of the stationary transformation of consumption as:

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t \ln Z_t^* + E_0 \sum_{t=0}^{\infty} \beta^t u(\hat{C}_t^a, H_t^a) .$$

Defining a new variable $\breve{V}_0^a = E_0 \sum_{t=0}^{\infty} \beta^t u(\hat{C}_t^a, H_t^a)$**,** we can rewrite the conditional welfare under policy regime *a* as:

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t \ln Z_t^* + \breve{V}_0^a .$$

It is assumed that economy begins at time zero, at which all variables of the system are equal to their respective initial values. I further assume that the economy begins from the same state and grows at the same rate under the two alternative policy regimes. This delivers a constrained optimal policy regime associated with a particular initial state of the economy.[66]

Let λ^c denote the welfare cost of adopting policy regime *a* instead of the optimal policy regime *r* conditional on a particular state of the economy in period zero. λ^c is defined as the fraction of regime *r*'s consumption process that a representative household is willing to give up to be as well off under the regime *a* as under regime *r*. Then, λ^c can be implicitly defined by:

$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t u((1-\lambda^c) C_t^r, H_t^r) .$$

Using the definitions above, one can further rewrite this expression as:

$$\breve{V}_0^a = \breve{V}_0^r + \frac{\ln(1-\lambda^c)}{1-\beta} .$$

---

[66] In principle, the welfare ranking of alternative exchange rate arrangements might depend upon the initial value (distribution) of the state vector. For further discussion, see Kim et al (2003).

Now, we can derive a direct formula for calculating the welfare cost measure of adopting regime *a* instead of regime *r*:

$\lambda^{c}=\left(1-\exp\left((\breve{V}_0^{a}-\breve{V}_0^{r})(1-\beta)\right)\right)\mathrm{x}100\%$.[67]

I also decompose conditional welfare costs for each combination of alternative monetary and fiscal policy regimes into mean and variance components. Let λ be the fraction of consumption of the nonstochastic steady state consumption level that consumers are willing to give up in order to avoid risk and be as well-off under the stochastic environment under some combination of monetary and fiscal policies. Let us also denote by λ_{mean} welfare costs due to changes in means and λ_{var} costs due to variance effect. Given the second order approximation to the utility function and (detrended) steady state levels of consumption, $\bar{C}$, and labor, $\bar{H}$, one can decompose λ as follows:[68]

$$u([1-\lambda]\bar{C},\ \bar{H})\approx u(\bar{C},\ \bar{H})+(1-\beta)\sum_{t=0}^{\infty}\beta^{t}\left\{E(\tilde{C}_t-\bar{H}^{1+\psi}\tilde{H}_t)-\frac{1}{2}\mathrm{var}(\tilde{C}_t)-\frac{1}{2}\psi\bar{H}^{1+\psi}\ \mathrm{var}(\tilde{H}_t)\right\},$$

where a tilde denotes log-deviation from the deterministic steady state. The change in mean consumption, λ_{mean}, is computed from the following expression:

$$u([1-\lambda_{mean}]\bar{C},\ \bar{H})=u(\bar{C},\ \bar{H})+(1-\beta)\sum_{t=0}^{\infty}\beta^{t}\left\{E(\tilde{C}_t-\bar{H}^{1+\psi}\tilde{H}_t)\right\}. \tag{3.2}$$

The change in conditional variance of consumption is given by

$$u([1-\lambda_{\mathrm{var}}]\bar{C},\ \bar{H})=u(\bar{C},\ \bar{H})-(1-\beta)\sum_{t=0}^{\infty}\beta^{t}\left\{\frac{1}{2}\mathrm{var}(\tilde{C}_t)+\frac{1}{2}\psi\bar{H}^{1+\psi}\ \mathrm{var}(\tilde{H}_t)\right\}. \tag{3.3}$$

---

[67] In equation (3.1), Z_t^{*} is a stationary process since the productivity growth rates in both tradable and nontradable sectors are stationary processes (see Appendix B). Hence, the first term in equation (3.1) is finite. Furthermore, it is similar across all alternative policy regimes. Therefore, for the comparisons of conditional welfare under alternative policy regimes we can omit it and compare $\breve{V}_0^{r}$ and $\breve{V}_0^{a}$ instead of calculating V_0^{r} and V_0^{a} .

[68] In the following derivations I already assume that ρ=1.

It can be easily shown that the following relation holds:

$$(1-\lambda) = (1-\lambda_{mean})(1-\lambda_{\text{var}})\ . \tag{3.4}$$

As there are no closed-form solutions to (3.2) and (3.3), I simulate the conditional moments for 2000 periods and compute the discounted sum. I calculate λ_{var} from (3.3) and λ_{mean} is computed using (3.4). The analytical formulas for the computation of conditional moments are derived and provided in Paustian (2003) and Marzo, Strid and Zagaglia (2006).

3.4 Optimal monetary and fiscal policy rules

In this section, I compute optimal policy mix for different combinations of alternative monetary and fiscal rules. The model setup, equations and monetary and fiscal policy rules are described in detail in the previous chapter. Monetary rules that are considered are inflation targeting, inflation targeting with managed float, and fixed exchange rate regime. The fiscal authority can follow one of the three rules: debt rule, deficit rule, and the composite SGP rule. Moreover, for each combination of monetary and fiscal regimes, I calculate conditional welfare under two different tax instruments – consumption and labor income taxes.

I follow Schmitt-Grohe and Uribe (2007a) in defining optimal policy. For a policy rule to be optimal and implementable I require that (i) the associated equilibrium is locally unique; (ii) the equilibrium is locally unique everywhere in the neighborhood of radius 0.15 around the optimized monetary and fiscal policy coefficients; (iii) welfare is at its local optimum within that neighborhood, and (iv) the volatility of nominal interest rate relative to its target value is low. Specifically, I impose the condition $\ln(1+\bar{i}) > 2\sigma_i$, where σ_i denotes the unconditional standard deviation of the nominal interest rate, and $\bar{i}$ denotes steady state value of nominal interest rate.

The first condition rules out parameter combinations that are associated with indeterminate equilibrium. The second requirement excludes parameter combinations that are in the vicinity of a bifurcation point. The welfare calculations near a bifurcation point may be inaccurate. The third condition rules out the selection of an element of sequence of parameter combinations associated with increasing welfare that converges to a bifurcation point. The final condition is used to approximate the zero bound constraint by requiring a low volatility of the nominal interest rate, since the perturbation method used to approximate the equilibrium is ill-suited to handle nonnegativity constraints.

In Chapter 2, I have already examined determinate regions for each combination of monetary and fiscal policy coefficients in the range from 0 to 3 with a step of 0.1. For each combination of monetary and fiscal policy parameters in the determinate area I calculate conditional welfare.

3.4.1 Optimized policy under inflation targeting

As already discussed in the previous section, I assume that at time zero all (detrended) state variables of the economy are equal to their respective steady state values. Therefore, the non-stochastic steady state is the same across all policy regimes that are considered in this paper. This makes possible the comparison of alternative combinations of fiscal and monetary rules. Before proceeding to the discussion of the welfare outcomes, it is worthwhile to briefly describe monetary and fiscal regimes. Inflation targeting regime is given as:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t/\bar{\pi}) + \Omega_e \ln(e_t/\bar{e}) .$$

The monetary authority adjusts interest rate if inflation deviates from the target level, $\bar{\pi}$, which might be thought of as the average inflation rate of the three best performing countries in the

Euro zone. Under this monetary regime, the CB does not react if nominal exchange rate deviates from the desired level $\bar{e}$. However, in order to ensure stationarity of nominal exchange rate the exchange rate coefficient is assigned a small positive value, $\Omega_e = 10^{-3}$.

The fiscal authority can use one of the three alternative fiscal rules based on the SGP fiscal requirements. Under the debt rule, the government ties taxes, consumption or labor income, to government liabilities:[69]

$$\tau_t^j = \tau^j + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t ,$$

where j={c, l}. Superscript c is used to denote consumption tax and l is for labor income tax. This notation is also employed for the other fiscal rules.

If debt-to-GDP ratio exceeds the level of $\kappa_2 = 60$ percent then the government raises tax rates. Under the deficit rule, taxes are adjusted if budget deficit-to-GDP ratio diverges from $\kappa_1 = 3$ percent target:

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t .$$

Finally, under the composite SGP rule, the government simultaneously attempts to meet 3 percent budget deficit and 60 percent debt objectives:

$$\tau_t^j = \tau^j + \Omega_1 (G_t - \tau_t + i_{t-1} B_{H,t-1} / P_t - \kappa_1 gdp_t) / gdp_t + \Omega_2 (B_{H,t-1} / P_t + M_{t-1} / P_t - \kappa_2 gdp_t) / gdp_t .$$

Table 3.1 presents a summary of welfare maximizing combinations of inflation targeting and one of the three fiscal regimes (given the grid size). One can observe that the highest welfare under all fiscal regimes is achieved when the CB aggressively reacts to the inflation deviations from the desired target. Given the grid size from 0 to 3, it is optimal that the monetary authority sets the inflation feedback coefficient as high as possible under all fiscal rules and tax

[69] Note that only one type of tax at a time can be used as an instrument, while the other is kept at its steady state level.

instruments, $\Omega_\pi = 3$.[70] This is similar to the findings by Schmitt-Grohe and Uribe (2007a) in the case of inflation targeting without interest rate smoothing and output gap feedback. In their view, under the optimal policy inflation in fact would be forever constant so that in such an economy inflation volatility would be zero. Their intuition goes as follows and is also relevant for the results of this paper. In their paper (and also in this paper), the nonstochastic steady state level of inflation is positive. Therefore, the distortions brought about by price stickiness are present even in the steady state. Further, the nonstochastic steady state level of welfare is globally concave in the steady state inflation rate with a maximum at zero inflation. Therefore, in general, consumers do not like randomizing around the long run steady state of inflation.

Under the debt rule with consumption tax instrument, the highest welfare is associated with $\Omega_2 = 0.2$, which relates to the case of an active fiscal policy. It means that the fiscal authority's reaction to the deviation of the debt from the desired target should be minimal. The conditional welfare associated with these policy parameter combinations is -100.40571, whereas the (detrended) non-stochastic conditional welfare, which is the same for all policy combinations, $\breve{\bar{V}} = -100.40181$.[71] In contrast, when labor income tax is used under the debt rule, the highest welfare is achieved when the fiscal authority follows a relatively passive fiscal policy with $\Omega_2 = 1.2$. Though, the welfare under consumption tax is higher than under labor tax, the welfare loss of the latter relative to the former is only 0.004 percent.[72]

[70] This may not hold true under the composite SGP rule if we search for optimal policy regime simultaneously along all three dimensions: inflation, deficit and debt coefficients. Such calculations would require enormous computational time. Therefore, the search for welfare maximizing combinations is implemented along two dimensions.

[71] Note that this is not the exact value of the detrended non-stochastic welfare value, since it ignores the first term in (1). However, it is not important for welfare ranking purposes since this term is the same across all policy combinations.

[72] Welfare ranking might change if capital is introduced into the model. Quantitatively small conditional welfare losses obtained in this paper are quite common in this strand of literature. For example, Schmitt-Grohe and Uribe

Welfare outcomes under inflation targeting and a fiscal rule based on the SGP budget deficit requirement are provided in the second line of Table 3.1. As already noted, the maximum welfare under both consumption and labor income taxes are achieved when inflation coefficient takes the maximum value in the grid, $\Omega_\pi = 3$. In the case of consumption tax, deficit coefficient associated with the maximum welfare is 1, which is substantially smaller than that under labor income tax, which equals 3 and is the maximum value in the grid. Thus, like in the case of the debt rule, welfare cost minimizing fiscal policy under consumption tax has to be less passive compared to labor income tax situation. However, the welfare loss associated with the deficit rule and labor income tax relative the consumption tax counterpart is quantitatively negligible. It is only 0.008 percent of consumption equivalent.

Results of welfare calculations under the composite SGP rule based on both budget deficit and debt requirements are presented in the last line of Table 3.1. I have experimented fixing Ω_1 (Ω_2) and searching for optimal combinations of Ω_π and Ω_2 (Ω_1). The results of the experiments always returned the highest possible value for Ω_π. Therefore, when calculating optimal policy combinations under the SGP composite rule and inflation targeting I fix inflation coefficient at 3. In this case the CB commits itself to fight inflation rigorously, whereas the fiscal authority has to choose Ω_1 and Ω_2 that ensures determinacy and maximizes the conditional welfare. Interestingly, under the composite SGP rule with the consumption tax the optimal policy picks $\Omega_1 = 0$ and $\Omega_2 = 0.2$. That is, it collapses to the debt rule. [73] In contrast to consumption tax, under labor income tax both coefficients are positive ($\Omega_1 = 2.1$, $\Omega_2 = 3$). One can note that

(2007a) report welfare loss of 0.0029 percentage points relative to the optimal policy under inflation targeting and distortionary taxation.

[73] If the fiscal authority is not allowed to set $\Omega_1 = 0$ under the composite SGP rule, the optimized policy picks $\Omega_1 = 0.2$ and $\Omega_2 = 0.2$ with the associated conditional welfare level of -100.40680.

under consumption taxation, it is desirable that the fiscal authority follows the debt rule, whereas under labor tax the composite SGP rule entails the lowest welfare costs.

Table 3.1. Welfare maximizing monetary and fiscal policy under inflation targeting

	Consumption Tax				Labor Income Tax			
	Ω_π	Ω_1	Ω_2	Cond. Welfare	Ω_π	Ω_1	Ω_2	Cond. Welfare
Debt Rule	3	-	0.2	-100.40571	3	-	1.2	-100.40161
Deficit Rule	3	1	-	-100.40890	3	3	-	-100.40085
Composite SGP Rule with preset $\Omega_\pi = 3$	3	0	0.2	-100.40571	3	2.1	3	-100.40057

The main observation coming from the results is that under inflation targeting and under all fiscal rules welfare losses associated with labor income tax are smaller than under consumption tax.[74] Moreover, from the welfare prospective it is desirable that, regardless of the fiscal policy followed by the government, the CB should take a strong stance in fighting inflation by setting the inflation coefficient as high as possible.[75]

3.4.2 Optimized policy under inflation targeting with managed exchange rate regime

Inflation targeting with managed float is described by the similar equation as in the case of inflation targeting:

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t / \bar{\pi}) + \Omega_e \ln(e_t / \bar{e}) .$$

Now, $\Omega_e = 1$ indicates that the CB along with the possibility of targeting inflation also more aggressively responds to the deviations of nominal exchange rate from the target, $\bar{e}$, than under

[74] It would be interesting to see whether or not this would still hold if capital is added into the model.

[75] I have experimented enlarging positive range for Ω_π . I found that the optimal policy picks the highest value allowed for the inflation coefficient, at least in the case of the debt and deficit rule. In the case of the composite SGP rule, the search for the optimal policy requires optimization along the all three dimensions.

the 'pure' inflation targeting with $\Omega_e = 10^{-3}$. Considering the necessity to comply with the Maastricht's nominal exchange rate criterion, $\bar{e}$ may be thought of as the central parity around which the CB would like to keep exchange rate fluctuations within ±15 percent band. This rule still allows for exchange rate fluctuations, which would be seen in the following section, though they are now much smaller compared to inflation targeting. Setting $\Omega_e = 1$ is somewhat arbitrary. However, it is desirable to prevent the weight of the exchange rate objective from driving monetary policy if it is assigned considerably higher value. At the same time, giving much smaller weight to the exchange rate objective would be bringing us back to the case of inflation targeting. Quantitative implications of assigning different values to Ω_e on welfare outcomes are discussed below.

Table 3.2. Welfare maximizing monetary and fiscal policy under inflation targeting with managed exchange rate

	Consumption Tax				Labor Income Tax			
	Ω_π	Ω_1	Ω_2	Cond. Welfare	Ω_π	Ω_1	Ω_2	Cond. Welfare
Debt Rule	3	-	0.2	-100.48370	3	-	1.2	-100.44826
Deficit Rule	3	0.9	-	-100.48519	3	3	-	-100.45349
Composite SGP Rule with preset $\Omega_\pi = 3$	3	0	0.2	-100.48370	3	2.6	3	-100.44714

Table 3.2 presents a summary of conditional welfare results when inflation targeting with managed float is combined with one of the fiscal rules.[76] A quick look at the table reveals some interesting observations. First, inflation targeting with the highest possible value (in the grid) of the inflation coefficient still remains a desired practice under the managed float. Under all fiscal

[76] Inflation targeting with managed exchange rate regime and managed float will be used interchangeably throughout the paper.

regimes, the optimal policy chooses $\Omega_\pi = 3$. Second, under the debt rule, the optimized monetary and fiscal policy coefficients have the same values as under inflation targeting with the respective tax instruments: $\Omega_\pi = 3$ and $\Omega_2 = 0.2$ under consumption tax , and $\Omega_\pi = 3$ and $\Omega_2 = 1.2$ under labor income tax. Moreover, under the consumption tax based composite SGP rule policy coefficients associated with the highest welfare are the same as under inflation targeting: $\Omega_\pi = 3$, $\Omega_1 = 0$ and $\Omega_2 = 0.2$.[77] The optimal policy under the deficit rule with labor tax features the same policy parameters as in the case of inflation targeting. Further, one can observe that, similar to the inflation targeting regime, it is desired to follow the fiscal policy based on the debt rule with consumption taxation, and employ the composite SGP rule in the case of labor income tax. Moreover, like in the case of inflation targeting, under the managed float it is more desirable to use labor income taxation for it entails smaller welfare losses.[78]

It can be observed that the levels of conditional welfare associated with any monetary and fiscal policy mix under the managed float are uniformly smaller than under inflation targeting. This finding suggests that the interventions on the exchange rate markets in the EMU candidate countries might entail higher welfare costs.[79]

Costs of managing nominal exchange rate

Managing exchange rate comes at welfare cost of 0.08 percent under consumption tax and 0.05 percent under labor income tax relative to the flexible exchange rate environment with

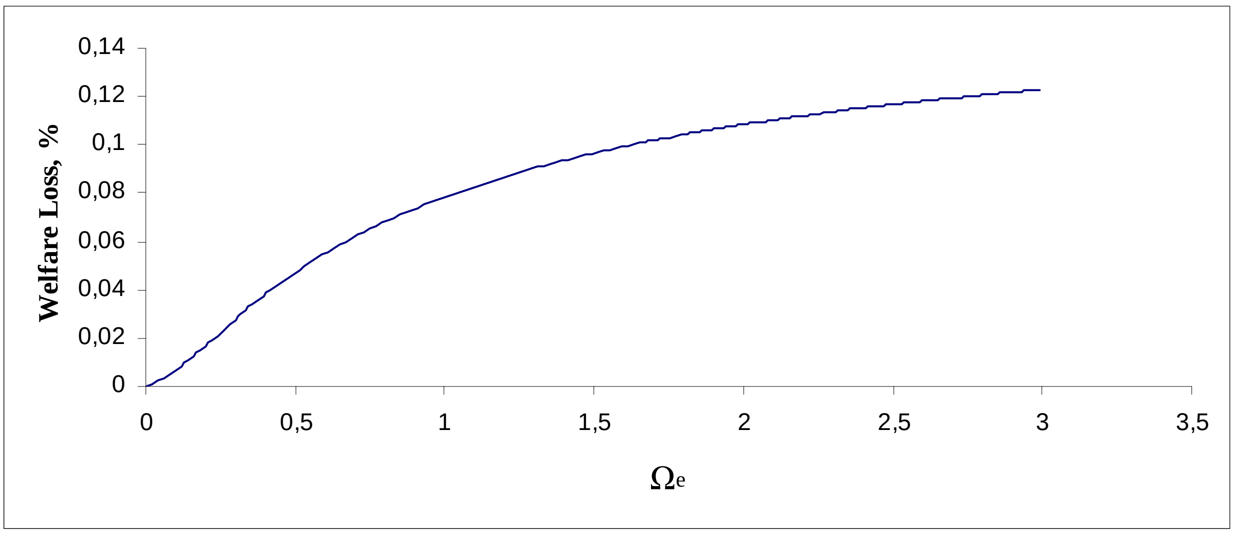
[77] If the fiscal authority is not allowed to set $\Omega_1 = 0$ under the composite SGP rule, the optimized policy picks $\Omega_1 = 0.2$ and $\Omega_2 = 0.2$, which is the same combination as under inflation targeting, with the associated conditional welfare level of -100.48591..

[78] Similar experiments of enlarging the positive range for Ω_π were undertaken. Like in the case of inflation targeting, the optimal policy is associated with the highest value allowed for the inflation coefficient.

[79] Of course, there are also some positive aspects of managing exchange rate that are not considered here and beyond the scope of this paper. In countries with large unhedged foreign currency denominated debt managing exchange rate reduces exchange rate risk exposure.

the debt rule. Trying to reduce exchange rate fluctuations under the deficit rule entails welfare losses of 0.08 and 0.05 percent under consumption and labor taxes, respectively. Figure 3.1 plots welfare costs of managing exchange rate relative to the inflation targeting in the case of the debt rule with consumption tax. It can be seen that higher weights on the exchange rate in the Taylor rule bring about higher welfare losses. Similar experiments have been carried out for the other fiscal regimes. The findings are similar: managing exchange rate results in decreased conditional welfare. Increasing the value of Ω_e under alternative fiscal rules leads to the increased welfare losses in the range of 0.04 to 0.2 percent. Assigning large positive values to the exchange rate coefficient would be bringing us to the fixed exchange rate regime.

Figure 3.1. Costs of managing exchange rate under consumption tax debt rule: $\Omega_\pi = 3$, and $\Omega_2 = 0.2$



This finding suggests that if the exchange rate in a given EMU candidate country is already relatively close to the long run equilibrium it is desirable that its CB does only minor interventions on the foreign exchange market. That is, the exchange rate stabilization should be achieved more as an endogenous equilibrium outcome rather than through an active monetary policy.[80]

3.4.3 Optimized fiscal policy under fixed exchange rate regime

Fixed exchange rate regime is obtained from inflation targeting by setting $\Omega_{\pi} = 0$ and $\Omega_{e} = 10^{3}$:

$\ln((1+i_t)/(1+\bar{i})) = \Omega_e \ln(e_t / \bar{e})$.

