When Leaner Isn't Meaner:

Measuring Benefits and Spillovers

of Greater Competition in Europe*

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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 macroeconomic benefits and international spillovers of an increase in competition. After calibrating the model to the euro-area vs. the rest of the industrial world, the paper draws three conclusions. First, greater competition produces large effects on standard measures of macroeconomic performance. In particular, we estimate 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 increasing the responsiveness of prices and wages to market conditions. Third, greater competition can generate large spillovers to the rest of the world through its impact on the terms of trade.

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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 Economy Model (GEM) to estimate the effects of changing competition on performance within a country and spillovers to the rest of the world. Building on the recent literature in monetary policy and open-economy macroeconomics, GEM is a choice-theoretic model based on consistent microeconomic foundations. Specifically, the model posits imperfect competition in product and labor markets 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/inputs, 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

[1] See MacFarlan, Edison, and Spatafora (2003) for a survey. Key references include Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2002).

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

[3] Earlier work includes OECD (1997) and European Commission (2002).

United States — is used to explore how altering domestic competition in labor and product markets affects 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 prevailing 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 wage-price rigidities. These benefits also provide positive spillovers to the rest of the world, mainly through a favorable terms of trade effect which boosts consumption abroad by more than output. 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 boost output by 12.4 percent in the euro area as both investment and hours worked rise markedly, and by 0.8 percent in the rest of the world. The consumption benefits are more evenly spread, with euro area consumption rising 8.3 percent versus 1.3 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) declines significantly. 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, thereby 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 industrial 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 shrink the production 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] 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 (sectoral) 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 consumption good 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 $\Gamma^*_{PM,t}(h)$:

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

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

where $\phi_Q, \phi^*_M, \geq 0$. The quadratic costs of price adjustment are related to changes in firm h's price inflation relative to the past observed inflation rate in the relevant market, allowing the model to reproduce realistic inflation dynamics encompassing nominal inertias.

Formally, denoting the nominal exchange rate as $\mathcal{E}$ (defined as Home currency per unit

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

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 ($\phi_Q = 0$), 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 $p_t(h) \approx MC_t(h)$ regardless of how sizable ϕ_Q is. 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, when θ is small, 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.[10]

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_M^* is 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:

$$\mathcal{W}_t(j) \equiv \mathsf{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[U_\tau \left(C_\tau \left(j \right) \right) - V_\tau \left(\ell_\tau(j) \right) \right] \tag{27}$$

where β is the discount rate, assumed to be identical across countries. There is habit persistence in consumption according to the specification:

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

[10] From a related vantage point, one can think of a change in θ and in the associated markup as a (positive) 'cost-push' shock.

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

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

$$V_t(j) = Z_{V,t} \frac{\left(\frac{\ell_t(j) - b_\ell \ell_{t-1}}{1 - b_\ell} \right)^{1+\zeta}}{1+\zeta} \tag{29}$$

where $\zeta > 0$, $Z_{V,t}$ is a shock to labor disutility and $0 \leq b_\ell < 1$.[12] 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 $t-1$.[13] The two short-term rates are directly controlled by the national governments. Without loss of generality, only one bond (namely, the Foreign-currency one) is traded internationally and is in zero net supply worldwide, while the other (Home) bond is in zero net supply at the domestic level.[14]

A 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

[12] This specification allows for habit persistence in labor effort and is not standard in the literature. It allows for the possibility that there can be additional costs to large business cycles if they result in excessive variability in labor effort. During transitions from low (high) to high (low) inflation regimes, high values of b_ℓ will result in dynamics that look very similar to hysteresis. Figure (3) shows how the dynamic responses of GEM to disinflation shocks change based on different values of b_ℓ.

[13] 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.

[14] International arbitrage makes the second bond redundant for consumption-smoothing purposes.

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, that is $(1/s)\,\mathcal{E}_t \int_0^s B^*_{t+1}(j)dj/P_t$, and is zero only when Home agents do not hold any Foreign-currency assets ($\Gamma_B(0) = 0$). This implies that in a non-stochastic steady state Home agents have no incentive to hold Foreign bonds and net asset positions are zero worldwide. An appropriate parameterization allows the model to generate realistic dynamics for the current account and net asset positions. 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)).

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:

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

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 (16) 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:

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

where $\phi_W \geq 0$. 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.[15]

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 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:

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

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

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:

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

The above expression is the 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.

