Trade and Optimal Monetary Policy *

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Abstract

Using a stochastic business cycle model of a small open economy we ask how the problem of the optimizing policy-maker changes endogenously as the international trade structure is altered. From input-output data for OECD and emerging market economies, we document that differences in trade across countries are substantial, and that the composition of trade varies as much as openness to trade. The trade and production structures examined in our theoretical model easily map into measurable macroeconomic characteristics of countries. Our results are as follows. First, the traditional imports to GDP ratio turns out to be close to irrelevant for the ranking of monetary policies. Second, the composition of imports has a very substantial impact on welfare. Given the same degree of openness, the exchange rate peg is more inefficient if the bias towards non-tradable goods is high, and less inefficient if the share of imported intermediates is low. That is, open countries engaging in much vertical trade find it more costly to peg the exchange rate. Third, while a stylized regularity of emerging market economies is the very high share of imported capital goods, compared with industrial countries, this turns out to have no impact on the welfare result. Fourth, local currency pricing has a muted impact . This is the consequence of two assumptions: the existence of a long chain of substitutability in demanded goods, and the mobility of labor across sectors, so that imported inputs affect factor prices in all sectors directly, rather than through general equilibrium effects.

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1 Introduction

Small open economies can differ along many dimensions, and economists have carefully investigated how a vast number of these dimensions affect the choice of exchange rate regime. The list is long and ranges from the credibility of policy-making institutions (Giavazzi and Pagano, 1988) to the currency denomination of the external debt (Mendoza, 2001, Calvo and Rheinart, 2002), the substitutability of domestic and imported intermediate goods (Shi and Xu, 2008), the currency denomination of external trade (Devereux and Engel, 2002).

Most of the arguments suggested in the literature rely on the extent of trade carried between the small open economy and the rest of the world. In fact the very argument suggested by Mundell (1961) and Friedman (1953) in support of flexible exchange rates rests on the idea that the trade and production structure of an economy make the terms of trade an important price for the welfare of the household.

In this paper we investigate how international trade affects monetary policy. We ask how the technology and preference constraints defining the trade relationships between an economy and the rest of the world, and the structure of goods and production inputs' markets, affect the choice of an optimal monetary policy. We document that differences in trade across countries (especially EME and OECD countries) are substantial, and that the composition of trade varies as much as openness to trade. Our business cycle model has a simple structure but a broad enough array of goods, so that it can explain different policies observed across countries as the endogenous response to different trade structure. While our model is not simple enough to derive analytical results, we show how to dissect the numerical results to illustrate through which channels the welfare impact of the trade structure works.

Questions that can be answered in our framework include: What is the benefit of exchange rate flexibility as the trade structure changes? Can we build a measure of 'openness' which is correlated with the welfare benefit from stabilizing the exchange rate? What are the dimensions of 'openness' of an economy that matter in the choice of the optimal policy? How does trade structure affect the incentives to join a currency union?

The relevance of the trade dimension for the choice of policy is highlighted by a vast literature on growth and international trade. Stylized differences among emerging and developed economies include: 1) the factor intensity in production; 2) the larger share of imported capital goods in emerging economies, and the correlated higher price of capital (Eaton and Kortum, 2001); 3) the difference in investment composition (Caselli and Wilson, 2004); 4) the amount of vertical trade - import of intermediates geared towards the export of finished goods.

Our methodology is aimed at providing policy-relevant prescriptions. Analytical methods widely used in the literature, which proved useful to analyze closed economies, can under very restrictive assumptions at best characterize the *optimal* policy in open economies. They are completely silent on the welfare cost of any alternative, sub-optimal policy. Using a second-order approximation to the solution of the Ramsey problem to numerically compute the welfare

level, we can compare the gain from optimal policy relative to simple rules. If sub-optimal policies carry a very low welfare penalty, the costs of creating incentives for policy-makers to implement exactly the optimal policy (such as changing policy-making institutions or creating monetary unions) may be unjustified.

Our results show that the trade and production structure affects welfare through three different channels: the exposure of the economy to foreign business cycle shocks, the size of the sector where rigidities constrain the choice of firms and households in the disaggregated equilibrium, and, most importantly, the substitutability between alternative consumption goods and factor inputs, and its impact on the propagation mechanism. The welfare implications of alternative technology and preference constraints easily map into measurable macroeconomic characteristics of countries. First, the traditional imports to GDP ratio turns out to be close to irrelevant for the ranking of monetary policies. Second, the composition of imports has a very substantial impact on welfare. Given the same degree of openness, the exchange rate peg is more inefficient if the bias towards non-tradable goods is high, and less inefficient if the share of imported intermediates is low. That is, open countries engaging in much vertical trade find it more costly to peg the exchange rate. Third, while a stylized regularity of emerging market economies is the very high share of imported capital goods, compared with industrial countries, this turns out to have no impact on the welfare result. Fourth, local currency pricing has a muted impact . This is the consequence of two assumptions: the existence of a long chain of substitutability in demanded goods, and the mobility of labor across sectors, so that imported inputs affect factor prices in all sectors directly, rather than through general equilibrium effects.

1.1 Related literature

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2 Trade and Production Structure across Countries

We use the OECD input-output tables for the year 2000 to classify goods as tradeable or non-tradeable, and to measure according to our classification the composition of domestic absorption. We follow Betts and Kehoe [(5)] and Bems [(4)] by assuming that the wholesale and retail sector produces non-tradable goods. Any other sector whose share of export plus import relative to its gross output is smaller or equal than that of the wholesale and retail sector is assumed to produce non-tradeable goods. We apply this methodology to eleven countries: Czech France,Germany, Italy, Spain, Czech Republic, Hungary, Poland, Slovak Republic, Canada, Brasil and USA. The first four countries are among the founding members of the Euro Area. The second set of four countries have joined the European Union in 2004 and have only recently or will soon join

the Euro Area (the Slovak Republic joined in January 2009). Finally the last set of three countries provide examples of two non-European large advanced economies and a non-European emerging economy (Brasil).

Tables 1 to 3 show our classification for intermediate inputs, consumption and investment.[1]. From the input-output tables we are also able to measure the degree of openness of each country as well as the composition of import. Table 5 divides total import (as a share of GDP) into its main components: Intermediates, consumption and investment.

3 The Model

We build a model of a small open economy along the lines of Obstfeld and Rogoff (39), Devereux (20) (21), Devereux and Lane (23), Gali and Monacelli (28).

The small open economy produces a non-tradable good (N) and a domestic tradable good (H). The latter is also produced abroad and its price is exogenously determined in the world market. Consumers work in both production sectors. Their preferences are defined over a basket of tradable (T) and non-tradable (N) goods. The tradable good basket includes two goods: a foreign good (F), that must be imported, and the domestic good (H). Consumers can save by holding real money balances and domestic/foreign nominal bonds. As in Kim and Yun (1996), the aggregate capital stock is fixed, and capital can costlessly be allocated among firms. The domestic tradable sector H uses domestic value added - a Cobb-Douglas aggregate of labor and capital - and an imported intermediate input. Output in the N sector is obtained combining labor and capital. To introduce a role for monetary policy, we assume nominal price-rigidities in the non-tradable sector.

The model is meant to capture some important features of many emerging markets small open economies: a high share of imported intermediates, a high share of imported capital goods, a low share of consumption imported good while at the same time allowing for a large fraction of domestically demanded goods to be exposed to foreign competition, and be priced on international markets.

3.1 Consumption, Investment, and Price Composites

Household preferences are defined over the index C_t, a composite of non-tradable and tradable good consumption, $C_{N,t}$ and $C_{T,t}$ respectively:

$$C_t = \left[(\gamma_{cn})^{\frac{1}{\rho_{cn}}} (C_{N,t})^{\frac{\rho_{cn}-1}{\rho_{cn}}} + (1-\gamma_{cn})^{\frac{1}{\rho_{cn}}} (C_{T,t})^{\frac{\rho_{cn}-1}{\rho_{cn}}} \right]^{\frac{\rho_{cn}}{\rho_{cn}-1}} \quad (1)$$

where $0 \leq \gamma_{cn} \leq 1$ is the share of the N good and $\rho_{cn} > 0$ is the elasticity of substitution between N and T goods. The tradable consumption good is a