Under this monetary environment, the CB very strongly responds to the deviations of nominal exchange rate from the target $\bar{e}$. Table 3.3 provides a summary of the welfare maximizing combinations of fiscal policy coefficients under the fixed exchange rate regime. Quick observation of the results shows that conditional welfare under all fiscal regimes are uniformly smaller than under inflation targeting with managed float and inflation targeting. Optimized debt coefficient is the same under the debt rule with consumption tax as in the corresponding fiscal regime and inflation targeting and inflation targeting with managed float. In the case of the debt rule with labor income tax the coefficient is slightly lower compared to inflation targeting and managed float. The relative losses across different taxation instruments are now much larger compared to the previous monetary regimes. For instance, the relative loss of employing consumption tax relative to the use of labor income tax under the debt rule is 0.08 percent compared to the corresponding loss of 0.004 percent under inflation targeting. Again, like in the previous monetary arrangements, it is optimal to use the debt rule under consumption taxation and the composite SGP rule if labor tax is used. At the same time, the stance of fiscal authority in response to the deviation of the debt from the target should not be aggressive in the former case,

[80] Of course, if the exchange rate is relatively far from the long run equilibrium level then it could be still welfare improving for the CB to also stabilize the exchange rate to meet more rapidly the requirements for the membership. Joining the EMU has advantages, which are not accounted for in this type of models.

whereas under the labor tax, it has to be quite aggressive with respect to both the debt and the deficit components under the SGP rule. Again, the use of labor income taxation results in smaller welfare losses compared to the situation when consumption tax is used.

Table 3.3. Welfare maximizing fiscal policy under fixed exchange rate regime

	Consumption Tax			Labor Income Tax		
	Ω_1	Ω_2	Cond. Welfare	Ω_1	Ω_2	Cond. Welfare
Debt Rule	-	0.2	-100.57038	-	1	-100.49325
Deficit Rule	0.9	-	-100.57742	3	-	-100.50290
Composite SGP Rule	0	0.2	-100.57038	3	2	-100.49199

3.4.4 Summary of conditional welfare results and policy implications

Table 3.4 summarizes welfare outcomes for various combinations of different monetary and fiscal policy rules. It can be seen from the table that the highest welfare is associated with inflation targeting and labor tax based composite SGP rule with $\Omega_\pi = 3$, $\Omega_1 = 2.1$ and $\Omega_2 = 3$. It is optimal that the CB vigorously fights inflation. On the fiscal side, the fiscal authority should try to achieve both targets simultaneously but with a more emphasis on the debt criterion. Should the government decide to use consumption tax it is desirable to follow the debt rule and the CB should still be aggressive in combating inflation. However, unlike the composite SGP rule with labor tax, the fiscal authority's response to the deviations of the debt from the target should be minimal: $\Omega_2 = 0.2$. As already discussed, the intuition behind the optimality of the CB's strong anti-inflationary stance is that inflation stabilization helps to reduce inefficient cross-firm price dispersion and hence reduce volatility of the CPI inflation rate, which is disliked by consumers[81]. Thus, the price stability is desirable despite the fact that in this economy increasing inflation has the additional benefit of increasing seignorage revenues which allows the social planner to lower distortionary tax rates.[82] Moreover, being harsh on inflation helps to meet the Maastricht's criterion on the inflation rate required for the Eurozone membership.

Table C.5 reports the unconditional means and standard deviations of key variables under the optimized policy coefficients. The table shows that the standard deviation of the nominal interest rate varies between 0.6 to 0.7 percentage points under inflation targeting. At the same time, the steady state value of the nominal interest rate is 3.04 percent. Considering these two figures implies that for the nominal interest rate to hit the zero bound, roughly, it must fall more than 5 standard deviations. The probability of this happening is quite low. Further, it can be noted from the table that unconditional mean values of consumption under inflation targeting are higher than under managed and fixed exchange rate arrangements. Moreover, one can observe from Table C.6 that under inflation targeting "mean component" of the welfare measure is negative, whereas under the other monetary regimes it is positive.[83]

[81] See Table A.5 for the comparison of standard deviations of the CPI inflation across different monetary and fiscal rules.
[82] See Schmitt-Grohe and Uribe (2007b) for a further discussion why price stability is desirable even in the presence of distortionary taxation.
[83] To save on computational time, I do not calculate unconditional welfare and do not decompose unconditional welfare loss into the mean and variance components since the ranking obtained through maximizing unconditional utility are different from those obtained through conditional welfare. For instance, see Kim and Kim (2003) and the results of Chapter 1.

Table 3.4. Summary of welfare results under optimized monetary and fiscal policy coefficients

		Inflation Targeting		Inflation Targeting with Managed Float		Fixed Exchange Regime	
		Welfare	Welfare Loss, %[1]	Welfare	Welfare Loss, %[1]	Welfare	Welfare Loss, %[1]
Debt Rule	Consumption tax	-100.40571	0.0051	-100.48370	0.0831	-100.57038	0.1697
	Labor tax	-100.40161	0.0010	-100.44826	0.0477	-100.49325	0.09264
Deficit Rule	Consumption tax	-100.40890	0.0083	-100.48519	0.0846	-100.57742	0.1767
	Labor tax	-100.40085	0.0003	-100.45349	0.0529	-100.50290	0.1022
Composite SGP Rule[2]	Consumption tax	-100.40680	0.0062	-100.48591	0.0853	-100.59117	0.1904
	Labor tax	-100.40057	0	-100.44714	0.0465	-100.49199	0.0914

Notes: [1] – welfare loss relative to the monetary and fiscal policy mix with the highest welfare, which is inflation targeting and the composite SGP rule with labor income tax.

[2] – in the case of inflation targeting and inflation targeting with managed exchange rate results are reported when Ω_{π} is fixed at 3. For the sake of comparison, under the composite SGP rule with consumption tax the results are provided for the case when Ω_1 is not allowed to be zero.

Further, it can be seen from Table 3.4 that conditional welfare under managed and fixed exchange rate regimes are uniformly lower than under inflation targeting. The more aggressively the CB manages the exchange rate the higher the welfare losses are. This finding, basically, supports the general argument in favor of flexible exchange rate regimes that in presence of price stickiness a floating regime allows relative prices to adjust in response to country specific real demand and supply shocks. This is especially true for the new EU member states that have already enjoyed or are expected to enjoy higher productivity growth in tradable sector. Thus, another policy implication arising from the analysis is that it is not desirable to try to smooth exchange rate fluctuations. Once again, it should be stressed that this result is true if the exchange rate is already relatively close to its long run equilibrium. In this case, the central bank should do only minor intervention and let the exchange rate be stabilized endogenously. These answer the first two questions posed in the beginning of the paper.

3.4.5 Maastricht convergence criteria and optimal monetary and fiscal policies

In this section, I test whether or not the Maastricht nominal exchange rate and inflation criteria are violated if the CB and the government follow optimal monetary and fiscal policies that were described in the previous section. To test the compliance with the two nominal convergence criteria under the optimal policy, the economy is disturbed by an initial shock of 1.7 percent to tradable productivity. This roughly generates 30 percent increase in a ten year period like in Masten (2005) and is roughly equivalent to an annual productivity growth of 2.65 percent considered by Natalucci and Ravenna (2007). The impulse responses to a 1.7 percent permanent productivity shock to the tradable sector under selected optimized fiscal and monetary rules are presented in Figures C.4-C.9 in Appendix C.

Productivity shock to the tradable sector leads to the decrease in domestically produced tradable goods prices. Given higher productivity, real wages in the tradable sector increase. Due to mobility of labor between sectors real wages in the nontradable sector also increase, which results in the higher nontradable sector inflation rate. CPI inflation goes up due to the depreciation of nominal exchange rate. However, it does not represent risk of violating the inflation criterion under any of optimized monetary and fiscal policy mixes. Under inflation targeting nominal exchange rate deviates from the target level by more than 10 percent over a forty quarters time period. Therefore, there is some possibility that the nominal exchange rate may be violated under inflation targeting. Under both managed float and fixed exchange rate regimes, both nominal exchange rate and inflation criteria are satisfied.

As for the compliance with the fiscal limits set by the Maastricht Treaty, one can observe that the deviation of debt and deficit-to-GDP ratios from the 60 and 3 percent targets in response to a permanent productivity shock in the tradable sector are not that drastic. For instance, the maximum deviation of the budget deficit takes place under the optimized labor tax based composite SGP rule and inflation targeting. The budget deficit goes up to 3.4 percent of GDP and then gradually returns to the three percent level (see Figure C.6.). The maximum deviation of the debt-to-GDP ratio from the steady state is 4 percent, which roughly corresponds to 62.4 percent. Of course, if the fiscal authorities in the Eurozone accession countries start with lower initial fiscal conditions, for instance with 2.5% budget deficit and 55%, debt-to-GDP ratio, then they satisfy the fiscal requirements (see Figure C.10.)

To sum up, there is no threat of violating the inflation criterion under any of optimized monetary and fiscal policy combinations. However, there is a possibility of not conforming with the nominal exchange rate requirement under inflation targeting, which calls for some minor interventions on the foreign exchange rate markets. For instance, if the monetary authority sets, $\Omega_e = 0.1$ and at the same time targets inflation aggressively by setting $\Omega_\pi = 3$ the nominal exchange rate requirement is met (see Figure C.10). Such an intervention comes at a cost of 0.01 percent, which is rather negligible, relative to the inflation targeting with labor income based composite SGP rule.

3.5 Conclusion

The paper has studied welfare implications of different combinations of alternative monetary and fiscal policy rules for the EMU candidate countries in a small open economy framework. The paper has considered three monetary regimes that are compatible with ERM II and three fiscal rules dictated by the SGP fiscal criteria. More specifically, monetary rules include inflation targeting, inflation targeting with managed float and fixed exchange rate regimes. The fiscal rules comprise the debt, the deficit and the composite SGP rules. Moreover, for each monetary and fiscal regime, the paper considered two alternative taxation instruments.

The main findings are as follows. First, under all three fiscal regimes and inflation targeting the highest conditional welfare are attained when the inflation coefficient takes the highest possible value which is allowed in the grid. Second, the use of labor income tax instrument is more desirable compared to consumption tax since it entails lower welfare losses under all monetary and fiscal policy combinations considered in the paper. However, it would be interesting to see whether this would still be true if capital is added into the model. Third, the higher the response by the CB to the deviations of nominal exchange rate from the target, the higher the welfare costs are. This holds true under all fiscal regimes that are considered in the paper. Fourth, under inflation targeting when consumption tax is used the highest welfare is associated with more active fiscal policy compared to the situation with labor income tax. This is also the case under the both inflation targeting with managed float and fixed exchange rate regimes. Finally, there is no threat to fulfilling the Maastricht inflation criteria under the optimized monetary and fiscal policy combinations. However, there may be a possibility of not complying with the nominal exchange rate requirement under inflation targeting regime, which may call for some minor interventions on the foreign exchange rate markets.

Appendix A

Appendix for Chapter 1

Table A.1. Reported ratios of foreign currency deposits (FCD) broad money in countries with IMF arrangements since 1986

Country	1990	1991	1992	1993	1994	1995
		Highly dollarized economies (FCD/broad money > 30 percent) (18)				
Argentina	34.2	35.1	37.1	40.4	43.2	43.9
Azerbaijan	. . .	. . .	. . .	14.8	58.9	50.3
Belarus	. . .	. . .	. . .	40.6	54.3	30.7
Bolivia	70.8	76.8	80.8	83.9	81.9	82.3
Cambodia	. . .	. . .	26.3	38.8	51.8	56.4
Costa Rica	. . .	37.7	31.9	29.5	30.3	31.0
Croatia	. . .	. . .	. . .	53.8	50.2	57.4
Georgia	. . .	. . .	. . .	. . .	80.1	30.8
Guinea-Bissau	41.5	34.7	31.6	30.9	31.1	31.2
Lao P. D. R.	42.0	39.4	36.8	41.4	34.4	35.6
Latvia	. . .	. . .	. . .	27.2	27.5	31.1
Mozambique	. . .	11.8	16.7	23.2	25.3	32.6
Nicaragua	. . .	28.7	37.4	45.6	48.6	54.5
Peru	. . .	59.9	65.0	70.2	64.2	64.0
Tajikistan	. . .	. . .	. . .	. . .	. . .	33.7
Turkey	23.2	29.7	33.7	37.9	45.8	46.1
Uruguay	80.1	78.5	76.2	73.3	74.1	76.1
Median	41.7	36.4	36.8	40.4	48.6	39.7
Average	48.6	43.3	43.0	43.4	49.4	45.5
	Moderately dollarized economies (FCD/broad money < 30 percent) (34)[1]					
Albania	2.1	1.3	23.8	20.4	18.5	. . .
Armenia	. . .	. . .	. . .	. . .	41.6	20.4
Bulgaria	12.0	33.4	23.4	20.3	32.6	28.4
Czech Republic	. . .	. . .	. . .	. . .	7.2	5.9
Dominica	. . .	3.0	3.9	3.5	2.5	1.5
Ecuador	. . .	. . .	. . .	2.8	5.4	. . .
Egypt	. . .	50.7	37.3	26.7	23.4	25.1
El Salvador	. . .	1.4	1.0	0.9	0.6	1.7
Estonia	. . .	. . .	23.0	3.8	9.9	11.4

Guinea . . .	6.5	6.9	10.0	9.4	9.6	
Honduras	. . .	3.1	5.1	7.6	11.4	13.0
Hungary	12.2	16.5	14.3	18.7	20.4	26.6
Jamaica	. . .	. . .	21.3	19.5	28.1	25.0
Jordan	12.5	13.0	12.8	11.5	12.2	15.2
Lithuania	. . .	. . .	. . .	. . .	27.0	25.9
Macedonia, FYR	. . .	. . .	. . .	. . .	. . .	18.1
Malawi	. . .	. . .	. . .	. . .	10.6	8.0
Mexico	. . .	3.9	4.1	3.6	6.2	7.2
Moldova	. . .	. . .	. . .	. . .	10.3	11.0
Mongolia	. . .	. . .	7.5	33.0	19.5	20.5
Pakistan	2.6	8.9	11.9	13.9	13.6	. . .
Philippines	17.4	18.0	21.0	22.6	20.9	21.5
Poland	31.4	24.7	24.8	28.8	28.5	20.4
Romania	. . .	3.9	17.9	29.0	22.1	21.7
Russia	. . .	. . .	. . .	29.5	28.8	20.6
Sierra Leone	. . .	. . .	. . .	3.3	7.8	16.5
Slovak Republic	. . .	. . .	. . .	11.5	13.0	11.1
Trinidad and Tobago	. . .	. . .	. . .	6.9	12.6	13.6
Uganda	12.0	10.5	11.5	15.7	13.3	13.5
Ukraine	. . .	. . .	. . .	19.4	32.0	26.9
Uzbekistan	. . .	. . .	20.1	5.1	22.5	15.5
Vietnam	. . .	. . .	25.9	20.9	20.4	19.7
Yemen		10.8	12.1	19.7	20.7	20.9
Zambia	. . .	. . .	. . .	. . .	8.1	16.2
Median	12.1	9.7	14.3	15.7	13.6	16.5
Average	12.8	13.3	15.9	15.0	17.2	16.4
Memorandum						
Selected industrial countries						
Greece	11.5	13.2	14.8	16.6	15.0	21.6
Netherlands	8.7	7.2	7.2	3.9	4.7	4.4
United Kingdom	11.4	7.7	10.5	10.9	12.6	15.4

Source: Baliño, Bennett, and Borensztein (1999)

Table A.2. Summary of welfare effects under producer currency pricing

	Welfare Loss Relative to Steady State (%)						Welfare Loss (Gain) of Flexible relative to Fixed (%):		
	Flexible Regime			Fixed Regime			"+ " - loss, "-" - gain		
Import Share=0.2	Shocks			Shocks			Shocks		
Degree of Dollarization	Both (1)	Monetary (2)	Technology (3)	Both (4)	Monetary (5)	Technology (6)	Both: (1)-(4)	Monetary: (2)-(5)	Technology: (3)-(6)
Φ=3/5 (40%)	0.256	0.148	0.110	0.140	0.060	0.080	0.116	0.088	0.030
Φ=4/5 (20%)	0.140	0.079	0.057	0.068	0.025	0.043	0.072	0.054	0.014
Φ=17/20 (15%)	0.117	0.067	0.050	0.061	0.020	0.041	0.056	0.047	0.009
Φ=9/10 (10%)	0.100	0.055	0.046	0.058	0.015	0.043	0.042	0.040	0.003
Φ=1 (0%)	0.072	0.025	0.005	0.068	0.010	0.058	0.004	0.015	-0.053
Import Share=0.4									
Degree of Dollarization									
Φ=3/5 (40%)	0.600	0.320	0.280	0.314	0.097	0.218	0.286	0.223	0.062
Φ=4/5 (20%)	0.238	0.121	0.117	0.132	0.036	0.096	0.106	0.085	0.021
Φ=17/20 (15%)	0.177	0.088	0.091	0.101	0.026	0.075	0.076	0.022	0.016
Φ=9/10 (10%)	0.131	0.059	0.072	0.081	0.017	0.064	0.050	0.042	0.008
Φ=1 (0%)	0.081	0.019	0.062	0.082	0.009	0.074	-0.001	0.010	-0.012

Notes. The welfare loss is computed as the percentage steady state consumption loss. The numbers in the brackets represent degrees of dollarization.

Table A.3. Summary of welfare effects under local currency pricing

	Welfare Loss Relative to Steady State						Welfare Loss (Gain) of Flexible relative to Fixed: "+ " - loss, "-" - gain		
	Flexible Regime			Fixed Regime					
	Shocks			Shocks			Shocks		
	Both (1)	Monetary (2)	Technology (3)	Both (4)	Monetary (5)	Technology (6)	Both: (1)-(4)	Monetary: (2)-(5)	Technology: (3)-(6)
Import Share=0.2									
Φ=3/5 (40%)	0.216	0.126	0.091	0.091	0.043	0.048	0.125	0.083	0.043
Φ=4/5 (20%)	0.096	0.061	0.035	0.032	0.013	0.019	0.064	0.048	0.016
Φ=17/20 (15%)	0.074	0.048	0.027	0.030	0.009	0.021	0.044	0.039	0.006
Φ=9/10 (10%)	0.058	0.035	0.023	0.032	0.008	0.024	0.026	0.027	-0.001
Φ=1 (0%)	0.041	0.013	0.028	0.056	0.010	0.046	-0.015	0.003	-0.018
Import Share=0.4									
Φ=3/5 (40%)	0.590	0.330	0.260	0.200	0.008	0.120	0.390	0.322	0.140
Φ=4/5 (20%)	0.210	0.127	0.083	0.057	0.020	0.037	0.153	0.107	0.046
Φ=17/20 (15%)	0.140	0.086	0.054	0.038	0.014	0.024	0.102	0.072	0.030
Φ=9/10 (10%)	0.090	0.058	0.032	0.031	0.006	0.025	0.059	0.052	0.007
Φ=1 (0%)	0.030	0.006	0.024	0.059	0.010	0.049	-0.029	-0.004	-0.025

Notes. The welfare loss is computed as the percentage steady state consumption loss. The numbers in the brackets represent degrees of dollarization.

Table A.4. Summary of welfare effects under producer currency pricing: higher risk aversion (ρ=30)

	Welfare Loss Relative to Steady State (%)						Welfare Loss (Gain) of Flexible relative to Fixed (%): "+ " - loss, "-" - gain		
	Flexible Regime			Fixed Regime					
Import Share=0.2	Shocks			Shocks			Shocks		
Degree of Dollarization	Both (1)	Monetary (2)	Technology (3)	Both (4)	Monetary (5)	Technology (6)	Both: (1)-(4)	Monetary: (2)-(5)	Technology: (3)-(6)
Φ=3/5 (40%)	0.354	0.179	0.184	0.177	0.061	0.117	0.177	0.118	0.067
Φ=4/5 (20%)	0.188	0.095	0.096	0.087	0.025	0.062	0.101	0.070	0.034
Φ=17/20 (15%)	0.159	0.079	0.082	0.077	0.019	0.058	0.082	0.060	0.024
Φ=9/10 (10%)	0.137	0.065	0.073	0.071	0.015	0.059	0.066	0.050	0.014
Φ=1 (0%)	0.110	0.040	0.070	0.089	0.012	0.077	0.021	0.028	-0.007

Notes. The welfare loss is computed as the percentage steady state consumption loss. The numbers in the brackets represent degrees of dollarization.

Table A.5. Summary of welfare effects under producer currency pricing: habits persistence

	Welfare Loss Relative to Steady State (%)						Welfare Loss (Gain) of Flexible relative to Fixed (%): "+ " - loss, "-" - gain		
	Flexible Regime			Fixed Regime					
Import Share=0.2	Shocks			Shocks			Shocks		
Degree of Dollarization	Both (1)	Monetary (2)	Technology (3)	Both (4)	Monetary (5)	Technology (6)	Both: (1)-(4)	Monetary: (2)-(5)	Technology: (3)-(6)
Φ=3/5 (40%)	0.360	0.056	0.300	0.115	0.029	0.087	0.245	0.027	0.213
Φ=4/5 (20%)	0.120	0.023	0.097	0.063	0.016	0.047	0.057	0.007	0.050
Φ=9/10 (10%)	0.062	0.012	0.049	0.052	0.009	0.043	0.010	0.003	0.006
Φ=1 (0%)	0.045	0.005	0.041	0.050	0.002	0.048	-0.005	0.003	-0.007

Notes. The welfare loss is computed as the percentage steady state consumption loss. The numbers in the brackets represent degrees of dollarization.