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) holds as equality and the transversality condition is satisfied:

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

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:

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

The government controls the short-term rate i_{t+1}. Monetary policy is specified in terms of annualized interest rate rules of the form:

$$\begin{aligned}&(1+i_{t+1})^4-1=\omega_i\left[(1+i_t)^4-1\right]\\&+(1-\omega_i)\left[\left(1+\overline{i_{t+1}}\right)^4-1\right]+\omega_1\mathsf{E}_t\left[\frac{P_{t+\tau}}{P_{t+\tau-4}}-\Pi_{t+\tau}\right]+\Theta\left(\digamma_t\right)\end{aligned}\tag{38}$$

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:

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

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 (primarily the output gap, but possibly including exchange rate, current account, wage inflation, employment 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:

$$\int_0^s A_t(x)dx \quad \geq \quad \int_0^s C_t(j)[1+\Gamma_{S,t}(j)]dj + sG_{C,t} \tag{44}$$

$$\int_0^s E_t(y)dy \quad \geq \quad \int_0^s I_t(j)dj + sG_{I,t} \tag{45}$$

The resource constraints for labor and capital are:

$$\ell_t(j) \geq \int_0^s \ell_t(h,j)dh \qquad\qquad \int_0^s K_t(j)dj \geq \int_0^s K_t(h)dh \tag{46}$$

Similar expressions hold abroad.[16] Finally, market clearing in the asset market requires:

$$\int_0^s B_t(j)dj = 0, \qquad \int_0^s B^*_t(j)dj + \int_s^1 B^*_t(j^*)dj^* = 0. \tag{47}$$

By aggregating the budget constraints across private and public agents we derive expressions for the nominal current account and gross national product.[17]

[16] It is worth noticing that in equilibrium $p(n) = P_N$, $p(h) = P_Q$, $p(f) = P_M$, $p^*(n) = P^*_N$, $p^*(h) = P^*_M$, $p^*(f) = P^*_Q$, $W(j) = W$, $W^*(j^*) = W^*$.

[17] In the model, real income is measured in terms of consumption baskets, and thereby affected by current changes in relative prices. It is the appropriate concept for measuring how the production possibility frontier of the economy shifts in response to changes in the degree of competition. In the simulation exercises where we compare our results to other models, which are based on data from the national accounts, our measure of real (constant-dollar) GDP will be obtained by evaluating expenditures using fixed (steady-state) relative prices. Also, our measure of output gap is the deviation of GDP from its steady-state level.

3 Calibration and model properties

This section describes the baseline calibration of the model. In what follows we 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.[18] The import-to-GDP 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 some key variables in the baseline solution of the model.

The monetary transmission mechanisms for the Home and Foreign country have been calibrated to approximately replicate the dynamics responses of policy simulation models developed at the European Central Bank (ECB) and the Federal Reserve Board (FRB). These central-bank reduced-form models are consistent with the impulse response analysis of monetary VARs, as well as other empirical evidence suggesting that there is significantly higher structural inflation persistence in the euro area than in the United States. Also, there are significant differences in real-financial linkages among the two industrial blocks, in the sense that interest rate hikes result in larger changes in investment in the euro area *vis-à-vis* the U.S. Our model has been calibrated to be consistent with these basic stylized facts.[19]

The baseline steady-state wage and price markups for the euro area and the U.S. are based on previous empirical work according to which the euro area has significantly less

[18] To calibrate the dynamics of the Foreign country we rely heavily upon model results for the US economy.

[19] Our baseline calibration gives rise to a plausible, empirically-based, representation of macroeconomic dynamics. At a minimum, it establishes a sensible set of initial priors based on central bank modelers' views about the monetary transmission mechanism, setting the stage for the introduction of Bayesian estimation methods. For a critique of classical estimation techniques see Sims (2002). Based on smaller single-country models, the results by Smets and Wouters (2002b) suggest that it may be feasible to use Bayesian methods to estimate the parameters of fairly large models such as GEM.

competition in both labor and product markets. As will be shown below, differences in the degrees of competition between the euro area and the United States may be the principal factors that explains why the sacrifice ratio is considerably higher in the euro area than in the United States.[20]

3.1 Assumptions about elasticities and markups

The inverse of the parameter ζ represents the Frisch elasticity of labor supply, which in the baseline calibration of the model has been set to 1/3 ($\zeta = 3$). 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 $\zeta = 6.7$) is also considered.

In the base-case calibration of the model we set the elasticity of substitution between domestic and imported inputs in the production of consumption and investment goods (μ_A and μ_E) equal to 2.5. 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 spillover effects on per capita real income and consumption. An estimate of 2.5 is lower than the estimate employed by Erceg, Guerrieri and Gust (2003) in a model of the US economy, but it is significantly higher than what has been used in several previous macro simulation models — see, for example, Laxton and others (1998), Chari, Kehoe and McGrattan (2001), Smets and Wouters (2002a), and Gali and Monacelli (2002). Erceg, Guerrieri and Gust (2003) argue that in models with significant adjustment costs on imports, a long-run import price

[20]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.

elasticity of this magnitude is not inconsistent with the short-run and medium-term elasticities that have been derived from aggregate trade equations. The section on sensitivity analysis shows the implications of reducing μ_A and μ_E to 1.5.[21]

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 an elasticity of substitution among labor inputs (ψ) equal to 3. Similarly, the steady-state price markup is $\theta/(\theta-1)$, so that a markup of (say) 1.1 would imply an elasticity of substitution among differentiated goods (θ) equal to 10.

