When Leaner Isn't Meaner:

Measuring Benefits and Spillovers

of Greater Competition in Europe[1]

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Abstract

Using a variant of the IMF's Global Economy Model (GEM), featuring nominal rigidities and monopolistic competition in product and labor markets, this paper estimates the benefits and spillovers of greater competition, with an application where euro-area competition is raised to US levels. The paper draws three conclusions. First, greater competition produces large effects on standard measures of macroeconomic performance. In particular, we show that differences in competition can account for over half of the current gap in GDP per capita between the euro area and the US. Second, it may improve macroeconomic management by reducing the degree of structural inflation persistence. Third, greater competition can generate large spillovers to the rest of the world.

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1 Introduction

Why are there such large differences in income per capita across countries, both within the industrial core and between this core and the rest of the world? For much of the postwar period, the standard answer to this question focused on the process of technological catch-up. More recently, however, it is becoming increasingly clear that structural differences across countries play a key role, both directly and by providing impediments to the successful implementation of macroeconomic policies.[1] This switch in emphasis is particularly evident in continental Europe, where the leading explanation of the continuing divergence in material wealth from that of the United States is that labor and product markets are more hampered by regulations than their U.S. counterparts. Indeed, the action plans endorsed in a series of recent summits of European leaders suggests that increasing competition in Europe through deregulation has become a major policy priority.[2] Despite the importance of this topic, however, estimates of the benefits from greater competition are limited.[3]

This paper uses the IMF's Global Economic Model (GEM) to estimate the effects of changing competition on performance within a country and spillovers to the rest of the world. Unlike traditional macroeconomic models, which combine relationships only loosely related to theory, GEM has been developed from strong and fully consistent microeconomic foundations. In product and labor markets, for example, the model posits imperfect competition which drives a wedge between the true marginal cost/product and actual prices/wages. These markups are inversely related to the degree of substitutability across goods, and hence the underlying level of competition. A two-country version of GEM involving the euro area and the rest of the world — where the calibration of the latter is based on the United States — is used to explore how altering domestic competition in labor and product markets affects

[1] See IMF (2003) and OECD (2003) for surveys. Key references include Hall and Jones (19XX) and ???.

[2] See Bailey (2003) for a detailed analysis.

[3] References. Blanchard.....

performance at home and abroad across a wide range of elasticities/markups and other key parameters in the model. Empirical estimates of euro area and U.S. markups are then used to estimate the impact of increasing competition in the euro area to levels prevalent in the United States.

Anticipating our conclusions, we find that increasing competition leads to sizable increases in domestic output and consumption as well as easing the task of the monetary authorities by reducing the distortions associated with wages-price rigidities. These benefits also provide positive spillovers to the rest of the world, both through a favorable terms of trade effect which boosts consumption abroad by more than output, and by allowing the domestic monetary authorities to stabilize output more effectively. In short, this is one case where leaner is not meaner, but provides substantial benefits at home and abroad.

Indeed, our estimates of the potential long-term gains from greater competition in the euro area are substantial, and would greatly diminish the difference in material well-being between the euro area and the United States. Our simulations indicate that increasing competition in the euro area to U.S. levels could increase output by over 10 percent in the euro area as both investment and hours worked rise markedly, and by 2 percent in the rest of the world. The consumption benefits are more evenly spread, with euro area consumption rising 7 percent versus 3 percent elsewhere. In addition, monetary policy becomes more effective in the euro area, as the sacrifice ratio (i.e. the cost in foregone output required to reduce inflation by 1 percent) halves. These benefits come about because greater competition reduces the monopolistic power of producers and workers, and hence the degree to which they restrict their respective supplies to raise prices and wages, while increasing the responsiveness of prices and wages to market conditions.

The next section discusses the theoretical background to the model. Section 3 discusses the calibration and properties of the model. Section 4 reports how changes in price and wage markups impact the home and foreign economy. Section 5 reports a simulation in

which euro area markups fall to U.S. levels, while Section 6 concludes.

2 The model

2.1 Consumption and investment goods

The world economy consists of two countries, Home (the euro area) and Foreign (the rest of the world). Foreign variables are indexed with a star. The structure of the model is illustrated in Figure 1.[4]

In each country there is a continuum of symmetric firms producing a nontradable consumption good under perfect competition. Home firms producing the consumption good are indexed by $x \in [0, s]$, where $0 < s < 1$ is a measure of country size. World size is normalized to 1, and Foreign firms producing the Foreign final good are indexed by $x^* \in (s, 1]$.

Home firm x's output at time (quarter) t is denoted $A_t(x)$.[5] The consumption good is produced with the following CES technology:

$$A_t(x) = \left(\nu_A^{\frac{1}{\mu_A}} Q_{A,t}(x)^{1-\frac{1}{\mu_A}} + (1-\nu_A)^{\frac{1}{\mu_A}} \left[M_{A,t}(x) \left(1 - \Gamma_{MA,t}(x)\right) \right]^{1-\frac{1}{\mu_A}} \right)^{\frac{\mu_A}{\mu_A - 1}} \quad (1)$$

Two intermediate inputs are used in the production of the consumption good A: a basket Q_A of domestically-produced tradable goods, and a basket M_A of imported tradable goods. The elasticity of substitution between domestic and imported inputs is $\mu_A > 0$. The parameter $\nu_A \in (0, 1)$ is the weight of local inputs in the production of the good A, which is a measure of home bias in consumption.

To model sluggish adjustment of imports volumes to changes in incomes and relative prices, we assume that imports as a share of total production are subject to external ad-

[4] The model introduced in this section is a simpler variant of the IMF's GEM. For a detailed presentation of *GEM* see Pesenti (2003) and Laxton and Pesenti (2003).

[5] The convention throughout the model is that variables which are not explicitly indexed (to firms or households) are expressed in per-capita (average) terms. For instance, $A_t \equiv (1/s) \int_0^s A_t(x)dx$.

justment costs Γ_{MA}:[6]

$$\Gamma_{MA,t}(x) \equiv \frac{\phi_{MA}}{2}\left(\frac{M_{A,t}(x)}{A_t(x)}/\frac{M_{A,t-1}}{A_{t-1}}-1\right)^2 \tag{2}$$

As is the case for adjustment costs on investment dynamics, these adjustment costs are assumed to shrink the consumption possibilities frontier of the economy.

The baskets Q_A and M_A are CES indexes of differentiated intermediate tradables, respectively produced in the Home country and imported from the Foreign country. Each intermediate good is produced by a single firm under conditions of monopolistic competition.[7] Home firms in the tradables sector are indexed by $h \in [0, s]$, Foreign firms in the tradables sector are indexed by $f \in (s, 1]$. Defining as $Q_A(h, x)$ and $M_A(f, x)$ the use by firm x of the intermediate goods produced by firms h and f respectively, we have:

$$Q_{A,t}(x) = \left[\left(\frac{1}{s}\right)^{\frac{1}{\theta}} \int_0^s Q_{A,t}\left(h, x\right)^{1-\frac{1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}} \tag{3}$$

$$M_{A,t}(x) = \left[\left(\frac{1}{1-s}\right)^{\frac{1}{\theta^*}} \int_s^1 M_{A,t}\left(f, x\right)^{1-\frac{1}{\theta^*}} df\right]^{\frac{\theta^*}{\theta^*-1}} \tag{4}$$

where $\theta, \theta^* > 1$ are the elasticities of substitution across differentiated goods.

In the Home country, the prices of the intermediate goods are denoted $p(h)$ and $p(f)$. Each Home firm x takes these prices as given and minimizes its costs. Home firm x's demand for input h is then obtained as:

$$Q_{A,t}\left(h, x\right) = \left(\frac{p_t\left(h\right)}{P_{Q,t}}\right)^{-\theta} \frac{Q_{A,t}(x)}{s} \tag{5}$$

where P_Q is the cost-minimizing price of one basket of local intermediates:

$$P_{Q,t} = \left[\left(\frac{1}{s}\right) \int_0^s p_t\left(h\right)^{1-\theta} dh\right]^{\frac{1}{1-\theta}} \tag{6}$$

Similarly we can derive $M_A(f, x)$ and P_M — respectively firm x's optimal demand of imports f and the cost-minimizing price of the imports basket.

[6] In our symmetric framework it is assumed that a firm finds it costly to adjust its current imports/output ratio $M_{A,t}(x)/A_t(x)$ relatively to the past aggregate imports/output ratio $M_{A,t-1}/A_{t-1}$.

[7] This is a convenient assumption that entails no loss of generality.

Next, each Home firm x takes the prices of the intermediate baskets P_Q and P_M as given and minimizes $P_{Q,t}Q_{A,t}(x) + P_{M,t}M_{A,t}(x)$ subject to 1. As the consumption good sector is perfectly competitive, each firm takes the price of the final good P as given and equates its marginal cost to the price. Cost minimization in Home consumption good production yields:

$$Q_{A,t}(x) = \nu_A \left(\frac{P_{Q,t}}{P_t}\right)^{-\mu_A} A_t(x) \tag{7}$$

$$M_{A,t}(x) = (1-\nu_A)\left(\frac{P_{M,t}}{P_t \Omega_{MA,t}(x)}\right)^{-\mu_A} \frac{A_t(x)}{1-\Gamma_{MA,t}(x)} \tag{8}$$

where the variable $\Omega_{MA}(x)$ is a function of the imports/output ratio.[8]

Mutatis mutandis, the investment good sector is similar to the consumption good sector described above. Symmetric Home firms producing the investment good under perfect competition are indexed by $y \in [0, s]$, and Foreign firms by $y^* \in (s, 1]$. Home firm y's output is denoted $E_t(y)$. Using self-explanatory notation, output is given by:

$$E_t(y) = \left(\nu_E^{\frac{1}{\mu_E}} Q_{E,t}(y)^{1-\frac{1}{\mu_E}} + (1-\nu_E)^{\frac{1}{\mu_E}} \left[M_{E,t}(y)\left(1-\Gamma_{ME,t}(y)\right)\right]^{1-\frac{1}{\mu_E}}\right)^{\frac{\mu_E}{\mu_E - 1}} \tag{9}$$

The other variables can be similarly derived. For instance, Home firm y's demand for the basket of local intermediates is:

$$Q_{E,t}(y) = \left[\left(\frac{1}{s}\right)^{\frac{1}{\theta}} \int_0^s Q_{E,t}(h,y)^{1-\frac{1}{\theta}}\, dh\right]^{\frac{\theta}{\theta-1}} = \nu_E \left(\frac{P_{Q,t}}{P_{E,t}}\right)^{-\mu_E} E_t(y) \tag{10}$$

where P_E is the price of one unit of E, and Home firm y's demand for input h is:

$$Q_{E,t}(h,y) = \left(\frac{p_t(h)}{P_{Q,t}}\right)^{-\theta} \frac{Q_{E,t}(y)}{s} \tag{11}$$

Aggregating across x- and y-type firms we obtain the following demand schedule for Home tradable intermediate goods h:

$$\int_0^s Q_{A,t}(h,x)\, dx + \int_0^s Q_{E,t}(h,y)\, dy = \left(\frac{p_t(h)}{P_{Q,t}}\right)^{-\theta} (Q_{A,t} + Q_{E,t}) \tag{12}$$

[8] To wit, $\Omega_{MA,t}(x) \equiv 1 - \Gamma_{MA,t}(x) - \phi_{MA}\left(\frac{M_t(x)}{A_t(x)} / \frac{M_{t-1}}{A_{t-1}} - 1\right)\left(\frac{M_t(x)}{A_t(x)} / \frac{M_{t-1}}{A_{t-1}}\right)$.

Similar considerations hold for the demand of Foreign tradable intermediate goods f, accounting for differences in country size s:

$$\int_0^s M_{A,t}(f,x)\,dx + \int_0^s M_{E,t}(f,y)\,dy = \frac{s}{1-s}\left(\frac{p_t(f)}{P_{M,t}}\right)^{-\theta^*}(M_{A,t}+M_{E,t}) \tag{13}$$

Foreign variables are similarly characterized.

2.2 Intermediate goods

We denote by $T(h)$ the supply of each Home-country intermediate h according to the following CES technology:

$$T_t(h) = Z_t\left\{(1-\alpha)^{\frac{1}{\xi}}\,\ell_t(h)^{1-\frac{1}{\xi}} + \alpha^{\frac{1}{\xi}}K_t(h)^{1-\frac{1}{\xi}}\right\}^{\frac{\xi}{\xi-1}} \tag{14}$$

Firm h uses labor $\ell(h)$ and capital $K(h)$ with constant elasticity of input substitution $\xi > 0$, while Z is a productivity shock common to all producers of Home tradables.

Each firm h uses a CES combination of differentiated labor inputs. Labor inputs are immobile geographically. In each country, they are defined over a continuum of mass equal to the country size: Home labor inputs are indexed by $j \in [0,s]$, Foreign labor inputs by $j^* \in (s,1]$. We can then write:

$$\ell_t(h) = \left[\left(\frac{1}{s}\right)^{\frac{1}{\psi}}\int_0^s \ell(h,j)^{1-\frac{1}{\psi}}dj\right]^{\frac{\psi}{\psi-1}} \tag{15}$$

where $\ell(h,j)$ is the demand of the labor input of type j by the producer of good h and $\psi > 1$ is the elasticity of substitution among labor inputs.