Table A.6. Selected (unconditional) statistics of the domestic variables. PCP case and Cobb-Douglas monetary aggregator

	Fllexible				Fixed			
	FI=3/5 (40%)		FI=1 (0%)		FI=3/5 (40%)		FI=1 (0%)	
	Means (in %)	Std.Dev (in %)	Means (in %)	Std.Dev (in %)	Means (in %)	Std.Dev (in %)	Means (in %)	Std.Dev (in %)
consumption	-0.004	0.930	-0.010	0.881	0.002	0.948	-0.026	0.931
domestic money	0.142	1.361	0.085	1.704	0.129	5.045	0.065	3.384
capital	0.300	3.014	0.087	2.873	0.148	3.018	0.001	3.335
inflation	0.002	0.541	0.000	0.410	0.002	0.463	-0.002	0.409
labor	0.058	2.918	-0.002	2.147	-0.020	2.853	-0.011	2.183
aggregate demand	0.189	3.852	0.030	2.382	0.110	3.414	-0.001	2.360
foreign money	0.132	2.332	-	-	0.051	2.556	-	-
bonds	0.047	2.814	-0.055	4.705	-0.012	2.302	0.065	3.779
exchange rate	-209.360	73.700	-14.811	36.200	0.000	0.001	0.000	0.000

Appendix B

Appendix for Chapter 2

B.1 Stationary variables

The economy features two permanent productivity shocks. Therefore, some variables such as output, consumption, and the real wage will not be stationary along the balanced growth path. Below, I carry out a necessary change to obtain a set of equilibrium conditions that involve only stationary variables. Before, we proceed to perform a change to induce stationarity, let us rewrite nominal variables in real terms: $m_t = M_t / P_t$, $b_{H,t} = B_{H,t} / P_t$, $d_t = e_t B_{F,t} / P_t$.

One can note that variables $Y_t, C_t, G_t, m_t, w_t, b_{H,t}, d_t$ are cointegrated with Z_t. Where $Z_t = A_{N,t}^{\gamma} A_{H,t}^{\varepsilon(1-\gamma)}$.[1] Variables x_t^1, x_t^2 are cointegrated with $A_{N,t}$. Similarly, x_t^3, x_t^4 are cointegrated with $A_{H,t}$.

Now, we can divide these variables by the appropriate cointegrating factors and denote the corresponding stationary variables with the hats. Some detrended variables do not have the hats.

Let us introduce new and transformed variables:

$$Z_t = A_{N,t}^{\gamma} A_{H,t}^{\varepsilon(1-\gamma)}$$

$$Z_{N,t} = A_{N,t} / A_{N,t-1}$$

$$Z_{H,t} = A_{H,t} / A_{H,t-1}$$

$$\hat{Y}_t = \frac{Y_t}{Z_t}$$

[1] I assume that $\rho = 1$ in order for this transformation to be valid. This can be clearly seen from the household's FOC with respect to labor.

$$\hat{Y}_{H,t} = \frac{Y_{H,t}}{A_{H,t}}$$

$$\hat{Y}_{N,t} = \frac{Y_{N,t}}{A_{N,t}}$$

$$\hat{Y}_t^* = Y_t^*$$

$$\hat{C}_t = \frac{C_t}{Z_t}$$

$$\hat{w}_t = \frac{W_t}{Z_t P_t}$$

$$\hat{m}_t = \frac{M_t}{Z_t P_t}$$

$$\hat{x}_t^1 = \frac{x_t^1}{A_{N,t}}$$

$$\hat{x}_t^2 = \frac{x_t^2}{A_{N,t}}$$

$$\hat{x}_t^3 = \frac{x_t^3}{A_{H,t}}$$

$$\hat{x}_t^4 = \frac{x_t^4}{A_{H,t}}$$

$$\hat{G}_t = \frac{G_t}{Z_t}$$

$$\hat{b}_{H,t} = \frac{B_{H,t}}{Z_t P_t}$$

$$\hat{d}_t = \frac{e_t B_{F,t}}{Z_t P_t}$$

$$\hat{P}_t = P_t Z_t$$

$$\hat{P}_{F,t} = P_{F,t}$$

$$\hat{P}_{H,t} = P_{H,t} A_{H,t}$$

$$\hat{P}_{N,t} = P_{N,t} A_{N,t}$$

$$\hat{\sigma}_{t,t+1} = \sigma_{t,t+1}\frac{Z_{t+1}}{Z_t}$$

Scaled internal price ratio:

$$\hat{Q}_t = \frac{\hat{P}_{N,t}}{\hat{P}_{H,t}}$$

Scaled terms of trade:

$$\hat{S}_t = \frac{\hat{P}_{F,t}}{\hat{P}_{H,t}}$$

Using definitions of price indexes, one can get the following identities that will be useful later:

$$\frac{\hat{P}_{N,t}}{\hat{P}_t} = \hat{Q}_t^{1-\gamma}\hat{S}_t^{(\varepsilon-1)(1-\gamma)}$$

$$\frac{\hat{P}_{H,t}}{\hat{P}_t} = \hat{Q}_t^{-\gamma}\hat{S}_t^{(\varepsilon-1)(1-\gamma)}$$

$$\frac{\hat{P}_{F,t}}{\hat{P}_t} = \hat{Q}_t^{-\gamma}\hat{S}_t^{\varepsilon(1-\gamma)+\gamma}$$

Variables that do not have to be transformed are:

i_t, π_t, $\pi_{H,t}$, $\pi_{N,t}$, τ_t^j, $j=\{c,l\}$, e_t, $i_{f,t}$, H_t, $\hat{\hat{P}}_N$, $\hat{\hat{P}}_H$, $s_{N,t}$, $s_{H,t}$, i_t^*, π_t^*, Y_t^*

B.2 Equilibrium conditions in stationary variables

As discussed in the calibration section, I set $\rho = 1$ in order to ensure stationarity in the labor supply equation.

$$\beta E_t\left[\left(\frac{\hat{C}_{t+1}Z_{t+1}}{\hat{C}_t Z_t}\right)^{-\rho}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{1}{\pi_{t+1}}\frac{e_{t+1}}{e_t}(1+i_{f,t})\right] = 1 \tag{B.1}$$

$$\beta E_t\left[\left(\frac{\hat{C}_{t+1}Z_{t+1}}{\hat{C}_t Z_t}\right)^{-\rho}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\frac{1}{\pi_{t+1}}(1+i_t)\right] = 1 \tag{B.2}$$

$$\hat{C}_t^{-\rho}\hat{\omega}_t\frac{1-\tau_t^l}{1+\tau_t^c} - H_t^{\psi} = 0 \tag{B.3}$$

$$\hat{m}_t = \nu \hat{w}_t H_t \quad \text{(B.4)}$$

$$H_t = H_{H,t} + H_{N,t} \quad \text{(B.5)}$$

$$mc_{N,t} = \frac{\hat{w}_t (1+\nu \frac{i_t}{i_t+1})\hat{P}_t}{\alpha H_{N,t}^{\alpha-1} \hat{P}_{N,t}} \quad \text{(B.6)}$$

$$\hat{Y}_{N,t} = H_{N,t}^{\alpha} / s_{N,t} \quad \text{(B.7)}$$

$$\hat{a}_{N,t} = \gamma \left(\frac{\hat{P}_{N,t}}{\hat{P}_t} \right)^{-1} \hat{Y}_t = \hat{Y}_{N,t} \quad \text{(B.8)}$$

$$\hat{x}_t^1 = \hat{\tilde{P}}_{N,t}^{-\omega-1} \hat{a}_{N,t} mc_{N,t} + \theta E_t \hat{\sigma}_{t,t+1} \frac{Z_t}{Z_{t+1}} \left(\frac{\hat{\tilde{P}}_{N,t}}{\hat{\tilde{P}}_{N,t+1}} \frac{1}{\pi_{N,t+1}} \right)^{-\omega-1} \hat{x}_{t+1}^1 \frac{A_{N,t+1}}{A_{N,t}} \quad \text{(B.9)}$$

$$\hat{x}_t^2 = \hat{\tilde{P}}_{N,t}^{-\omega} \hat{a}_{N,t} + \theta E_t \hat{\sigma}_{t,t+1} \frac{Z_t}{Z_{t+1}} \left(\frac{\hat{\tilde{P}}_{N,t}}{\hat{\tilde{P}}_{N,t+1}} \frac{1}{\pi_{N,t+1}} \right)^{-\omega} \hat{x}_{t+1}^2 \frac{A_{N,t+1}}{A_{N,t}} \quad \text{(B.10)}$$

$$\hat{x}_t^1 \frac{\omega}{\omega-1} = \hat{x}_t^2 \quad \text{(B.11)}$$

$$\theta \pi_{N,t}^{\omega-1} + (1-\theta) \hat{\tilde{P}}_{N,t}^{1-\omega} = 1 \quad \text{(B.12)}$$

$$s_{N,t} = (1-\theta) \hat{\tilde{P}}^{-\omega} + \theta \pi_{N,t}^{\omega} s_{N,t-1} \quad \text{(B.13)}$$

$$mc_{H,t} = \frac{\hat{w}_t (1+\nu \frac{i_t}{i_t+1})\hat{P}_t}{\alpha H_{H,t}^{\alpha-1} \hat{P}_{H,t}} \quad \text{(B.14)}$$

$$\hat{Y}_{H,t} + \varepsilon^* \left(\frac{\hat{P}_{H,t}}{\hat{P}_{F,t}} \right)^{-1} \hat{Y}_t^* = H_{H,t}^{\alpha} / s_{H,t} \quad \text{(B.15)}$$

$$\hat{a}_{H,t} = \varepsilon(1-\gamma) \left(\frac{\hat{P}_{H,t}}{\hat{P}_t} \right)^{-1} \hat{Y}_t + \varepsilon^* \left(\frac{\hat{P}_{H,t}}{e_t P_t^*} \right)^{-1} \hat{Y}_t^* = \left(\frac{\hat{P}_{H,t}}{\hat{P}_t} \right)^{-1} \hat{Y}_t + \varepsilon^* \left(\frac{\hat{P}_{H,t}}{\hat{P}_{F,t}} \right)^{-1} \hat{Y}_t^* \quad \text{(B.16)}$$

$$\hat{x}_t^3 = \hat{\tilde{P}}_{H,t}^{-\eta-1} \hat{a}_{H,t} mc_{H,t} + \theta E_t \hat{\sigma}_{t,t+1} \frac{Z_t}{Z_{t+1}} \left(\frac{\hat{\tilde{P}}_{H,t}}{\hat{\tilde{P}}_{H,t+1}} \frac{1}{\pi_{H,t+1}} \right)^{-\eta-1} \hat{x}_{t+1}^3 \frac{A_{H,t+1}}{A_{H,t}} \quad \text{(B.17)}$$

$$\hat{x}_t^4 = \hat{\tilde{P}}_{H,t}^{-\eta}\hat{a}_{H,t} + \theta E_t \hat{\sigma}_{t,t+1}\frac{Z_t}{Z_{t+1}}\left(\frac{\hat{\tilde{P}}_{H,t}}{\hat{\tilde{P}}_{H,t+1}}\frac{1}{\pi_{H,t+1}}\right)^{-\eta}\hat{x}_{t+1}^4\frac{A_{H,t+1}}{A_{H,t}} \tag{B.18}$$

$$\hat{x}_t^3\frac{\omega}{\omega-1} = \hat{x}_t^4 \tag{B.19}$$

$$\theta\pi_{H,t}^{\eta-1} + (1-\theta)\hat{\tilde{P}}_{H,t}^{1-\eta} = 1 \tag{B.20}$$

$$s_{H,t} = (1-\theta)\hat{\tilde{P}}^{-\eta} + \theta\pi_{H,t}^{\eta}s_{H,t-1} \tag{B.21}$$

$$\frac{\hat{S}_t}{\hat{S}_{t-1}} = \frac{e_t\pi_t^* A_{H,t-1}}{e_{t-1}\pi_{H,t}A_{H,t}} \tag{B.22}$$

$$\frac{\hat{Q}_t}{\hat{Q}_{t-1}} = \frac{\pi_{N,t}A_{H,t-1}}{\pi_{H,t}A_{H,t}}\frac{A_{N,t}}{A_{N,t-1}} \tag{B.23}$$

$$\pi_t = \pi_{N,t}^{\gamma}\pi_{H,t}^{\varepsilon(1-\gamma)}\pi_t^{*(1-\varepsilon)(1-\gamma)}(e_t/e_{t-1})^{(1-\varepsilon)(1-\gamma)} \tag{B.24}$$

$$\hat{Y}_t = \hat{C}_t + \hat{G}_t \tag{B.25}$$

$$\hat{d}_t = (1+i_{F,t-1})\frac{1}{\pi_t}\frac{Z_{t-1}}{Z_t}\frac{e_t}{e_{t-1}}\hat{d}_{t-1} + \hat{C}_{H,t}^*\frac{\hat{P}_{H,t}}{\hat{P}_t} - \hat{Y}_t \tag{B.26}$$

$$\hat{m}_t + \hat{b}_t + \tau_t^c\hat{C}_t + \tau_t^l\omega_t H_t = (1+i_{t-1})\hat{b}_{t-1}\frac{Z_{t-1}}{Z_t}\frac{1}{\pi_t} + \hat{m}_{t-1}\frac{Z_{t-1}}{Z_t}\frac{1}{\pi_t} + \hat{G}_t \tag{B.27}$$

$$GDP_t = \hat{Y}_t - \frac{\hat{P}_{F,t}}{\hat{P}_t}\hat{Y}_{F,t} \tag{B.28}$$

$$\hat{\tau}_t = \tau_t^c\hat{C}_t + \tau_t^l\hat{w}_t H_t \tag{B.29}$$

$$\tau_t^j = \tau^j + \Omega_1(\hat{G}_t - \hat{\tau}_t + i_{t-1}\hat{b}_{t-1}\frac{Z_{t-1}}{\pi_t Z_t} - \kappa_1 GDP_t)/GDP_t,\ j=\{c, l\} \tag{B.30}$$

$$\tau_t^j = \tau^j + \Omega_2(\hat{b}_{t-1}\frac{Z_{t-1}}{\pi_t Z_t} + \hat{m}_{t-1}\frac{Z_{t-1}}{\pi_t Z_t} - \kappa_2 GDP_t)/GDP_t,\ j=\{c, l\} \tag{B.31}$$

$$\tau_t^j = \tau^j + \{\Omega_1(\hat{G}_t - \hat{\tau}_t + i_t\hat{b}_{t-1}\frac{Z_{t-1}}{\pi_t Z_t} - \kappa_1 GDP_t) + \Omega_2(\hat{b}_{t-1}\frac{Z_{t-1}}{\pi_t Z_t} + \hat{m}_{t-1}\frac{Z_{t-1}}{\pi_t Z_t} - \kappa_2 GDP_t)\}/GDP_t,\quad j=\{c, l\} \tag{B.32}$$

$$\ln((1+i_t)/(1+\bar{i})) = \Omega_\pi \ln(\pi_t/\bar{\pi}) + \Omega_e \ln(e_t/\bar{e}) \tag{B.33}$$

$$\ln(\hat{G}_t / \overline{G}) = \rho_g \ln(\hat{G}_{t-1} / \overline{G}) + e_{g,t} \tag{B.34}$$

$$\ln(\pi_t^* / \overline{\pi}^*) = \rho_\pi \ln(\pi_{t-1}^* / \overline{\pi}^*) + \varepsilon_\pi \tag{B.35}$$

$$\ln(Y_t^* / \overline{Y}^*) = \rho_Y \ln(Y_{t-1}^* / \overline{Y}^*) + \varepsilon_Y \tag{B.36}$$

$$\ln((1+i_t^*)/(1+\overline{i}^*)) = \rho_I \ln((1+i_{t-1}^*)/(1+\overline{i}^*)) + \varepsilon_i \tag{B.37}$$

$$\ln(A_{j,t}) = (1-\varphi)\ln A + (1+\varphi)\ln(A_{j,t-1}) - \varphi \ln(A_{j,t-2}) + \varsigma_{j,t}\,,\ j=\{H, N\} \tag{B.38}$$

$$H_t = H_{H,t} + H_{N,t} \tag{B.39}$$

B.3 Model equations, states and controls

The system is given by: consumption Euler equations (B.1) and (B.2), cash in advance constraint (B.4), domestic nontradable intermediate goods market clearing condition (B.7), domestic nontradable sector price setting equations (B.9) and (B.10), law of motion for domestic nontradable price dispersion (B.13), domestic tradable goods market clearing condition (B.15), domestic tradable sector price setting equations (B.17) and (B.18), law of motion for domestic tradable price dispersion (B.21), laws of motion for scaled terms of trade and scaled internal price ratio (B.22) and (B.23), law of motion for CPI inflation (B.24), foreign debt accumulation equation (B.26), government budget constraint (B.27), money rule (B.33), exogenous stochastic processes (B.34-38), and one of the equations describing different fiscal regimes (B.30-32). There are 25 first order difference equations describing equilibrium conditions. In addition, there are two auxiliary equations linking previous period nominal exchange rate and domestic bond holdings to the current period, since we have these variables entering the system with *t-1*, *t* and *t+1* time subscripts.

I have used the following *intratemporal* conditions to make additional simplifications to reduce the number of equations: (B.8) to substitute out domestic demand for domestically produced nontradable good; (B.6) and (B.3) to substitute for nontradable marginal cost and real wage; (B.11) to substitute out $\hat{x}_t^2$; (B.12) to express the relative price of the nontradable intermediate good as a function of nontradable price inflation; (B.14) to substitute for marginal costs in the tradable sector; (B.16) to substitute for the domestically produced tradable intermediate good; (B.19) to substitute out $\hat{x}_t^4$; (B.20) to substitute for the relative price in the tradable sector; (B.25) to express the final good as a function of private and public consumption; (B.28) for the definition of the gross domestic product.

All together, I have 27 first order difference equations in 27 variables. The next step is to split the variables into controls and states. The state variables are collected in *x*: $x_t = \begin{bmatrix} x_t^{endog} \\ x_t^{exog} \end{bmatrix}$, where x_t^{endog} is a vector of endogenous state variables, and x_t^{exog} is a vector of exogenous state variables.

$$x_t^{endog} = \left[e_{t-1}\ \hat{S}_{t-1}\ \hat{Q}_{t-1}\ i_{t-1}\ \hat{m}_{t-1}\ \hat{b}_{t-1}\ s_{N,t-1}\ s_{H,t-1}\ \hat{d}_{t-1} \right]'.$$

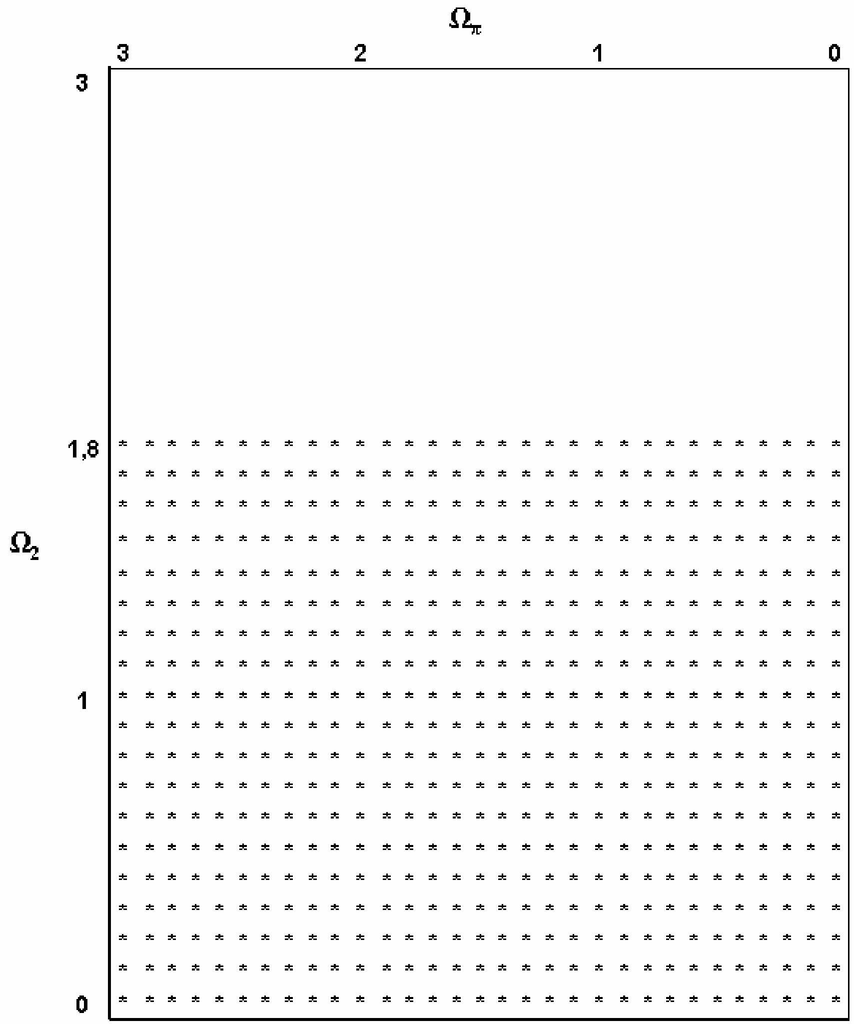
$$x_t^{exog} = \left[\hat{Y}_{t-1}^*\ \pi_{t-1}^*\ \hat{G}_{t-1}\ Z_{N,t}\ Z_{H,t}\ i_{t-1}^* \right]'.$$

The vector of controls, *y*, is given by: $y_t = \left[\hat{C}_t\ H_t\ H_{N,t}\ i_t\ \pi_t\ \pi_{H,t}\ \pi_{N,t}\ i_t\ e_t\ \hat{x}_t^1\ \hat{x}_t^3\ \tau_t^j \right]'$, *j*={c,*l*} depending on which tax instrument is used.