3.2 Assumptions about steady-state ratios

The following steady-state ratios were calibrated to be consistent with recent data from national accounts. The steady-state investment-to-GDP ratio was set to be equal 22 percent in both countries, with 19 percent representing private sector investment and 3 percent investment by the government. Based on a quarterly depreciation rate of 2.5 percent, this implies a steady-state capital-to-GDP ratio of around 2.2. We chose the values for α and α^*, the weight of capital in the production of tradables, to obtain a smaller labor income share in the Home country (47 percent) than in the Foreign country (58 percent).

The steady-state import-to-GDP ratio was set at 18 percent in the Home country and 13 percent abroad. The split of imports into investment and consumption goods was based on recent data according to which for the euro area approximately two thirds of imported goods are investment goods, while for the United States this figure is only slightly greater than one half. The steady-state level of imports of investment goods relative to GDP was set at 13 percent in the euro area and 7 percent in the rest of the industrial world, allocating the remainder to imports of consumption goods. These ratios were calibrated by setting the

[21] The econometric evidence that is based on disaggregated data suggests that imports may be much more responsive to relative price movements than what is suggested by the estimates that have been derived from aggregate trade equations.

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 Assumptions about dynamics

The remaining parameters were calibrated to match the monetary transmission mechanism as embedded in the models used for forecasting and policy analysis at the ECB and the FRB, estimated on the basis of monetary VARs as well as information specific to the two monetary institutions. More specifically, taking the parameters discussed above as given, the remaining parameters of GEM were calibrated to mimic the dynamic responses of the ECB's Area-Wide Model (AWM) and the Board of Governor's FRB-US model in response to a 1-year hike in interest rates.

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. These responses are compared with results from the same experiment using the ECB's AWM, whose empirical apparatus does not build upon a choice-theoretic structural model.[22] Table 3 repeats the same experiment for the Foreign economy, and the results are compared with those of the FRB-US model. 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 two years of the simulation horizon.

To replicate the hump-shaped response of consumption to an interest rate hike, we combined a fairly high value for the consumption habit persistence parameter ($b_C = 0.97$ in both countries) with relatively high values for the intertemporal elasticity of substitution ($1/\sigma$). In fact, in the simulations reported in Tables 2 and 3 we set $1/\sigma$ equal to 5.0 in both countries. While the values of these elasticities are above the point estimates typically adopted in structural models that ignore or downplay habit persistence, in the context of

[22]These responses are reported in Fagan, Henry and Mestre (2001).

our model they allow us to generate a realistic monetary transmission mechanism — such that the effects of interest rate hikes build up gradually over time — even in the absence of artificial assumptions such as predetermined consumption expenditures.

To understand the interaction of habit persistence and the intertemporal elasticity of consumption in generating hump-shaped consumption responses, Figure 2 reports some results for exactly the same experiments conducted in Table 2 and 3.[23] The top panel reports consumption responses for the Home country without habit persistence in consumption ($b_C = 0$) 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 logarithmic utility.[24] 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 consumption peaks (unrealistically) in the very first period when the shock is assumed to take place. The two middle panels report results when the habit persistence parameter as been set at 0.6 and 0.8 respectively, well within the consensus range of estimates for b. 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.[25]

[23] In these experiments the habit persistence parameter on work effort (b_ℓ) has been set equal to zero. We will discuss below some of the implications of habit persistence in labor effort for macroeconomic dynamics.

[24] When preferences are additive over consumption and leisure, the main virtue of logarithmic utility — aside from analytical tractability — 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.

[25] To understand how combinations of b_C and σ generate different dynamic responses it may be useful to consider the linearized version of the Euler equation (35), ignoring transaction costs Γ_S in eq. (34): $c_t = \frac{b_C}{1+b_C} c_{t-1} + \mathsf{E}_t \frac{1}{1+b_C} c_{t+1} - \frac{i_{t+1} - \mathsf{E}_t p_{t+1} + p_t}{\sigma(1+b_C)}$. As can be seen from this equation a habit persistence parameter that approaches one induces a first-order lag that approaches 1/2 and, for a given σ, reduces the sensitivity of consumption to changes in the real interest rate. Our preliminary estimation results using Bayesian methods suggest that we need high values of habit persistence and very low values of σ to produce

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 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, GEM comes closest to replicating these features when there are very high degrees of habit persistence ($b_C = 0.97$) 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.

To illustrate the implications of habit persistence for labor effort, Figure 3 shows the responses of some key macrovariables to a permanent decline in the inflation target of the Home country under different assumptions on the value of b_ℓ. As can be seen in the Figure high values of this parameter induce high persistence in the economy, as it can take well over a decade for the economy to return to equilibrium following a disinflationary episode. Based on our preliminary econometric analysis of US data, we set b_ℓ equal to 0.5 in both countries. [26]

The elasticity of substitution between capital and labor in the production function (ξ) 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. The model has been

the types of hump-shaped dynamics that are apparent in the data.