[1]The tradable content of Government expenditures turned out to be negligible as shown in 5

composite of home and foreign tradable goods, $C_{H,t}$ and $C_{F,t}$, respectively:

$$C_{T,t} = \left[(\gamma_{ch})^{\frac{1}{\rho_{ch}}} (C_{H,t})^{\frac{\rho_{ch}-1}{\rho_{ch}}} + (1-\gamma_{ch})^{\frac{1}{\rho_{ch}}} (C_{F,t})^{\frac{\rho_{ch}-1}{\rho_{ch}}} \right]^{\frac{\rho_{ch}}{\rho_{ch}-1}} \tag{2}$$

where $0 \leq \gamma_{ch} \leq 1$ is the share of the H good and $\rho_{ch} > 0$ is the elasticity of substitution between H and F goods. The non-tradable consumption good N is an aggregate defined over a continuum of differentiated goods:

$$C_{N,t} = \left[\int_0^1 C_{N,t}^{\frac{\varrho-1}{\varrho}}(z)dz \right]^{\frac{\varrho}{\varrho-1}} \tag{3}$$

with $\varrho > 1$. Investment in the non-tradable and domestic tradable sector is defined in a similar manner - a composite of N, H, and F goods. However, we assume that shares and elasticities may differ from those of the consumption composites (the superscript J refers to the sector):

$$I_t^J = \left[(\gamma_{in})^{\frac{1}{\rho_{in}}} \left(I_{N,t}^J\right)^{\frac{\rho_{in}-1}{\rho_{in}}} + (1-\gamma_{in})^{\frac{1}{\rho_{in}}} \left(I_{T,t}^J\right)^{\frac{\rho_{in}-1}{\rho_{in}}} \right]^{\frac{\rho_{in}}{\rho_{in}-1}}, J = N, H \tag{4}$$

$$I_{T,t}^J = \left[(\gamma_{ih})^{\frac{1}{\rho_{ih}}} \left(I_{H,t}^J\right)^{\frac{\rho_{ih}-1}{\rho_{ih}}} + (1-\gamma_{ih})^{\frac{1}{\rho_{ih}}} \left(I_{F,t}^J\right)^{\frac{\rho_{ih}-1}{\rho_{ih}}} \right]^{\frac{\rho_{ih}}{\rho_{ih}-1}}, J = N, H \tag{5}$$

$$I_{N,t}^J = \left[\int_0^1 \left(I_{N,t}^J\right)^{\frac{\varrho-1}{\varrho}}(z)dz \right]^{\frac{\varrho}{\varrho-1}} \tag{6}$$

Households' demand functions imply that the composite good price indices can be written as:

$$P_t^c = \left[(\gamma_{cn}) (P_{N,t})^{1-\rho_{cn}} + (1-\gamma_{cn}) \left(P_{T,t}^c\right)^{1-\rho_{cn}} \right]^{\frac{1}{1-\rho_{cn}}}$$

$$P_{T,t}^c = \left[(\gamma_{ch}) (P_{H,t})^{1-\rho_{ch}} + (1-\gamma_{ch}) (P_{F,t})^{1-\rho_{ch}} \right]^{\frac{1}{1-\rho_{ch}}}$$

$$P_{N,t} = \left[\int_0^1 P_{N,t}^{1-\varrho}(z)dz \right]^{\frac{1}{1-\varrho}}$$

where P_t^c, $P_{T,t}^c$, and $P_{N,t}$ are the consumer price index (CPI), the price index for T consumption goods, and the price index for N consumption goods, respectively. Investment price indices (P_t^i, $P_{T,t}^i$, and $P_{N,t}$) can be similarly obtained. The real exchange rate is then defined as $q_t^c = \frac{P_{T,t}^c}{P_{N,t}}$.

3.2 Households

We consider a cashless economy where the preferences of the representative household are given by

$$V = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ D_t(\ln C_t) - \ell \frac{(H_t)^{1+\eta_L}}{1+\eta_L} \right\} \tag{7}$$

where D_t is an exogenous preference shock, η_L is the inverse of the labor supply elasticity and H_t is the labor supply

$$H_t = H_t^N + H_t^H. \tag{8}$$

Let W_t^N (W_t^H) denote the nominal wage in the N (H) sector, e_t the nominal exchange rate, B_t (B_t^*) holdings of discount bonds denominated in domestic (foreign) currency, v_t (v_t^*) the corresponding price, R_t^N (R_t^H) the real return to capital that is rented to firms in the N (H) sector, Π_t nominal profits from the ownership of firms in the monopolistically competitive N sector, and T_t nominal government lump-sum taxes. The household's budget constraint is then given by

$$P_t^c C_t + e_t B_t^* v_t^* + B_t v_t + P_t^i I_t^N + P_t^i I_t^H + M_t = W_t^H H_t^H + W_t^N H_t^N + \tag{9}$$

$$e_t B_{t-1}^* + B_{t-1} + M_{t-1} + P_{N,t} R_t^N K_{t-1}^N + P_{H,t} R_t^H K_{t-1}^H + \Pi_t - T_t$$

The household's revenues come from supplying labor and renting capital to firms in the N and H sectors, from holdings of domestic money and domestic/foreign bonds, and from firms' profits. These revenues are then used to purchase consumption and investment goods, or saved in domestic and foreign assets.

The household is assumed to maximize the inter-temporal utility function (7) subject to (1), (2), (3), (4), (5), (6), (8), (9), and the law of accumulation of the capital stocks:

$$K_t^N = \Phi\left(\frac{I_t^N}{K_{t-1}^N}\right) K_{t-1}^N + (1-\delta) K_{t-1}^N \tag{10}$$

$$K_t^H = \Phi\left(\frac{I_t^H}{K_{t-1}^H}\right) K_{t-1}^H + (1-\delta) K_{t-1}^H \tag{11}$$

We assume that capital, contrary to labor, is immobile across sectors. Capital accumulation incurs adjustment costs, with $\Phi'(\bullet) > 0$ and $\Phi''(\bullet) < 0$.

The solution to the household decision problem gives the following first order conditions (FOCs):

Euler equation

$$\lambda_t^C = \beta E_t \left\{ \lambda_{t+1}^C (1+i_t) \frac{P_t^c}{P_{t+1}^c} \right\} \tag{12}$$

where $\lambda_t^C = \frac{1}{C_t}$ is the marginal utility of total consumption and $(1+i_t) = \frac{1}{v_t}$.

Uncovered interest parity condition

$$E_t \left\{ \lambda_{t+1}^C \frac{P_t^c}{P_{t+1}^c} \left[(1+i_t) - (1+i_t^*) \frac{e_{t+1}}{e_t} \right] \right\} = 0 \tag{13}$$

Intra-temporal consumption allocations

$$C_{N,t} = \frac{\gamma_{cn}}{1-\gamma_{cn}} \left(\frac{P^c_{T,t}}{P_{N,t}} \right)^{\rho_{cn}} C_{T,t} \quad ; \quad C_{H,t} = \frac{\gamma_{ch}}{1-\gamma_{ch}} \left(\frac{P_{F,t}}{P_{H,t}} \right)^{\rho_{ch}} C_{F,t} \tag{14}$$

Labor supply

$$\lambda^C_t \frac{W^N_t}{P^c_t} = \ell \left(H_t \right)^{\eta_H} \quad ; \quad \lambda^C_t \frac{W^H_t}{P^c_t} = \ell \left(H_t \right)^{\eta_H} \tag{15}$$

The labor supply optimality conditions imply that $\frac{W^N_t}{P^c_t} = \frac{W^H_t}{P^c_t}$.

Inter-temporal investment choice

$$\begin{aligned} \lambda^C_t \frac{P^i_t}{P^c_t} Q^J_t = \beta E_t \{ \lambda^C_{t+1} \left(\frac{P_{J,t+1}}{P^c_{t+1}} R^J_{t+1} \right) + \lambda^C_{t+1} \frac{P^i_{t+1}}{P^c_{t+1}} Q^J_{t+1} [\Phi \left(\frac{I^J_{t+1}}{K^J_t} \right) \\ - \frac{I^J_{t+1}}{K^J_t} \Phi' \left(\frac{I^J_{t+1}}{K^J_t} \right) + (1-\delta)] \}, \ J \ is \ N, H \end{aligned} \tag{16}$$

where Q^J_t is Tobin's Q and is defined as

$$Q^J_t = \left[\Phi' \left(\frac{I^J_t}{K^J_{t-1}} \right) \right]^{-1} \ J = N, H \tag{17}$$

Intra-temporal investment allocations;

$$I^J_{N,t} = \frac{\gamma_{in}}{1-\gamma_{in}} \left(\frac{P^i_{T,t}}{P_{N,t}} \right)^{\rho_{in}} I^J_{T,t}, J = N, H \tag{18}$$

$$I^J_{H,t} = \frac{\gamma_{ih}}{1-\gamma_{ih}} \left(\frac{P_{F,t}}{P_{H,t}} \right)^{\rho_{ih}} I^J_{F,t}, J = N, H \tag{19}$$

3.3 Firms

3.3.1 Non-tradable (N) Sector

The non-tradable sector is populated by a continuum of monopolistically competitive firms owned by households. Each firm $z \in [0,1]$ combines an imported intermediate good, $X_{NM,t}$, and domestic value added, $V_{N,t}$ according to the production function:

$$Y_{N,t}(z) = \left[(\gamma_{nv})^{\frac{1}{\rho_{nv}}} \left(V_{N,t}(z) \right)^{\frac{\rho_{nv}-1}{\rho_{nv}}} + (1-\gamma_{nv})^{\frac{1}{\rho_{nv}}} \left(X_{NM,t}(z) \right)^{\frac{\rho_{nv}-1}{\rho_{nv}}} \right]^{\frac{\rho_{nv}}{\rho_{nv}-1}} \tag{20}$$

A_t^N is an exogenous productivity shock. Cost minimization gives the factor demands:

$$\frac{W_t^N}{P_{N,t}} = MC_t^N(z)\left[1-\alpha_n\right](\gamma_{nv})^{\frac{1}{\rho_{nv}}}\frac{V_{N,t}(z)}{L_t^N(z)}\left(\frac{Y_{N,t}(z)}{V_{N,t}(z)}\right)^{\frac{1}{\rho_{nv}}} \tag{21}$$

$$R_t^N = MC_t^N(z)\alpha_N(\gamma_{nv})^{\frac{1}{\rho_{nv}}}\frac{V_{N,t}(z)}{K_{t-1}^N(z)}\left(\frac{Y_{N,t}(z)}{V_{N,t}(z)}\right)^{\frac{1}{\rho_{nv}}} \tag{22}$$

$$\frac{P_{M,t}}{P_{N,t}} = RATM_t = MC_t^N(z)(1-\gamma_{nv})^{\frac{1}{\rho_{nv}}}\left(\frac{Y_{N,t}}{X_{NM,t}}\right)^{\frac{1}{\rho_{nv}}} \tag{23}$$

where $MC_t^N(z)$ is the real marginal cost for firm z. Given the first order conditions for factor demands and the aggregate demand schedule, $Y_{N,t}(z) = \left[\frac{P_{N,t}(z)}{P_{N,t}}\right]^{-\varrho}(C_{N,t}+I_{N,t}^H+I_{N,t}^N)$, firm z maximizes expected discounted profits by choosing the optimal price $P_{N,t}(z)$. We assume firms follow a Calvo (8) pricing rule, where $(1-\vartheta)$ is the probability of being able to reset the price in each period. Aggregation over firms and log-linear approximation gives the widely used New Keynesian price adjustment equation for non-tradable good inflation.