Firms producing intermediate goods take the prices of labor inputs and capital as given. Cost minimization in the intermediate sector implies that the demand for labor input j by firm h is a function of the relative wage:

$$\ell_t(h,j) = \left(\frac{1}{s}\right)\left(\frac{W_t(j)}{W_t}\right)^{-\psi}\ell_t(h) \tag{16}$$

where $W(j)$ is the nominal wage paid to Home labor input j and the wage index W is defined as:

$$W_t = \left[\left(\frac{1}{s}\right)\int_0^s W_t(j)^{1-\psi}dj\right]^{\frac{1}{1-\psi}} \tag{17}$$

Denoting by R the Home nominal rental price of capital, cost minimization yields:

$$\ell_t(h) = (1-\alpha)\left(\frac{W_t}{MC_t(h)Z_t}\right)^{-\xi}\frac{T_t(h)}{Z_t} \tag{18}$$

$$K_t(h) = \alpha\left(\frac{R_t}{MC_t(h)Z_t}\right)^{-\xi}\frac{T_t(h)}{Z_t} \tag{19}$$

where the marginal cost $MC(h)$ is given by:

$$MC_t(h) = \frac{\left\{(1-\alpha)\,W_t^{1-\xi} + \alpha R_t^{1-\xi}\right\}^{\frac{1}{1-\xi}}}{Z_t} \tag{20}$$

Similar considerations hold for the production of Foreign intermediates.

2.3 Price setting in the intermediate sector

Consider now profit maximization in the Home country's intermediate sector. Each firm h takes into account the demand for its product in both countries (that is, expression 12 and the Foreign-country analog of expression 13) and sets the nominal prices $p(h)$ in the Home market and $p^*(h)$ in the Foreign market by maximizing the present discounted value of its real profits. In both markets there is sluggish price adjustment due to resource costs measured in terms of total profits.[9] The adjustment cost are denoted $\Gamma_{PQ,t}(h)$ and $\Gamma^*_{PM,t}(h)$:

$$\Gamma_{PQ,t}(h) \equiv \frac{\phi_{Q1}}{2}\left(\frac{p_t(h)}{\pi p_{t-1}(h)} - 1\right)^2 + \frac{\phi_{Q2}}{2}\left(\frac{p_t(h)/p_{t-1}(h)}{P_{Q,t-1}/P_{Q,t-2}} - 1\right)^2 \tag{21}$$

$$\Gamma^*_{PM,t}(h) \equiv \frac{\phi^*_{M1}}{2}\left(\frac{p^*_t(h)}{\pi^* p^*_{t-1}(h)} - 1\right)^2 + \frac{\phi^*_{M2}}{2}\left(\frac{p^*_t(h)/p^*_{t-1}(h)}{P^*_{M,t-1}/P^*_{M,t-2}} - 1\right)^2 \tag{22}$$

where $\phi_{Q1}, \phi_{Q2}, \phi^*_{M1}, \phi^*_{M2} \geq 0$ and $\pi, \pi^* > 0$. The quadratic costs of price adjustment have two components. The first one is related to changes of the nominal price relative to a parameter π at Home or π^* abroad, which is equal to the gross steady-state rate of inflation.[10] The second component is related to changes in firm h's price inflation relative

[9] See among others Rotemberg (1982) and Ireland (2001).

[10] This specification implies that the steady-state inflation rate be known at any point in time. More generally, the adjustment cost can be specified relative to any variable that converges asymptotically to the steady-state inflation rate.

to the past observed inflation rate in the relevant market. As costs apply to both changes in the nominal price level and the inflation rate, they allow the model to reproduce realistic inflation dynamics encompassing nominal inertias and staggering.

Formally, denoting the nominal exchange rate with $\mathcal{E}$ (defined as Home currency per unit of Foreign currency), firm h sets its prices by maximizing its profits:

$$\max_{\{p_\tau(h),p^*_\tau(h)\}_{\tau=t}^{\infty}} \mathsf{E}_t \sum_{\tau=t}^{\infty} D_{t,\tau} \left[(p_\tau(h) - MC_\tau(h)) \left(\frac{p_\tau(h)}{P_{Q,\tau}}\right)^{-\theta} (Q_{A,\tau} + Q_{E,\tau}) (1 - \Gamma_{PQ,\tau}(h)) \right.$$
$$\left. + (\mathcal{E}_\tau p^*_\tau(h) - MC_\tau(h)) \left(\frac{p^*_\tau(h)}{P^*_{M,\tau}}\right)^{-\theta} \left(M^*_{A,\tau} + M^*_{E,\tau}\right) \left(\frac{1-s}{s}\right) \left(1 - \Gamma^*_{PM,\tau}(h)\right) \right] \tag{23}$$

where $D_{t,\tau}$ is the appropriate discount rate (with $D_{t,t} = 1$), to be defined below.

Denoting $\pi_t(h) = p_t(h)/p_{t-1}(h)$ and $\pi_{Q,t} = P_{Q,t}/P_{Q,t-1}$, the first-order condition with respect to $p_t(h)$ can be written as:

$$(1 - \Gamma_{PQ,t}(h)) (p_t(h) (1-\theta) + \theta MC_t(h)) - (p_t(h) - MC_t(h)) \frac{\partial \Gamma_{PQ,t}(h)}{\partial p_t(h)} p_t(h)$$
$$= \mathsf{E}_t \left(D_{t,t+1} (p_{t+1}(h) - MC_{t+1}(h)) \left(\frac{Q_{A,t+1} + Q_{E,t+1}}{Q_{A,t} + Q_{E,t}}\right) \left(\frac{\pi_{t+1}(h)}{\pi_{Q,t+1}}\right)^{-\theta} \frac{\partial \Gamma_{PQ,t+1}(h)}{\partial p_t(h)} p_t(h) \right) \tag{24}$$

Equation 24 is key to our results. First, note that when prices are fully flexible ($\phi_{Q1} = \phi_{Q2} = 0$), the optimization problem collapses to the standard markup rule:

$$p_t(h) = \frac{\theta}{\theta - 1} MC_t(h) \tag{25}$$

where the fixed gross markup $\theta/(\theta - 1)$ is a negative function of the elasticity of input substitution. More crucially, equation 24 clarifies the link between imperfect competition and nominal rigidities: when θ is very large, equation 24 is solved by $p_t(h) = MC_t(h)$ regardless of how sizable ϕ_{Q1} or ϕ_{Q2} are. This implies that in a competitive economy (large θ) prices must move in tandem with the shocks affecting marginal costs, even though such flexibility entails large adjustment costs. Instead, if price setters have strong monopoly power (θ is close to one, its minimum value), they can charge a high average markup over marginal costs. In this case, when marginal costs increase due to cyclical conditions,

firms find it optimal to maintain prices relatively stable and absorb such changes through a markup squeeze. In fact, monopolistic distortions are such that firms can minimize their adjustment costs while maintaining their prices well above marginal costs, and changes in demand can be accommodated through supply adjustments without corresponding changes in prices.

Similar considerations hold for the price of goods h abroad, $p^*(h)$. If nominal rigidities in the export market are highly relevant (that is, if ϕ^*_{M1} and ϕ^*_{M2} are relatively large), the prices of Home goods in the Foreign market will be characterized by significant inertia.[11] In this case, exchange rate pass-through in the Foreign economy will be low due to the fact that exports are invoiced in Foreign currency and prices are sticky in the consumer currency. In the absence of price stickiness, instead, optimal price setting is consistent with the cross-border law of one price:

$$\mathcal{E}_t p^*_t(h) = p_t(h) = \frac{\theta}{\theta - 1} MC_t(h) \tag{26}$$

Foreign variables are similarly characterized.

2.4 Consumer optimization

In each country there is a continuum of symmetric households. Home households are indexed by $j \in [0, s]$ and Foreign households by $j^* \in (s, 1]$, the same indexes of labor inputs.

Households' preferences are additively separable in consumption and labor effort. Denoting with $\mathcal{W}_t(j)$ the lifetime expected utility of Home agent j, we have:

$$\mathcal{W}_t(j) \equiv E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[U\left(C_\tau\left(j\right)\right) - V\left(\ell_\tau(j)\right) \right] \tag{27}$$

where β is the discount rate, assumed to be identical across countries. There is habit

[11] Substantially, this is the "local currency pricing" scenario analyzed by Devereux and Engel (2000), Corsetti and Pesenti (2001) and others.

persistence in consumption according to the specification:

$$U_t(j) = Z_{U,t}\frac{(C_t(j) - bC_{t-1})^{1-\sigma} - 1}{1-\sigma} \tag{28}$$

where C_{t-1} is past per-capita Home consumption and $0 < b < 1$. The term $Z_{U,t}$ is a preference shock common to all Home residents. The parametric specification of V is:

$$V_t(j) = Z_{V,t}\frac{\ell_t(j)^{1+\zeta}}{1+\zeta} \tag{29}$$

where $\zeta > 0$ and $Z_{V,t}$ is a shock to labor disutility. Foreign agent j^*'s preferences are similarly specified.

The individual flow budget constraint for agent j in the Home country is:

$$\begin{aligned}
&\mathcal{M}_t(j) + \mathcal{E}_t B^*_{t+1}(j) + B_{t+1}(j) \leq \mathcal{M}_{t-1}(j) + (1+i^*_t)\left[1-\Gamma_{B,t}\right]\mathcal{E}_t B^*_t(j) \\
&+(1+i_t)B_t(j) + R_t K_t(j) + W_t(j)\ell_t(j)\left[1-\Gamma_{W,t}(j)\right] \\
&-P_t C_t(j)\left[1+\Gamma_{S,t}(j)\right] - P_t I_t(j) + \Phi_t - NETT_t(j)
\end{aligned} \tag{30}$$

Home agents hold domestic money $\mathcal{M}$ and two bonds, B and B^*, denominated in Home and Foreign currency, respectively. The short-term nominal rates i_t and i^*_t are paid at the beginning of period t and are known at time $t-1$.[12] The two short-term rates are directly controlled by the national governments. Only the Foreign-currency bond is traded internationally: the Foreign bond is in zero net supply worldwide, while the Home bond is in zero net supply at the domestic level.

The financial friction Γ_B is introduced to guarantee that net asset positions follow a stationary process and the economies converge asymptotically to a steady state. Home agents face a transaction cost Γ_B when they take a position in the Foreign bond market. This cost depends on the average net asset position of the whole economy and is zero only when Home agents do not hold any Foreign-currency assets. This implies that in a non-stochastic steady state Home agents have no incentive to hold Foreign bonds and net asset

[12] We adopt the notation of Obstfeld and Rogoff [1996, ch.10]. Specifically, our timing convention has $B_t(j)$ and $B^*_t(j)$ as agent j's nominal bonds accumulated during period $t-1$ and carried over into period t.

positions are zero worldwide. An appropriate parameterization allows the model to generate realistic dynamics for the current account and net asset positions and. In particular, the friction Γ_B can be subject to random shocks, isomorphic to 'uncovered interest parity shocks' or risk-premium fluctuations in other open-economy models (such as McCallum and Nelson (1999) or Kollmann (2001)).[13]

Home agents accumulate Home physical capital which they rent to Home firms at the nominal rate R. The law of motion of capital is:

$$K_{t+1}(j) = (1-\delta) K_t(j) + \Psi_t K_t(j) \qquad 0 < \delta \leq 1 \tag{31}$$

where δ is the depreciation rate. To simulate realistic investment flows, capital accumulation is subject to adjustment costs. Capital accumulation is denoted $\Psi_t K_t(j)$, where $\Psi(.)$ is an increasing, concave, and twice-continuously differentiable function of the investment/capital ratio $I_t(j)/K_t(j)$ with two properties entailing no adjustment costs in steady state: $\Psi(\delta) = \delta$ and $\Psi'(\delta) = 1$. The specific functional form we adopt is quadratic:

$$\Psi_t \equiv \frac{I_t(j)}{K_t(j)} - \frac{\phi_{I1}}{2}\left(\frac{I_t(j)}{K_t(j)} - \delta\left(1 + Z_{I,t}\right)\right)^2 - \frac{\phi_{I2}}{2}\left(\frac{I_t(j)}{K_t(j)} - \frac{I_{t-1}}{K_{t-1}}\right)^2 \tag{32}$$

where $\phi_{I1}, \phi_{I2} \geq 0$ and $Z_{I,t}$ is a temporary shock (an unexpected increase in $Z_{I,t}$ is equivalent to an increase in the rate of capital depreciation that raises investment relative to baseline).