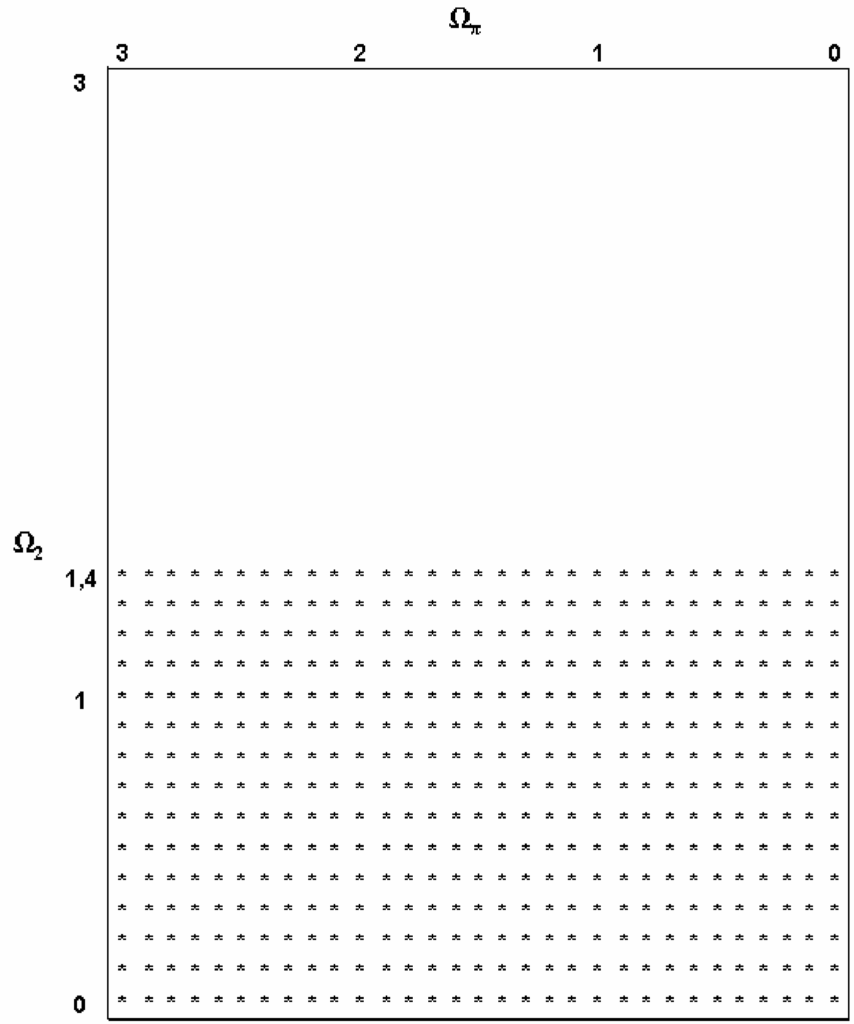
B.4 Stability results and impulse responses

Figure B.1. Determinacy regions under the debt rule and inflation targeting

Panel A: Consumption Tax

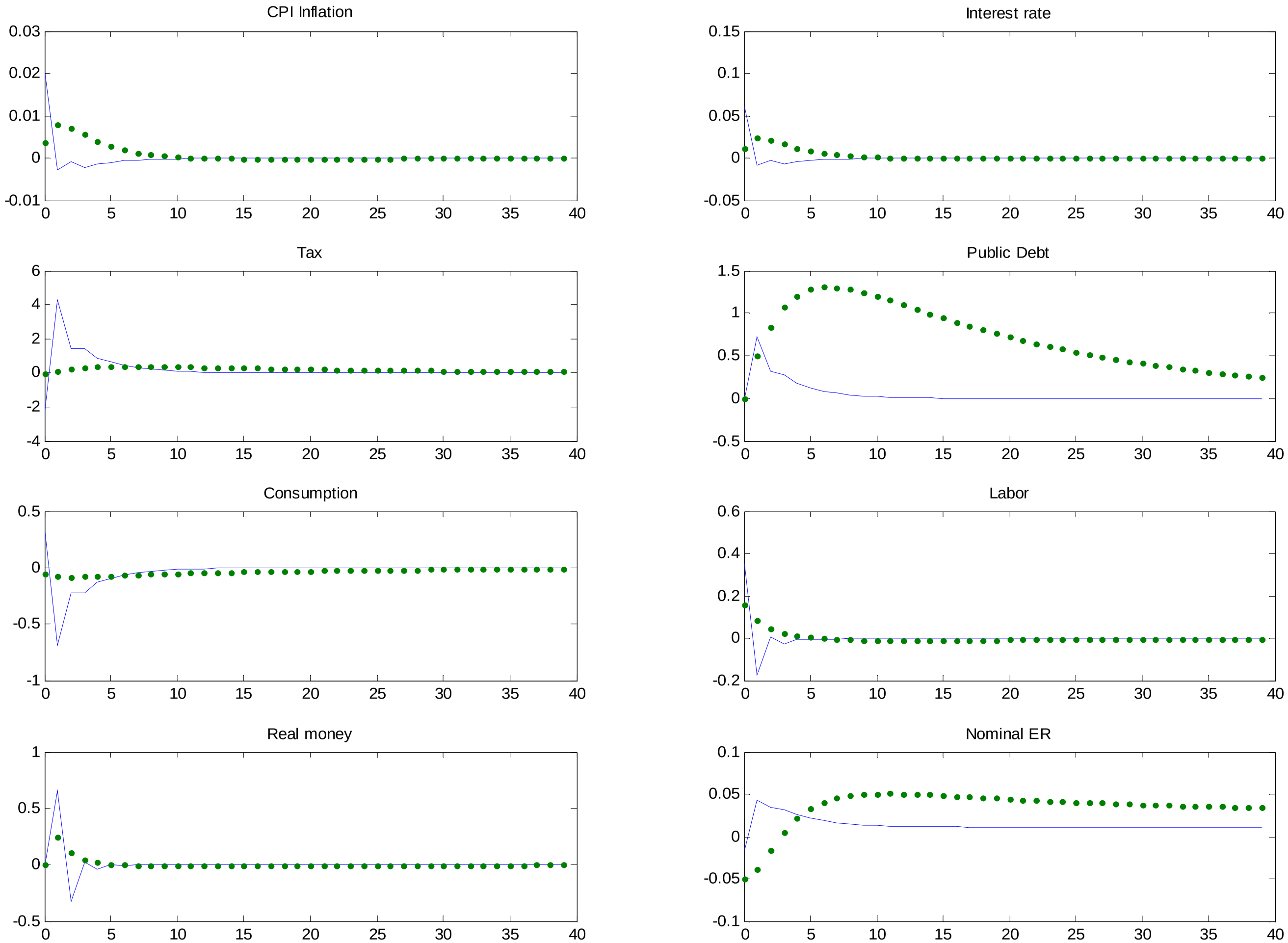


Panel B: Labor Income Tax



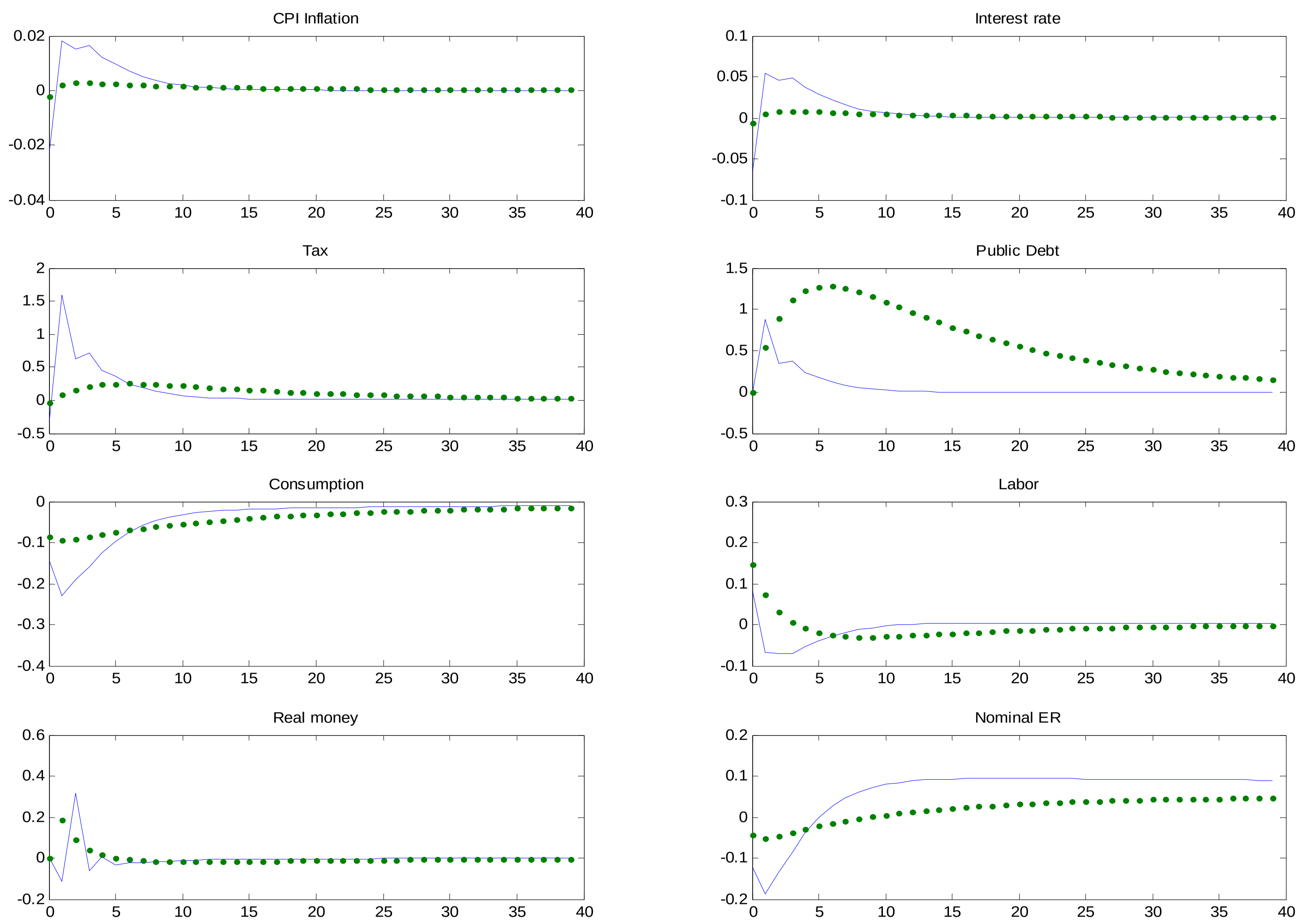
Note. A star represents parameter combinations for which equilibrium is determinate. Blank area corresponds to explosive solutions.

Figure B.2. Government consumption shock under consumption tax based debt rule and inflation targeting. Percent deviations from steady state.



Note. Solid line: $\Omega_\pi = 3$ and $\Omega_2 = 1.5$, dotted line: $\Omega_\pi = 3$ and $\Omega_2 = 0.1$.

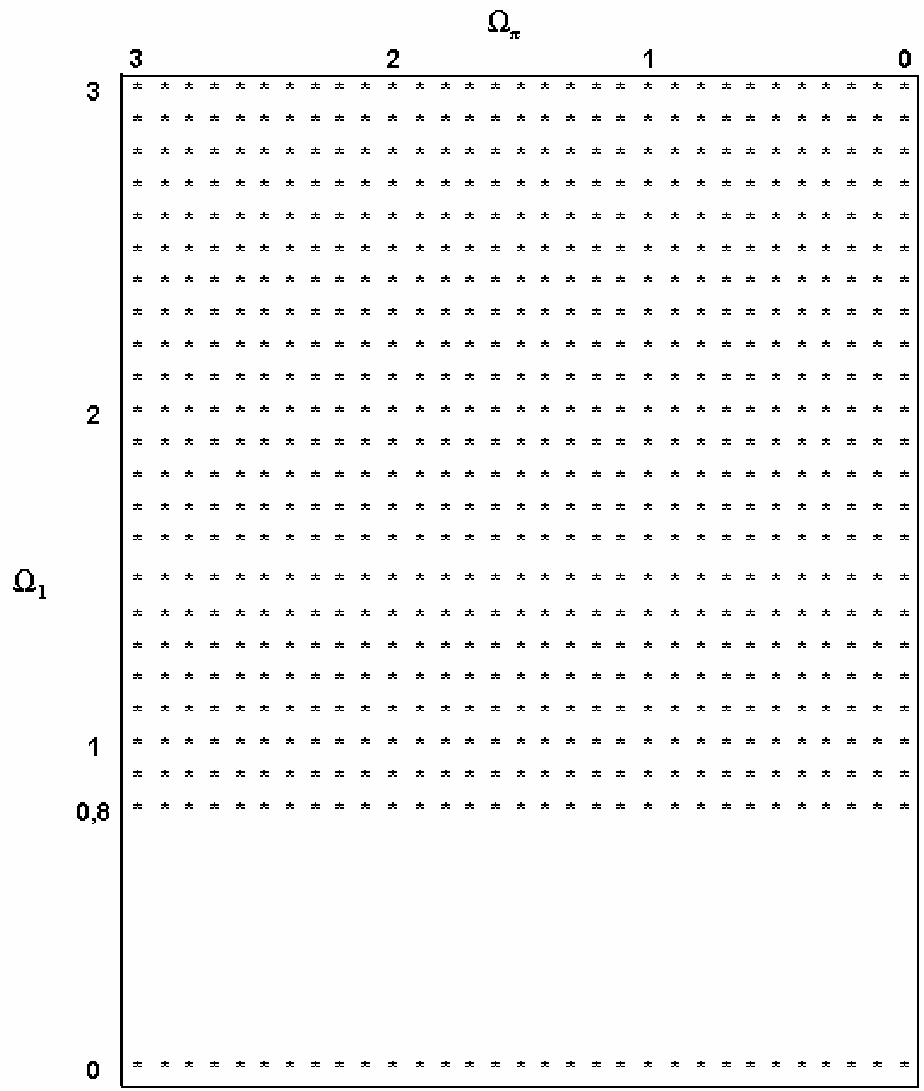
Figure B.3. Government consumption shock under labor tax based debt rule and inflation targeting. Percent deviations from steady state.



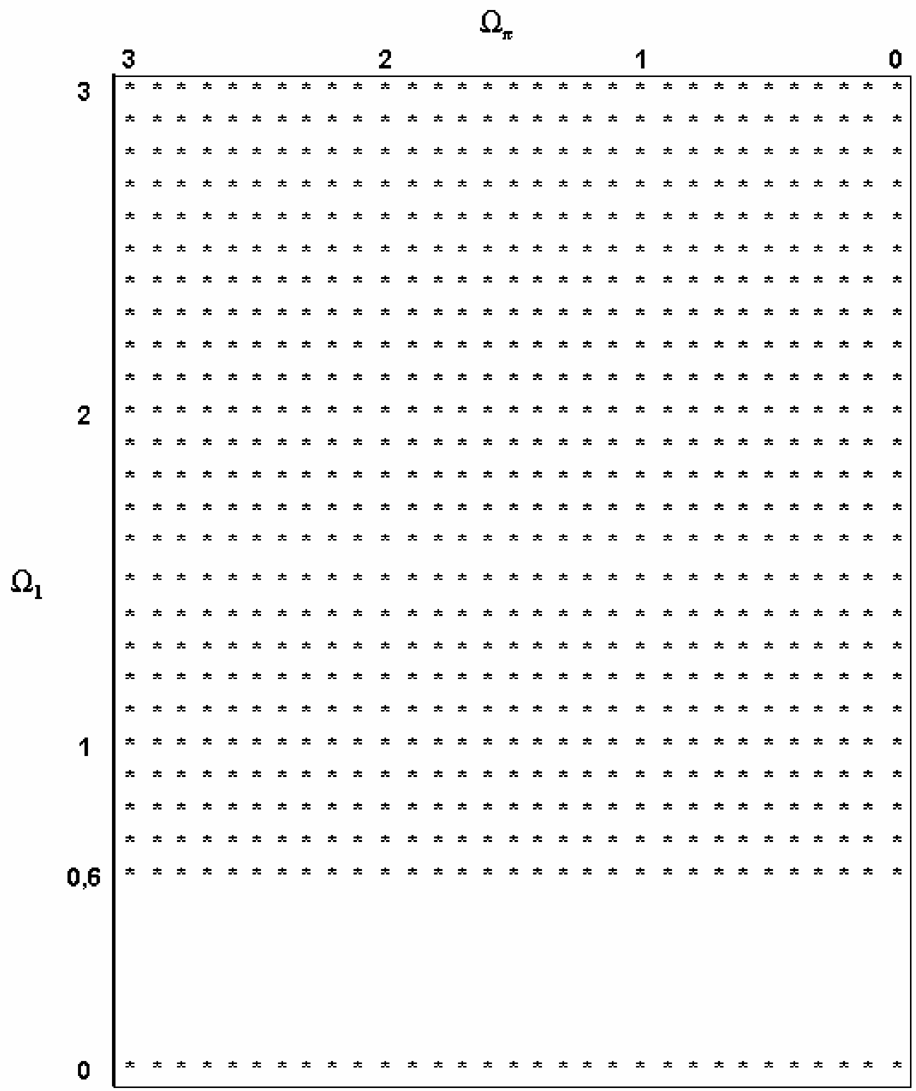
Note. Solid line: $\Omega_\pi = 3$ and $\Omega_2 = 1$, dotted line: $\Omega_\pi = 3$ and $\Omega_2 = 0.1$.

Figure B.4. Determinacy regions under the deficit rule and inflation targeting

Panel A: Consumption Tax

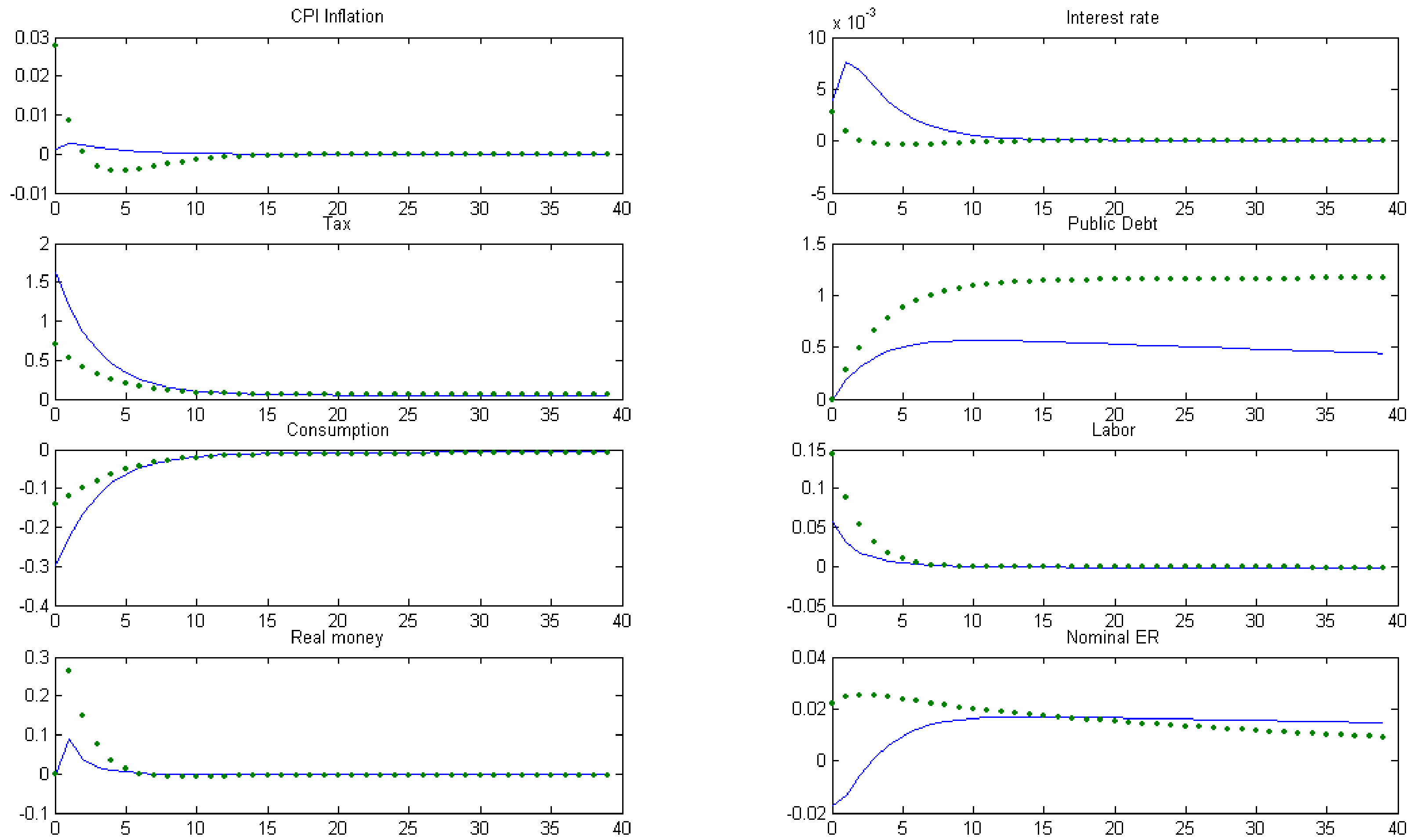


Panel B: Labor Income Tax



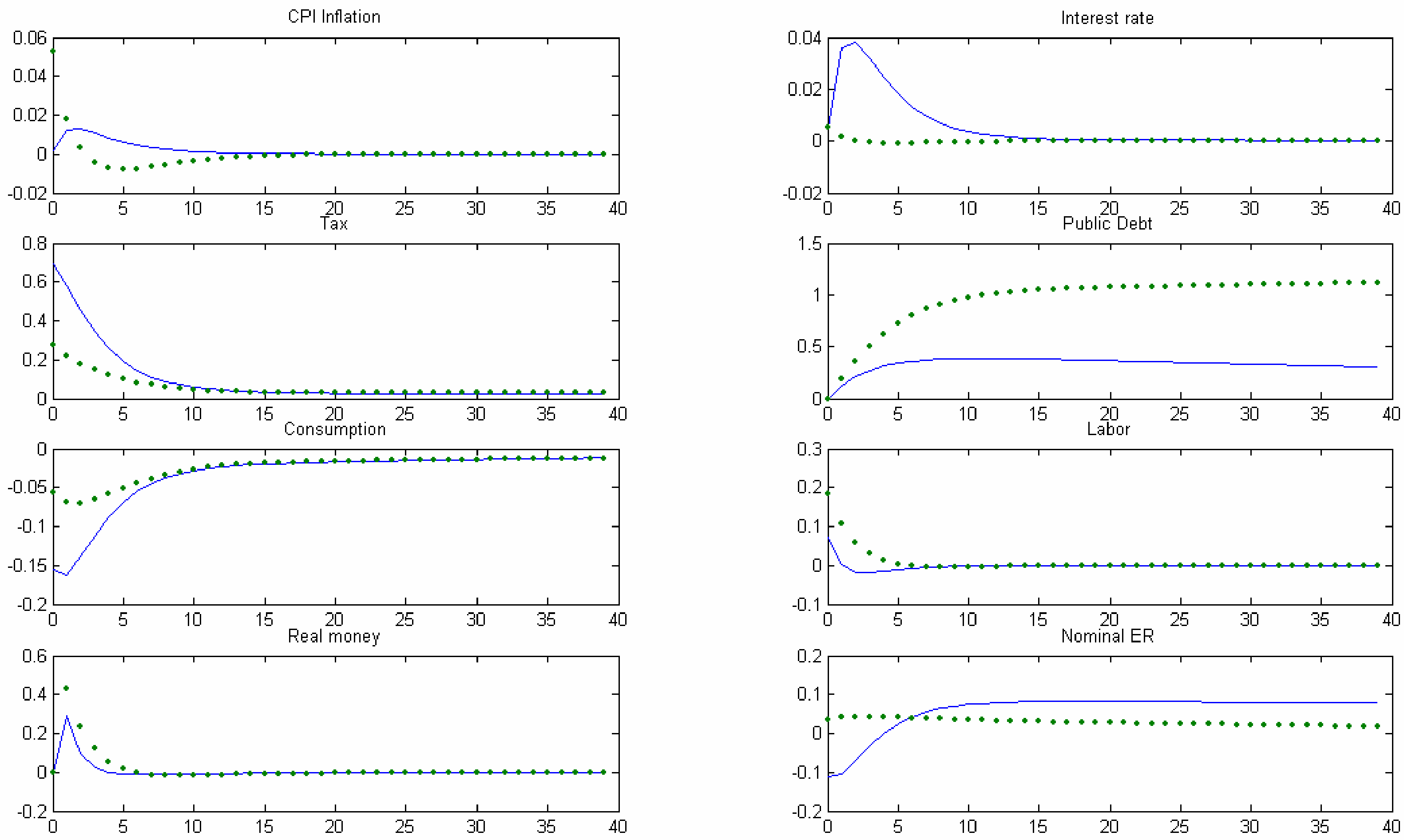
Note. see note to Figure B.1.