3.3.2 Domestic Tradable (H) Sector

The tradable good H is produced both at home and abroad in a perfectly competitive environment, where the Law of One Price holds:

$$P_{H,t} = e_t P_{H,t}^* \tag{24}$$

where $P_{H,t}^*$ follows an exogenous stochastic process. Domestic producers combine an imported intermediate good, $X_{M,t}$, and domestic value added, $V_{H,t}$, according to the production function:

$$Y_{H,t} = \left[(\gamma_v)^{\frac{1}{\rho_v}}(V_{H,t})^{\frac{\rho_v-1}{\rho_v}} + (1-\gamma_v)^{\frac{1}{\rho_v}}(X_{M,t})^{\frac{\rho_v-1}{\rho_v}}\right]^{\frac{\rho_v}{\rho_v-1}} \tag{25}$$

Domestic value added is produced using labor and sector-specific capital as inputs:

$$V_{H,t} = A_t^H\left(K_{t-1}^H\right)^{\alpha_h}\left(H_t^H\right)^{1-\alpha_h} \tag{26}$$

where A_t^H is an exogenous productivity shock.

Cost minimization gives the factor demands:

$$\frac{W_t^H}{P_{H,t}} = (1-\alpha_h)(\gamma_v)^{\frac{1}{\rho_v}}\frac{V_{H,t}}{H_t^H}\left(\frac{Y_{H,t}}{V_{H,t}}\right)^{\frac{1}{\rho_v}} \tag{27}$$

$$R_t^H = \alpha_h(\gamma_v)^{\frac{1}{\rho_v}}\frac{V_{H,t}}{K_{t-1}^H}\left(\frac{Y_{H,t}}{V_{H,t}}\right)^{\frac{1}{\rho_v}} \tag{28}$$

$$\frac{P_{M,t}}{P_{H,t}} = (1-\gamma_v)^{\frac{1}{\rho_v}}\left(\frac{Y_{H,t}}{X_{M,t}}\right)^{\frac{1}{\rho_v}} \tag{29}$$

$P_{M,t}$ is the domestic currency price of the imported intermediate good.

3.4 Foreign Sector

We assume that the foreign-produced good F is purchased by a continuum of monopolistically competitive firms in the import sector as an input for production. Each firm z can costlessly differentiate the imported good X_F to produce a consumption good $C_F(z)$ and an investment good $I_F(z)$ using the production technology $Y_F(z) = X_F(z)$, where $X_F(z)$ denotes the amount of input imported by firm z. The nominal marginal cost of producing one unit of output is defined as $MC_t^{F,nom}(z) = e_t P_{F,t}^*$ where $P_{F,t}^*$ is the foreign-currency price of X_F. The domestic-currency price $P_F(z)$ is set by solving an optimal pricing problem that is analogous to the problem discussed for the N sector. The producer faces an aggregate demand schedule given by:

$$Y_{F,t}(z) = \left[\frac{P_{F,t}(z)}{P_{F,t}}\right]^{-\varrho} (C_{F,t} + I_{F,t}^H + I_{F,t}^N)$$

where $Y_{F,t}(z) = C_{F,t}(z) + I_{F,t}^H(z) + I_{F,t}^N(z)$, and the state-independent probability of resetting the price at every period t is equal to $(1 - \vartheta_F)$ (Calvo (8)). As Monacelli (**?**) pointed out, this production structure generates deviations from the law of one price in the short run, while asymptotically the pass-through from the price of the imported good to the price of the consumption and investment basket F is complete.[2] We will refer to this pricing structure as the Local Currency Pricing (LCP) case.

When producers can optimally reset prices every period, the pass-through is complete also in the short-run and the law of one price holds. In this case, labeled Producer Currency Pricing (PCP), the domestic-currency price of good F is given by

$$P_{F,t} = \mu_F e_t P_{F,t}^* \tag{30}$$

where μ_F is a constant markup. Note that in a symmetric equilibrium all producers charge the same price $P_{F,t}^*(z)$. Under LCP, the markup μ_F responds to business cycle shocks by altering the wedge between the price of the imported (intermediate) and the price of the retail product.

The law of one price is assumed to hold for the imported intermediate good M:

$$P_{M,t} = e_t P_{M,t}^* \tag{31}$$

where $P_{F,t}^*$ and $P_{M,t}^*$ follow exogenous stochastic processes.

Following Schmitt-Grohe and Uribe (44), the nominal interest rate at which households can borrow internationally is given by the exogenous world interest rate $\tilde{\imath}^*$ plus a premium, which is assumed to be increasing in the real value of the country's stock of foreign debt:

$$(1 + i_t^*) = (1 + \tilde{\imath}_t^*) g(-B_{H,t}) \tag{32}$$

[2] In log-linear form the aggregate inflation equation for good F is given by $\pi_{F,t} = \lambda mc_t^F + \beta E_t \pi_{F,t+1}$ where $\lambda = \frac{(1-\vartheta_F)(1-\beta\vartheta_F)}{\vartheta_F}$ and $mc_t^F = e_t + p_{F,t}^* - p_{F,t}$.

where $B_{H,t} = \frac{e_t B_t^*}{P_{H,t}}$ and $g(\cdot)$ is a positive, increasing function. Eq. (32) ensures the stationarity of the model.

3.5 Market Clearing

We assume government expenditures in H and N goods, $G_{H,t}$ and $G_{N,t}$, follow an exogenous stochastic process and are financed by lump-sum taxes. The resource constraint in the non-tradable and domestic tradable sector is given by

$$Y_{N,t} = (C_{N,t} + I_{N,t}^N + I_{N,t}^H + G_{N,t}) \int_0^1 \left[\frac{P_{N,t}(z)}{P_{N,t}}\right]^{-\varrho} dz \tag{33}$$

$$Y_{H,t} = AB_{H,t} + C_{H,t}^* \tag{34}$$

$$AB_{H,t} = C_{H,t} + I_{H,t}^N + I_{H,t}^H + G_{H,t} \tag{35}$$

where $AB_{H,t}$ is domestic absorption and $C_{H,t}^*$ are net exports of the H good.

The trade balance, expressed in units of good H, can be written as

$$NX_{H,t} = C_{H,t}^* - \frac{P_{F,t}}{P_{H,t}} X_{F,t} - \frac{P_{M,t}}{P_{H,t}} (X_{M,t} + X_{NM,t}) \tag{36}$$

where $X_{F,t} = \int_0^1 Y_{F,t}(z)dz = Y_{F,t}$. With complete pass-through, it holds: $Y_{F,t} = X_{F,t} = (C_{F,t} + I_{F,t}^N + I_{F,t}^H)$. Assuming that domestic bonds are in zero net supply, the current account (in nominal terms) reads as

$$e_t B_t^* = \left(1 + i_{t-1}^*\right) e_t B_{t-1}^* + P_{H,t} NX_{H,t} \tag{37}$$

Finally, labor market clearing requires

$$H_t^d = H_t^N + H_t^H = H_t^s \tag{38}$$

Using the aggregate consumption good as numeraire, we obtain the total value added in the economy as:

$$GDP_t^c = \frac{P_{N,t} Y_{N,t} + P_{H,t} Y_{H,t}}{P_t^c} - (X_{M,t} + X_{NM,t}) S_{M,t} \frac{P_H}{P_t^c} \tag{39}$$

3.6 Terms of trade and real exchange rate

The definition of the two terms of trade is:

$$S_{F,t} = \frac{P_{F,t}}{P_{H,t}} \tag{40}$$

and

$$S_{M,t} = \frac{P_{IM,t}}{P_{H,t}} \tag{41}$$

Also define

$$RATM_t = S_{M_t} RATT_t^c q_t^c = \frac{P_{M,t}}{P_{N,t}}$$

In the economy there exist two relevant (internal) real exchange rates, based on the tradable price index we use:

$$q_t^c = \frac{P_{T,t}^c}{P_{N,t}} \tag{42}$$

$$q_t^i = \frac{P_{T,t}^i}{P_{N,t}} \tag{43}$$

4 Model Parameterization

We choose a baseline parameterization that ensures a business cycle behaviour consistent with observations from emerging market economies, for a monetary policy following a Taylor rule. This step provides benchmark values for the variance of the shocks driving the business cycle, that is, for the amount of exogenous volatility an economy is exposed to. In the model economy, business cycle fluctuations are generated by four domestic shocks (total factor productivity in the tradable and non-tradable good sector, shifts in household preferences, and interest rate innovations) and four foreign shocks (price of the domestically-produced tradable good, price of the imported intermediate input, price of the imported tradable good, and interest rate on foreign-denominated debt). Conditional on a constant exogenous volatility, we then study how the problem of the optimal policymaker, and the cost of suboptimal policies, change as the trade and production structure is altered. The Appendix provides details on the baseline parameterization.