Each household is the monopolistic supplier of a labor input j. Each household sets the nominal wage for type j-labor input facing a downward-sloping demand, obtained by aggregating equation **??** across h firms. Following Kim (2000), there is sluggish wage adjustment due to resource costs that are measured in terms of the total wage bill. The adjustment cost is denoted $\Gamma_{W,t}$, with:

$$\Gamma_{W,t}(j) \equiv \frac{\phi_{W1}}{2}\left(\frac{W_t(j)}{\pi W_{t-1}(j)} - 1\right)^2 + \frac{\phi_{W2}}{2}\left(\frac{W_t(j)/W_{t-1}(j)}{W_{t-1}/W_{t-2}} - 1\right)^2 \tag{33}$$

[13] For more details on the specification of the financial intermediation technology see Pesenti (2003) and Laxton and Pesenti (2003).

where $\phi_{W1}, \phi_{W2} \geq 0$ and $\pi > 0$. As was the case for prices above, wage adjustment costs have two components. The first one is related to changes of the nominal wage relative to its gross steady-state rate of inflation. The second component is related to changes in wage inflation relative to the past observed rate for the whole economy.

Consumption spending is subject to a proportional transaction cost Γ_S that depends on the household's money velocity v, where $v_t(j) \equiv P_t C_t(j)/\mathcal{M}_t(j)$. Agents optimally choose their stock of real money holdings $\mathcal{M}/P$ so that at the margin shopping costs measured in terms of foregone consumption are equal to the benefits from investing in yield-bearing assets.[14]

Home agents own all Home firms and there is no international trade in claims on firms' profits. The variable Φ includes all profits accruing to Home households, plus all Home-currency revenue from nominal and real adjustment rebated in a lump-sum way to all Home households, plus revenue from financial intermediation which is assumed to be provided by Home firms exclusively.

Finally, Home agents pay lump-sum (non-distortionary) net taxes $NETT_t(j)$ denominated in Home currency. Similar relations hold in the Foreign country, with the exception of the intermediation frictions in the financial market.

The representative Home household chooses bond and money holdings, capital and consumption paths, and sets wages to maximize its expected lifetime utility (27) subject to (30) and (31). Defining the variable $D_{t,\tau}$ as:

$$D_{t,\tau} \equiv \beta \frac{P_t U'(C_\tau) \left[1 + \Gamma_{S,t} + \Gamma'_{S,t} v_t\right]}{P_\tau U'(C_t) \left[1 + \Gamma_{S,\tau} + \Gamma'_{S,\tau} v_\tau\right]} \tag{34}$$

which is Home agents' stochastic discount rate and the Home pricing kernel, the first-order conditions with respect to $B_{t+1}(j)$ and $B^*_{t+1}(j)$ are, respectively:

$$1 = (1 + i_{t+1}) \, \mathsf{E}_t D_{t,t+1} = \left(1 + i^*_{t+1}\right) (1 - \Gamma_{B,t+1}) \, \mathsf{E}_t \left(D_{t,t+1} \mathcal{E}_{t+1}/\mathcal{E}_t\right) \tag{35}$$

[14] Following Schmitt-Grohe and Uribe (2001), the particular functional form for the transaction cost is $\Gamma_S(v_t) = \phi_{S1} v_t + \phi_{S2}/v_t - 2\sqrt{\phi_{S1}\phi_{S2}}$.

The above expression is a risk-adjusted uncovered-interest-parity relationship, recalling that the return on lending to Foreign is reduced (and the cost of borrowing from Foreign is increased) by to the costs of intermediation Γ_B. In a non-stochastic steady state the interest differential $(1+i)/(1+i^*)$ is equal to the steady-state nominal depreciation rate of the Home currency and $1+i=\pi/\beta$ where π is the gross steady-state inflation rate and $1/\beta$ is the steady-state real rate of interest (equal to the gross rate of time preference).

The first-order conditions with respect to $\mathcal{M}_t(j)$, $K_{t+1}(j)$ and $W_t(j)$ are standard. Real money balances $\mathcal{M}/P$ are a positive function of consumption and a negative function of the nominal interest rate. Capital accumulation is linked to the behavior of the real price of capital R/P. In steady state $1+R/P$ is equal to the sum of the rate of time preference $1/\beta$ and the rate of capital depreciation δ. Also, in steady state the real wage W/P is equal to the marginal rate of substitution between consumption and leisure, V'/U', augmented by the markup $\psi/(\psi-1)$ which reflects monopoly power in the labor market.

Optimization implies that households exhaust their intertemporal budget constraint: the flow budget constraint 30 hold as equality and the transversality condition is satisfied:

$$\lim_{\tau\to\infty} E_t D_{t,\tau}\left[\mathcal{M}_{\tau-1}(j)+(1+i_\tau)B_\tau(j)+(1+i^*_\tau)(1-\Gamma_{B,\tau})\mathcal{E}_\tau B^*_\tau(j)\right]=0 \qquad (36)$$

Similar results characterize the optimization problem of Foreign agent j^*.

2.5 Government

Public spending falls both on consumption and investment goods. In the model G_C is per-capita public purchases of the Home consumption goods and G_I is public investment, financed through net lump-sum taxes and seigniorage revenue. The budget constraint of the Home government is:

$$sP_tG_{C,t}+sP_{E,t}G_{I,t}\leq\int_0^s NETT_t(j)dj+\int_0^s\left[\mathcal{M}_t(j)-\mathcal{M}_{t-1}(j)\right]dj \qquad (37)$$

The government controls the short-term rate i_{t+1}. Monetary policy is specified in terms

of annualized interest rate rules of the form:

$$(1+i_{t+1})^4 - 1 = \omega_i \left[(1+i_t)^4 - 1\right] + (1-\omega_i)\left[\left(1+\overline{i_{t+1}}\right)^4 - 1\right] + \omega_1 E_t \left[\frac{P_{t+\tau}}{P_{t+\tau-4}} - \Pi_{t+\tau}\right] + \Theta\left(\digamma_t\right) \tag{38}$$

where the left hand side is the annualized interest rate, i_t is the lagged interest rate (with $0 < \omega_i < 1$) and $\overline{i_{t+1}}$ is the desired interest rate, defined as:

$$\left(1+\overline{i_{t+1}}\right)^4 = E_t \frac{1}{\beta^4} \frac{P_{t+\tau}}{P_{t+\tau-4}} \tag{39}$$

In the expression above $P_{t+\tau}/P_{t+\tau-4}$ is the year-on-year gross CPI inflation rate τ quarters into the future, and $\Pi_{t+\tau}$ is the year-on-year gross inflation target τ quarters into the future. The term Θ is a function of a set $\digamma_t$ of observable variables (output gap, exchange rate, current account, etc.) expressed as deviations from their targets, determining feedback rules for the nominal interest rate. In a steady state with constant inflation target Π it is:

$$\pi = P_t/P_{t-1} = \left(P_t/P_{t-4}\right)^{0.25} = \Pi^{0.25} \tag{40}$$

and when all targets are reached it must be the case that:

$$1 + i_{t+1} = 1 + \overline{i_{t+1}} = \frac{\Pi^{0.25}}{\beta}. \tag{41}$$

Foreign variables are similarly characterized. Any steady-state discrepancy between i and i^* (thus, between π and π^*) determines the steady-state rate of exchange rate depreciation (for $\pi > \pi^*$) or appreciation (for $\pi < \pi^*$).

2.6 Market clearing

The model is closed by imposing the following resource constraints and market clearing conditions.

The Home tradable h can be used by Home firms or imported by Foreign firms, so that:

$$T(h) \geq \int_0^s Q_{A,t}(h,x)\,dx + \int_0^s Q_{E,t}(h,y)\,dy + \int_s^1 M^*_{A,t}(h,x^*)\,dx^* + \int_s^1 M^*_{E,t}(h,y^*)\,dy^* \tag{42}$$

and similarly the Foreign tradable f can be used domestically or abroad:

$$T^{*}(f) \geq \int_{s}^{1} Q_{A,t}^{*}(f,x^{*})\,dx^{*} + \int_{s}^{1} Q_{E,t}^{*}(f,y^{*})\,dy^{*} + \int_{0}^{s} M_{A,t}(f,x)\,dx + \int_{0}^{s} M_{E,t}(f,y)\,dy \tag{43}$$

The Home good A can be used for private or public consumption, and similarly the Home good E is used for private or public investment:

$$\int_{0}^{s} A_t(x)dx \geq \int_{0}^{s} C_t(j)[1+\Gamma_{S,t}(j)]dj + sG_{C,t} \tag{44}$$

$$\int_{0}^{s} E_t(y)dy \geq \int_{0}^{s} I_t(j)dj + sG_{I,t} \tag{45}$$

The resource constraints for labor and capital are:

$$\ell_t(j) \geq \int_{0}^{s} \ell_t(h,j)dh \tag{46}$$

$$\int_{0}^{s} K_t(j)dj \geq \int_{0}^{s} K_t(h)dh \tag{47}$$

Similar expressions hold abroad.[15]

Finally, market clearing in the asset market requires:

$$\int_{0}^{s} B_t(j)dj = 0, \qquad \int_{0}^{s} B_t^{*}(j)dj + \int_{s}^{1} B_t^{*}(j^{*})dj^{*} = 0. \tag{48}$$

3 Calibration and model properties

This section describes the baseline calibration of the model. In what follows we will refer to the euro area as the Home country (assumed to make up 35 percent of the industrial world) and the Foreign country as the rest of the industrial world.[16] The import-to-GDP

[15] It is worth noticing that in equilibrium $p(n) = P_N$, $p(h) = P_Q$, $p(f) = P_M$, $p^{*}(n) = P_N^{*}$, $p^{*}(h) = P_M^{*}$, $p^{*}(f) = P_Q^{*}$, $W(j) = W$, $W^{*}(j^{*}) = W^{*}$.

[16] The objective is to build a version of the model for the Euro area that models trade linkages with the rest of the high-income industrialized world. However, to calibrate the dynamics of the Foreign country we rely heavily upon model results for the US economy provided by the model development teams at the ECB and Federal Reserve Board of Governors.

ratio was set to be 18 percent for the euro area and 13 percent for the rest of the world (which is approximately the openness of the US economy). Table 1 provides a summary of the key parameter values as well as steady-state values for a some key variables in the baseline solution of the model.

The monetary transmission mechanism for the Home country has been calibrated to approximately replicate the hump-shaped dynamics of VARs and the ECB's area-Wide Model (AWM), while the monetary transmission mechanism for the Foreign rest-of-world block has been calibrated to approximately replicate the dynamics of VARs and the Federal Reserve Board's FRB-US model of the US economy. As will be shown below, despite the strong theoretical foundations present in the GEM, it is possible to calibrate it in a way that gives rise to a plausible, empirically-based, representation of the monetary transmission mechanism.[17] The monetary transmission mechanisms of the monetary VARs and the two central-bank models are consistent with other empirical evidence that suggests there is significantly higher structural inflation persistence in the euro area than in the United States and that there are significant differences in real-financial linkages in the sense that interest rate hikes result in larger changes in investment in the euro area and smaller changes in consumption. The model has been calibrated to be consistent with these basic stylized facts.

[17] We are currently investigating the possibility of using Bayesian estimation methods to estimate different versions of the GEM. These methods, which require specifying priors for the distributions.of the parameters, are much closer in spirit to how policy models have been estimated-calibrated in practise. One purpose of this paper is to establish a sensible set of initial priors based on central banker modelers' views about the monetary transmission mechanism. For a critique of classical estimation techniques see Sims (2002). Based on a smaller single-country model, Smets and Wouters (2002b) have provided some encouraging results that suggest it may be feasible to use Bayesian methods to estimate the parameters of fairly large SDGE models. The use of such methods will represent an important step forward because it will eliminate the gap between econometric theory and practise and allow researchers to do meaningful statistical inference and model validation exercises.

The baseline steady-state wage and price markups for the euro area and the US are based on previous empirical work that suggests that the euro area has significantly less competition in both labor and product markets. As will be shown below, differences in the degrees competition between the euro area and the United States may be the principal factors that explains why the sacrifice ratio is so much higher in the euro area than in the United States.[18]

3.1 Assumptions about elasticities and markups

The inverse of the parameter ζ represents the Frisch elasticity of labor supply and in the baseline calibration of the model it has been set to 1/3 (ζ =3). This estimate is at the high end of the range of estimates from micro studies, which vary from about .05 to .35, but is significantly lower than what is typically used in the real business cycle literature (see, e.g., Cogley and Prescott, 1995). Because the results are sensitive to the assumption about this parameter value, an alternative estimate that is closer to the mean estimates from micro studies (0.15 or ζ =6.7) is also considered.

Following Chari, Kehoe and McGrattan (2001), Smets and Wouters (2002a) and others, the elasticity of substitution between domestic and imported inputs in the production of consumption and investment goods (μ_A and μ_E) have both been set equal to 1.50. These elasticities determine the long-run responses of the import shares of consumption and investment goods to changes in their relative prices. An estimate of 1.5 is somewhat higher than econometric estimates based on specifications that do not disaggregate imports of consumption and investment goods. For example, using aggregate measures of import shares, Laxton and others (1998) provide a pooled estimate of 1.0 based on data for the Group of Major Industrial Countries. Gali and Monacelli (2002) also choose a value equal to one as

[18]The sacrifice ratio is a useful metric for measuring the degree of structural inflation persistence in the economy. As in other studies, it is defined here to be the cumulative annual output gap that is required to permanently reduce the inflation rate by one percentage point.

their baseline in their analysis of an SDGE model. These elasticities are critical determinants of the long-run spillover effects of changes in the degree of competition in one country on other countries because they affect the response of the real exchange rate and therefore the average levels of per capita real income and consumption. The Section on sensitivity analysis shows the implications of setting these elasticities as low as 1.0 and as high as 2.0.