[26] Following other studies, our initial empirical work was based on pre-filtering the data prior to estimation. We expect that estimates of such critical parameters as b_ℓ, which fundamentally influence the speed of adjustment of the model, might well contain significant pre-filter bias. In such circumstances it may be important to allow for a more general set of stochastic processes that can acount for permanent shifts in the fundamentals.

calibrated with sizable adjustment costs on the change in investment (ϕ_{I2} is equal to 70 for the Home country and 80 for the Foreign country) and relatively small adjustment costs on capital accumulation ($\phi_{I1} = 1$ for both countries) to generate the hump-shaped response of investment that is found in both the AWM and FRB-US models.[27] Note, however, that in the absence of exogenous lags on expenditure decisions the short-run response may be too responsive to interest rate shocks.

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 years the effective elasticity is around 1.5. These adjustment cost parameters combined with the other parameters allow the model to do a reasonable job at replicating the dynamics of the AWM 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 nominal variables adjust 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 symmetric adjustment costs on wages and prices.[28] Given full-exchange rate pass-through ($\phi_M = 0$), a value of 2800 for ϕ_W and ϕ_Q 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 1400 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

[27]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.

[28]We are currently investigating the importance of these types of rigidities to see how they influence the analysis that is presented below.

is that they may significantly overstate the degree of structural inflation persistence, to the extent that the observed persistence reflects at least partially slow learning and signal extraction problems in moving from high to low inflation regimes — see Erceg and Levin (2001) and Laxton and N'Diaye (2002). In effect, estimates of ϕ_W and ϕ_Q should be expected to be biased upwards if they rely upon samples that include adaptation of expectations after an inflation regime shift. Short of strong empirical evidence about the magnitude of this bias we have reduced these parameters in half to establish a benchmark calibration of the model. According to the latter parameterization the sacrifice ratio is 2.0 in the Home country and 0.9 in the Foreign country. The original estimates without adjustment generate sacrifice ratios of 2.9 in the Home country and 1.3 in the Foreign country.

As a final check on the calibration of the system we compared the impulse response functions (IRFs) of the model to a VAR estimated by Altig and others (2003) for the US economy. The dashed lines in Figure 4 report the IRFs (and confidence bands) for the VAR and the solid line reports the results when the same interest rate path is imposed on GEM's Foreign economy for the first 8 quarters of simulation horizon. As can be seen in the Figure, if we ignore the initial responses of the model, the GEM's IRFs generally fit within the confidence bands for output, consumption, investment and the price level. It is noteworthy that the GEM's price level declines monotonically but the VAR's price level increases somewhat over the first year of the shock. This may reflect the fact that the prices indices reported are different across experiments (the GDP deflator from the VAR analysis and the consumption deflator for GEM), as a result of which the VAR may have less feedback from the real exchange rate.[29]

[29] Altig and others (2003) emphasize that the initial response of the price level to a rise in interest rates in the VAR may be to raise marginal costs, thus explaining why the price level might rise initially before declining.

4 Simulation results

This section focuses on how differing levels of competition affect two key aspects of performance, the level of activity and the sacrifice ratio faced by 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, investment, 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 and the induced 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 the presence of even modest transaction costs in nominal contracts, higher levels of competition (i.e. higher markups) lead to less structural inflation persistence.

4.1 Effects of higher markups on economic activity

The impact of changing markups on the long-run levels of economic activity using the baseline calibration are shown in Figure 5. 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 extent of 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 held at their baseline values. These simulations are, of course, highly stylized, particularly as lack of

competition in product markets tends to lead to higher wage markups, implying that the two markups are generally not independent of each other.[30]

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 less elastic demand curves. They reduce capital more than labor effort (hereafter assumed to be equivalent to hours worked) as labor is the scarcer resource, and hence restricting hours worked causes a larger increase in wage costs than an equivalent reduction in the capital stock does interest 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 at the margin with the benefits of consumption (adjusted by the appropriate relative prices).

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 the impact on the overall propensity to import coming from shifts in spending (investment has a higher foreign component than consumption). For both reasons, spillovers are larger for product market reforms. This favorable terms-of-trade effect cushions the impact on consumption at home and exacerbates it abroad.

These considerations shed light on the simulations reported in Figure 5. The first feature to note is that higher markups in either market (and hence lower levels of competition) lead to mildly concave reductions in output and consumption at home and abroad. In the case of product markets, for example, an increase in the price markup from half a percent to

[30]See Jean and Nicoletti (2002).

five-and-a-half percent reduces output by 3.5 percent, while a similar increase from 50 to 55 percent reduces output by 1.9 percent.[31] 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.