5 Trade and the Choice of Monetary Policy

This section discusses the implications of alternative technology and preference constraints on the external trade and domestic production structure of our model economy, and the implications for the choice of monetary policy. We do not focus on how the optimal policy itself changes across economies. Fully optimal policies are very model-specific, and policymakers are wary of committing to one given uncertainties in the shocks' propagation mechanisms and model parameters. The optimal policy is though a useful benchmark to gauge how costly the adoption of simple policy rules is. Among the many rules that countries adopt, pegging the exchange rate to a foreign currency is the avenue more readily available to a country to credibly and transparently commit to stated policy objectives. This will be our benchmark. If sub-optimal policies carry a very low welfare penalty, the costs of creating incentives for policy-makers to implement exactly the optimal policy (such as changing policy-making institutions or creating monetary unions) may be unjustified.

5.1 Welfare Measure

The domestic monetary authority solves the problem of a benevolent planner maximizing the household's objective function conditional on the first order conditions of the competitive equilibrium. This approach provides the equilibrium sequences of endogenous variables solving the Ramsey problem.[3] The absolute level of welfare that monetary policy can achieve depends on the parameters characterizing the trade and production structure of the economy. We cannot exclude that the production structure of the economy is endogenous to the policy regime , at least to a certain extent. Nevertheless solving for the optimal production structure conditional on the policy regime is a daunting task.[4] Furthermore the empirical evidence on this endogeneity is not yet conclusive and we can reasonably believe that the this effect plays a limited role in the actual choice of exchange rate regime in practice. Therefore, we assume that the policymaker cannot change the technological constraints of the economy in which it operates. We show that not only the absolute level achieved by a given policy, but the relative ranking and welfare cost of alternative policies relative to the Ramsey plan is dependent on the trade and production structure of the economy.

To measure the welfare level associated with a given policy in each economy, we compute the expected lifetime utility conditional on the economy's state variables starting at a level equal to the non-stochastic steady state in time $t = 0$ (see Schmitt-Grohe and Uribe, 2004, for a similar application of this welfare measure in the context of a closed economy):

$$V_0^o = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^o, H_t^o)$$

where C^o, H^o are the level of consumption and labor associated with the optimal Ramsey plan in a given economy. All policy regimes share the same non-stochastic steady state in a given economy. [5] Let the welfare loss associated with any alternative non-optimal regime be defined by:

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

Define λ as the fraction of non-stochastic steady state consumption C_{SS} that a household would be willing to give up to achieve the utility level associated with the policy regime $i = [o, a]$:

[3] For a discussion of the Ramsey approach to optimal policy, see Schmitt-Grohe and Uribe (2005), Benigno and Woodford (2006), Kahn et al. (2003).

[4] Many have argued that one of the effects of the creation of a single currency for the European Union could be the increase in trade integration XXX references XXX

[5] For each regime the average state of the economy will be different. Therefore there exists the possibility that the conditional welfare ranking of policies depends on the initial condition. Note that using the unconditional expected lifetime utility as welfare measure runs into the problem that the policy-maker ranks policies based on *different* initial conditions.

$$V_0^o = E_0 \sum_{t=0}^{\infty} \beta^t U((1-\lambda_o)C_{SS}, H_t^o)$$
$$V_0^a = E_0 \sum_{t=0}^{\infty} \beta^t U((1-\lambda_a)C_{SS}, H_t^a)$$

The welfare loss in terms of units of steady state consumption from choosing the suboptimal policy a relative to the optimal policy o is then given by:

$$loss = \lambda_a - \lambda_o$$

5.2 Technology, Preference Constraints and the Cost of Fixing the Exchange Rate

This section focuses on ten model parameters among the ones defining the preferences of the household and the technological constraints for the production sector. The parameters $\gamma_{ch},\ \gamma_{ih},\ \gamma_v$ are equal in steady state to the shares $C_H/C_T,\ I_H^J/I_T^J,\ X_M/Y_H$, since the terms of trade $S_F,\ S_M$ are exogenous in the steady state, and can be set equal to unity without loss of generality. Implicitly, the ratios C_H/C_F and I_H/I_F also depend each exclusively upon $\gamma_{ch},\ \gamma_{ih}$. The corresponding elasticities of substitution for the goods in the tradable consumption and investment aggregates, and for the inputs the tradable good production function, are $\rho_{ch},\ \rho_{ih}$ and ρ_v. The parameters $\gamma_{cn},\ \gamma_{in}$ do not uniquely define the steady state ratios $C_T/C,\ I_T^J/I^J$, since these will depend on the endogenous internal real exchange rates $q^i,\ q^c$ and on the elasticities $\rho_{cn},\ \rho_{in}$. We keep the parameter $(1-\gamma_{nv})$, proportional to X_{NM}/Y_N, fixed at a value of zero, implying the non-tradable good is produced exclusively with domestic inputs of production.

To gain intuition about how the structure of trade and production affects the welfare cost of fixing the exchange rate, we start by looking at welfare outcomes conditional on combinations of the parameters. Later, we translate the parameters into measurable ratios for the economy macroeconomic magnitudes, and relate these to the welfare cost of alternative policies.

Let policy a be an exchange rate peg. Figure 1 shows the welfare loss $\lambda_a - \lambda_o$ for different combination of γ_{cn}, ρ_{cn}. In this experiment, we assume $\gamma_{in} = \gamma_{cn}$ and $\rho_{in} = \rho_{cn}$. Each surface is indexed by a value of γ_v. Consider the surface generated for $\gamma_v = 0.5$. For a given value of ρ_n, the loss from fixing the exchange rate increases with γ_n, going from about 0.3% for $\gamma_n = 0.3$ to 0.7% for $\gamma_n = 0.9$. This behaviour of the welfare function reflects the cost from pegging the exchange rate as the economy becomes more and more closed (because the demand for goods is increasingly biased toward non-tradables). As γ_n increases, the exchange rate is less and less a relevant variable for the efficient allocation of domestic resources. In fact, for $\gamma_n = 1$ the Ramsey planner would want to minimize the pricing distortion in the N sector, and fully stabilize prices charged by the N-sector firms. For given γ_n, the welfare loss increases the

lower the substitutability between N and T goods. This behaviour reflects the same incentive for the policymaker. Consider a positive domestic productivity shock in the H sector. Since P_F and P_H are fixed under a peg, the relative price P_N/P_H can only adjust through movements in P_N. But the less goods are substitutable, the *more* P_N has to adjust (since there is little demand moving away from the N good and compensating for the change in price). Since inflation in P_N generates both variability in the markup and price dispersion, the lower ρ_n, the higher the inefficiency from q^c adjusting through changes in P_N rather than changes in $e * P_H^*$.

This intuition though does not translate into the welfare loss from fixing the exchange rate increasing the more the economy is closed to trade. The same figure shows that as γ_v decreases, so that tradable goods are produced with a *larger* amount of imported intermediates, the welfare loss *increases*, even if the economy trades more with the rest of the world. This behaviour reflects a different incentive for the optimal policymaker, highlighted by Mundell (1961) and Friedman (1953). Given price rigidities in the non-tradable sector, a flexible exchange rate could generate the required adjustment in the relative price of non-tradable goods and imported goods for an efficient allocation of resources. The more open an economy, the larger the impact of an inefficiently adjusting real exchange rate on the utility of the household and the efficiency of investment allocation. For high values of γ_v, implying a more closed economy where the traded good is produced with a low input share of intermediates, the exchange rate could generate an expenditure-switching effect for a smaller portion of the consumption and investment expenditure. Therefore, a fixed exchange rate resulting in a misaligned relative price would have smaller consequences for welfare.

The trade-off between these two incentives for the policymaker depends heavily on the input-output structure of the economy. While it is true that being more open through a low γ_n or a low γ_v has opposite effects of our welfare measure, it is also true that increasing the steady state share of imported tradable over the domestically produced tradable good has a minimal impact. This is shown in figure 2, where we assume ρ_n is fixed at its benchmark value. The figure is drawn assuming local currency pricing for the imported F good. Under producer currency pricing, the figure is essentially unaltered. Any explanation for the behaviour of the welfare function must account for the fact that nominal rigidity in the F sector is not an important determinant of the policymaker's incentives, relative to the other inefficiencies in the economy.

5.3 Welfare and the Propagation Mechanism of Business Cycle Shocks

Because of the complexity of the trade and production structure in the economy, the parameters γ_i, ρ_i do not translate directly into steady state ratios for a number of aggregate macroeconomic variables. We consider now the more illustrative dimensions of trade and production in the economy, jointly with how they translate into standard aggregate macroeconomic measures, to discuss the

trade-offs faced by the policymaker.