The steady-state price and wage markups are allowed to vary in the simulations. The wage markup is equal to $[\psi/(\psi-1)]$ so that a markup of (say) 1.5 reflects a elasticity of substitution for labor services of (ψ) of 3. Similarly, the steady-state price markup is $[\theta/(\theta-1)]$, so a markup of (say) 1.1 would imply an elasticity of substitution of goods across firms (θ) of 10.

3.2 Assumptions about steady-state ratios

The following steady-state ratios were calibrated to be consistent with recent data from the national accounts. The steady-state investment-to-GDP ratio was set to be equal 0.22 in both countries with 0.19 representing private sector investment and .03 representing investment by government. Based on a quarterly depreciation rate of 0.025 this implies a steady-state capital-to-GDP ratio of around 2.2. The values for α have been chosen to produce a smaller labour income share in the Home country (0.56) than in the Foreign country (0.68).

The steady-state import-to-GDP ratio for the Home country was set at 0.18 and 0.13 in the rest of the world. The split of imports into investment and consumption goods was based on recent data that suggests that for the euro area approximately 2/3 of imported goods are investment goods while for the United States this is number is only slightly greater than 1/2. The steady-state level of imports of investment goods relative to GDP is set at 0.13 for the euro area and 0.07 for the United States, and the remainder is allocated to imports of consumption goods. These ratios are calibrated by setting the appropriate values for

the scale parameters (ν_A and ν_E) in the import demand functions for both the Home and Foreign countries.

3.3 Calibration of the dynamics

The remaining parameters were calibrated so that the model matches the monetary transmission mechanisms in monetary VARs and those used for forecasting and policy analysis at the ECB and Federal Reserve Board of Governors. Table 2 reports the responses of key macro-variables in our model to a 1-year hike in the policy rate in the Home country, followed by reversal to the base-case Taylor rule. In addition, results from the same experiment using the ECB's area-Wide Model (AWM), whose empirical apparatus does not build upon a choice-theoretic structural model, are also shown (these responses are reported in Fagan, Henry and Mestre, 2001). [Discussion of VAR results]. Table 3 repeats the same experiment except this time the interest rate hike is imposed on the Foreign economy and the results are compared to the Federal Reserve Board of Governor's FRB-US model [and a VAR]. Taking the parameters discussed above as given, the remaining parameters of the GEM were calibrated to mimic the dynamic responses of the AWW model and the FRB-US models in response to a 1-year hike in interest rates. To make the results more easily comparable we have included a summary column in Table 2 and 3 that reports the sum of the responses over the first 2 years of the simulation horizon.

To approximately replicate the hump-shaped response of consumption to an interest rate hike, it was necessary to use a fairly high value for the persistence parameter (b = 0.97 in both countries) as well as high values for the intertemporal elasticity of substitution ($1/\sigma$). Indeed, in the simulations reported in Tables 2 and 3, the value of the intertemporal elasticity of substitution ($1/\sigma$) has been set equal to 3.0 in the Home country and 5.0 in the Foreign country. The relatively higher value for the Foreign country was necessary to be consistent with the dynamic responses of the ECB's AWM and FRB-US models, as well

as some other empirical evidence that suggests that interest rates have stronger effects on consumption in the United States than in the euro area. While these estimates for $(1/\sigma)$ might seem large when compared to models that ignore habit persistence, they are necessary to generate a monetary transmission mechanism where the effects of interest rate hikes build up gradually over time.

To understand the interaction of b and $(1/\sigma)$ in generating hump-shaped consumption responses, Figure 2 reports some results for exactly the same experiments conducted in Table 2 and 3, computed for various values of $(1/\sigma)$ and b. The top panel reports consumption responses for the Home country without habit persistence (b=0) for three values of the intertemporal elasticity of substitution that range between 1/3 and 3.0, with an intermediate case of 0.99 that approximates the assumption of log utility that is typically relied upon in real business cycle models.[19] The top panel shows that without habit persistence, consumption responds as a pure jump variable in response to interest rate hikes, and indeed in all three cases the maximum response of consumption is in the very first period when the shock is assumed to take place. The two middle panels show results when the habit persistence parameter as been set at 0.6 and 0.8 respectively. These fall within the range of estimates that researchers have estimated for b after imposing a log utility specification in their models $(1/\sigma = 1)$.

Consumption in these simulations falls significantly in the period when the shock occurs and then its magnitude grows only slightly over the next 2 quarters before converging quickly back to its baseline value. There are two types of inconsistencies between these responses and the results reported in the AWM model and FRB-US models (see Tables 2 and 3). First, the maximum effect on consumption in both of these models occurs after about 3-4

[19] When preferences are additive over consumption and leisure the main virtue of log utility—aside from analytical tractibility—is that it gives rise to a balanced growth path. Unfortunately, this constrains the range over which the parameters can vary to replicate conventional views about hump-shaped macro dynamics.

quarters and is about 3 to 4 times larger than the impact effect in the first quarter. Second, the results from the AWM and FRB-US models suggest that consumption converges more slowly back to the baseline path in the second year. As can been seen in the bottom panel of Figure 2, the GEM comes closest to replicating these features when there are very high degrees of habit persistence (b= 0.97) and intertemporal rates of substitution (3 or greater). The base-case calibration of the GEM is based on these high estimates for $1/\sigma$, but we also consider an alternative parameterization in the section on sensitivity analysis that assumes a more conventional estimate that approximates log utility.

The elasticity of substitution (ξ) between capital and labor in the production function has been set to be 0.80 in the Home country and 0.70 in the Foreign country. This is in line with other studies that suggest it is significantly lower than one. This choice allows us to simulate a lesser response of capital to interest rate changes than would be the case under a Cobb-Douglas calibration. Along with adjustment costs on the change in investment this allows the model to approximately replicate the magnitudes of investment responses that are found in the two central-bank models of the monetary transmission mechanism. The slightly larger value for ξ in the Home country combined with the same adjustment adjustment cost parameters in both countries ($\phi_{I1} = 1$ and $\phi_{I2} = 70$) implies that investment is more responsive to interest rate hikes in the euro area than in the United States. The model has been calibrated with significant adjustment costs on the change in investment ($\phi_{I2} = 70$) and very small adjustment costs on capital accumulation ($\phi_{I1} = 1$) to generate the hump-shaped response of investment that is found in both of these central bank models.[20] Note, however, that the short-run response may be too responsive to interest rate shocks.[21]

[20] This calibration of the adjustment costs for investment dynamics is very similar to Altig and others (2003) which assume zero adjustment costs on capital formation but significant adjustment costs on the change in investment.

[21] One possibility would to allow for decision lags on both consumption and investment to slow down the short-run responsiveness of these variables in response to intertest rate hikes—see Woodford (2002). This

Likewise, the adjustment cost parameters for imports have been calibrated to slow down the responsiveness of the import shares to changes in relative prices. These adjustment costs suggest that it takes the import share several quarters to adjust to a permanent change in the real exchange rate and that over periods of about 2-3 years the effective elasticity is around 1.0. These adjustment cost parameters combined with the other parameters allow the model to do a reasonable job at replicating the dynamics of the AWW and FRB-US models.

The only remaining parameters that needed to be calibrated are the adjustment cost parameters on wages, prices and import prices, which determine how quickly the price level adjusts in response to the interest rate hike. For the baseline calibration of the model it was decided to allow for full pass-through of the exchange rate into import prices and to impose the same adjustment costs on wages and prices given the paucity of reliable empirical evidence on wage and price inertia. The last Section of the paper focuses specifically on the implications of incomplete exchange rate pass-through and different nominal rigidities in wages and prices. Given full-exchange rate pass-through ($\phi_{M2} = 0$), a value of 3000 for ϕ_{W2} and ϕ_{Q2} is capable of approximately replicating the slow response of the price level in the ECB's model of the euro area and a value of 1764 is capable of replicating the significantly faster response of the price level in the FRB-US model. One criticism of relying upon estimated models of monetary transmission mechanism is that it may significantly overstate the degree of structural inflation persistence if part of the estimated historical inflation persistence was a result of slow learning in moving between low and high inflation regimes—see Erceg and Levin (2001) and Laxton and N'Diaye (2002). Accordingly, the benchmark calibration of the model imposes adjustment costs in wages and prices that are lower than the historical data suggest and identical in both countries (ϕ_{W2} and $\phi_{Q2} = 882$), so as to focus on the role of higher markups as factors for explaining why the sacrifice ratio

can be important for some issues related to the design of optimal monetary policy rules.

is typically found to be significantly higher in the euro area. In this benchmark calibration of the model the sacrifice ratio is 1.9 in the Home country and 0.9 in the Foreign country.

4 Results

This section focuses on how differing levels of competition affect two key aspects of performance, the level of activity and the sacrifice ratio for the monetary authorities. Increases in competition feed into output and demand as they reduce the ability of workers and firms to exploit market power by restricting the supply of goods and labor. As a result, a greater level of competition implies a higher level of real output and consumption. The rest of the world also benefits, as greater output in the home country leads to an increase in demand for imports from the foreign country but in addition to that direct effect a depreciation in the home exchange rate boosts real incomes and consumption abroad. In addition, as explained in the discussion of equation 24 above, greater competition makes monetary policy easier to implement by increasing the flexibility of wages and prices. By making wages and prices more flexible, competition thus makes it easier for the monetary authorities to stabilize domestic output and inflation. In short, in the presence of even modest transaction costs in nominal contracts, lower levels of competition lead to greater structural inflation persistence.

4.1 Long-Run Effects on Economic Activity of Higher Markups

The impact of changing markups on the long-run levels of economic activity using the baseline calibration are shown in Figure 3. Starting from a situation in which both labor and product markets are essentially in competitive equilibrium, with a markup of 1/2 percent (implying underlying elasticities of substitution between varieties of goods or different workers of 200), the goods and labor market competition is reduced by increasing the relevant markup in increments of 5 percentage points to a final value of around 55 percent (implying

underlying elasticities of around 3, almost a hundred-fold lower than the initial values). In all of these simulations, other markups at home and abroad are set to 1/2 percent, hence these markets are assumed highly competitive.

In analyzing these simulations, it is worth recalling the thought experiments being performed. Lower competition across firms raises the price markup as these firm reduce output to exploit their more downward sloping demand curves. They reduce capital more than hours worked as labor is the scarcer resource, and hence restricting hours worked causes a larger increase in costs. As a result, the most important impact of a reduction in product market competition is on the capital stock. By contrast, lower competition in labor markets allows workers to exploit their greater market power by reducing supply. In this case, the primary effect is through a reduction in hours worked as a result of which firms adjust their capital stock to remain efficient. In addition, the change in consumption is closely allied to the change in labor effort as, in steady state, the disutility of work has to be equated with the benefits of consumption (adjusted by the appropriate relative prices). Second, international spillovers depend crucially on the appreciation in the exchange rate as competition falls. This appreciation reflects the reduction in availability of home goods as opposed to foreign goods and (in some cases) the impact on the overall propensity to import coming from shifts in spending (investment has a higher foreign component than consumption). The favorable terms-of-trade effect cushions the impact on consumption at home and exacerbates it abroad.

Higher markups (and hence lower levels of competition) lead to mildly concave reductions in output and consumption at home and abroad (Figure 3). In the case of product markets, for example, an increase in the price markup from half a percent to five-and-a-half percent reduces output by 3.2 percent, while a similar increase from 50 to 55 percent reduces output

by 1.7 percent.[22] The costs associated with the same changes in wage markups are around half of these values. Given that wages comprise around two-thirds of costs, this implies that an increase in goods prices coming from greater competition across firms is somewhat more detrimental to output than an equivalent increase in costs coming from labor markets. This is because restricting output is the primary mechanism for raising price markups, while it is a secondary outcome of restricting hours worked when wage markups are involved. As a result, inefficiencies in labor markets have a smaller impact on output than equivalent impediments on the product side, and lesser spillovers to the rest of the world. In both cases, the impact on foreign output largely reflects lower investment rather than labor effort. This is because the effects on the rest of the world are channelled through competition between home and foreign firms, which principally affects the capital stock and investment.

Looking at the results in detail, an increase in the price markup has a particularly deleterious effect on the capital stock, which falls by over 40 percent as the markup rises from zero to one-half, about double the reduction in output. Hours worked also decline, but by less than two-thirds of the fall in output for the reasons outlined above. Consumption is reduced by only about half of the fall in domestic output as lower domestic output and the fall in investment leads to a favorable terms-of-trade effect, with the exchange rate appreciating by over 20 percent. Turning to the foreign country, when the markup rises from zero to one-half output falls by around 4 percent (about one-sixth of the reduction in the home country) as the demand for exports is lower and the terms-of-trade become more unfavorable. As a result of the terms-of-trade effect, consumption abroad falls by more than output, and indeed declines by around half of the decline in the domestic economy. In short, a lack of product market competition has a large impact on activity at home and in the rest of the world.