An increase in the price markup has a particularly deleterious effect on the capital stock, which falls by 50 percent as the markup rises from zero to one-half, about double the reduction in output. Hours worked also decline, but by about two-thirds of the fall in output. Consumption is reduced by a similar amount as lower domestic output and the fall in investment leads to a favorable terms-of-trade effect, with the exchange rate appreciating by some 15 percent.

Turning to the foreign country, when the domestic price markup rises from zero to one-half output falls by around 2 percent (less than one-tenth of the reduction in the home country) as the demand for exports falls and the terms-of-trade become more unfavorable. As a result of the terms-of-trade effect, the fall in foreign consumption is larger than in output, and indeed the ratio of the decline in foreign to domestic consumption is around one-fifth, double the one-tenth figure for output. In short, a lack of product market competition has significant consumption spillovers to the rest of the world.

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 the markup, output falls by under half as much. Labor effort, investment, and consumption all fall by similar amounts to output. The impact on consumption partly reflects the more limited real exchange rate appreciation, as the re-

[31] 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.

sponse of output, investment, and goods prices is more muted than when price markups increase by the same amount. The more limited exchange rate appreciation also constrains spillovers to the rest of the world, with foreign consumption falling by only about one-tenth of its domestic equivalent.

4.2 Effects of higher markups on sacrifice ratios

Changes in product and labor market competition also has a significant 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 Taylor rule with regards to inflation.[32] As a measure of the trade-off 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 5 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 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 its price responds more in the presence of market power. As a result, increases in the wage markup has a more deleterious effect

[32]See Taylor (1993). The rule in the simulations places equal weights of 0.5 on the output gap, the inflation gap, and the interest rate smoothing term.

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 effects 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 6 reports the results from reducing the Frisch elasticity of labor supply from 0.33 to 0.15.[33] 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. For the price markup, the equivalent falls are one-quarter to one-third, reflecting the greater importance of reductions in investment in this case. The impact on the sacrifice ratio also falls, particularly as regards the wage markup, as lower flexibility in labor supply translates into more accommodation through wages. Hence, the principal effects of reducing the labor response to changes in real wages are to decrease the impact on output and the sacrifice ratio.

The equivalent deep parameter for firms is the elasticity of substitution between labor and capital, as this affects the behavior of a key input for firms, namely capital. Figure

[33] 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 by macroeconomic models, presumably reflecting a judgement about the general equilibrium properties of such models.

7 shows the results from shifting this parameter down by 0.1 in both countries.[34] This change has little impact on the simulations, particularly those examining shifts in the wage markup. In the simulations of alternative price markups, it leads to a mildly larger fall in hours worked and smaller reduction in investment than in the base case, resulting in a slightly larger reduction in domestic consumption and smaller consumption spillovers to the rest of the world. Changes in this elasticity also have only marginal effects on the sacrifice ratio compared to the base case. The intuition for these small effects is that capital is a reproducible factor of production while labor supply is much more constrained, so that changes in the level of substitutability between capital and labor do not impact capital inputs significantly.

Next, the impact of changing the substitutability between domestic and foreign goods was examined. Figure 8 reports the results when this elasticity is lowered from the base value of two to one-and-a-half, moving it toward the values found in macroeconomic studies and away from those typical in microeconomic work. As might be expected, the main impact of decreased substitutability of domestic and foreign goods is to increase the exchange rate response to changes in markups. This, in turn, increases spillovers to the rest of the world through its impact on purchasing power at home and abroad. Indeed, both the appreciation of the real exchange rate and the impact on foreign consumption doubles compared to that in the baseline, while the increase in the ratio of the change in foreign to domestic consumption rises by even more as the appreciation cushions some of the impact on domestic consumers.

Finally, 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 re-calibrations elsewhere. As discussed earlier, this switch

[34]This is a more limited shift in value compared to the base case than for the other parameters, as larger changes in this coefficient require a relevant re-calibration of other parts of the model. 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.

has significant implications for the short-term consumptions dynamics of the model. It turns out, however, that the impact of greater sensitivity of consumption to real interest rates on the steady state effects of shifts in markups on activity is relatively limited, with domestic consumption losses from higher markups being reduced by 15-20 percent and their foreign counterparts by more like 30 percent (Figure 9).

To summarize, with the important exception of the Frisch elasticity, changing key parameters in the rest of the model generally has only limited effects on the impact of changes in markups on the domestic economy but 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 Frisch elasticity is an exception as it directly affects the degree to which workers need to constrain their labor input (a scarce resource) to achieve a desired rise in markups, and hence has a first-order effect in the simulations.

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.[35] 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

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

currency, both of which are aimed in large part at increasing competition.[36] Despite the importance of this topic, however, empirical estimates of the benefits from greater competition in the euro area remain limited.[37]

The first stage in this process is to calculate reasonable estimates of price and wage markups from existing empirical work. We chose a two-pronged strategy where we looked at evidence on these markups individually (and there interactions) and then, as a check on the plausibility of these estimates, we compared the estimates to results on overall markups on products across countries calculated using a different methodology.