Figure 3 shows the welfare isoquants as a function of γ_v, γ_n for three separate values of γ_h. The isoquants for the steady state share of imports to GDP are overlaid in the same plot. Along the isoquants representing openness, the same degree of openness is consistent with different compositions of demand and production. The fact that isoquants of the imports/GDP ratio are not parallel to the ones of the welfare loss implies that two countries with the same degree of openness can experience different losses of pegging the exchange rate. In fact, the shape of the isoquants implies that for any imports to GDP ratios between 20 and 100 percent an economy can experience a welfare loss from pegging the exchange rate ranging from 0.25% to over 1% of the steady state consumption, depending on the composition of imports and the domestic technology constraints.

To understand this result, consider that the impact of γ_v, γ_n operates through three channels. First, the more open the economy, the higher its exposure to foreign shocks. The volatility of P_M^*, P_F^* propagating through the economy depends on the degree of openness, and increases the less the exchange rate is left free to adjust. Second, the larger γ_n, the bigger the weight of the nominal rigidity inefficiency in the household's utility. Obviously, under LCP, for small values of γ_h a change in γ_n simply changes the share of nominal rigidity attributed to the F sector and to the N sector. But looking at the plots across different values of γ_h shows that the impact of LCP must be small, since γ_h has a large effect on the openness measure, but not on the welfare loss for a *given* level of the imports to GDP ratio. Our model highlights a third, important channel through which γ_v, γ_n impact welfare. As these parameters change, the propagation mechanism of the shocks, and the way in which they generate distortions, changes endogenously.

Consider the impact of γ_v. For given γ_n, an economy fixing the exchange rate is better off with a lower share $(1 - \gamma_v)$ of intermediate imports in the tradeable good production. Since P_H, P_M are both fixed in foreign currency, a fixed exchange rate results in any shock to, say P_M, affecting directly also the relative price P_H/P_M. Since the price of one input in the tradable sector has changed, but producers cannot adjust the output price, all adjustment is left to the factor demands. This results in an endogenous change in the price paid for the domestic inputs, including the salary paid to workers. Since labor is a mobile factor across sectors, the change in P_M results in a change also for the salary in the non-traded sector, and in an adjustment for P_N. Since changes in P_N come at a cost in efficiency, the welfare loss can be explained by the exchange rate not performing the Friedman-Mundell role in adjusting relative prices. The higher the intermediate imports' share in production, the larger the movements in input prices and in P_N.

The role of γ_n was discussed earlier. An important observation is that the welfare isoquants in figure 3 become more parallel to the horizontal axis as γ_n decreases. That is, γ_v becomes irrelevant as the economy becomes more biased towards tradables. Also, the relative loss itself becomes very small for low values of γ_n. This is not a consequence of the fact that the allocation under a fixed

exchange rate is close to the first best. The allocation might be very far from the first best; but for low values of γ_n monetary policy becomes ineffective, therefore the Ramsey planner can do very little to improve on the fixed exchange rate allocation.

Consider now the impact of γ_H. We already observed that the business cycle distortion from LCP has a negligible impact on the results. A change in γ_H also implies that the way in which shocks propagate in the economy changes. This is also true for how the foreign shocks - changes in P_F - affect eventually P_N. But while a shock to P_M, whose impact depends on γ_v, affects *directly* the N sector through the input prices, a shock to P_F affects the other sectors only through a long chain of demand for substitutable goods. The good F is substitutable for the good H, which in turn is substitutable for the good N. The chain of substitutabilities mutes the impact of any shock to P_F into the rest of the economy.

This is also true if we allow only the change in the imported tradable share of investment to change, rather than the consumption share, by changing γ_{ih}. The result of this experiment is shown in figure 4. The welfare and imported investment measure isoquants are close to perpendicular regardless of the choice of γ_n in each of the four panels.

6 A Welfare-weighted Index of Openness

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7 Conclusions

In this paper we investigate how international trade affects monetary policy. We ask how the technology and preference constraints defining the trade relationships between an economy and the rest of the world, and the structure of goods and production inputs' markets, affect the choice of an optimal monetary policy. We document that differences in trade across countries (especially EME and OECD countries) are substantial, and that the composition of trade varies as much as openness to trade.

Our results show that the trade and production structure affects welfare through three different channels: the exposure of the economy to foreign business cycle shocks, the size of the sector where rigidities constrain the choice of firms and households in the disaggregated equilibrium, and, most importantly, the substitutability between alternative consumption goods and factor inputs, and its impact on the propagation mechanism. The welfare implications of alternative technology and preference constraints easily map into measurable macroeconomic characteristics of countries. First, the traditional imports to GDP ratio turns out to be close to irrelevant for the ranking of monetary policies. Second, the composition of imports has a very substantial impact on welfare. Given the same degree of openness, the exchange rate peg is more

inefficient if the bias towards non-tradable goods is high, and less inefficient if the share of imported intermediates is low. That is, open countries engaging in much vertical trade find it more costly to peg the exchange rate. Third, while a stylized regularity of emerging market economies is the very high share of imported capital goods, compared with industrial countries, this turns out to have no impact on the welfare result. Fourth, local currency pricing has a muted impact . This is the consequence of two assumptions: the existence of a long chain of substitutability in demanded goods, and the mobility of labor across sectors, so that imported inputs affect factor prices in all sectors directly, rather than through general equilibrium effects.

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7.1 Parameterization

The quarterly discount factor β is set equal to 0.99, which implies a steady-state real world interest rate of 4 percent in a steady state with zero inflation. The elasticity of labor supply is set equal to $\frac{1}{2}$, and the ratio of average hours worked relative to total hours equal to $\frac{1}{3}$. The elasticity of substitution between tradable and non-tradable goods in the consumption and investment index, ρ_{cn} and ρ_{in}, is set equal to 0.9,a value slightly higher than Stockman and Tesar (45). We assume that the foreign and domestic goods in the tradable consumption and investment aggregates are closer substitutes, setting $\rho_{ch} = \rho_{ih} = 1.5$. Similarly, we will assume $\gamma_{cn} = \gamma_{in} = \gamma_n$and $\gamma_{ch} = \gamma_{ih} = \gamma_h$.

The aggregate consumption (and investment) index parameter γ_n is equal to 0.4. This implies that the steady-state share of non-tradable goods in total consumption is 63 percent, and 68percent in total investment. This value is comparable with the data on GDP by origin in the Czech Republic, one of the new EU member states with the highest GDP per capita. Note that the share of non-tradable goods in CPI data is typically smaller: This share, in fact, excludes a large part of GDP consumed by the government sector. Lipinska (**?**) reports that the weight of non-tradable goods in the CPI of the new EU member states ranges from 37 percent (Estonia) to 49 percent (Slovenia) over the 2000-05 period, and is 51 percent for EU-15. Data on GDP by origin in emerging markets suggest values close to the model parameterization. We assume 40 percent of domestic non-tradable output is absorbed by the government sector in steady state. The share $\gamma_h$of the domestically produced tradable good H in the tradable good consumption composite is set to 0.8, implying C/Y equal to 47 percent.

We assume there are no capital adjustment costs in steady state. The elasticity of Tobin's Q with respect to the investment-capital ratio is taken to be 0.5. The quarterly depreciation rate of capital, δ, is assigned the conventional value of 0.025. Following Cooks and Devereux (**?**) the tradable sector is assumed to be more capital-intensive than the non-tradable sector, with $\alpha_h = 0.67$ and $\alpha_n = 0.33$. The elasticity of substitution ρ_v between the imported intermediate good $X_{M,t}$ and domestic Hsector value added $V_{H,t}$ is set equal to 0.5.

The share of domestic value added in the tradable good production function, γ_v, is such that in a balanced-trade steady state the ratio of imports to GDP is 60 percent. Among the new EU member states, this share ranges from 35 percent (Poland) to 86 percent (Estonia) (Lipinska (**?**), ECB (26)). We set $\gamma_{nv} = 1$implying the non-traded sector good is produced entirely with domestic inputs. The speed of price-

adjustment in the non-tradable sector is assumed to be slower than in the US, and on the upper end of estimates for European countries reported by Clarida et al. (13). The unconditional probability $(1-\vartheta)$ of adjusting prices in any period is set equal to 0.2. With larger values, CPI inflation would be too volatile, given that the share of non-tradable consumption goods—whose price cannot be adjusted in every period—is about two-thirds. The steady-state mark-up in the non-tradable sector is set equal to 10 percent, consistent with macroeconomic evidence for OECD countries. The markup and the price-adjustment speed in the consumption good import sector are assumed identical to the non-traded good sector.

The monetary authority adjusts the nominal interest rate according to the rule:

$$(1+i_t) = \left[\left(\frac{1+\pi_t}{1+\pi_{ss}}\right)^{\omega_\pi}\left(\frac{e_t}{e_{ss}}\right)^{\omega_e}\left(\frac{Y_t}{Y_{ss}}\right)^{\omega_Y}\right]^{(1-\chi)}[(1+i_{t-1})]^{\chi}\,\varepsilon_{i,t} \qquad (44)$$

where $\omega_\pi, \omega_e, \omega_Y \geq 0$ are the feedback coefficients to CPI inflation, nominal exchange rate, and GDP in units of domestic consumption aggregate (Y_t), $\chi \in [0,1)$ is the degree of smoothing and $\varepsilon_{i,t}$ is an exogenous shock to monetary policy. The subscript ss indicates the steady-state value of a variable. We set $\omega_\pi = 1,\ \omega_Y = 0.4, \omega_e = 0.1,\ \chi = 0.8$.