[22] This concavity stems largely from the fact that a percentage point increase in the markup has a smaller percentage increase on overall prices or wages as the markup itself increases.

The effects of an increase in the wage markup of a similar magnitude produces a significantly different response in domestic inputs, consumption, and spillovers to the rest of the world. For an equivalent rise in markups, output falls by about half as much with labor effort falling by slightly more than investment and output. Consumption falls by only slightly less than output, reflecting the greater role played by reductions in hours worked and more limited real exchange rate appreciation, as the response of output, investment, and the impact on goods prices is more muted than when price markups increase. The more limited exchange rate appreciation also limits spillovers to the rest of the world, with foreign consumption falling by only about one-fifth of its domestic equivalent. In short, wage markups have smaller spillovers to the rest of the world.

4.2 Effects of Higher Markups on Sacrifice Ratios

Changes in product and labor market competition also has a substantial impact on the flexibility of monetary policy, measured using the sacrifice ratio. The sacrifice ratio is the loss of output needed to reduce inflation by a percentage point, which (as discussed earlier) is calculated as the cumulated annual output gap required to lower inflation by one percentage point when the monetary authorities follow a relatively aggressive Taylor rule with regards to inflation.[23] As a measure of the tradeoff between output and inflation faced by monetary authorities, the sacrifice ratio is an estimate of the flexibility the monetary authorities have in conducting policy. Put differently, monetary policy is easier to operate if the output losses associated with changing inflation are small.

Increases in the wage markup have a greater impact on the sacrifice ratio than equivalent changes in product markets, even though wages comprise only two-thirds of costs. Figure 3 graphs the relationship between markups in goods and labor markets and the sacrifice ratio. The differences in impact of the two markups are substantial for low levels of the

[23] See Taylor (1993). The rule in the simulations puts no weight on the output gap, unity on the deviation of year-on-year inflation from its target, and one-half on the interest rate smoothing term.

markup but erode as the markups increase, moving to near equality at markups of around 50 percent. This reflects the fact that the relationship is convex for price markups and concave for wage markups.

The greater sensitivity of wage-price flexibility to labor market competition comes from the fact that labor is the scarce resource, and hence has less incentive to be flexible in the presence of market power. As a result, increases in the wage markup has a more deleterious effect on nominal flexibility. The bottom line of this analysis is labor market inefficiencies have a smaller impact on long-term output than equivalent product market inefficiencies but, for reasonable parameters, the opposite is true for monetary policy flexibility. These differences largely reflect the fact that firms face direct competition from abroad while labor does not. Both create negative spillovers to the rest of the world, either through lower demand and a less favorable terms-of-trade (in the case of output) or a lower ability to stabilize domestic output (in the case of monetary policy).

4.3 Sensitivity Analysis

We now examine the sensitivity of these results to changes in assumptions about other key parameters in the model that feed into some of the relationships examined above. (In all cases, alternative changes in the parameters were also examined, but are not reported for the sake of brevity as the qualitative results were similar). Figure 4 reports the results from reducing the Frisch elasticity of labor supply from 0.33 to 0.15.[24] Compared to the base case, the more limited labor supply response approximately halves the impact of changes in the wage markup on both domestic and foreign variables. This makes sense as it is this elasticity that provides labor with market power when competition is reduced. For the price

[24] As discussed earlier, this is closer to the mean of microeconomic estimates (the base-case parameterization is at the upper end of such estimates) but further away from the values generally used real business-cycle-models, presumably reflecting a judgement about the general equilibrium properties of such models.

markup, the situation is more complicated. Domestic hours worked and consumption also fall by about half compared to the base case, as shifts in labor supply affect wages by more, while the decline in investment is similar. As a result, domestic and foreign output fall by only about one quarter compared to the results discussed above, and the ratio of the fall in foreign consumption relative to domestic consumption rises from one-half in the base case to around two-thirds. The sacrifice ratio also falls, particularly as regards the wage markup, as lower flexibility in labor supply translates into more accommodation in wages. Hence, the principal effects of reducing the labor response to changes in real wages are to decrease the impact on output, increase the consumption spillovers for changes in price markups, and reduce the sacrifice ratio.

The equivalent deep parameter for firms is the elasticity of substitution between labor and capital, as this again affects the substitutability of a key input for firms, namely capital. Figure 6 shows the results from shifting this parameter down by 0.05 in both countries.[25] As might be expected, the main impact is on the price markup simulations. Making it more difficult to substitute between capital and labor reduces the impact on the capital stock and increases the decline in hours worked. While this leads to a smaller steady-state reduction in domestic output, consumption falls by more than in the base case, reflecting the large fall in hours worked and smaller terms-of-trade effect through the exchange rate, which also leads to a diminution in international spillovers. In the simulation using wage markups the impact is small, as in this case firms simply maintain an efficient level of production in the face of a reduction in hours worked and a resulting increase in real wages. Changes in this elasticity also have only marginal effects on the sacrifice ratio compared to the base case.

Next, the impact of changing the substitutability between domestic and foreign goods was examined. Figure 7 reports the results when this elasticity is raised from the base value

[25] In the base case the parameters are different as the sensitivity of investment to interest rates appears to vary between the euro area and the United States.

of one-and-a-half (and the upper end of the results from aggregate trade equations) to two, a value much more in the line with the higher elasticities that come from microeconomic evidence. As might be expected, the main impact of increasing the substitutability of domestic and foreign goods is to reduce the exchange rate response to changes in markups. This, in turn, reduces spillovers to the rest of the world through its impact on purchasing power at home and abroad.

Two further experiments were carried out. In the first, the intertemporal elasticity of substitution on consumption was reduced in both countries to unity (0.99 to be exact), corresponding to the log-utility value used in many other papers, with appropriate recalibrations elsewhere. As discussed earlier, this switch has significant implications for the short-term consumptions dynamics of the model. It turns out, however, that it has relatively little impact on the steady-state effects on the domestic economy (see Figure 8), although spillovers to the rest of the world are reduced. Finally, we examined the impact of changing the coefficients on the costs of adjustment of wages and prices on the sacrifice ratio (it has no impact on the steady-state results). As discussed earlier, the base calibration reduced the costs compared to those implied by historical data and made them equal across the two regions. When the parameters defining the costs of adjustment were increased to levels implied by historical data (which approximately double the coefficient in the United States, and increase that in the euro area by over three times) these changes had an approximately proportional effect on the level of the sacrifice ratio, but little impact on the relationship between this ratio and the markups (see Figure 4). As discussed earlier, this indicates structural inflation persistence can be introduced through a greater degree of imperfect competition as well as by altering the level of adjustment costs, as long as there are some costs to changing nominal variables.

To summarize, with the important exception of the Frisch elasticity, changing key parameters in the rest of the model has only limited effects on the impact of changes in markups

on the domestic economy but often alter the international spillovers significantly. The intuition is that in the home economy change in markups have a first-order effect which tends to dominate, but the spillovers to the foreign country come through indirect channels which are much more sensitive to the specification of the rest of the model. The exception is the Frisch elasticity, which directly affects the degree to which workers need to constrain their labor input to achieve a desired rise in markups, and hence has a first-order effect in the wage-markup simulations. The equivalent for firms is the substitutability between labor and capital, however the impact appears more limited as labor is, fundamentally, the scarce resource.

4.4 How much is a lack of competition costing the euro area?

One application of the analysis above is to gauge the detrimental effects of low levels of competition in the euro area on the euro area itself and the rest of the world. A leading explanation of the continuing divergence in material wealth, particularly within policy circles, is that labor and product markets in continental Europe are more hampered by regulations than those in the United States.[26] Indeed, the actions plan endorsed in a series of recent summits of European leaders suggests that increasing competition in Europe through deregulation has become a major policy priority, building on the single market program and single currency, both of which are aimed in large part at increasing competition.[27] Despite the importance of this topic, however, empirical estimates of the benefits from greater competition in the euro area remain limited.[28]

The first stage in this process is to calculate reasonable estimates of price and wage

[26] Another possible explanation is that Europeans have a greater preference for leisure than their North American cousins.

[27] Such summits have been held in Luxembourg, Cologne, Cardiff, Lisbon (twice), and Barcelona. See Bailey (2003).

[28] See IMF (2003) for a discussion.

markups from existing empirical work. Wage markups were taken from Sebastian and Nicoletti (2002), a paper that examines relative wages across sectors in a range of countries. The markup was measured by comparing the wage differential in sectors that are relatively competitive to the average wage in the economy as a whole. Three sectors in apparel manufacturing (textiles, worn apparel, and leather) were chosen, as these are relatively fragmented industries facing stiff competition from abroad, where wages are probably close to their competitive values. The OECD results imply a wage markup of around 15 percent for the United States and almost 30 percent for France (the most important euro area country included in the study). The paper also finds that public ownership drives down wage premiums in some nonmanufactured sectors in France, likely reflecting the market power of a single employer and underlying inefficiencies associated with public ownership of commercial industries. This implies that the true wage premiums in France are larger than these numbers suggest. Price differentials were taken from a paper that estimates markups by looking at differences in prices across countries for a large number of disaggregated products (Bradford and Lawrence, 2003). The empirical results in the paper yielded an estimate of the gap between marginal costs and prices of 15-20 percent in the United States and 50 percent or so in the euro area.

Based on these results, the wage markup was set at 15 percent for the United States and 40 percent for the euro area, and the price markup at 10 percent for the United States and 20 percent for the euro area (see Table 4). These values were chosen to broadly correspond to the stylized facts above. The U.S. wage markup was set equal to its estimated value, while for the euro area the French wage markup of 30 percent was increased to 40 percent to take account of the negative influence of public ownership on wages in some nonmanufactured sectors. Given that wages comprise some two-thirds of all costs, these wage markups imply prices that are some 10 and 25 percent above their competitive levels in the United States and the euro area, respectively. The price markups were then chosen to fill the remaining

gap between marginal cost and prices, as measured by the study of international prices. Other parameters are set at their baseline levels.

The long-term benefits, summarized in Table 5, are that euro area real output rises by almost 13 percent, with the capital stock increasing by about double that of hours worked (over 20 percent compared to 10 percent). This represents over half of the gap in per capita GDP and labor utilization between the two regions (see OECD, 2003, Figure 1.1). The Table reports results when both markups are altered simultaneously and when each is on its own. In line with earlier results, greater labor market competition has a relatively large effect on domestic consumption and labor effort, while more competition in goods markets creates relatively larger boosts to investment, the exchange rate, and international spillovers. Greater competition in labor markets is also the driving force behind the reduction in the sacrifice ratio, which halves from 1.9 to 1.0, essentially identical to the value in the United States (using the base case calibration) (see Table 6). [Discussion of what this does to optimal monetary policy]. In short, lack of competition in the euro area hurts its own economy significantly, but also creates significant spillovers to the rest of the world. Put a different way, significant benefits from greater competition will be felt both in the euro area and the rest of the world.

To examine the adjustment process, dynamic simulations were conducted on GEM in which the size of the gap between the euro area's markups and those of the United States were reduced by 4 percent per quarter.[29] This gradual rate of convergence—the half life of the shock is around 6 years—was chosen to reflect the slow effects of most institutional change on behavior. In the initial simulations, the increase in competition is assumed to be fully anticipated and credible, so that consumers and producers respond to both current anticipated increases in competition. Figure 9 illustrates the gradual evolution of

[29] Given the aggregate nature of the model, this paper does not attempt to analyze the costs of shifting resources across sectors within the economy, or the distributional consequences of an increase in competition.

the markups as well as their impact on euro area and the rest of the world. The increase in the marginal product of capital brought about by the reforms leads to a sharp rise in investment over the first few years to a new plateau, as firms increase their capital stock. The accumulation of capital is initially financed mainly from abroad, with the exchange rate appreciating by some 20 percent on impact and the trade balance deteriorating by some 3 percentage points of GDP. Over time, the increase in investment is increasingly funded from domestic sources as a higher real interest rate chokes off consumption, which falls slightly over the first five years before experiencing a sustained boom as the benefits of earlier capital accumulation come on stream. Reflecting this switch from external to domestic financing, foreign debt reaches a zenith of over 15 percent of GDP after 3 years, before gradually returning to baseline. Most of beneficial spillovers to the foreign country occur rapidly, reflecting the immediate improvement in the terms of trade, although the impact on consumption is elongated by habit persistence. These dynamic paths depend upon the speed and sensitivity of investment and consumption to changes in the real rate of interest. These in turn depend upon deep structural parameters, most importantly the costs of adjustment on the capital stock and habit persistence in consumption (increases in which slow the responses of investment and consumption, respectively) and the elasticity of substitution between capital and labor and the intertemporal elasticity of consumption (which change the size of the responses).

The importance of expectations in determining these patterns was examined by repeating the simulation but instead of assuming all future changes are anticipated, assuming that none are anticipated. More specifically, for the first 10 years consumers and firms assume that the current level of competition will continue indefinitely into the future, so that all further improvements come as a surprise (see Figure 10). Qualitatively, the results are similar, but with the responses significantly elongated. For example, the boom in investment and the appreciation in the real exchange rate now occur over the 10 years it takes consumers and

firms to realize the scope of the reforms, while the consumption boom is similarly delayed. The initial trade deficit is smaller but lasts longer, leading to a slower but larger increase international debt. In short, a lack of credibility lengthens the adjustment process.