A number of authors have looked at price markups by sector following the initial work on U.S. manufacturing by Hall (1986 and 1988). To date, most studies using models of the type of GEM have focused such data for U.S. manufacturing, which may be atypical for at least two reasons. The United States has a lower regulatory burden than other countries, implying more competitive markets and lower markups, and manufacturing is probably more competitive than other sectors of the economy because of the high level of penetration by foreign producers. To get a broader view of markups, we use results from Martins, Scarpetta, and Pilat (1996) who estimate price markups across a wide range of countries and sectors using the methodology of Roeger (1995). Averaging reported markups across sectors — weighted by value added — generates estimates of 23 percent for the average markup in the United States and 35 percent in the euro area. These are considerably higher than the estimates for manufacturing of 15 and 19 percent, respectively.[38]

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

[37]See IMF (2003) for a discussion. Also, see EU Commision (2002) and OECD (1997) for attempts to combine microeconomic evidence with (not necessarily micro-founded) macroeconomic models to study the effects of structural reforms.

[38]In addition, the paper also notes that manufacturing markups are often lower in relatively homogeneous industries, characterized by low R&D spending, than in highly differentiated industries where such spending is higher, and this difference may reflect the return to innovation. Simple calculations suggest that the

Earlier calibrations of wage markups have tended to look at evidence on elasticities of demand in the United States.[39] We take a different approach to estimating these wage markups, based on estimated wage differentials across industries in different countries after taking account of other factors such as skill levels of the work force and age of workers, as reported in Jean and Nicoletti (2002). The wage markup is estimated by comparing wages are in sectors in which labor is likely to have relatively little bargaining power to the average wage across the economy as a whole.

The three sectors in which labor was assumed to have little bargaining power were textiles, worn apparel, and leather, all of which are fragmented industries facing stiff competition from abroad. The results imply a wage markup of around 16 percent for the United States and around 24 percent for the euro area (based on GDP-weighted data for France, Italy, Austria, Belgium, Greece, and Ireland).[40]

The paper also finds that regulation in product markets is linked to higher markups, implying that labor is able to capture some of the rents accruing from lower competition due to regulation, and hence that the markups on wages and prices are linked to some extent, although the wage premium also depends upon numerous other factors, including whether the industry is in the private or public sector. Regulation drives up relative wages in the private sector, but drives down relative wages when the industry is publicly owned. The later effect is large — for a given level of regulation the coefficient changes from 0.2 to minus 0.35 — probably reflecting underlying inefficiencies associated with public ownership of commercial industries. This implies that the wage premiums due to high levels of regulation and hence low levels of competition are larger than these numbers suggest for

markup for homogeneous manufacturing industries is about 11 percent in the United States compared with 19 percent in the euro area, but has little impact on the economy-wide markups quoted above.

[39] See Smets and Wouters (2002b).

[40] Germany is not included in the study. Spain was also excluded as it is mentioned in the text as having results that are less reliable due to the high use of part-time workers.

the euro area (the numbers for the United States are essentially unaffected given the low level of public ownership). Calculating the bias requires assumptions about the degree of regulatory impediments in the euro area and level of public ownership. Back-of-the-envelope calculations suggest, however, that it is probably of the order of 0.06, a number we adopt.[41]

Based on these results, the wage markup was set at 16 percent for the United States and 30 percent for the euro area, and the price markup at 23 percent for the United States and 35 percent for the euro area (see Table 4). As a further check, we also looked at estimates of overall differentials of a large number of disaggregated manufactured goods across countries reported in Bradford and Lawrence (2003). Their empirical results yield an estimate of the overall gap between marginal costs and prices of 15-20 percent in the United States and 50 percent or so in the euro area. Assuming wages are two-thirds of costs, these numbers are broadly consistent with our assumed values of wage and price mark-ups. Other parameters are set at their baseline levels.

The long-term benefits, summarized in Table 5, are that if the euro area increased competitiveness in both labor and product markets to U.S. levels, real output would rise by $12\frac{1}{2}$ percent, with the capital stock increasing by over double that of hours worked (over 20 percent compared to 10 percent). The output and labor input spillovers to the rest of the world are relatively muted (under 1 percent), so that the rise in relative output represents over half of the gap in per capita GDP and labor utilization between the two regions.[42] The benefits to consumption are more evenly spread, reflecting a real depreciation of the euro of some 5 percent, with an increase in consumption of over 8 percent in the euro area and

[41] Assume that the average regulatory burden in the public sector in the euro area is larger than the economy as a whole by around 1 1/2 (see Figure 1 in Jean and Nicoletti, 2002) and that such activity makes up 5-10 percent of the euro area economy. The bias is equal to (1 1/2 (additional regulatory burden) times (0.2+0.35) (bias in the coefficient on regulation) times 0.05 or 0.1 (proportion of activity in public sector) divided by 0.95 or 0.9 (proportion of activity not in public sector), which gives a range of 0.04-0.09.