Figure B.5. Government consumption shock under consumption tax based deficit rule. Percent deviations from steady state.



Note. Solid line: $\Omega_\pi = 3$ and $\Omega_1 = 3$, dotted line: $\Omega_\pi = 0.1$ and $\Omega_1 = 0.8$.

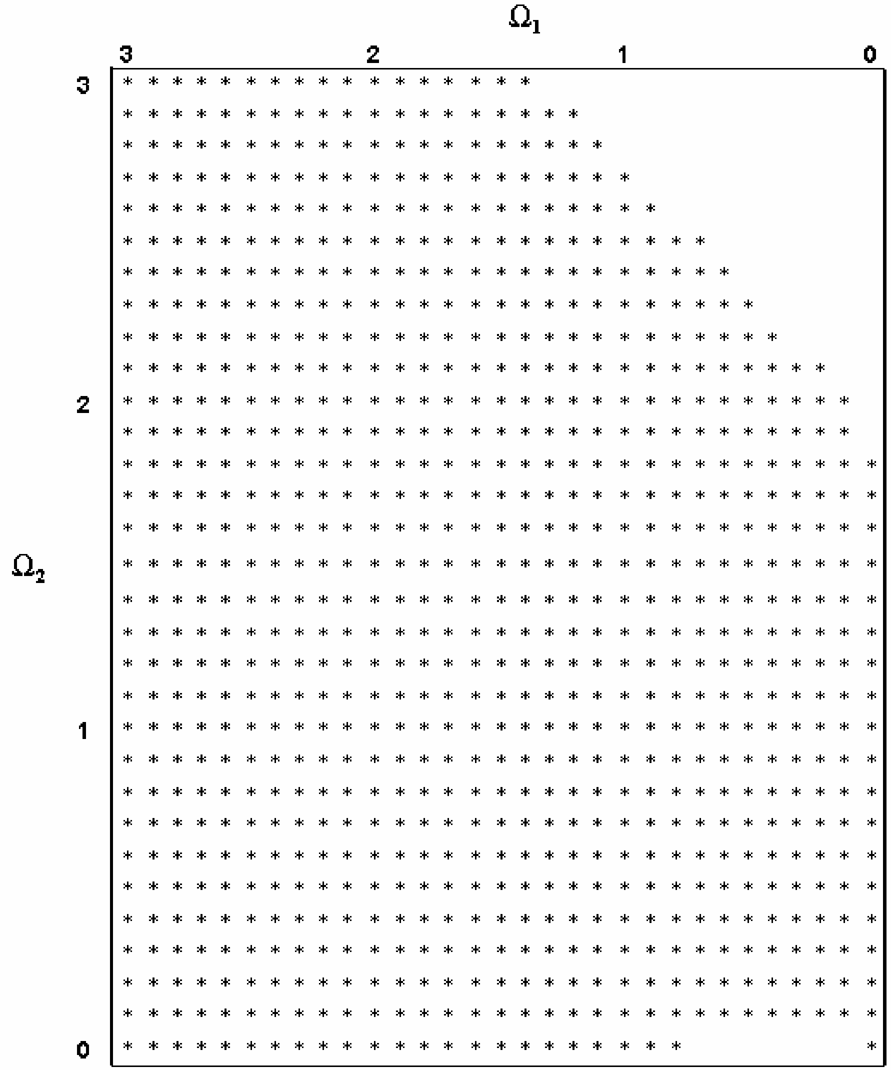
Figure B.6. Government consumption shock under consumption tax based deficit rule. Percent deviations from steady state.



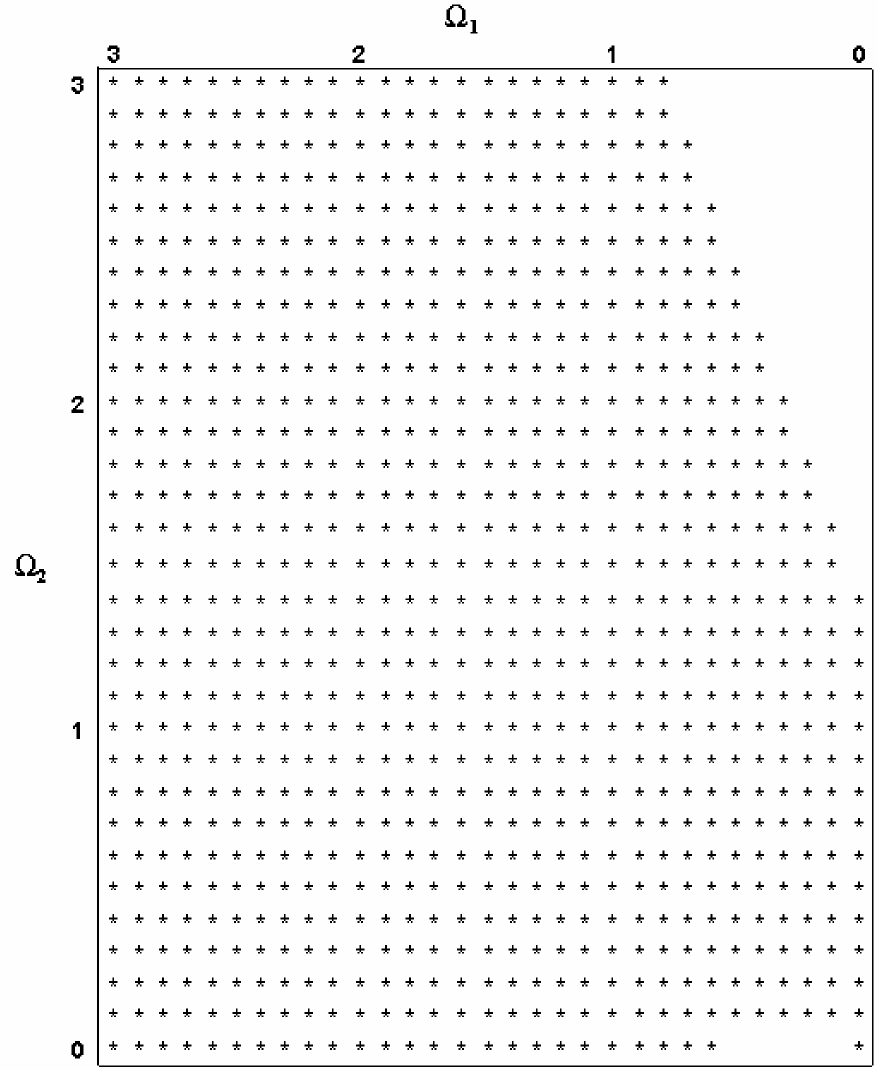
Note. Solid line: $\Omega_\pi = 3$ and $\Omega_1 = 3$, dotted line: $\Omega_\pi = 0.1$ and $\Omega_1 = 0.6$.

Figure B.7. Determinacy regions under the composite SGP rule and inflation targeting: $\Omega_\pi=3$

Panel A: Consumption Tax

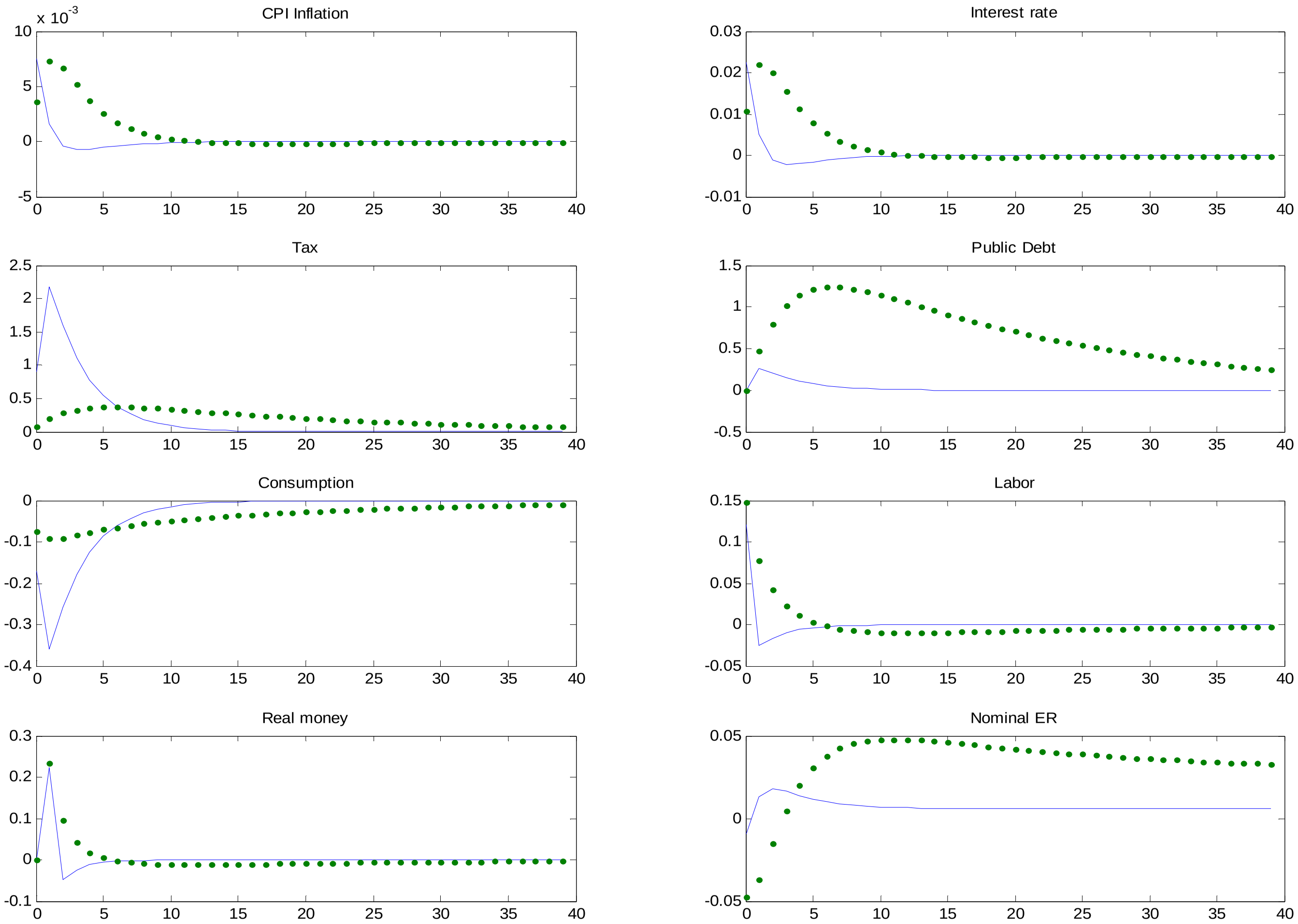


Panel B: Labor Income Tax



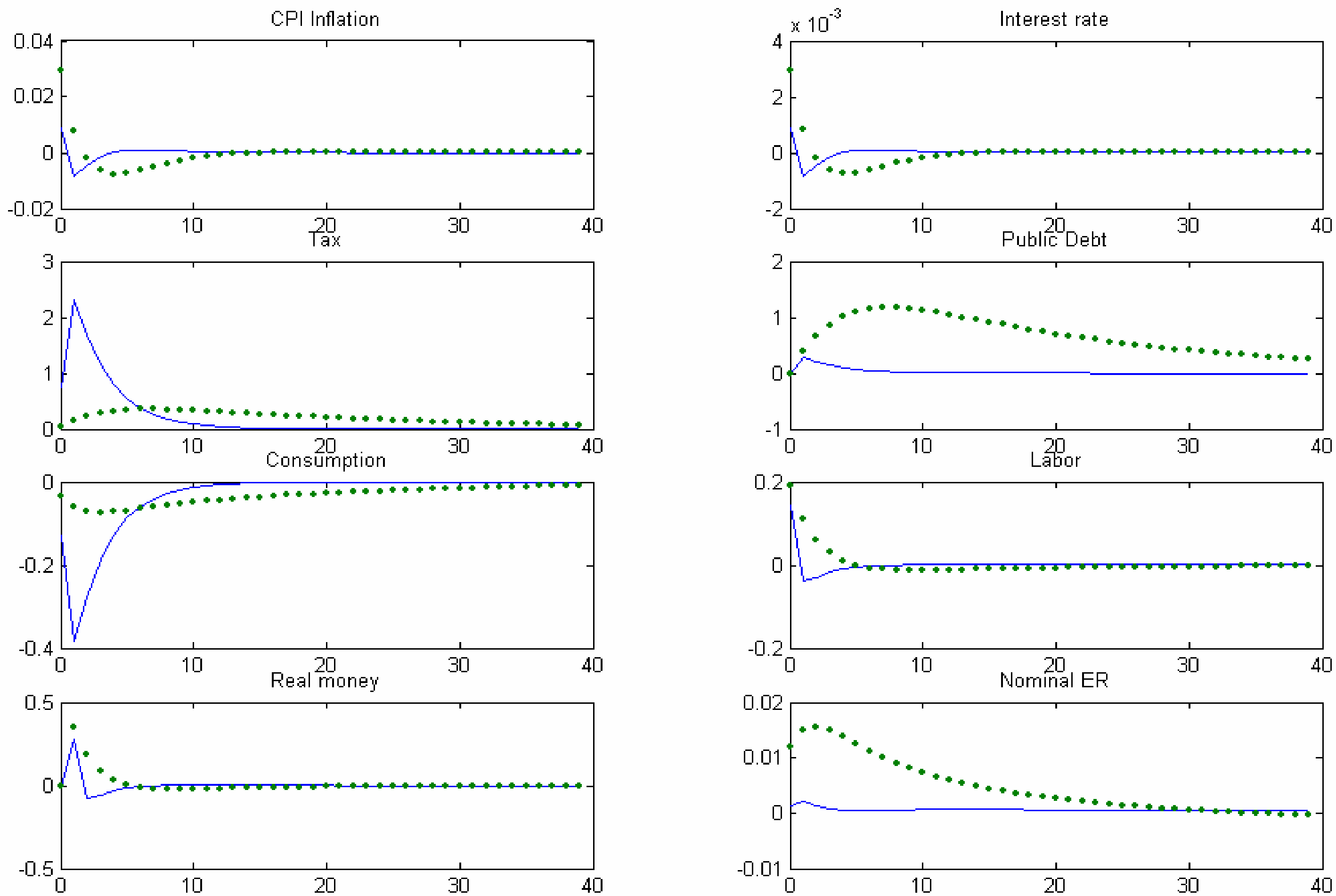
Note. see note to Figure 1.

Figure B.8. Government consumption shock under consumption tax based mixed rule: $\Omega_{\pi} = 3$. Percent deviations from steady state.



Note. Solid line: $\Omega_1 = 3$ and $\Omega_2 = 3$, dotted line: $\Omega_1 = 0.1$ and $\Omega_2 = 0.1$.

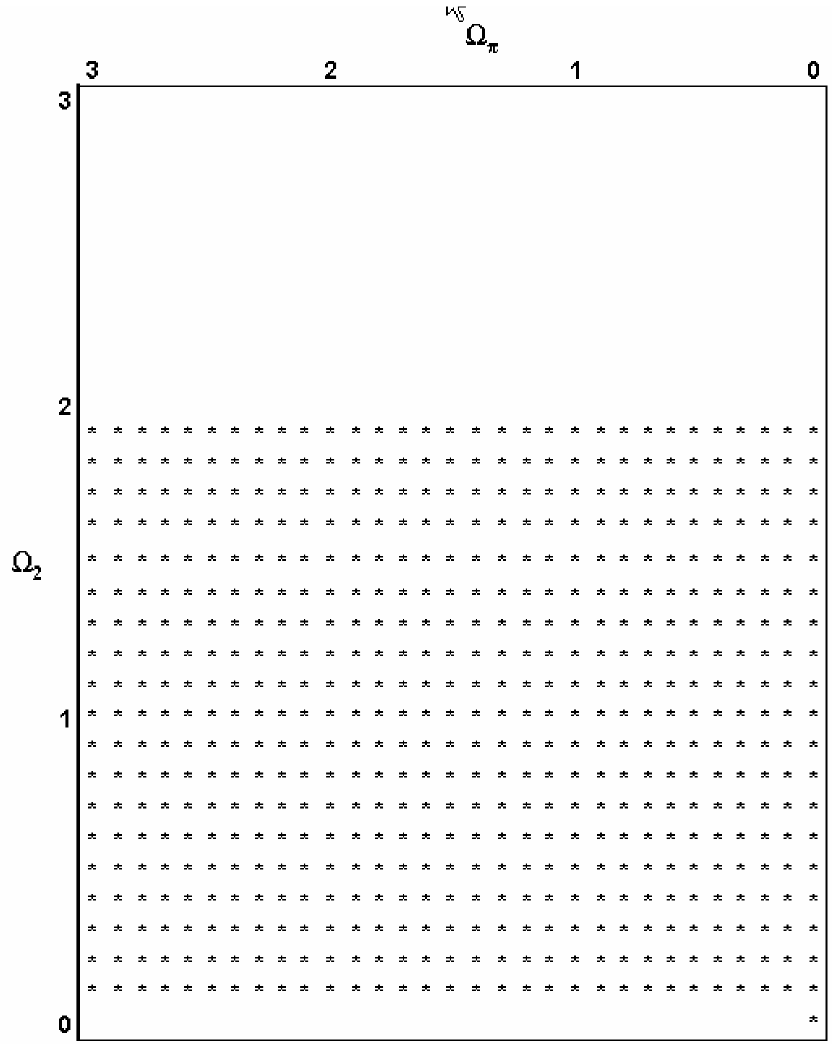
Figure B.9. Government consumption shock under consumption tax based mixed rule: $\Omega_\pi = 0.1$. Percent deviations from steady state.



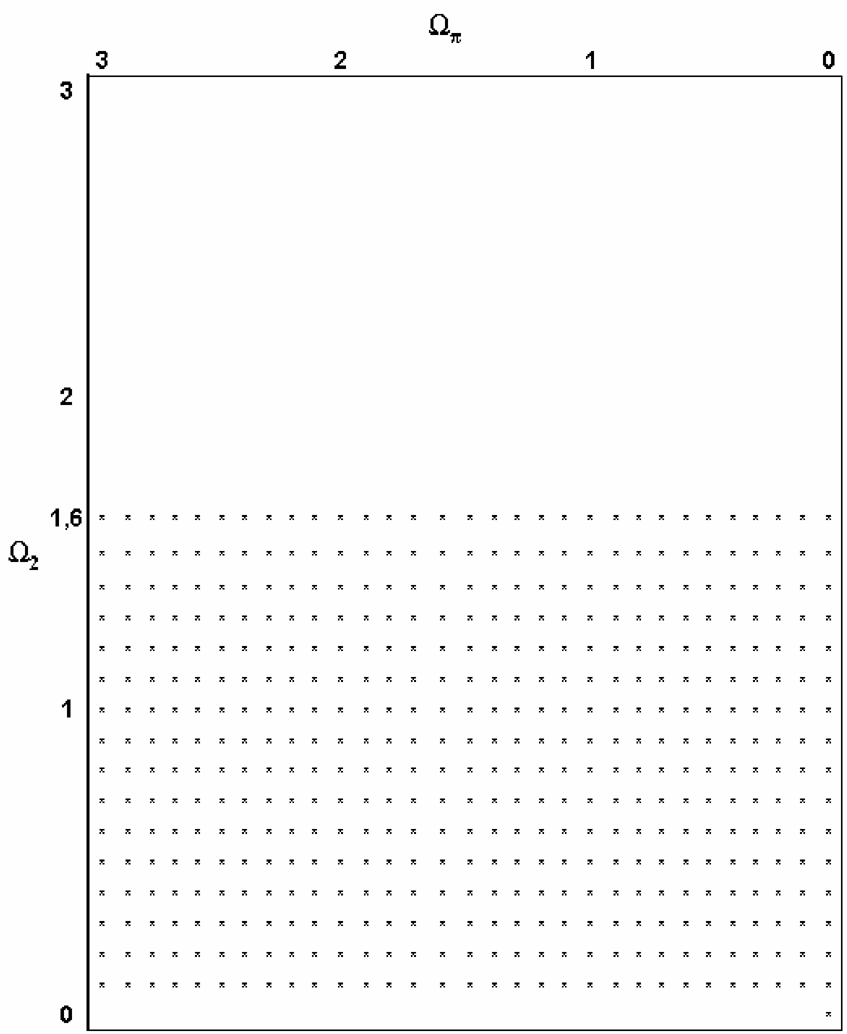
Note. Solid line: $\Omega_1 = 3$ and $\Omega_2 = 3$, dotted line: $\Omega_1 = 0.1$ and $\Omega_2 = 0.1$.