5 Conclusion

This paper has examined the benefits from greater competition in product and labor markets in GEM, a fully specified new open economy model. While structural policies are being viewed increasingly as a source of differences across countries, empirical estimates of these effects have to date been extremely limited. For our results, the most important characteristic of GEM is the assumption of imperfect competition, which drives a wedge between marginal returns and actual prices. As this wedge depends upon the underlying level of competition across workers or firms, increases in these markups can be thought of as reflecting reduced competition in these markets. To our knowledge, this is the first paper to use this type of model to examine the international impact of structural policies.

Our results indicate that GEM produces reasonable empirical estimates of the benefits of structural polices to improve competition. Initially, the general properties of the model are examined. Lower levels of competition are associated with significantly reduced output and consumption at home and abroad, with the spillovers in consumption between larger than those in output due to an appreciation in the domestic real exchange rate. In addition, lower levels of competition affects macroeconomic policies by increasing nominal inertia in the model. This reduces the flexibility of domestic monetary policy, making it more difficult to stabilize the economy in the face of disturbances.

Changes in goods and wage markups have significantly different effects on the economy. Greater competition across firms leads to a more marked rise in the capital stock and output, and larger benefits to the rest of the world. Indeed, in our base case parameterization, the rise in foreign consumption is some 40 percent of that at home Greater competition in

labor markets results in a more marked increase in hours worked, nominal flexibility, and somewhat smaller international spillovers. Experiments varying the value of key elasticities indicate that the impact on the home country are relatively robust, while the size of the international spillovers is more sensitive to the parameterization of the rest of the model.

The model was then applied to the euro area using estimated markups in the euro area and the United States. Structural polices that increase competition in the euro area to U.S. levels is estimated to increase output in the euro area by over 10 percent, and that in the United States by 2 percent. This represents over half the current difference in per capita GDP. The gains in consumption are more evenly spread, with euro area consumption rising by 7 percent and U.S. consumption up 3 percent, in part because the euro depreciates against the dollar by some 10 percent. Equally importantly, these policies also benefits policy makers by making macroeconomic policies more effective. Indeed, the sacrifice ratio (i.e. the output cost of reducing inflation by one percentage point) halves. Hence, structural policies have effects on both long-term activity and the role of monetary policy in stabilization.

Dynamic simulations, in which the benefits of greater competition occur over a period of about 10 years, indicate that the investment boom in the euro area is initially financed mainly from external sources and external debt rises, but that after a while this rotates to domestic saving. The pace of responses depends on the credibility of the policies, with faster responses if people anticipate future improvements in competition.

The important message from this paper is that GEM can be used to calculate the impact of structural policies. Indeed, such simulations are particularly well suited to this type of model as the microeconomic underpinnings allow the various effects of structural policies on the real economy and monetary policies (through changes in structural inflation inertia) to be traced out. At the same time, it should be emphasized that this paper represent only an initial experiment. More work will have to be done to examine how robust these results are to varying structures and assumptions. In addition, one can think of many more

structural policies that could be examined, for example opening up to trade. An ambitious and exciting agenda lies ahead.

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Figure 1: The Light Version of the Global Economy Model

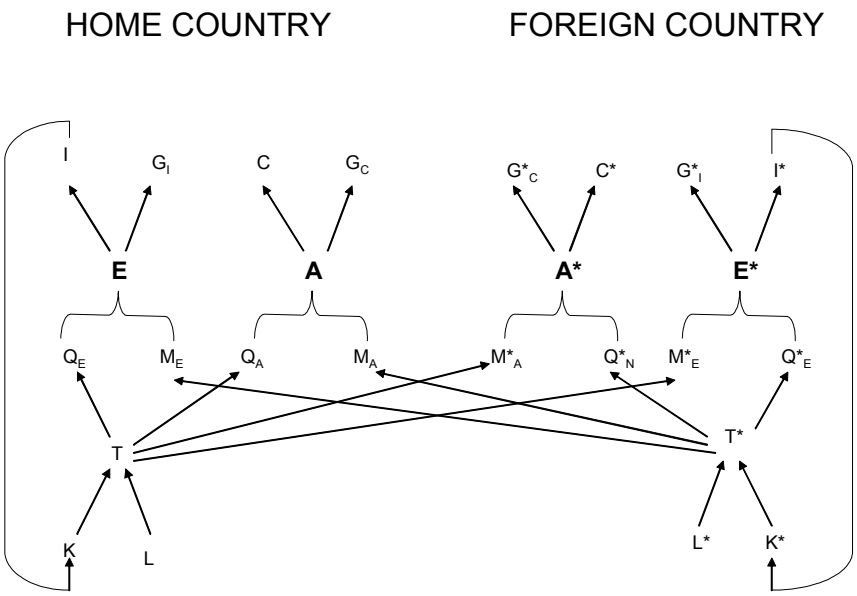


Table 1: Assumptions About Parameters and Steady-State Ratios

Parameters:	euro area (H)	Rest of World (F)
Discount Rate β	$1.03^{-0.25}$	$1.03^{-0.25}$
Depreciation Rate on Capital δ	0.025	0.025
Habit Persistence Parameter b	0.97	0.97
Intertemporal Elasticity of Substitution $1/\sigma$	3.33	5.00
Elasticity of Input Substitution for Intermediate Goods ξ	0.80	0.70
Elasticity of Input Substitution for Consumption μ_A	1.50	1.50
Elasticity of Input Substitution for Investment Goods μ_E	1.50	1.50
Inverse of Frisch Elasticity of Labor Supply ζ	3.00	3.00
Production Function Parameter that Determines Capital's Share α	0.63	0.69
Adjustment Cost Parameter for Imports of Consumption Goods ϕ_{MA}	10.00	10.00
Adjustment Cost Parameter for Imports of Investment Goods ϕ_{ME}	10.00	10.00
Adjustment Cost Parameter for Capital Accumulation ϕ_{I1}	1.00	1.00
Adjustment Cost Parameter for Investment Changes ϕ_{I2}	70.00	70.00
Adjustment Cost Parameter for Structural Wage Persistence ϕ_{W2}	3000	1764
Adjustment Cost Parameter for Import Price Persistence ϕ_{M2}	0.00	0.00
Adjustment Cost Parameter for Domestic Prices Persistence ϕ_{Q2}	3000	1764
Steady-State Ratios:	euro area (H)	Rest of World (F)
Labor's Share	0.56	0.68
Consumption Goods-to-GDP Ratio	0.78	0.78
Private Consumption	0.58	0.62
Government Consumption	0.20	0.16
Investment Goods-to-GDP Ratio	0.22	0.22
Private Investment	0.19	0.19
Government Investment	0.03	0.03
Imports-to-GDP Ratio	0.18	0.13
Consumption Goods	0.05	0.06
Investment Goods	0.13	0.07

Table 2: A Comparison of GEM's Monetary Transmission Mechanism with the ECB's Area Wide Model (AWM)

(Responses to a 100 Basis Point Interest Rate Hike)

			Quarter							
Variable:	Model:	Sum	1	2	3	4	5	6	7	8
Real GDP:	*GEM Home*	-2.4	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3	-0.3	-0.3
	ECB's AWW	-2.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
Consumption:	*GEM Home*	-1.8	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2
	ECB's AWW	-1.9	-0.0	-0.2	-0.2	-0.3	-0.4	-0.3	-0.3	-0.3
Investment:	*GEM Home*	-8.5	-0.6	-1.0	-1.2	-1.3	-1.3	-1.2	-1.0	-0.9
	ECB's AWW	-7.8	-0.1	-0.5	-0.8	-1.2	-1.5	-1.4	-1.3	-1.2
Exports:	*GEM Home*	-1.8	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2
	ECB's AWW	-1.6	-0.1	-0.2	-0.3	-0.4	-0.3	-0.2	-0.2	-0.1
Imports:	*GEM Home*	-3.8	-0.3	-0.4	-0.6	-0.6	-0.6	-0.5	-0.4	-0.4
	ECB's AWW	-4.9	-0.2	-0.5	-0.7	-0.9	-0.9	-0.7	-0.6	-0.6
Real Exchange Rate:	*GEM Home*	4.5	1.4	1.1	0.8	0.6	0.3	0.2	0.1	0.1
	ECB's AWW	-1.0	0.5	0.3	0.0	-0.2	-0.5	-0.4	-0.4	-0.3
CPI	*GEM Home*	-0.8	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
	ECB's AWW	-0.4	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1

Table 3: A Comparison of GEM's Monetary Transmission Mechanism with the Fed's Model (FRBUS)

(Responses to a 100 Basis Point Interest Rate Hike)

			Quarter							
Variable:	Model:	Sum	1	2	3	4	5	6	7	8
Real GDP:	*GEM Foreign*	-2.3	-0.2	-0.3	-0.4	-0.4	-0.4	-0.3	-0.2	-0.1
	FED's FRB-US	-2.7	-0.1	-0.2	-0.3	-0.4	-0.4	-0.5	-0.4	-0.4
Consumption:	*GEM Foreign*	-2.0	-0.2	-0.3	-0.4	-0.4	-0.3	-0.2	-0.2	-0.1
	FED's FRB-US	-2.6	-0.1	-0.2	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4
Investment:	*GEM Foreign*	-6.3	-0.6	-0.9	-1.1	-1.2	-1.0	-0.8	-0.5	-0.3
	FED's FRB-US	-5.6	-0.1	-0.5	-0.8	-0.9	-1.0	-0.9	-0.8	-0.6
Exports:	*GEM Foreign*	-0.9	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.0
	FED's FRB-US	-1.8	-0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4
Imports:	*GEM Foreign*	-2.3	-0.2	-0.4	-0.4	-0.4	-0.4	-0.3	-0.2	-0.1
	FED's FRB-US	-2.9	-0.1	-0.2	-0.4	-0.5	-0.5	-0.5	-0.4	-0.3
Real Exchange Rate:	*GEM Foreign*	2.0	1.1	0.8	0.5	0.2	-0.1	-0.2	-0.2	-0.2
	FED's FRB-US	4.3	1.0	0.9	0.7	0.6	0.4	0.3	0.2	0.2
CPI	*GEM Foreign*	-2.1	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
	FED's FRB-US	-1.7	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4

Figure 2: Consumption Responses to a 4-Quarter 100 Basis Point Hike in Interest Rates Under Various Assumptions for Habit Persistence and the Intertemporal Elasticity of Substitution

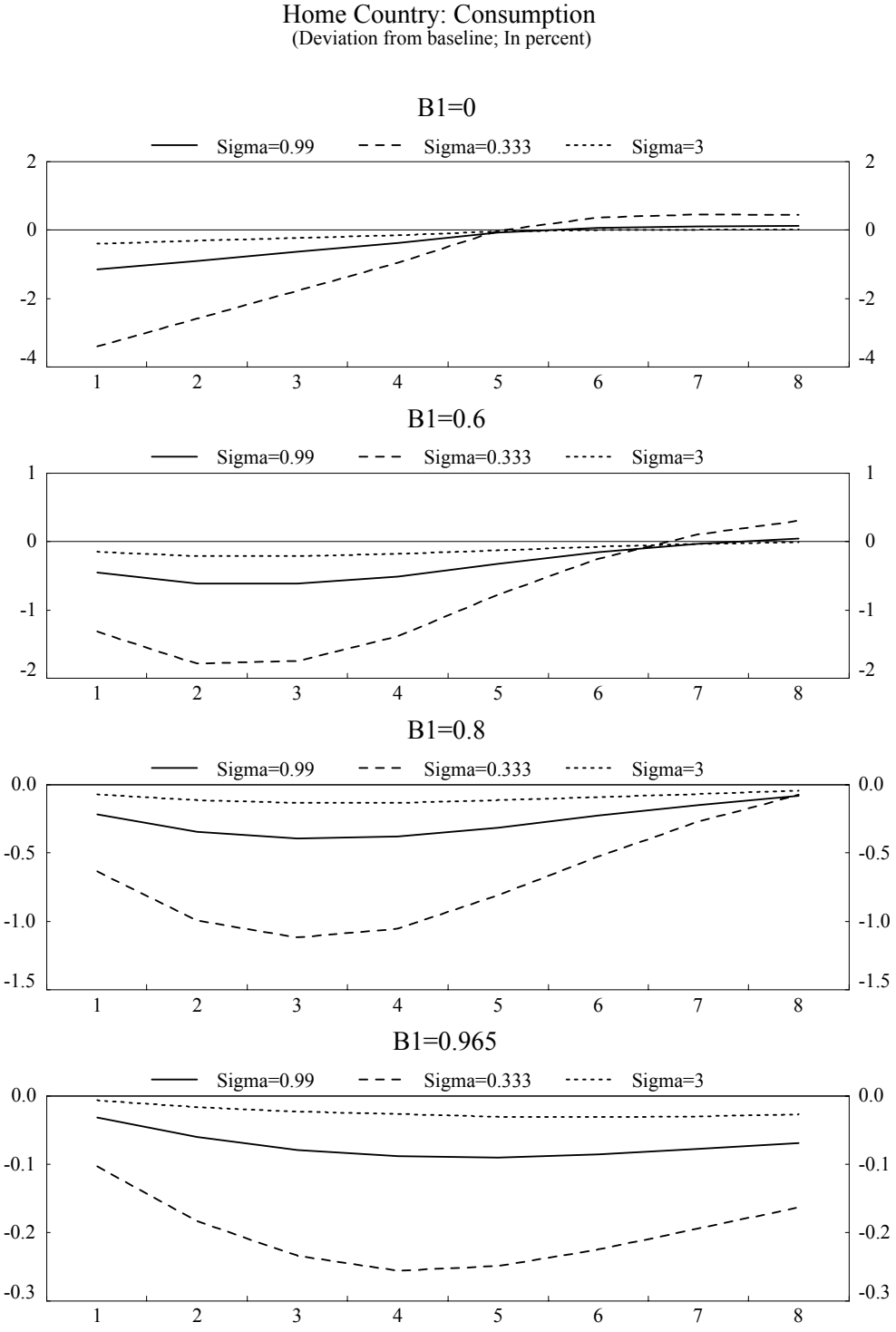
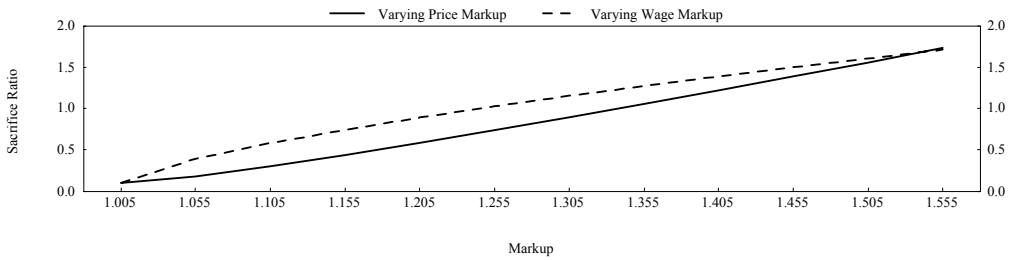