The parameterization of the exogenous stochastic processes follows the recent literature on micro-founded open-economy model with nominal rigidities (Gali and Monacelli (**?**), Kollman (32) (**?**), Laxton and Pesenti (**?**), Monacelli (**?**) (**?**)).The exogenous stochastic processes for the total factor productivity shock in the tradable and non-tradable good sector, the household preference shifter, the foreign-currency price of the tradable goods H and F and the imported intermediate input, and the foreign interest rate follow an AR(1) specification in logs:

$$\begin{aligned}
a_t^H &= \rho_{a^H} a_{t-1}^H + \varepsilon_{a^H,t} \\
a_t^N &= \rho_{a^N} a_{t-1}^N + \varepsilon_{a^N,t} \\
d_t &= \rho_d d_{t-1} + \varepsilon_{d,t} \\
p_{H,t}^* &= \rho_{p_H} p_{H,t-1}^* + \varepsilon_{p_H,t} \\
p_{F,t}^* &= \rho_{p_F} p_{F,t-1}^* + \varepsilon_{p_F,t} \\
p_{M,t}^* &= \rho_{p_M} p_{M,t-1}^* + \varepsilon_{p_M,t} \\
i_t^* &= \rho_{i^*} i_{t-1}^* + \varepsilon_{i^*,t}
\end{aligned}$$

where $\varepsilon_{j,t}$ is normally distributed with variance $\sigma^2_{\varepsilon_j}$. The productivity shock innovation volatility is set in both sectors equal to $\sigma_a = 0.008$ with $\rho_a = 0.95$. These values are in line with the international business cycle literature, and close to the ones in Gali and Monacelli (**?**) and Monacelli (**?**), and to the average estimate in Kollman (**?**) for UK, Japan, Germany over the 1973-1994 sample. The coefficients for the unobservable preference shock process d_t are left as free parameters, and are adjusted to ensure sufficient volatility in domestic output. We set $\rho_d = 0.85$ and $\sigma_d = 0.009$.These values are larger than those in Laxton and Pesenti (**?**) ($\rho_d = 0.7$ and $\sigma_d = 0.004$) and similar to the values reported by Monacelli (**?**). To parameterize the process for the foreign interest rate we use Eurostat data on the average money

market rate in the EU-15, resulting in estimates of $\rho_{i^*} = 0.95$ and $\sigma_{i^*} = 0.001$. The exogenous innovation $\varepsilon_{i,t}$ in the monetary policy rule follows an i.i.d. process, and its standard deviation is set at $\sigma_i = 0.001$, a low value that reflects the evidence on the small role played by non-systematic monetary policy in business cycle fluctuations in a number of countries.

To parameterize the stochastic process for the foreign prices we use data for a fast growing accession country, the Czech Republic, over the period 1994-2002. The time series for p_j^*, $j = F, M$, is obtained from detrended import commodity price indices converted in units of foreign currency (euro) using the Nominal Effective Exchange Rate . The weights for the foreign intermediate and consumption goods' price indices are the 1997-2006 average Commodity Composition of Imports as reported by IMF (30), the Czech Statistical Office, and the Czech National Bank (July 2006 data). p_H^* is obtained from the aggregate export price index converted in units of foreign currency using the Nominal Effective Exchange Rate.

Under the baseline parameterization the volatility of output in percentage terms is 2.25. Neumeyer and Perri (**?**) find an average GDP volatility for Argentina, Brazil, Korea, Mexico, and the Philippines equal to 2.79 percent over the period 1994-2001. Among the eight Central and Eastern European new EU members, GDP volatility ranged from 0.72 percent (Hungary) to 2.83 percent (Lithuania) in the 1998-2002 period (Darvas and Szapary (**?**)).

The standard deviation of consumption and net exports is equal to 2.71and 2.54 (respectively 3.63and 2.40 across five emerging markets economies,Neumeyer and Perri (**?**)). The policy rule implies a large volatility for the nominal exchange rate, equal to 8.02 percent (Kollman (32) reports an average value of 9.13 percent for Japan, UK, and Germany over the 1973-1994 period).

The volatility of inflation for the composite of tradable goods is 1.12,about twice as large as the volatility of the non-tradable good inflation (0.64), owing to the larger share of flexible prices in the tradable good sector. The volatility for CPI inflation is equal to 0.66.

Table 1: Intermediates

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
1 Agriculture,etc	T	T	T	T	T	N	T	N	T	T	N
2 Mining and quarrying (energy)	T	T	T	T	T	T	T	T	T	T	T
3 Mining and quarrying (non-energy)	T	T	T	T	T	T	T	T	T	T	T
4 Food products, beverages and tobacco	T	T	T	T	T	T	T	T	T	T	T
5 Textiles, textile products, etc.	T	T	T	T	T	T	T	T	T	T	T
6 Wood and products of wood and cork	T	T	T	T	T	T	T	T	T	T	T
7 Pulp, paper, paper products etc.	T	T	T	T	T	T	T	T	T	T	T
8 Coke, refined petroleum products etc.	T	T	T	T	T	T	T	T	T	T	T
9 Chemicals excluding pharmaceuticals	T	T	T	T	T	T	T	T	T	T	T
10 Pharmaceuticals	T	T	T	T	T	T	T	T	T	T	T
11 Rubber & plastics products	T	T	T	T	T	T	T	T	T	T	T
12 Other non-metallic mineral products	T	T	T	T	T	T	T	T	T	T	T
13 Iron & steel	T	T	T	T	T	T	T	T	T	T	T
14 Non-ferrous metals	T	T	T	T	T	T	T	T	T	T	T
15 Fab. metal prod., except mach. & equip.	T	T	T	T	T	T	T	T	T	T	T
16 Machinery & equipment, nec	T	T	T	T	T	T	T	T	T	T	T
17 Office, accounting & computing machinery	T	T	T	T	T	T	T	T	T	T	T
18 Electrical machinery & apparatus, nec	T	T	T	T	T	T	T	T	T	T	T
19 Radio, television & communication equipment	T	T	T	T	T	T	T	T	T	T	T
20 Medical, precision & optical instruments	T	T	T	T	T	T	T	T	T	T	T
21 Motor vehicles, trailers & semi-trailers	T	T	T	T	T	T	T	T	T	T	T
22 Building & repairing of ships & boats	T	T	T	T	T	T	T	T	T	T	T
23 Aircraft & spacecraft	T	T	T	T	T	T	T	T	T	T	T
24 Railroad equipment & transport equip nec.	T	T	T	T	T	T	T	T	T	T	T
25 Manufacturing nec; recycling etc.	T	T	T	T	T	T	T	T	T	T	T

Table 1: Intermediates

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
26 Production, coll. and distr. of elect.	N	N	N	N	N	N	T	N	N	T	N
27 Manuf. of gas; distr. of ga etc.	T	T	T	N	T	T	T	T	N	N	N
28 Steam and hot water supply	T	T	T	T	T	T	T	T	T	T	T
29 Colle., purif. and distr. of water	N	N	N	N	N	N	N	N	N	N	N
30 Construction	N	N	N	N	N	N	N	N	N	N	N
31 Wholesale & retail trade; repairs	N	N	N	N	N	N	N	N	N	N	N
32 Hotels & restaurants	N	N	N	N	T	T	N	N	N	T	T
33 Land transport; transport via pipelines	T	T	T	T	T	T	T	T	T	T	N
34 Water transport	T	T	N	T	T	T	T	T	N	T	T
35 Air transport	T	T	T	T	T	T	T	T	T	T	N
36 ... auxiliary transport activities; activitie etc.	T	T	N	T	N	N	T	T	N	T	N
37 Post & telecommunications	T	N	N	N	N	N	T	T	N	T	N
38 Finance & insurance	N	N	N	N	T	N	T	T	T	T	N
39 Real estate activities	N	N	N	N	N	N	N	N	N	N	N
40 Renting of machinery & equipment	T	N	N	T	N	N	T	T	N	T	T
41 Computer & related activities	T	T	N	T	N	T	T	T	N	T	T
42 Research & development	T	T	T	T	T	N	N	N	N	T	T
43 Other Business Activities	T	N	T	T	T	T	T	N	N	T	T
44 Public admin. & defence; comp. soc. Sec.	N	N	N	N	N	N	N	N	N	N	N
45 Education	N	N	N	N	N	N	N	N	N	N	N
46 Health & social work	N	N	N	N	N	N	N	N	N	N	N
47 Other community, social & personal services	N	N	N	T	T	N	T	N	N	T	N
48 Private households with empl, etc.	T	T	N	T	T	T	T	T	T	T	T