[42] See OECD (2003), Figure 1.1.

$1\frac{1}{4}$ percent in the United States. There is also a fall of about one-third in the sacrifice ratio, from 2 to 1.4 (see Table 6).[43] In short, significant benefits from greater competition are highly likely to be felt both in the euro area and the rest of the world.

Tables 5 and 6 also report results when the product and wage markups are changed separately. Greater product market competition has larger effects on activity than reducing labor market rigidities, with these differences being much starker for investment, output, and international spillovers than for consumption or labor effort. In the case of the sacrifice ratio, the impact of product and labor market reforms are the same, reflecting the relatively large effect on domestic nominal rigidities discussed above.

To examine the adjustment process associates with comprehensive reforms of competition policy, 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.[44] 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 10 illustrates the gradual evolution of the markups as well as their impact on the euro area and the rest of the world. The increase in the marginal product of capital brought about by structural reforms rapidly pushes investment toward a new plateau over the first few years, as firms increase their capital stock. The accumulation of capital is initially financed mainly from abroad, with the exchange rate appreciating by over 20 percent on impact, the trade balance deteriorating by some 4 percentage points of GDP, and consumption rising compared to the baseline.

Over time, the increase in investment is increasingly funded from domestic sources as

[43]This remains above the 0.9 for the United States, as the euro area also has higher costs of adjustment.

[44]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.

a higher real interest rate chokes off consumption, which moves somewhat below baseline levels 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 20 percent of GDP after 3 years, before gradually returning to baseline. Most of beneficial spillovers to the foreign country occur relatively quickly, reflecting the rapid improvement in the terms of trade.

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 under the assumption that future structural changes are unanticipated. More specifically, for the first ten 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 11). 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 increase international debt. In short, a lack of credibility lengthens the adjustment process.

5 Conclusion

While structural policies are being increasingly viewed as a source of differences across countries, empirical estimates of these effects have to date been extremely limited. This

paper has examined the benefits from greater competition in product and labor markets and the cross-border spillovers of structural reforms using a micro-founded, multi-country simulation model.

According to our simulations, structural polices that increase competition in the euro area to U.S. levels (based on empirically estimated markups in both regions) are found to increase output in the euro area by some $12\frac{1}{2}$ percent, and that in the United States by 1 percent. The implied change in relative output represents around half of the current difference in per capita GDP. The gains in consumption are more evenly spread, with euro area consumption rising by 8 percent and U.S. consumption by $1\frac{1}{4}$ percent, in part because the euro depreciates against the dollar by some 5 percent.

Equally importantly, these policies are also likely to benefit European policymakers by increasing the flexibility of the economy and making it easier for the central bank to stabilize output and prices in the face of disturbances. In fact, the sacrifice ratio (i.e. the output cost of reducing inflation by one percentage point) falls by a third. 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 through external borrowing, but that after a while domestic saving is the key source of funding. The pace of responses depends on the credibility of the policies, with faster responses if agents account for future improvements in competition.

As a final caveat, it should be emphasized that our simulations only provide a first pass at a macroeconomic assessment of structural reforms, and more work will be necessary to examine how robust our results are to varying structures and assumptions. In this context, our estimates are simply meant to represent a useful initial quantitative benchmark, based on a consistent methodology and a non-arbitrary choice-theoretic framework, for the ambitious and exciting research agenda that lies ahead.

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Table 1: Assumptions about parameters and steady-state ratios

Parameters:	Euro Area (H)	Rest Ind. World (F)
Discount Rate β	$1.03^{-0.25}$	$1.03^{-0.25}$
Depreciation Rate on Capital δ	0.025	0.025
Habit Persistence Parameters $b_c(b_\ell)$	0.97 (0.50)	0.97 (0.50)
Intertemporal Elasticity of Substitution $1/\sigma$	5.00	5.00
Elasticity of Input Substitution for Intermediate Goods ξ	0.80	0.70
Elasticity of Input Substitution for Consumption μ_A	2.50	2.50
Elasticity of Input Substitution for Investment Goods μ_E	2.50	2.50
Inverse of Frisch Elasticity of Labor Supply ζ	3.00	3.00
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	80.00
Adjustment Cost Parameter for Structural Wage Persistence ϕ_W	2800	1400
Adjustment Cost Parameter for Import Price Persistence ϕ_M	0.00	0.00
Adjustment Cost Parameter for Domestic Prices Persistence ϕ_Q	2800	1400
Steady-State Ratios:	Euro Area (H)	Rest Ind. World (F)
Labor's Share	0.47	0.58
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 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*	-2.3	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3	-0.3	-0.2
	ECB's AWM	-2.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
Consumption:	*GEM Home*	-2.0	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2
	ECB's AWM	-1.9	-0.0	-0.2	-0.2	-0.3	-0.4	-0.3	-0.3	-0.3
Investment:	*GEM Home*	-7.5	-0.5	-0.9	-1.1	-1.2	-1.2	-1.0	-0.9	-0.7
	ECB's AWM	-7.8	-0.1	-0.5	-0.8	-1.2	-1.5	-1.4	-1.3	-1.2
Exports:	*GEM Home*	-1.3	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1
	ECB's AWM	-1.6	-0.1	-0.2	-0.3	-0.4	-0.3	-0.2	-0.2	-0.1
Imports:	*GEM Home*	-3.3	-0.2	-0.4	-0.5	-0.6	-0.5	-0.4	-0.3	-0.3
	ECB's AWM	-4.9	-0.2	-0.5	-0.7	-0.9	-0.9	-0.7	-0.6	-0.6
Real Exchange Rate:	*GEM Home*	3.5	1.2	1.0	0.7	0.4	0.2	0.0	-0.0	-0.0
	ECB's AWM	-1.0	0.5	0.3	0.0	-0.2	-0.5	-0.4	-0.4	-0.3
CPI	*GEM Home*	-0.5	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1
	ECB's AWM	-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 (FRB-US)