Figure 3: Effects of Different Price and Wage Markups on Sacrifice Ratios and the Long-Run Levels of Economic Activity (BASE-CASE PARAMETERS WITH LOWER STRUCTURAL INFLATION PERSISTENCE AND IDENTICAL NOMINAL ADJUSTMENT COSTS IN THE HOME AND FOREIGN COUNTRY)

Sacrifice Ratios for Home Country Under Different Markups

	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.2	1.4	1.6	1.7
Sacrifice Ratio (Varying Wage Markup)	0.1	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7



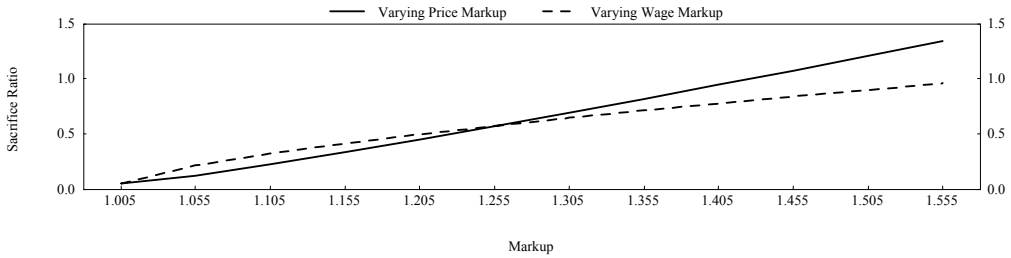
Long-Run Effects of Different Price Markups and Wage Markups

	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Home Country Long-run Effects of Higher Price Markups (In percent)											
GDP	-3.2	-6.1	-8.8	-11.4	-13.7	-16.0	-18.1	-20.1	-22.0	-23.7	-25.4
Consumption	-1.3	-2.6	-4.0	-5.4	-6.8	-8.3	-9.7	-11.1	-12.5	-13.8	-15.2
Investment	-6.9	-13.0	-18.5	-23.5	-28.0	-32.0	-35.7	-39.1	-42.2	-45.0	-47.7
Labor Effort	-2.0	-3.8	-5.6	-7.2	-8.7	-10.2	-11.6	-12.9	-14.1	-15.3	-16.4
Real Exchange Rate (- appreciation)	-3.5	-6.7	-9.6	-12.3	-14.7	-16.9	-19.0	-20.9	-22.7	-24.4	-26.0
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.5	-1.0	-1.4	-1.8	-2.2	-2.5	-2.8	-3.1	-3.4	-3.7	-3.9
Consumption	-0.8	-1.6	-2.3	-3.0	-3.6	-4.2	-4.7	-5.2	-5.7	-6.2	-6.6
Investment	-0.4	-0.8	-1.1	-1.4	-1.7	-2.0	-2.3	-2.5	-2.7	-2.9	-3.1
Labor Effort	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7	-0.7
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-1.4	-2.7	-3.9	-5.0	-6.1	-7.1	-8.1	-9.0	-9.9	-10.8	-11.6
Consumption	-1.2	-2.3	-3.3	-4.3	-5.3	-6.2	-7.0	-7.9	-8.6	-9.4	-10.1
Investment	-1.4	-2.7	-3.9	-5.1	-6.2	-7.2	-8.2	-9.1	-10.0	-10.9	-11.7
Labor Effort	-1.5	-2.8	-4.1	-5.3	-6.5	-7.6	-8.6	-9.6	-10.6	-11.5	-12.4
Real Exchange Rate (- appreciation)	-0.9	-1.8	-2.6	-3.4	-4.2	-4.9	-5.5	-6.2	-6.8	-7.4	-8.0
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-1.0	-1.1	-1.2
Consumption	-0.2	-0.4	-0.6	-0.8	-1.0	-1.2	-1.3	-1.5	-1.6	-1.8	-1.9
Investment	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.7	-0.8	-0.9	-0.9
Labor Effort	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2

Figure 4: Effects of Different Price and Wage Markups on Sacrifice Ratios and the Long-Run Levels of Economic Activity (BASE-CASE PARAMETERS WITH THE FRISCH ELASTICITY OF LABOR SUPPLY SET EQUAL TO THE MEAN ESTIMATE OF 0.15 FROM MICRO STUDIES ($\zeta = 1/.15 = 6.7$)

Sacrifice Ratios for Home Country Under Different Markups

	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3
Sacrifice Ratio (Varying Wage Markup)	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0



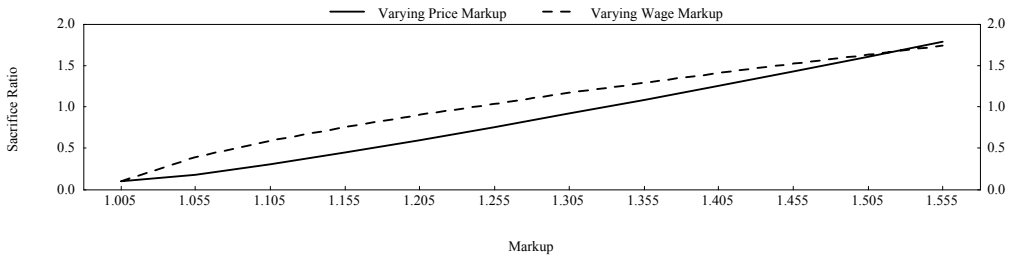
Long-Run Effects of Different Price Markups and Wage Markups

	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Home Country Long-run Effects of Higher Price Markups (In percent)											
GDP	-2.2	-4.3	-6.2	-8.0	-9.8	-11.4	-13.0	-14.5	-15.9	-17.3	-18.6
Consumption	-0.4	-0.9	-1.5	-2.2	-3.0	-3.8	-4.6	-5.4	-6.3	-7.1	-8.0
Investment	-6.0	-11.3	-16.2	-20.6	-24.6	-28.3	-31.7	-34.8	-37.7	-40.4	-42.8
Labor Effort	-0.9	-1.8	-2.7	-3.5	-4.2	-5.0	-5.6	-6.3	-6.9	-7.5	-8.1
Real Exchange Rate (- appreciation)	-2.9	-5.6	-8.0	-10.2	-12.3	-14.2	-15.9	-17.6	-19.1	-20.6	-21.9
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.4	-0.7	-1.1	-1.4	-1.6	-1.9	-2.1	-2.4	-2.6	-2.8	-3.0
Consumption	-0.7	-1.3	-1.8	-2.3	-2.8	-3.3	-3.7	-4.1	-4.5	-4.9	-5.2
Investment	-0.3	-0.6	-0.8	-1.0	-1.3	-1.5	-1.7	-1.8	-2.0	-2.2	-2.3
Labor Effort	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-0.6	-1.3	-1.8	-2.4	-2.9	-3.4	-3.9	-4.4	-4.8	-5.3	-5.7
Consumption	-0.6	-1.1	-1.6	-2.1	-2.5	-3.0	-3.4	-3.8	-4.2	-4.5	-4.9
Investment	-0.7	-1.3	-1.9	-2.4	-3.0	-3.5	-4.0	-4.4	-4.9	-5.3	-5.7
Labor Effort	-0.7	-1.3	-2.0	-2.6	-3.1	-3.7	-4.2	-4.7	-5.1	-5.6	-6.0
Real Exchange Rate (- appreciation)	-0.4	-0.9	-1.3	-1.6	-2.0	-2.3	-2.7	-3.0	-3.3	-3.6	-3.9
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5	-0.5
Consumption	-0.1	-0.2	-0.3	-0.4	-0.5	-0.5	-0.6	-0.7	-0.7	-0.8	-0.9
Investment	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4
Labor Effort	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0

Figure 5: Effects of Different Price and Wage Markups on Sacrifice Ratios and the Long-Run Levels of Economic Activity (BASE-CASE PARAMETERS WITH ELADTICITY OF SUBSTITUTION BETWEEN CAPITAL AND LABOR REDUCED BY 0.05)

Sacrifice Ratios for Home Country Under Different Markups

	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.2	0.3	0.4	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.8
Sacrifice Ratio (Varying Wage Markup)	0.1	0.4	0.6	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7



Long-Run Effects of Different Price Markups and Wage Markups

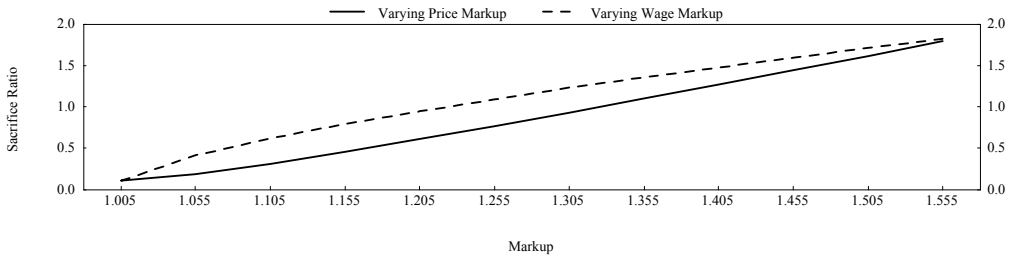
	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Home Country Long-run Effects of Higher Price Markups (In percent)											
GDP	-3.1	-6.0	-8.7	-11.2	-13.6	-15.9	-18.0	-20.0	-21.8	-23.6	-25.3
Consumption	-1.3	-2.7	-4.1	-5.5	-7.0	-8.4	-9.9	-11.3	-12.7	-14.1	-15.4
Investment	-6.6	-12.6	-17.9	-22.7	-27.1	-31.1	-34.7	-38.0	-41.1	-43.9	-46.5
Labor Effort	-2.0	-3.9	-5.6	-7.3	-8.8	-10.3	-11.7	-13.0	-14.2	-15.4	-16.5
Real Exchange Rate (- appreciation)	-3.4	-6.5	-9.4	-12.0	-14.4	-16.6	-18.6	-20.6	-22.3	-24.0	-25.6
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.5	-0.9	-1.4	-1.7	-2.1	-2.4	-2.7	-3.0	-3.3	-3.6	-3.8
Consumption	-0.8	-1.6	-2.3	-2.9	-3.5	-4.1	-4.6	-5.1	-5.6	-6.1	-6.5
Investment	-0.4	-0.7	-1.0	-1.3	-1.6	-1.9	-2.1	-2.3	-2.5	-2.7	-2.9
Labor Effort	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-0.6	-0.7	-0.7
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-1.4	-2.7	-3.9	-5.0	-6.1	-7.1	-8.1	-9.0	-9.9	-10.8	-11.6
Consumption	-1.2	-2.3	-3.3	-4.3	-5.3	-6.2	-7.0	-7.8	-8.6	-9.4	-10.1
Investment	-1.4	-2.7	-3.9	-5.1	-6.2	-7.2	-8.2	-9.2	-10.1	-10.9	-11.8
Labor Effort	-1.5	-2.8	-4.1	-5.3	-6.5	-7.6	-8.6	-9.6	-10.6	-11.5	-12.4
Real Exchange Rate (- appreciation)	-0.9	-1.8	-2.6	-3.4	-4.2	-4.9	-5.6	-6.2	-6.8	-7.4	-8.0
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-1.0	-1.1	-1.2
Consumption	-0.2	-0.4	-0.6	-0.8	-1.0	-1.2	-1.3	-1.5	-1.7	-1.8	-1.9
Investment	-0.1	-0.2	-0.3	-0.4	-0.5	-0.5	-0.6	-0.7	-0.8	-0.8	-0.9
Labor Effort	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2