Table 2: Consumption

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
1 Agriculture,etc	T	T	T	T	T	N	T	N	T	T	N
2 Mining and quarrying (energy)	T	T	T	T	T	T	T	T	T	T	T
3 Mining and quarrying (non-energy)	T	T	T	T	T	T	T	T	T	T	T
4 Food products, beverages and tobacco	T	T	T	T	T	T	T	T	T	T	T
5 Textiles, textile products, etc.	T	T	T	T	T	T	T	T	T	T	T
6 Wood and products of wood and cork	T	T	T	T	T	T	T	T	T	T	T
7 Pulp, paper, paper products etc.	T	T	T	T	T	T	T	T	T	T	T
8 Coke, refined petroleum products etc.	T	T	T	T	T	T	T	T	T	T	T
9 Chemicals excluding pharmaceuticals	T	T	T	T	T	T	T	T	T	T	T
10 Pharmaceuticals	T	T	T	T	T	T	T	T	T	T	T
11 Rubber & plastics products	T	T	T	T	T	T	T	T	T	T	T
12 Other non-metallic mineral products	T	T	T	T	T	T	T	T	T	T	T
13 Iron & steel	T	T	T	T	T	T	T	T	T	T	T
14 Non-ferrous metals	T	T	T	T	T	T	T	T	T	T	T
15 Fab. metal prod., except mach. & equip.	T	T	T	T	T	T	T	T	T	T	T
16 Machinery & equipment, nec	T	T	T	T	T	T	T	T	T	T	T
17 Office, accounting & computing machinery	T	T	T	T	T	T	T	T	T	T	T
18 Electrical machinery & apparatus, nec	T	T	T	T	T	T	T	T	T	T	T
19 Radio, television & communication equipment	T	T	T	T	T	T	T	T	T	T	T
20 Medical, precision & optical instruments	T	T	T	T	T	T	T	T	T	T	T
21 Motor vehicles, trailers & semi-trailers	T	T	T	T	T	T	T	T	T	T	T
22 Building & repairing of ships & boats	T	T	T	T	T	T	T	T	T	T	T
23 Aircraft & spacecraft	T	T	T	T	T	T	T	T	T	T	T
24 Railroad equipment & transport equip nec.	T	T	T	T	T	T	T	T	T	T	T
25 Manufacturing nec; recycling etc.	T	T	T	T	T	T	T	T	T	T	T

Table 2: Consumption

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
26 Production, coll. and distr. of elect.	N	N	N	N	N	N	T	N	N	T	N
27 Manuf. of gas; distr. of ga etc.	T	T	T	N	T	T	T	T	N	N	N
28 Steam and hot water supply	T	T	T	T	T	T	T	T	T	T	T
29 Colle., purif. and distr. of water	N	N	N	N	N	N	N	N	N	N	N
30 Construction	N	N	N	N	N	N	N	N	T	N	N
31 Wholesale & retail trade; repairs	N	N	N	N	N	N	N	N	N	N	N
32 Hotels & restaurants	N	N	N	N	T	T	N	N	N	T	T
33 Land transport; transport via pipelines	T	T	T	T	T	T	T	T	T	T	N
34 Water transport	T	T	N	T	T	T	T	T	N	T	T
35 Air transport	T	T	T	T	T	T	T	T	T	T	N
36 ... auxiliary transport activities; activitie etc.	T	T	N	T	N	N	T	T	N	T	N
37 Post & telecommunications	T	N	N	N	N	N	T	T	N	T	N
38 Finance & insurance	N	N	N	N	T	N	T	T	T	T	N
39 Real estate activities	N	N	N	N	N	N	N	N	N	N	N
40 Renting of machinery & equipment	T	N	N	T	N	N	T	T	N	T	T
41 Computer & related activities	T	T	N	T	N	T	T	T	N	T	T
42 Research & development	T	T	T	T	T	N	N	N	N	T	T
43 Other Business Activities	T	N	T	T	T	T	T	N	N	T	T
44 Public admin. & defence; comp. soc. Sec.	N	N	N	N	N	N	N	N	N	N	N
45 Education	N	N	N	N	N	N	N	N	N	N	N
46 Health & social work	N	N	N	N	N	N	N	N	N	N	N
47 Other community, social & personal services	N	N	N	T	T	N	T	N	N	T	N
48 Private households with empl, etc.	N	N	N	N	N	T	T	N	N	N	N

Table 3: Investment

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
1 Agriculture,etc	T	T	T	T	T	N	T	N	T	T	N
2 Mining and quarrying (energy)	T	T	T	T	T	T	T	T	T	T	T
3 Mining and quarrying (non-energy)	T	T	T	T	T	T	T	T	T	T	T
4 Food products, beverages and tobacco	T	T	T	T	T	T	T	T	T	T	T
5 Textiles, textile products, etc.	T	T	T	T	T	T	T	T	T	T	T
6 Wood and products of wood and cork	T	T	T	T	T	T	T	T	T	T	T
7 Pulp, paper, paper products etc.	T	T	T	T	T	T	T	T	T	T	T
8 Coke, refined petroleum products etc.	T	T	T	T	T	T	T	T	T	T	T
9 Chemicals excluding pharmaceuticals	T	T	T	T	T	T	T	T	T	T	T
10 Pharmaceuticals	T	T	T	T	T	T	T	T	T	T	T
11 Rubber & plastics products	T	T	T	T	T	T	T	T	T	T	T
12 Other non-metallic mineral products	T	T	T	T	T	T	T	T	T	T	T
13 Iron & steel	T	T	T	T	T	T	T	T	T	T	T
14 Non-ferrous metals	T	T	T	T	T	T	T	T	T	T	T
15 Fab. metal prod., except mach. & equip.	T	T	T	T	T	T	T	T	T	T	T
16 Machinery & equipment, nec	T	T	T	T	T	T	T	T	T	T	T
17 Office, accounting & computing machinery	T	T	T	T	T	T	T	T	T	T	T
18 Electrical machinery & apparatus, nec	T	T	T	T	T	T	T	T	T	T	T
19 Radio, television & communication equipment	T	T	T	T	T	T	T	T	T	T	T
20 Medical, precision & optical instruments	T	T	T	T	T	T	T	T	T	T	T
21 Motor vehicles, trailers & semi-trailers	T	T	T	T	T	T	T	T	T	T	T
22 Building & repairing of ships & boats	T	T	T	T	T	T	T	T	T	T	T
23 Aircraft & spacecraft	T	T	T	T	T	T	T	T	T	T	T
24 Railroad equipment & transport equip nec.	T	T	T	T	T	T	T	T	T	T	T
25 Manufacturing nec; recycling etc.	T	T	T	T	T	T	T	T	T	T	T

Table 3: Investment

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
26 Production, coll. and distr. of elect.	N	N	T	N	N	N	T	N	N	T	N
27 Manuf. of gas; distr. of ga etc.	T	T	T	N	T	T	T	T	N	N	N
28 Steam and hot water supply	T	T	T	T	T	T	T	T	T	T	T
29 Colle., purif. and distr. of water	N	N	T	N	N	N	N	N	N	T	N
30 Construction	N	N	N	N	N	N	N	N	N	N	N
31 Wholesale & retail trade; repairs	N	N	N	N	N	N	N	N	N	N	N
32 Hotels & restaurants	T	N	T	N	T	T	N	N	N	T	T
33 Land transport; transport via pipelines	T	T	T	T	T	T	T	T	T	T	N
34 Water transport	T	T	N	T	T	T	T	T	N	T	T
35 Air transport	T	T	T	T	T	T	T	T	T	T	N
36 ... auxiliary transport activities; activitie etc.	T	T	N	T	N	N	T	T	N	T	N
37 Post & telecommunications	T	N	N	N	N	N	T	T	N	T	N
38 Finance & insurance	N	N	T	N	T	T	T	T	T	T	T
39 Real estate activities	N	N	N	N	N	N	N	N	N	N	T
40 Renting of machinery & equipment	T	T	T	T	N	N	T	T	N	T	T
41 Computer & related activities	T	T	N	T	N	T	T	T	N	T	T
42 Research & development	T	T	T	T	T	N	N	N	N	T	T
43 Other Business Activities	T	N	T	T	T	T	T	N	N	T	T
44 Public admin. & defence; comp. soc. Sec.	N	N	N	N	N	N	N	N	N	N	N
45 Education	N	N	N	N	N	N	N	N	N	N	N
46 Health & social work	N	N	N	N	N	N	N	N	N	N	N
47 Other community, social & personal services	N	N	N	T	T	N	T	N	N	T	N
48 Private households with empl, etc.	T	T	N	T	T	T	T	T	T	T	T

Table 4: Production structure

Item	Ita	Deu	Fra	Esp	Cze	Svk	Hun	Pol	USA	Can	Bra
Imp. inv. over total inv.	45.7	50.83	41.39	109.28	137.61	334.63	179.85	165.34	39.4	211.97	36.13
Imp. cons. over total cons.	8.24	10.22	8.23	10.75	18.97	26.13	11.69	12.48	5.13	15.72	5.08
Cons over GDP	50.73	45.7	47.8	50.61	32.74	37.38	32.63	51.04	63.81	42.75	56.69
Non-tr. output over GDP	55.1	55.29	61.47	58.84	36.19	38.63	34.21	54.75	69.97	43.38	67.63
Inv. non-tr over tot. inv.	48.53	50.96	56.47	62.21	49.27	49.26	48.95	49.67	61.05	60.56	73.87
Cons. non-trad. over GDP	30.93	29.3	30.4	31.47	13.68	17.06	14.06	28.28	44.57	18.32	34.95