Figure B.10. Determinacy regions under the composite rule and inflation targeting: Ω_1=0.1

Panel A: Consumption Tax



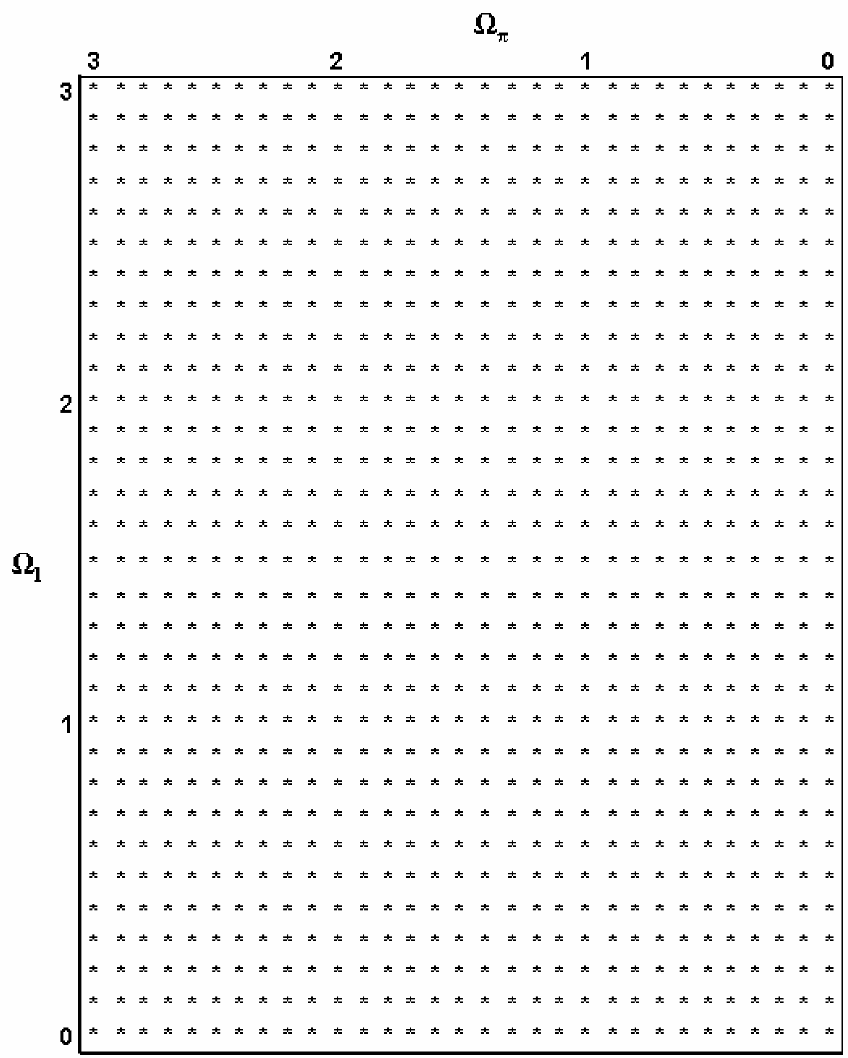
Panel B: Labor Income Tax



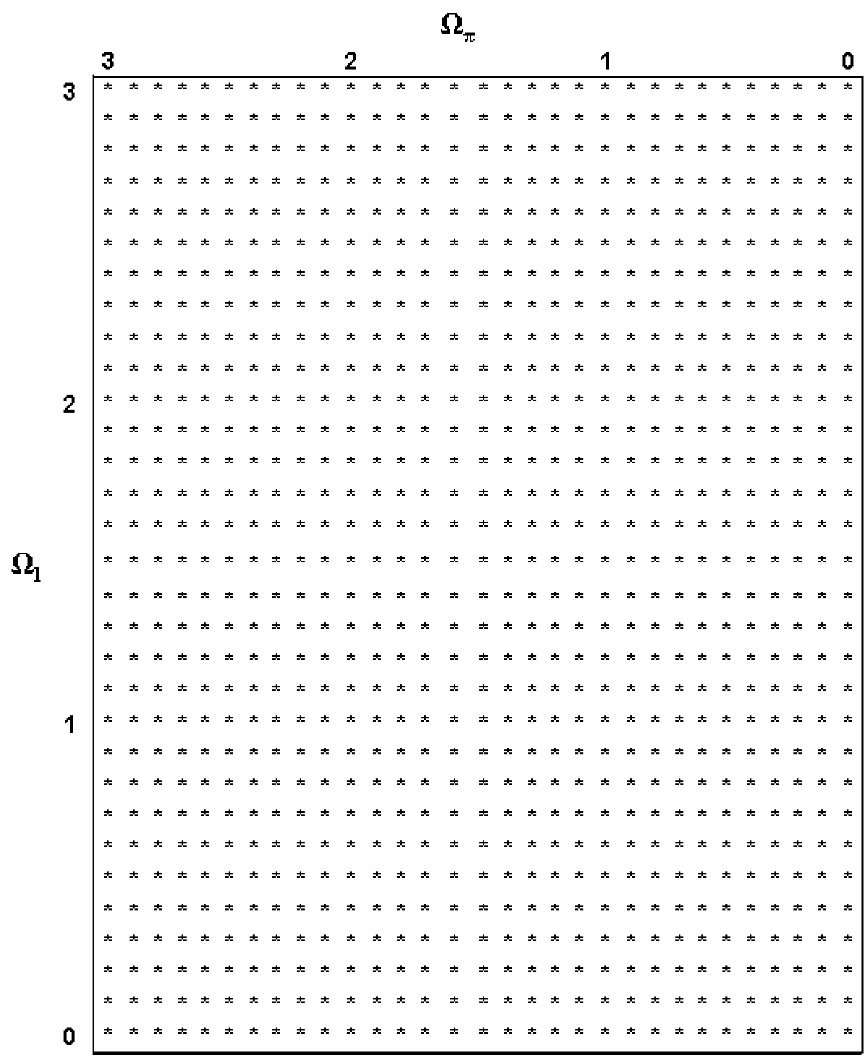
Note. see note to Figure B.1.

Figure B.11. Determinacy regions under the composite rule and inflation targeting: Ω_2=0.1

Panel A: Consumption Tax

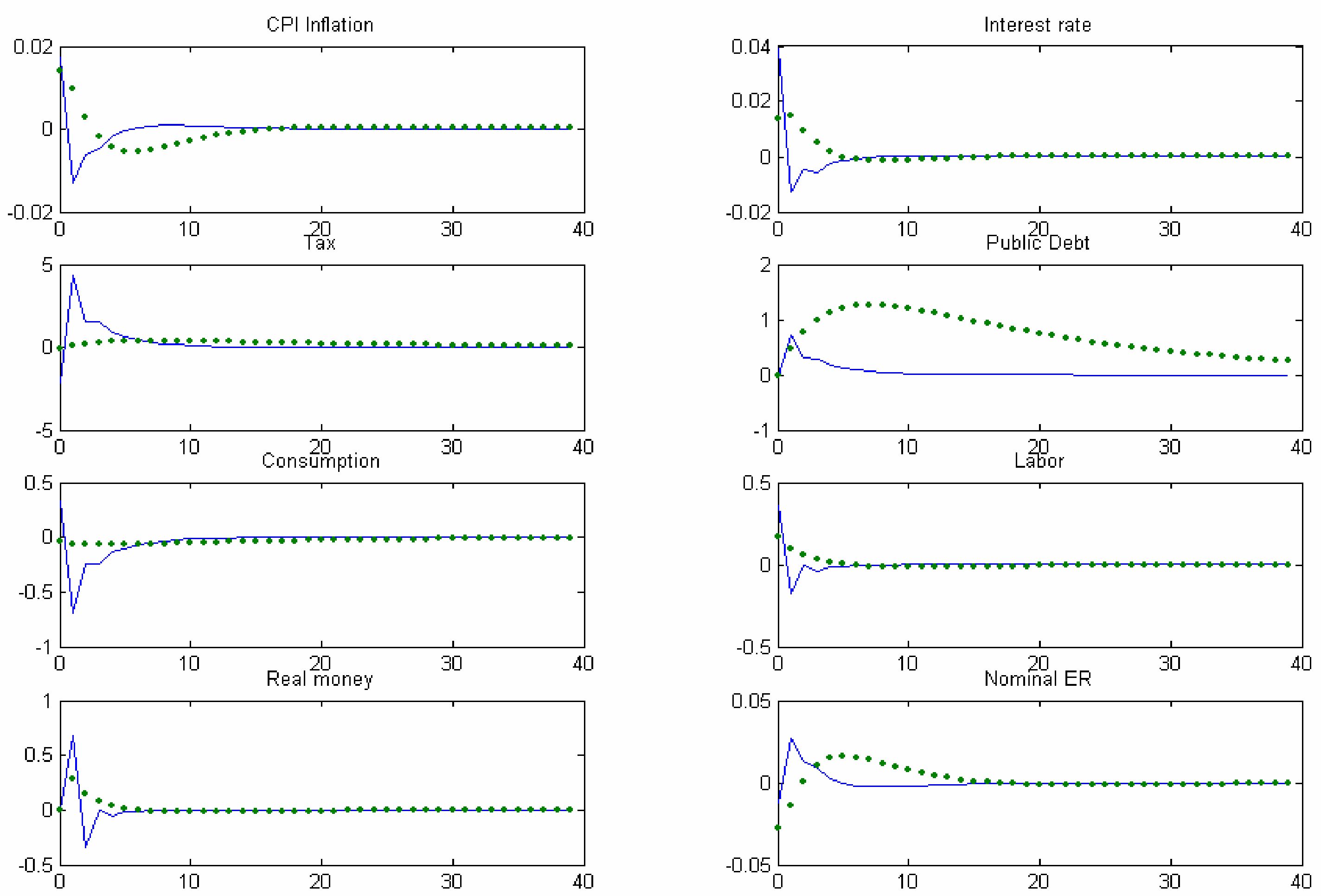


Panel B: Labor Income Tax



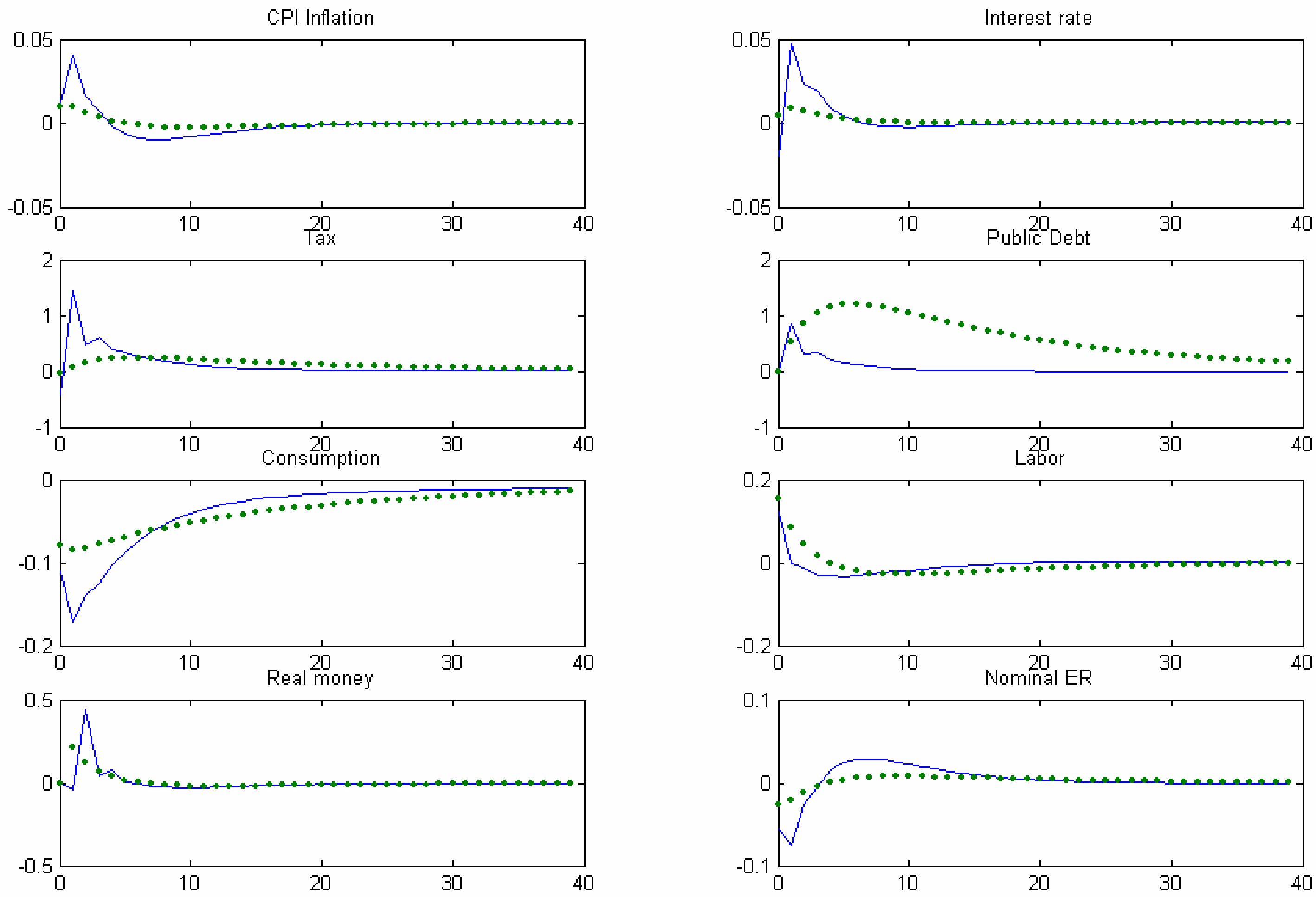
Note. see note to Figure B.1.

Figure B.12. Government consumption shock under consumption tax based debt rule and managed exchange regime. Percent deviations from steady state.



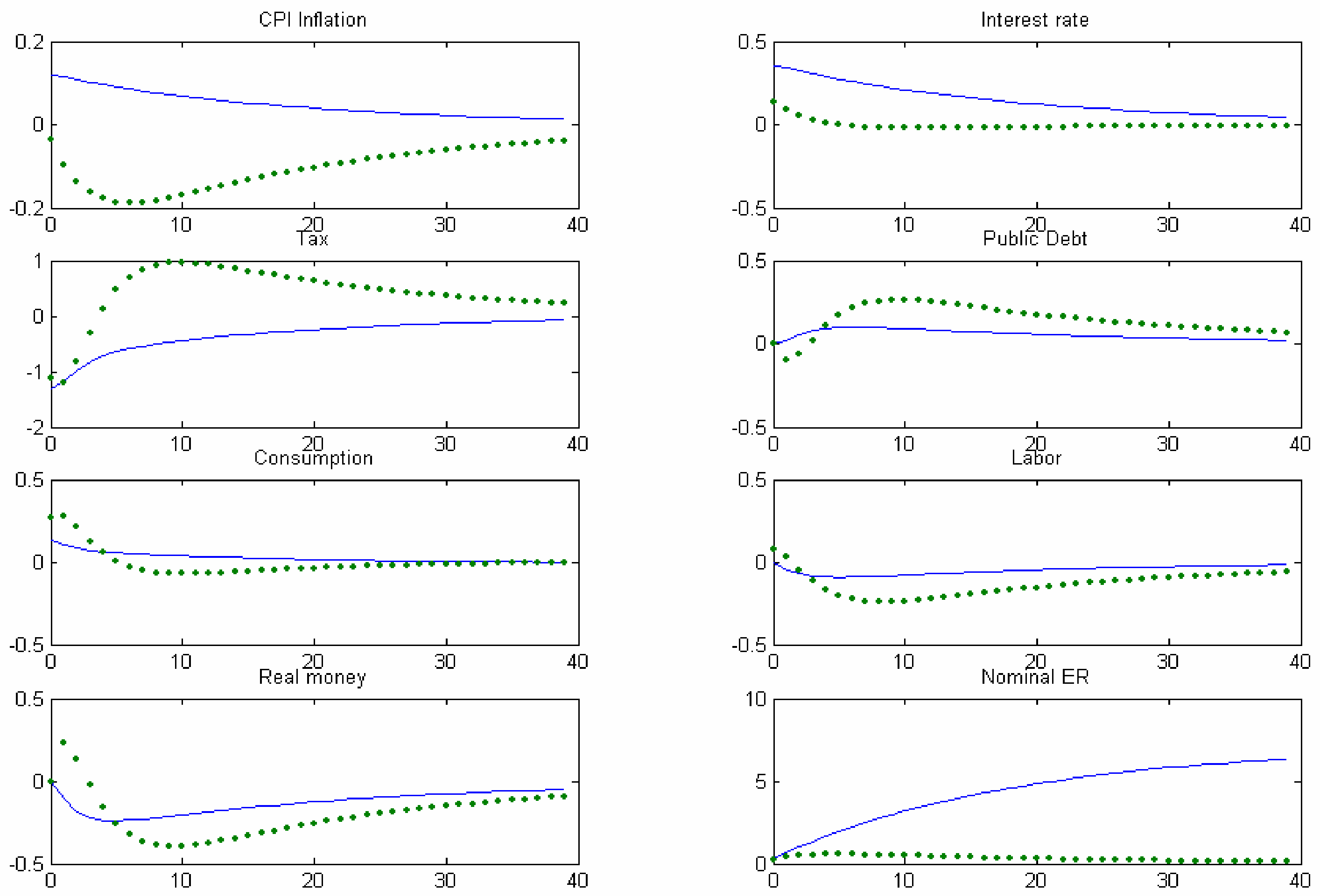
Note. Solid line: $\Omega_\pi = 3$ and $\Omega_2 = 1.5$, dotted line: $\Omega_\pi = 3$ and $\Omega_2 = 0.1$.

Figure B.13. Government consumption shock under labor tax based debt rule and managed exchange regime. Percent deviations from steady state.



Note. Solid line: $\Omega_\pi = 3$ and $\Omega_2 = 1$, dotted line: $\Omega_\pi = 3$ and $\Omega_2 = 0.1$.

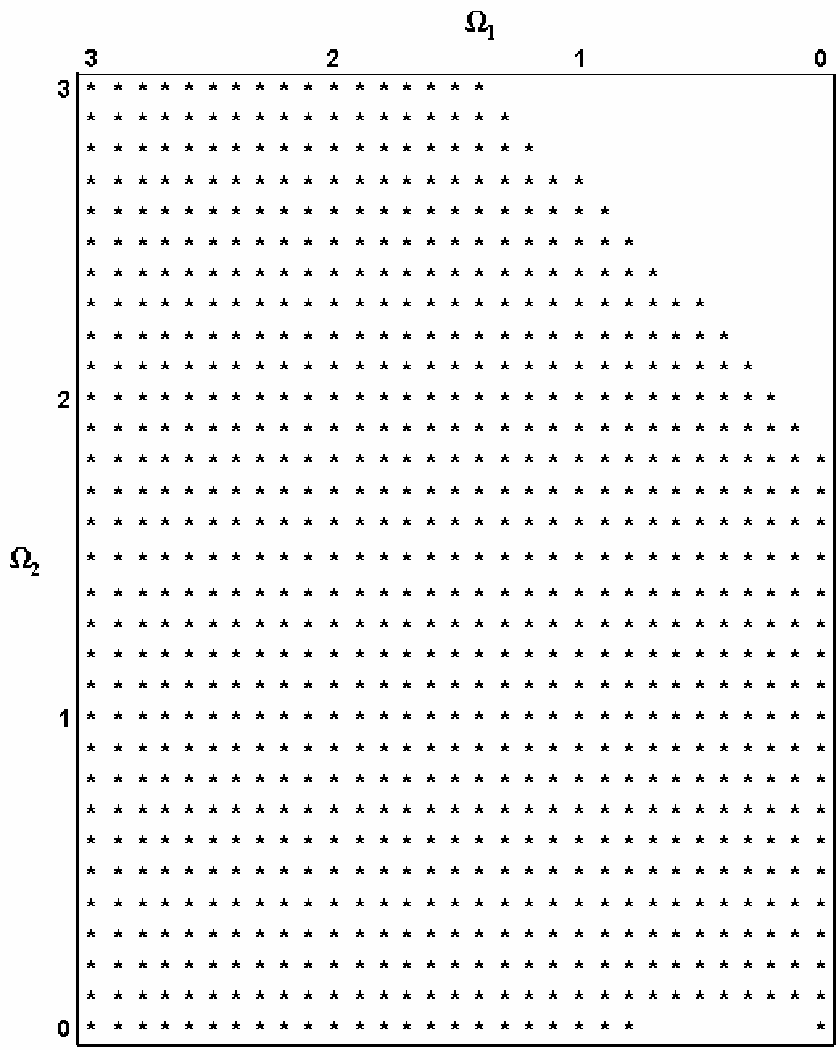
Figure B.14. One percent permanent tradable productivity shock under consumption tax based debt rule. Percent deviations from steady state.



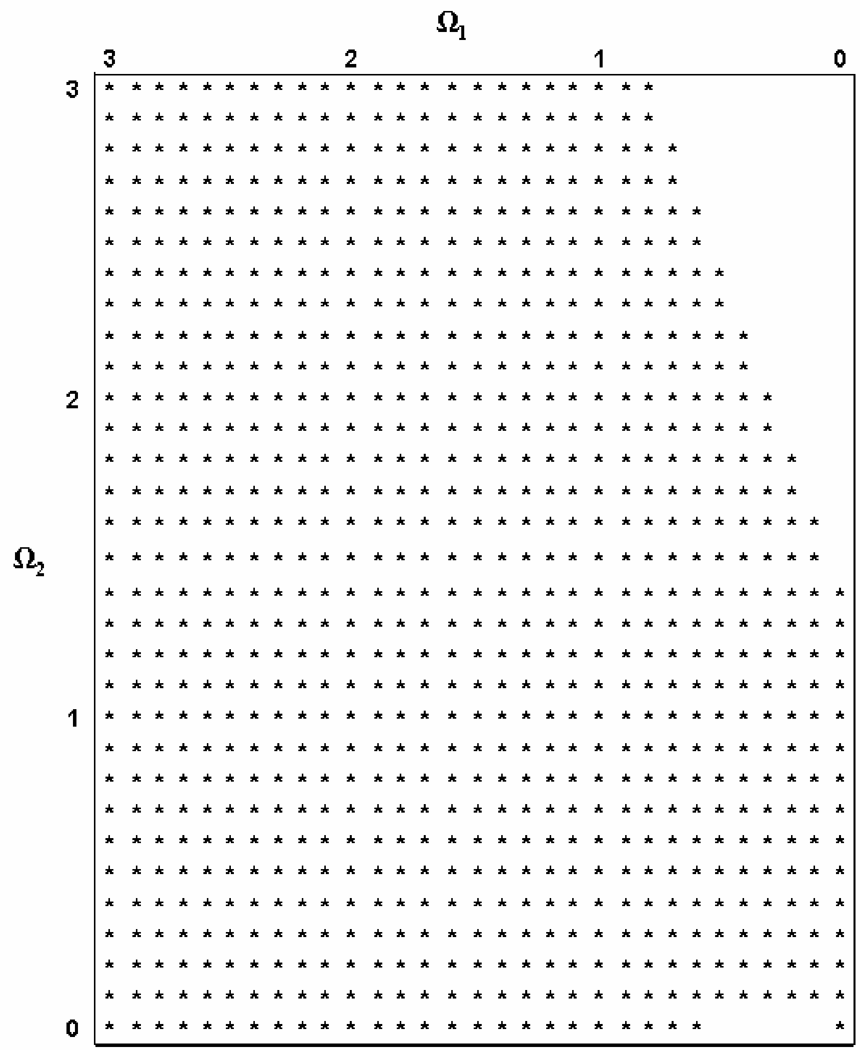
Note. Solid line: Inflation targeting with $\Omega_\pi = 3$ and $\Omega_2 = 1$, dotted line: Managed exchange rate regime with $\Omega_\pi = 3$ and $\Omega_2 = 1$.