Figure 6:

Figure 7: Effects of Different Price and Wage Markups on Sacrifice Ratios and the Long-Run Levels of Economic Activity (BASE-CASE PARAMETERS WITH LARGER LONG-RUN IMPORT DEMAND ELASTICITIES (μ_A and $\mu_E = 2.0$)

Sacrifice Ratios for Home Country Under Different Markups

	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.8
Sacrifice Ratio (Varying Wage Markup)	0.1	0.4	0.6	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.8



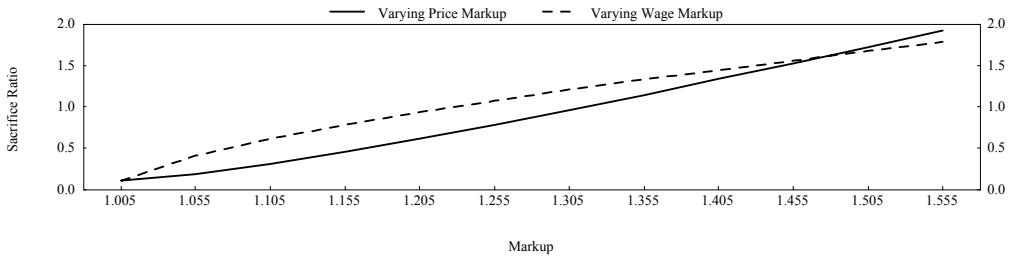
Long-Run Effects of Different Price Markups and Wage Markups

	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Home Country Long-run Effects of Higher Price Markups (In percent)											
GDP	-3.3	-6.3	-9.1	-11.7	-14.2	-16.5	-18.7	-20.7	-22.7	-24.5	-26.2
Consumption	-1.6	-3.2	-4.9	-6.5	-8.1	-9.6	-11.2	-12.7	-14.1	-15.6	-17.0
Investment	-7.0	-13.2	-18.8	-23.8	-28.3	-32.4	-36.1	-39.5	-42.6	-45.5	-48.2
Labor Effort	-2.0	-3.9	-5.6	-7.2	-8.8	-10.2	-11.6	-12.9	-14.2	-15.3	-16.5
Real Exchange Rate (- appreciation)	-2.4	-4.5	-6.5	-8.4	-10.1	-11.7	-13.2	-14.6	-15.9	-17.2	-18.4
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.3	-0.7	-0.9	-1.2	-1.4	-1.7	-1.9	-2.1	-2.3	-2.4	-2.6
Consumption	-0.6	-1.1	-1.6	-2.0	-2.4	-2.8	-3.1	-3.5	-3.8	-4.1	-4.3
Investment	-0.3	-0.5	-0.7	-1.0	-1.1	-1.3	-1.5	-1.7	-1.8	-1.9	-2.1
Labor Effort	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-1.4	-2.7	-4.0	-5.1	-6.2	-7.3	-8.3	-9.2	-10.2	-11.0	-11.9
Consumption	-1.3	-2.5	-3.6	-4.7	-5.7	-6.6	-7.6	-8.4	-9.3	-10.1	-10.9
Investment	-1.4	-2.7	-4.0	-5.2	-6.3	-7.3	-8.3	-9.3	-10.2	-11.1	-11.9
Labor Effort	-1.5	-2.8	-4.1	-5.3	-6.5	-7.6	-8.6	-9.6	-10.6	-11.5	-12.4
Real Exchange Rate (- appreciation)	-0.6	-1.2	-1.8	-2.3	-2.8	-3.3	-3.7	-4.2	-4.6	-5.0	-5.4
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.6	-0.7	-0.7	-0.8
Consumption	-0.1	-0.3	-0.4	-0.5	-0.7	-0.8	-0.9	-1.0	-1.1	-1.2	-1.3
Investment	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6
Labor Effort	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1

Figure 8: Effects of Different Price and Wage Markups on Sacrifice Ratios and the Long-Run Levels of Economic Activity (BASE-CASE PARAMETERS WITH A SMALLER INTERTEMPORAL ELASTICITY OF SUBSTITUTION $(1/\sigma) = 1/0.99$)

Sacrifice Ratios for Home Country Under Different Markups

	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.1	1.3	1.5	1.7	1.9
Sacrifice Ratio (Varying Wage Markup)	0.1	0.4	0.6	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.8



Long-Run Effects of Different Price Markups and Wage Markups

	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Home Country Long-run Effects of Higher Price Markups (In percent)											
GDP	-3.0	-5.7	-8.2	-10.5	-12.7	-14.8	-16.7	-18.5	-20.2	-21.9	-23.4
Consumption	-1.1	-2.2	-3.4	-4.6	-5.8	-7.0	-8.2	-9.4	-10.6	-11.8	-12.9
Investment	-6.7	-12.7	-18.0	-22.8	-27.1	-31.0	-34.6	-37.9	-40.9	-43.7	-46.2
Labor Effort	-1.8	-3.4	-4.9	-6.3	-7.6	-8.8	-10.0	-11.0	-12.1	-13.0	-13.9
Real Exchange Rate (- appreciation)	-3.5	-6.6	-9.5	-12.1	-14.5	-16.6	-18.6	-20.5	-22.2	-23.8	-25.3
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.3	-0.7	-0.9	-1.2	-1.4	-1.6	-1.9	-2.0	-2.2	-2.4	-2.5
Consumption	-0.7	-1.3	-1.9	-2.4	-2.9	-3.3	-3.7	-4.1	-4.5	-4.8	-5.2
Investment	-0.2	-0.5	-0.7	-0.8	-1.0	-1.1	-1.3	-1.4	-1.5	-1.7	-1.8
Labor Effort	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-1.2	-2.3	-3.3	-4.3	-5.2	-6.1	-7.0	-7.8	-8.6	-9.3	-10.0
Consumption	-1.0	-1.9	-2.8	-3.7	-4.5	-5.3	-6.0	-6.7	-7.4	-8.0	-8.7
Investment	-1.2	-2.3	-3.3	-4.3	-5.3	-6.2	-7.0	-7.9	-8.6	-9.4	-10.1
Labor Effort	-1.2	-2.4	-3.5	-4.6	-5.6	-6.5	-7.4	-8.3	-9.1	-9.9	-10.7
Real Exchange Rate (- appreciation)	-0.8	-1.6	-2.3	-3.0	-3.7	-4.3	-4.9	-5.5	-6.0	-6.6	-7.1
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7
Consumption	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-0.9	-1.1	-1.2	-1.3	-1.4
Investment	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5
Labor Effort	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2

Table 4: Estimates of Markups and Sacrifice Ratios fro the Euro Area and the United States

	Markups and Elasticities of Substitutiuon				Sacrifice Ratio	
	Wage Markup	Price Markup			Historical	Base Case
	$\psi/(\psi-1)$	$\theta/(\theta-1)$	ψ	θ		
euro area	1.40	1.20	3.5	6.0	4.4 $\phi_{W2}=\phi_{W2}=3000$	1.9 $\phi_{W2}=\phi_{W2}=882$
United States	1.15	1.10	7.7	11.0	1.5 $\phi_{W2}=\phi_{W2}=1764$	0.9 $\phi_{W2}=\phi_{W2}=882$

Table 5: GEM Estimates of the Long-Run Effects of More Competition-Friendly Policies in the Euro Area (Percent deviations from baseline)

	Labor Market Reforms	*Product Market Reforms*	*Both Reforms*
	$\psi^{EU} \Longrightarrow \psi^{US}$	$\theta^{EU} \Longrightarrow \theta^{US}$	$\psi^{EU} \Longrightarrow \psi^{US}$ and $\theta^{EU} \Longrightarrow \theta^{US}$
euro area:			
GDP	5.7	6.7	12.8
Consumption	4.9	2.5	7.4
Investment	5.8	14.5	21.2
Labor Effort	6.1	3.9	10.3
Real Exchange Rate	3.8	7.3	11.5
Rest of World:			
GDP	0.6	1.1	1.7
Consumption	0.9	1.8	2.7
Investment	0.5	0.9	1.4
Labor Effort	0.1	0.2	0.3

Table 6: GEM Estimates of the Sacrifice Ratio with More Competition-Friendly Policies in the Euro Area (Percent deviations from baseline)

	Labor Market Reforms	*Product Market Reforms*	*Both Reforms*
	$\psi^{EU} \Longrightarrow \psi^{US}$	$\theta^{EU} \Longrightarrow \theta^{US}$	$\psi^{EU} \Longrightarrow \psi^{US}$ and $\theta^{EU} \Longrightarrow \theta^{US}$
Sacrifice Ratio	$1.9 \Longrightarrow 1.2$	$1.9 \Longrightarrow 1.7$	$1.9 \Longrightarrow 1.0$

Figure 9: Dynamic Effects of More Competition Friendly Policies in the Euro Area (Assuming the Reform Path is Perfectly Credible)

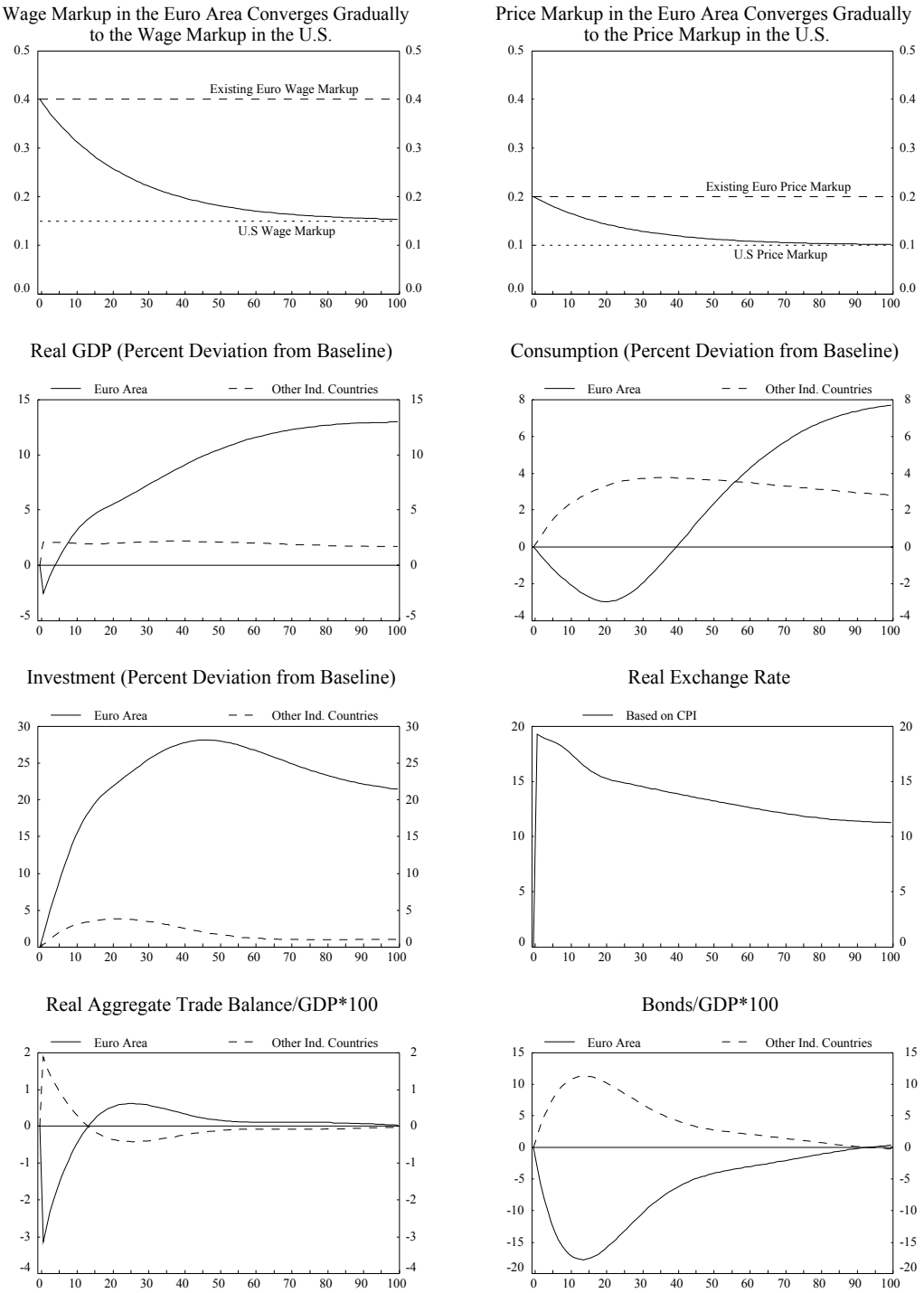


Figure 10: Dynamic Effects of More Competition Friendly Policies in the Euro Area (Assuming the Future Reform Path is Not Anticipated)