Table 5: Import shares of GDP

Item	Ita.	Deu.	Fra.	Esp.	Cze.	Svk	Hun.	Pol.	USA	Can.	Bra.
Interm.	16.12	16.26	11.72	18.54	34.61	33.95	41.14	17.51	6.16	20.28	7.8
Cons	4.18	4.67	3.93	5.44	6.21	9.77	3.81	6.37	3.27	6.72	2.88
Non Prof.	0	0	0.01	0	0	0.03	0	0	0	0	0
Govern.	0.01	0.21	0.21	0.14	0.42	0.98	0.42	0.07	0	0	0
Invest.	2.7	3.1	2.29	4.16	5.55	7.02	5.28	6.53	2.14	4.23	1.29
Inventor.	0.22	0.15	0.15	0.07	0.4	0.49	1.67	0.07	0.15	0.91	0.17
Valuables	0.03	0	0	0	0	0	0	0	0	0	0
Exports	0	4.19	6.55	0	0	0	1.13	1	0	0	0
Total imp.	23.26	24.39	18.32	28.34	47.19	52.24	52.33	30.56	11.71	32.14	12.13

Figure 1: Welfare loss in pp of steady-state consumption

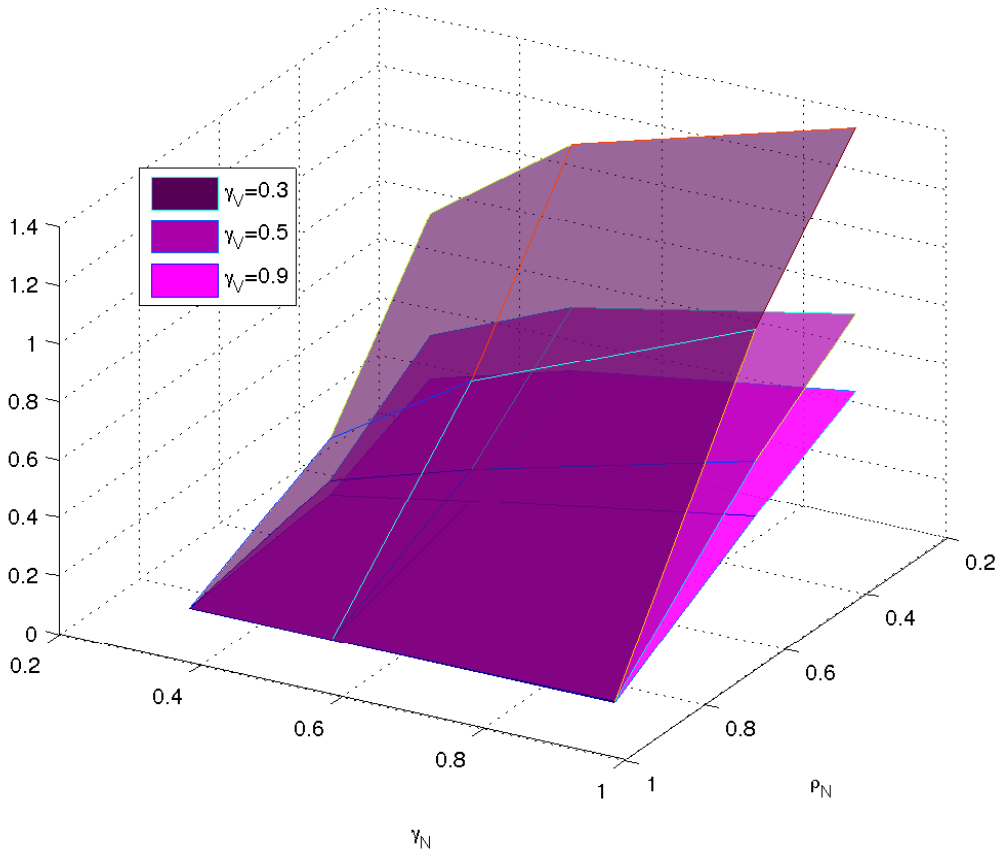

Figure 2: Welfare loss in pp of steady-state consumption

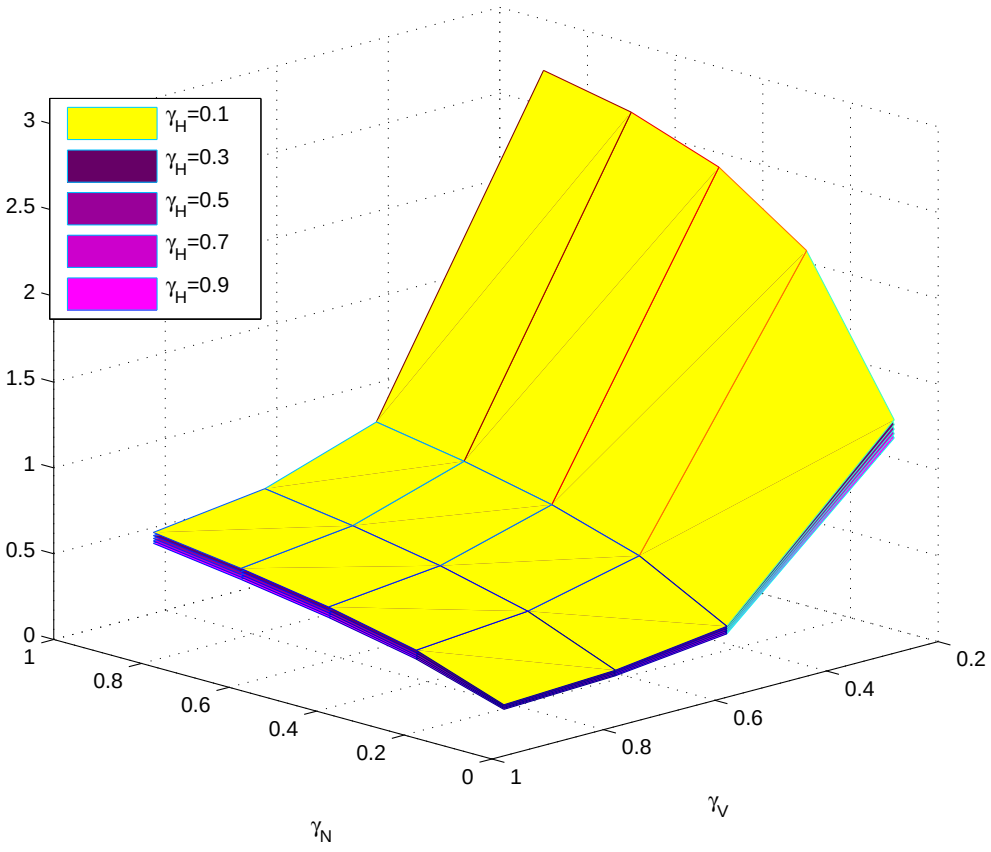

Figure 3: Welfare and import share of GDP

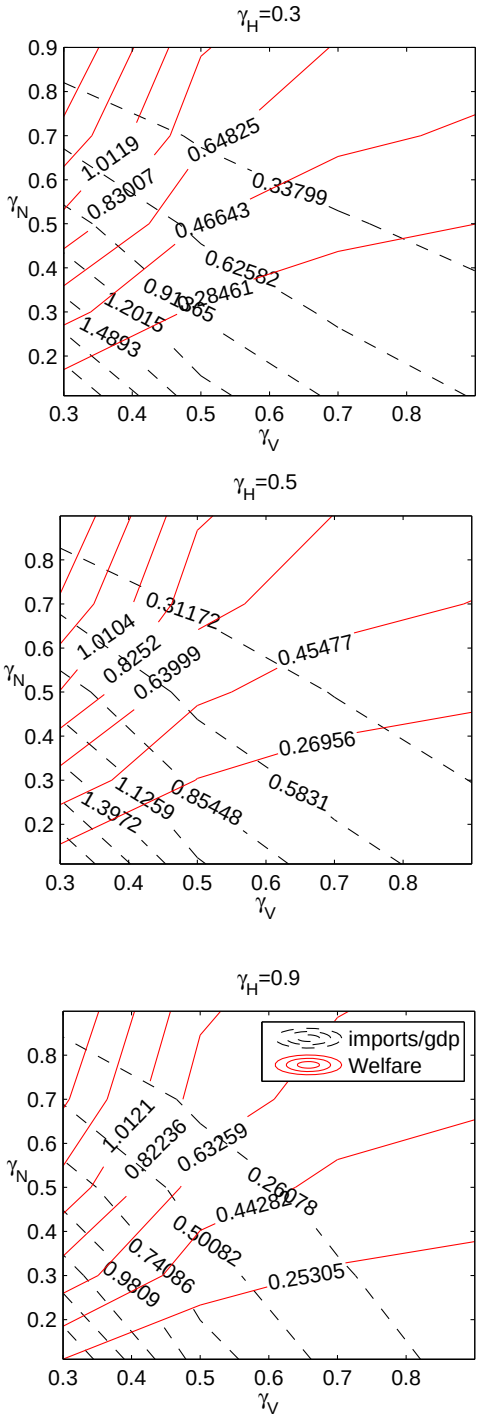

Figure 4: Welfare and imported investment as share of domestic tradable investment