Figure B.15. Determinacy regions under the composite rule and fixed exchange rate regime

Panel A: Consumption Tax

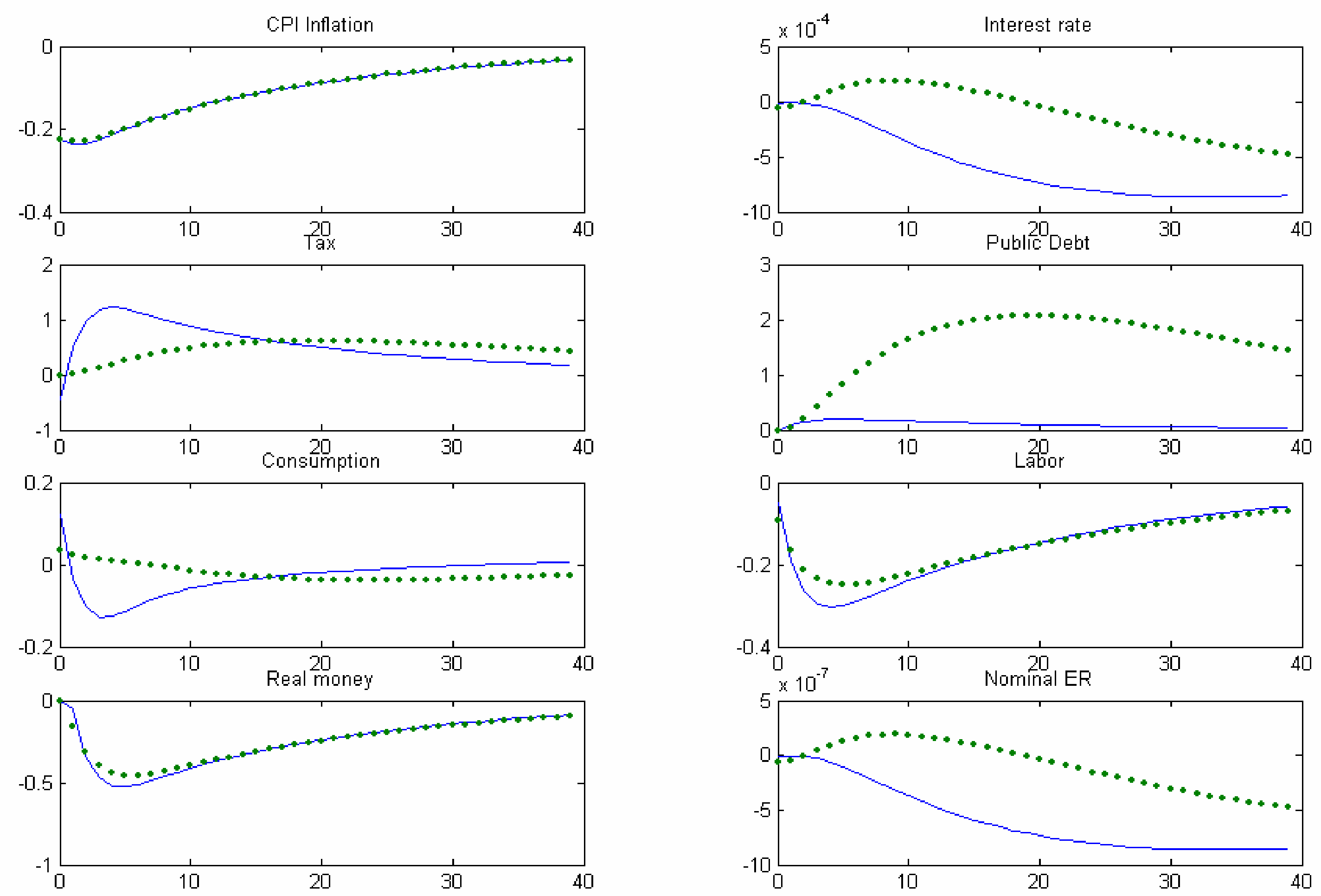


Panel B: Labor Income Tax



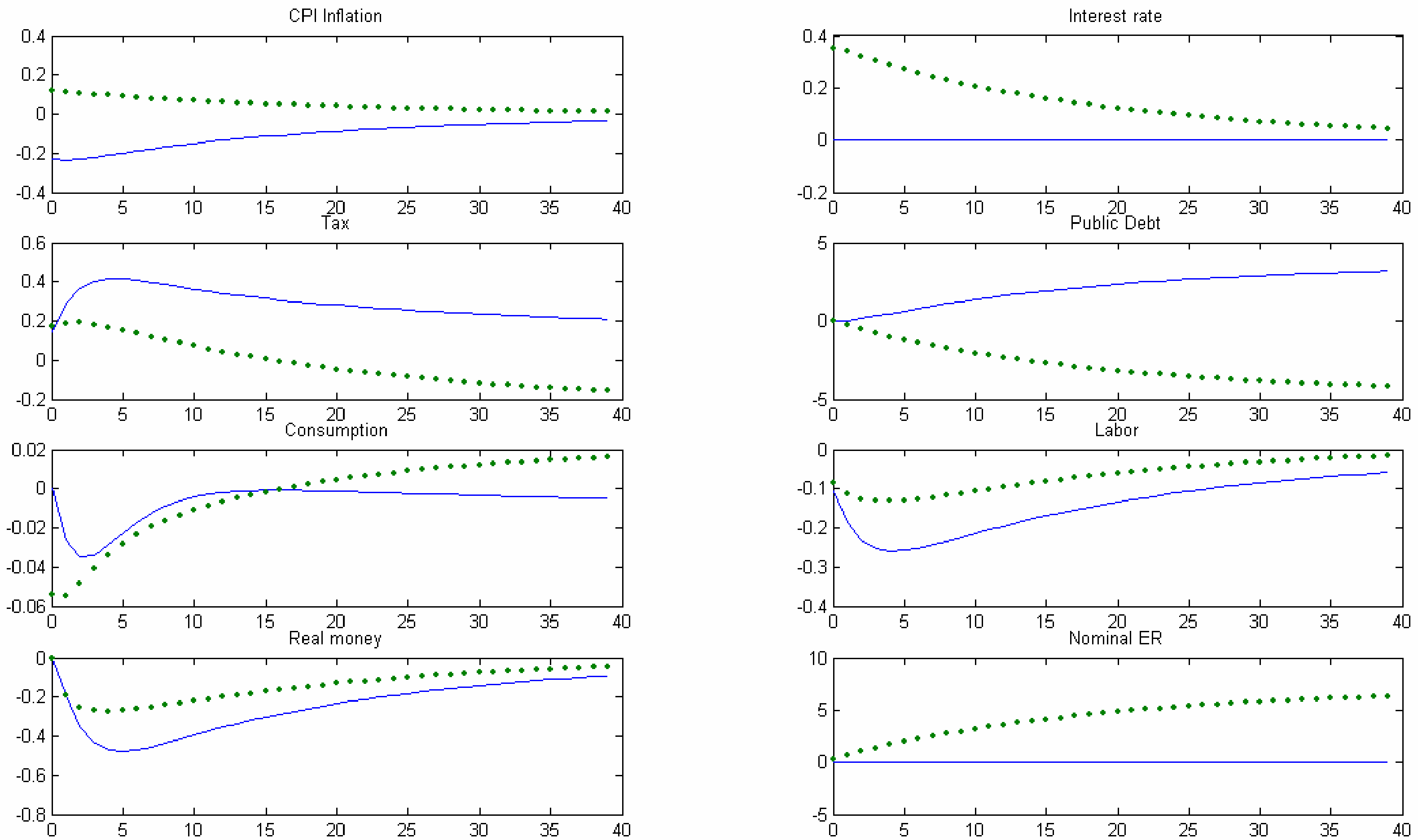
Note. see note to Figure B.1.

Figure B.16. One percent permanent tradable productivity shock under consumption tax based debt rule and fixed exchange regime. Percent deviations from steady state.



Note. Solid line: $\Omega_2 = 1.5$, dotted line: $\Omega_2 = 0.1$.

Figure B.17. One percent permanent tradable productivity shock under consumption tax based deficit rule: fixed exchange rate and inflation targeting regimes. Percent deviations from steady state.

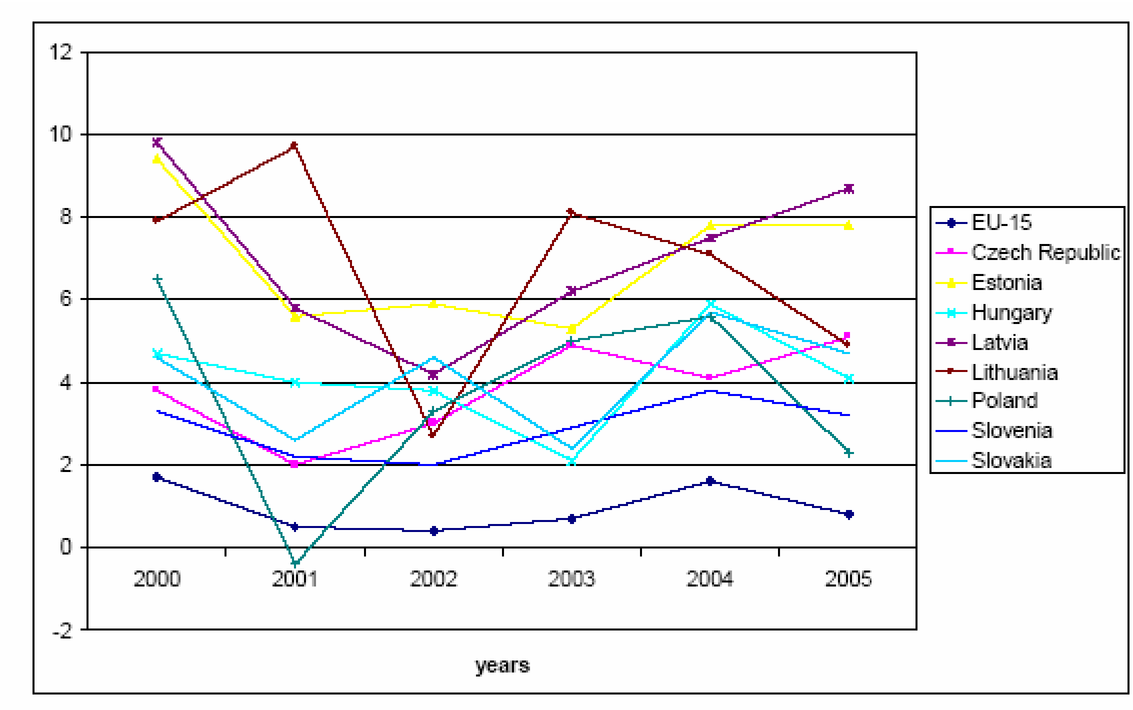


Note. Solid line: fixed exchange regime with $\Omega_1 = 0.8$, dotted line: inflation targeting with $\Omega_1 = 0.8$.

Appendix C

Appendix for Chapter 3

Figure C.1. Total annual labor productivity growth in new EU member states



Source: Lipinska (2007)

Table C.1. Structure of EU economies

countries	share on nontradables in consumption[1], %	share of imports in GDP[2], %
Czech Republic	42	68
Estonia	39	86
Hungary	44	71
Latvia	37	55
Lithuania	33	58
Poland	37	35
Slovenia	49	59
Slovakia	41	78
Average in the EU-15	51	63

Notes. 1 - average value for the period 2000 - 2005; 2 - average value for the period 2000 - 2007

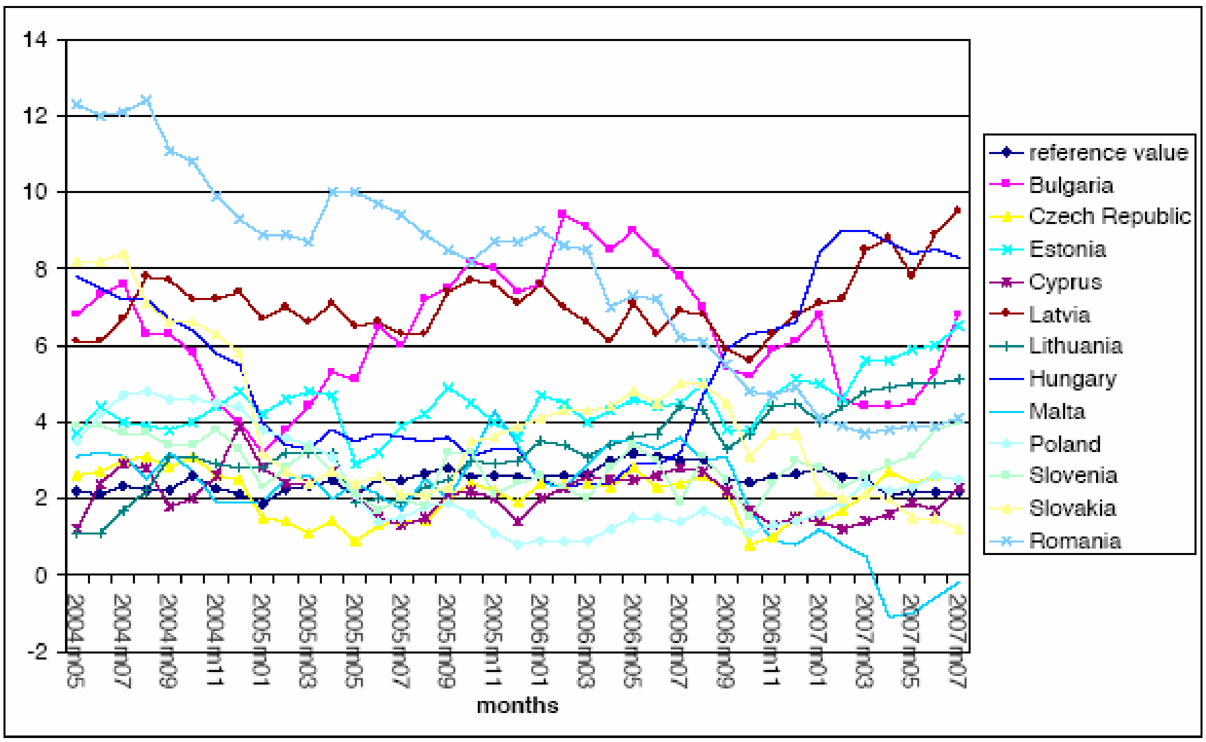
Source: Lipinska (2007)

Table C.2. Inflation Rate of EU economies: percent change compared with previous year, based on the harmonized index of consumer prices

	2004	2005	2006
Bulgaria	6.1	6.0	7.4
Czech Republic	2.6	1.6	2.1
Estonia	3.0	4.1	4.4
Cyprus	1.9	2.0	2.2
Latvia	6.2	6.9	6.6
Lithuania	1.2	2.7	3.8
Hungary	6.8	3.5	4.0
Malta	2.7	2.5	2.6
Poland	3.6	2.2	1.3
Slovenia	3.7	2.5	2.5
Slovakia	7.5	2.8	4.3
Euro area	2.1	2.2	2.2

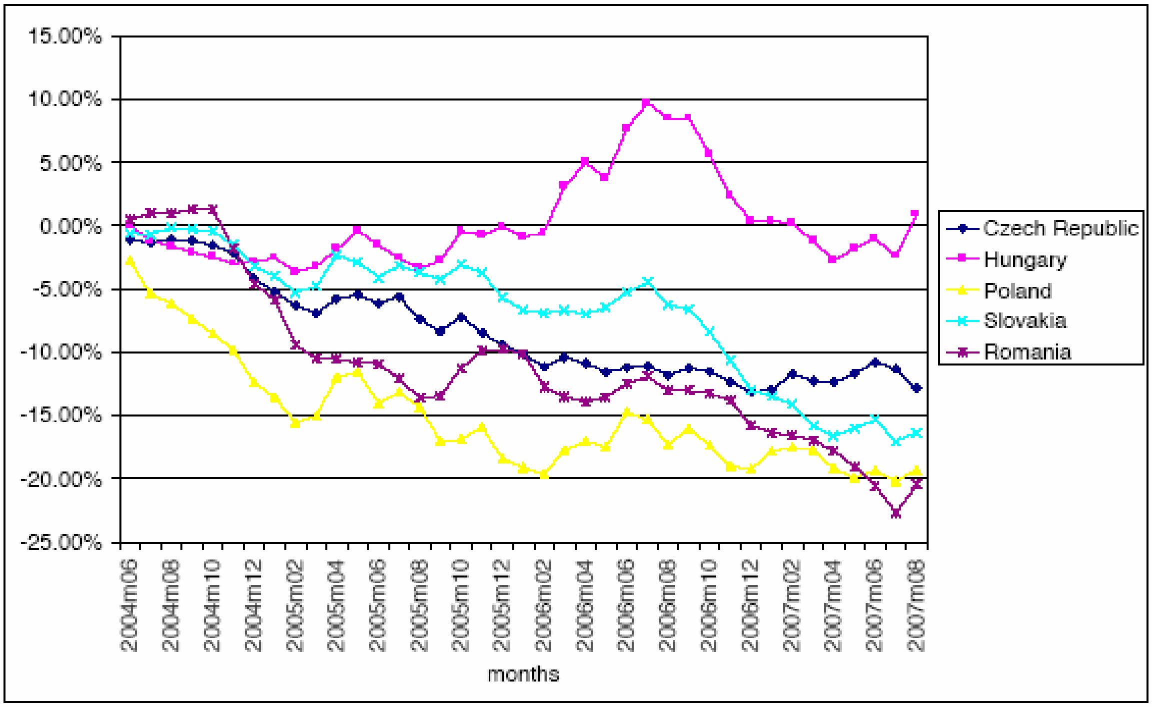
Source: Eurostat

Figure C.2. Inflation rates in the EMU accession countries



Source: Lipinska (2007)

Figure C.3. Nominal exchange rate fluctuations vs euro in the EMU accession countries



Source: Lipinska (2007)

Table C.3. Budget deficits in the EU economies

	2004	2005	2006	2007
Bulgaria	1.4	1.8	3.0	3.4
Czech Republic	-3.00	-3.6	-2.7	-1.6
Estonia	1.6	1.8	3.4	2.8
Cyprus	-4.1	-2.4	-1.2	3.3
Latvia	-1	-0.4	-0.2	0
Lithuania	-1.5	-0.5	-0.5	-1.2
Hungary	-6.5	-7.8	-9.2	-5.5
Malta	-4.6	-3	-2.6	-1.8
Poland	-5.7	-4.3	-3.8	-2
Slovenia	-2.3	-1.5	-1.2	-0.1
Slovakia	-2.4	-2.8	-3.6	-2.2

Notes. government surplus (+)/ government deficit (-)

Source: Eurostat

Table C.4. Government consolidated gross debt in the EU economies. Percent of GDP

	2004	2005	2006	2007
Bulgaria	37.9	29.2	22.7	18.2
Czech Republic	30.4	29.7	29.4	28.7
Estonia	5.1	4.5	4.2	3.4
Cyprus	70.2	69.1	64.8	59.8
Latvia	14.9	12.4	10.7	9.7
Lithuania	19.4	18.6	18.2	17.3
Hungary	59.4	61.6	65.6	66
Malta	72.6	70.4	64.2	62.6
Poland	45.7	47.1	47.6	45.2
Slovenia	27.6	27.5	27.2	24.1
Slovakia	41.4	34.2	30.4	29.4

Source: Eurostat

Table C.5. Unconditional statistics of selected variables under optimized policy coefficients.

	Debt Rule				Deficit Rule				Composite Rule			
	cons'n tax		labor tax		cons'n tax		labor tax		cons'n tax		labor tax	
	Means	Std.Dev	Means	Std.Dev	Means	Std.Dev	Means	Std.Dev	Means	Std.Dev	Means	Std.Dev
Infl'n targeting												
consumption	0.141	2.375	0.159	2.411	0.180	2.450	0.167	2.379	0.140	2.422	0.160	2.382
interest rate	0.003	0.626	0.001	0.693	0.003	0.596	0.001	0.676	0.003	0.617	0.001	0.718
CPI inflation	0.009	0.208	0.009	0.231	0.009	0.199	0.009	0.225	0.009	0.206	0.009	0.239
nontradable infl'n	0.011	0.224	0.011	0.205	0.011	0.237	0.011	0.205	0.011	0.228	0.011	0.195
tax rate	-0.248	3.268	-0.185	2.929	-0.792	3.261	-0.197	2.266	-0.246	3.278	-0.186	3.011
labor	-0.025	0.545	-0.022	0.585	0.009	0.655	-0.016	0.554	-0.025	0.561	-0.023	0.617
nominal ER	-23.852	43.657	-26.319	44.863	-23.692	43.484	-25.984	44.855	-23.755	43.591	-26.352	44.887
tradable infl'n	0.011	0.274	0.011	0.271	0.011	0.280	0.011	0.269	0.011	0.275	0.011	0.265
money	0.057	1.722	0.062	1.548	0.072	1.940	0.066	1.495	0.056	1.788	0.062	1.277
public debt	-0.382	4.554	0.047	0.923	-16.065	24.308	-1.738	6.611	-0.370	4.231	0.087	1.145
foreign borrowing	-5.248	6.304	-5.427	5.137	-5.252	5.882	-5.427	5.137	-5.242	6.305	-5.424	5.167
Managed float												
consumption	0.075	2.869	0.123	2.839	0.130	2.811	0.126	2.730	0.073	2.920	0.123	2.827
interest rate	-0.001	0.356	-0.005	0.403	-0.001	0.349	-0.004	0.389	-0.001	0.353	-0.005	0.413
CPI inflation	0.009	0.373	0.009	0.298	0.009	0.374	0.009	0.318	0.009	0.375	0.009	0.300
nontradable infl'n	0.011	0.586	0.011	0.455	0.011	0.594	0.011	0.490	0.011	0.590	0.011	0.451
tax rate	-0.248	6.104	-0.197	4.403	-0.913	4.722	-0.173	3.133	-0.242	6.023	-0.200	4.492
labor	0.001	0.440	-0.015	0.700	0.044	0.621	-0.005	0.586	0.001	0.480	-0.015	0.713
nominal ER	-0.028	1.185	-0.032	1.028	-0.029	1.172	-0.031	1.062	-0.028	1.184	-0.032	1.038
tradable infl'n	0.011	0.533	0.011	0.416	0.011	0.543	0.011	0.448	0.011	0.537	0.011	0.412
money	0.061	2.619	0.068	2.193	0.082	2.810	0.073	2.266	0.060	2.690	0.069	2.027
public debt	-0.577	8.884	0.036	0.814	-31.688	54.467	-2.011	9.041	-0.541	8.438	0.072	1.188
foreign borrowing	-5.097	6.868	-5.472	4.820	-5.142	5.886	-5.472	4.867	-5.090	6.863	-5.469	4.839
Fixed ERR												
consumption	0.001	3.395	0.084	3.222	0.027	3.411	0.082	3.113	-0.018	3.722	0.085	3.213
interest rate	-0.012	0.514	-0.015	0.517	-0.013	0.515	-0.015	0.517	-0.012	0.513	-0.015	0.517
CPI inflation	0.009	0.613	0.009	0.447	0.009	0.622	0.009	0.488	0.009	0.630	0.009	0.444
nontradable infl'n	0.011	0.798	0.011	0.573	0.011	0.809	0.011	0.627	0.011	0.823	0.011	0.569
tax rate	-0.186	7.916	-0.166	5.408	-0.469	6.532	-0.118	4.071	-0.200	8.613	-0.176	5.573
labor	0.020	0.987	-0.015	1.202	0.038	1.232	-0.003	1.097	0.019	1.240	-0.016	1.212
nominal ER	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001
tradable infl'n	0.011	0.741	0.011	0.529	0.011	0.753	0.011	0.581	0.011	0.762	0.011	0.525
money	0.054	4.123	0.072	3.117	0.055	4.491	0.075	3.282	0.038	4.556	0.073	2.954
public debt	-0.665	11.763	0.026	0.950	-32.749	69.961	-1.828	10.767	-0.492	9.677	0.053	0.871
foreign borrowing	-5.019	7.126	-5.506	4.667	-5.072	5.855	-5.506	4.709	-4.988	7.124	-5.503	4.685

Notes. Moments of all variables are relative deviations from steady state. All statistics are expressed in percentage terms.

Table C.6. Conditional welfare costs decomposition of optimal monetary and fiscal policy rules

	Inflation Targeting			Managed Float			Fixed ERR		
	λ	λ_{mean}	λ_{var}	λ	λ_{mean}	λ_{var}	λ	λ_{mean}	λ_{var}
Cons'n tax debt rule	0.0039	-0.0008	0.0047	0.0819	0.0751	0.0067	0.1684	0.1584	0.0101
Labor tax composite SGP rule	-0.0012	-0.0061	0.0049	0.0455	0.0386	0.0069	0.0904	0.0808	0.0095

Note. λ is computed relative to $\breve{\bar{V}}$.

Figure C.4. 1.7 percent permanent productivity shock under the optimized consumption based debt rule and inflation targeting. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.

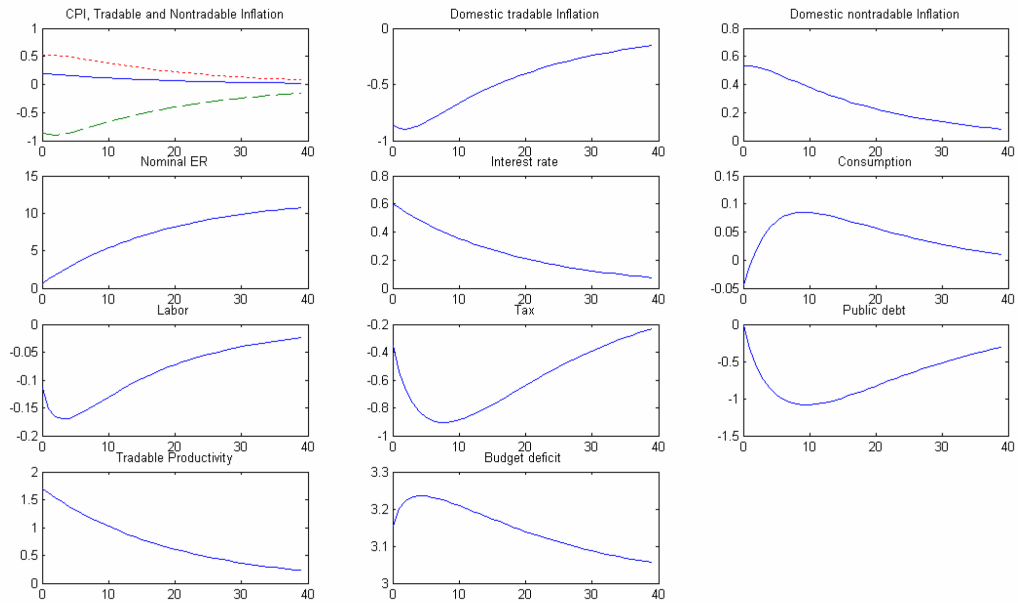


Figure C.5. 1.7 percent permanent productivity shock under the optimized labor tax based deficit rule and inflation targeting. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.

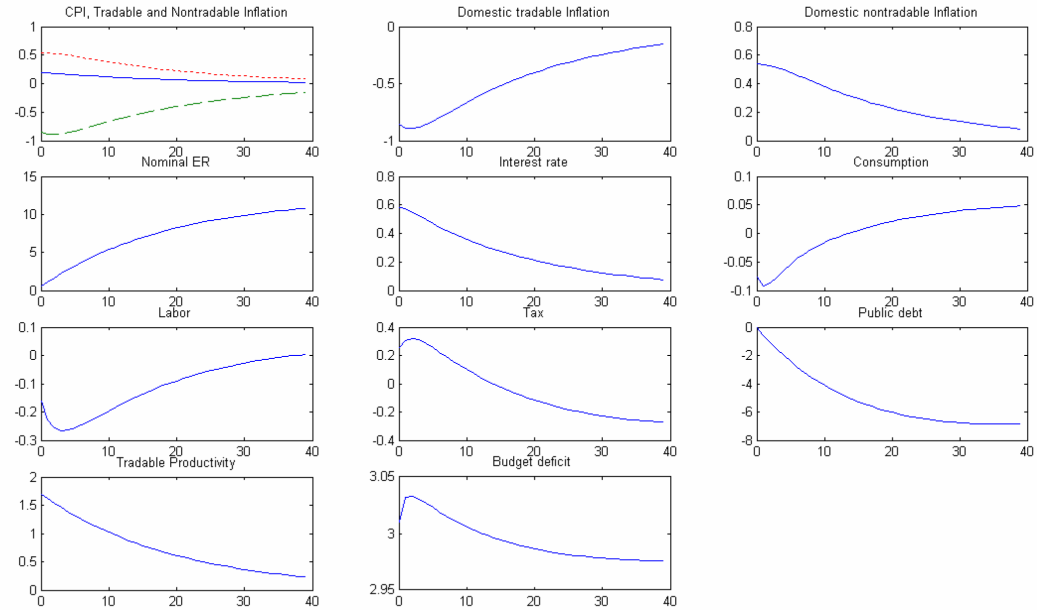


Figure C.6. 1.7 percent permanent productivity shock under labor tax based composite SGP rule and inflation targeting: $\Omega_{\pi} = 3, \Omega_1 = 2.1$ and $\Omega_2 = 3$. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.

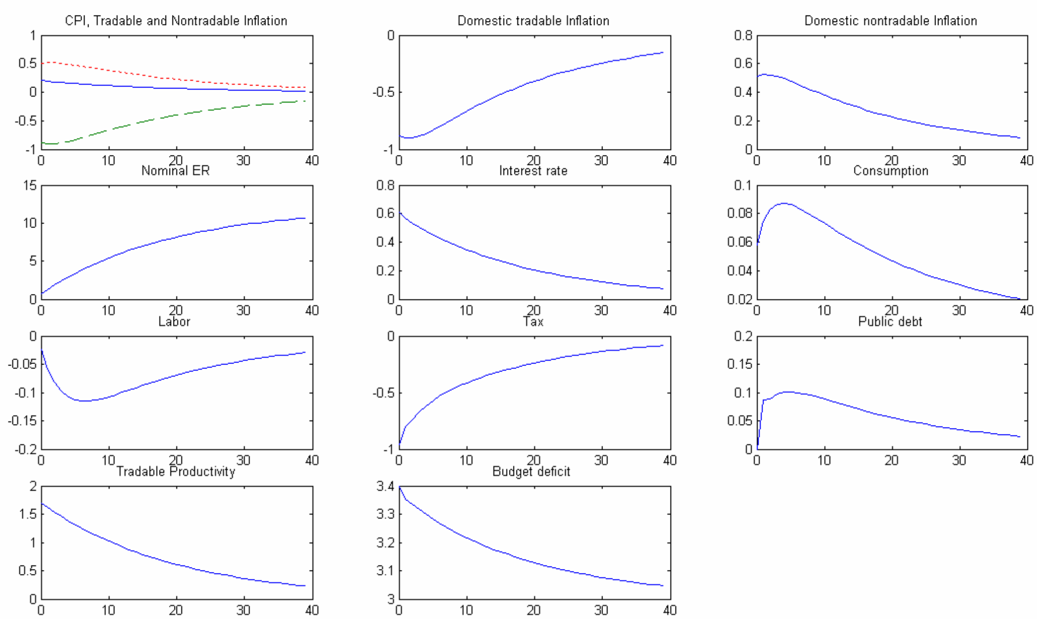


Figure C.7. 1.7 percent permanent productivity shock under the optimized consumption based debt rule and managed float. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.

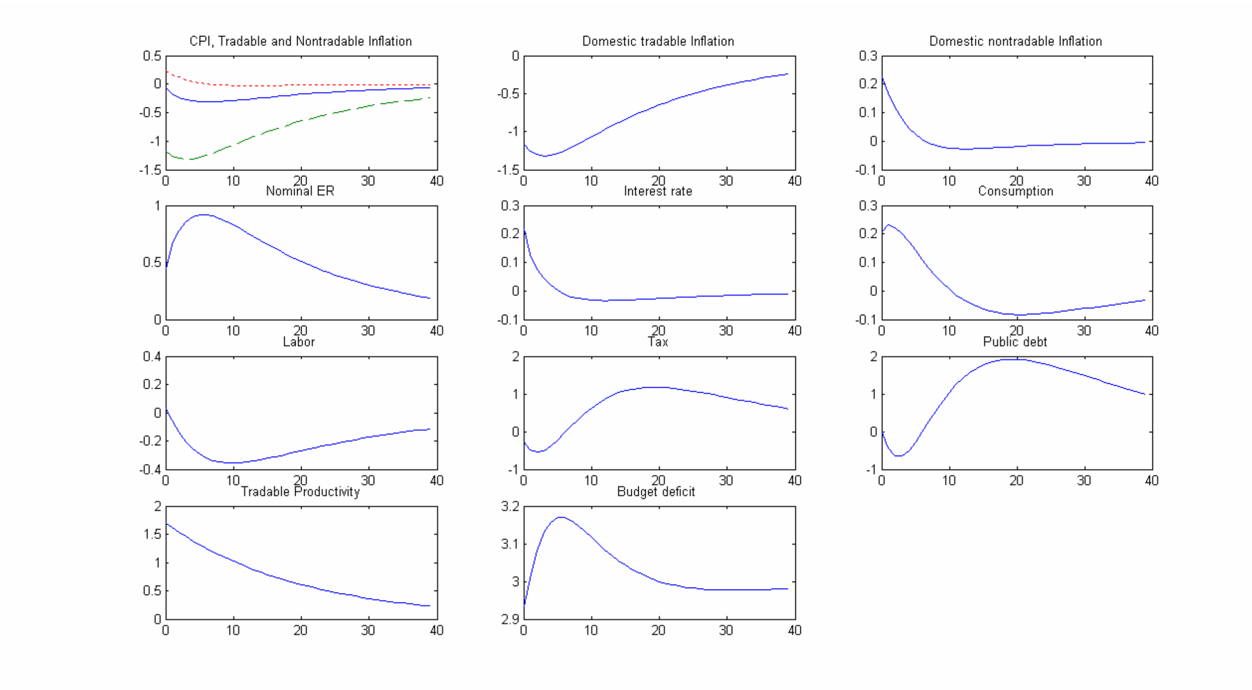


Figure C.8. 1.7 percent permanent productivity shock under the optimized consumption based deficit rule and managed float. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.

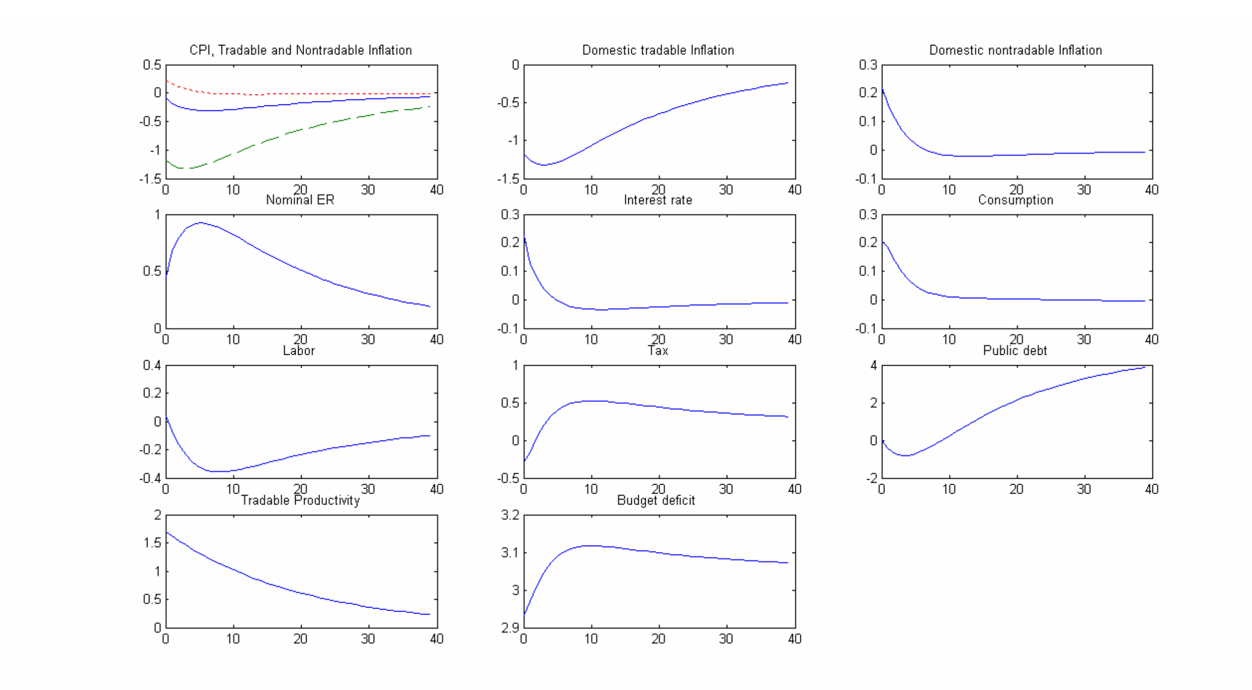


Figure C.9. 1.7 percent permanent productivity shock under the optimized labor based composite SGP rule and fixed exchange rate regime. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.

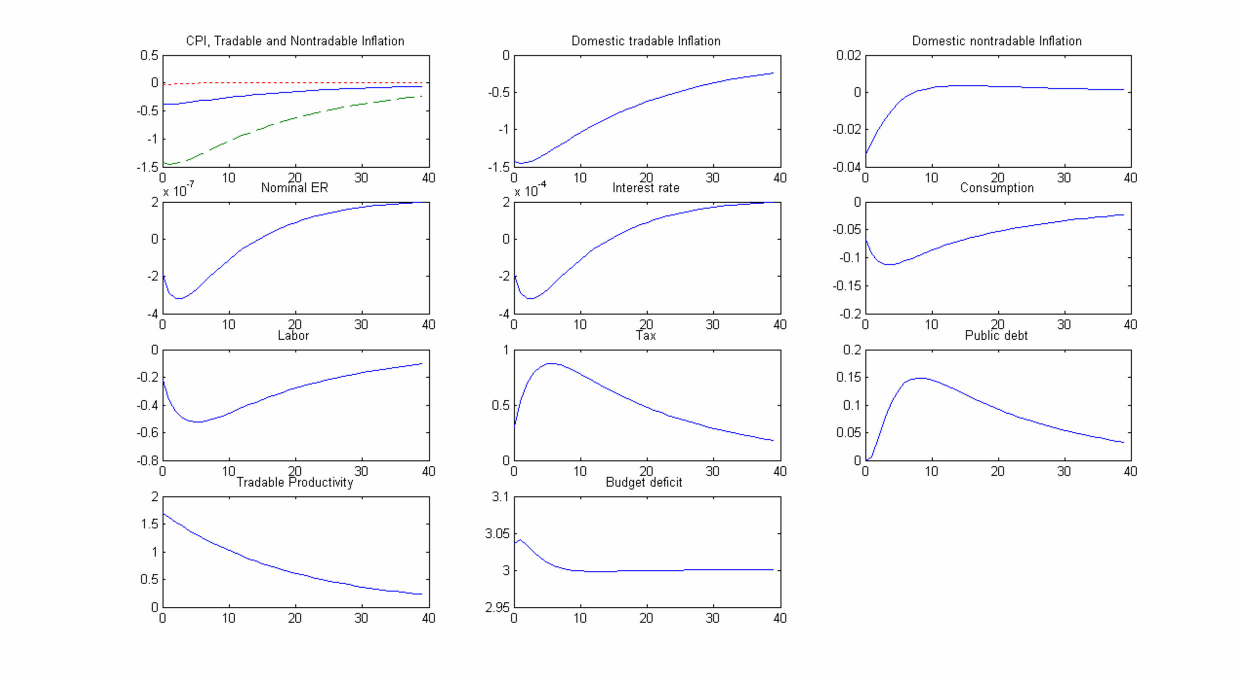
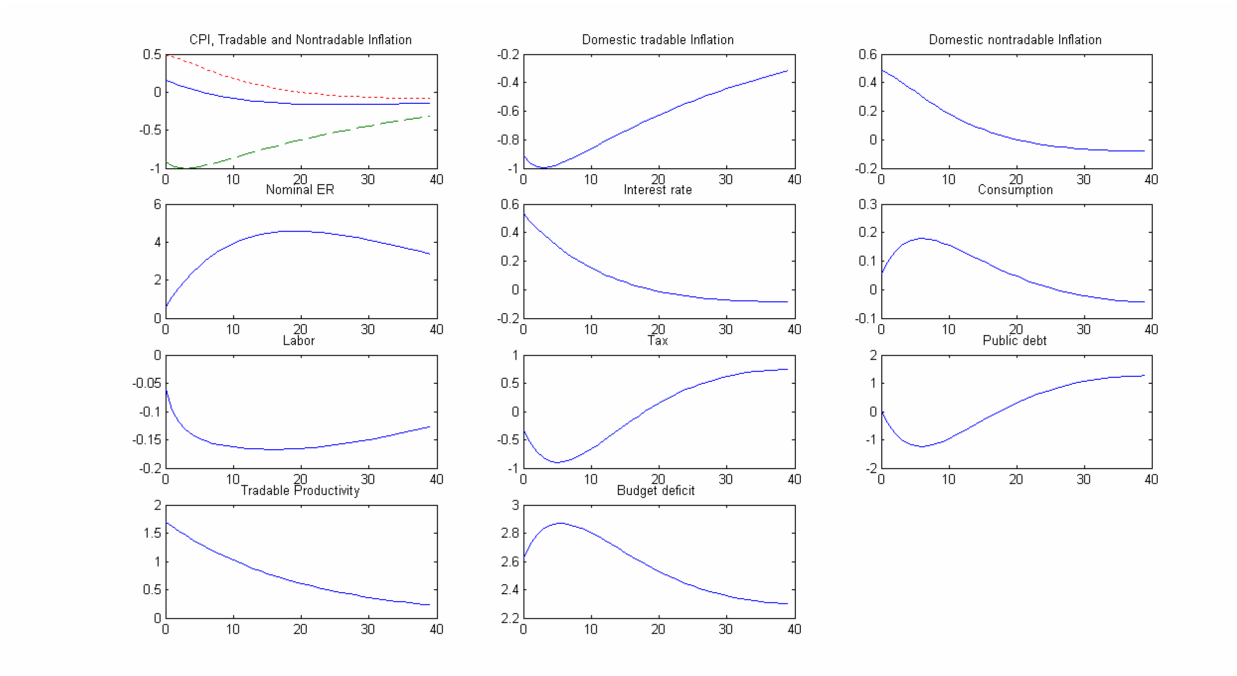


Figure C.10. 1.7 percent permanent productivity shock under the consumption based debt rule with $\Omega_\pi = 3, \Omega_e = 0.1$ and $\Omega_2 = 0.2$. Percent deviations from steady state, except for the budget deficit, which is in absolute terms. Time is in quarters.



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