(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	-0.2
	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*	-1.9	-0.1	-0.2	-0.3	-0.3	-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	-0.5	-0.8	-1.0	-1.1	-1.0	-0.8	-0.6	-0.4
	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*	-0.8	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-0.0	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*	-2.0	-0.2	-0.3	-0.4	-0.4	-0.3	-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*	2.2	1.1	0.9	0.6	0.3	-0.0	-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*	-1.5	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4
	FED's FRB-US	-1.7	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4

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

	Markups and Elasticities of Substitutiuon				Sacrifice Ratio
	Price Markup	Wage Markup			
	$\theta/(\theta-1)$	$\psi/(\psi-1)$	θ	ψ	
euro area	1.35	1.30	3.9	4.3	2.0
United States	1.23	1.16	5.4	7.3	0.9

Table 5: GEM estimates of the long-run effects of more competition-friendly policies in the euro area (percent deviations from baseline)

	Product Market Reforms	*Labor Market Reforms*	*Both Reforms*
euro area:			
GDP	8.6	3.5	12.4
Consumption	4.9	3.3	8.3
Investment	17.0	3.5	21.2
Labor Effort	4.5	3.6	8.3
Real Exchange Rate	4.2	1.1	5.3
Rest of World:			
GDP	0.7	0.2	0.8
Consumption	1.0	0.3	1.3
Investment	0.5	0.1	0.7
Labor Effort	0.1	0.0	0.2

Table 6: GEM estimates of the sacrifice ratio under more competition-friendly policies in the euro area (percent deviations from baseline)

	Labor Market Reforms	*Product Market Reforms*	*Both Reforms*
Sacrifice Ratio	$2.0 \Longrightarrow 1.7$	$2.0 \Longrightarrow 1.7$	$2.0 \Longrightarrow 1.4$

Figure 1: The structure of the model (variant of the IMF's Global Economy Model)

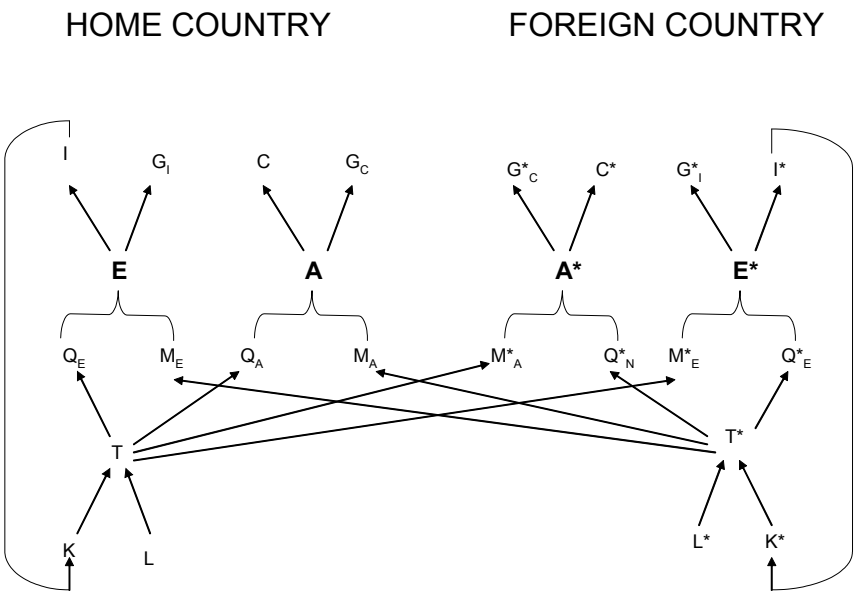


Figure 2: Consumption responses to a 4-quarter 100 basis point hike in interest rates under various assumptions for habit persistence and the intertemporal elasticity of substitution

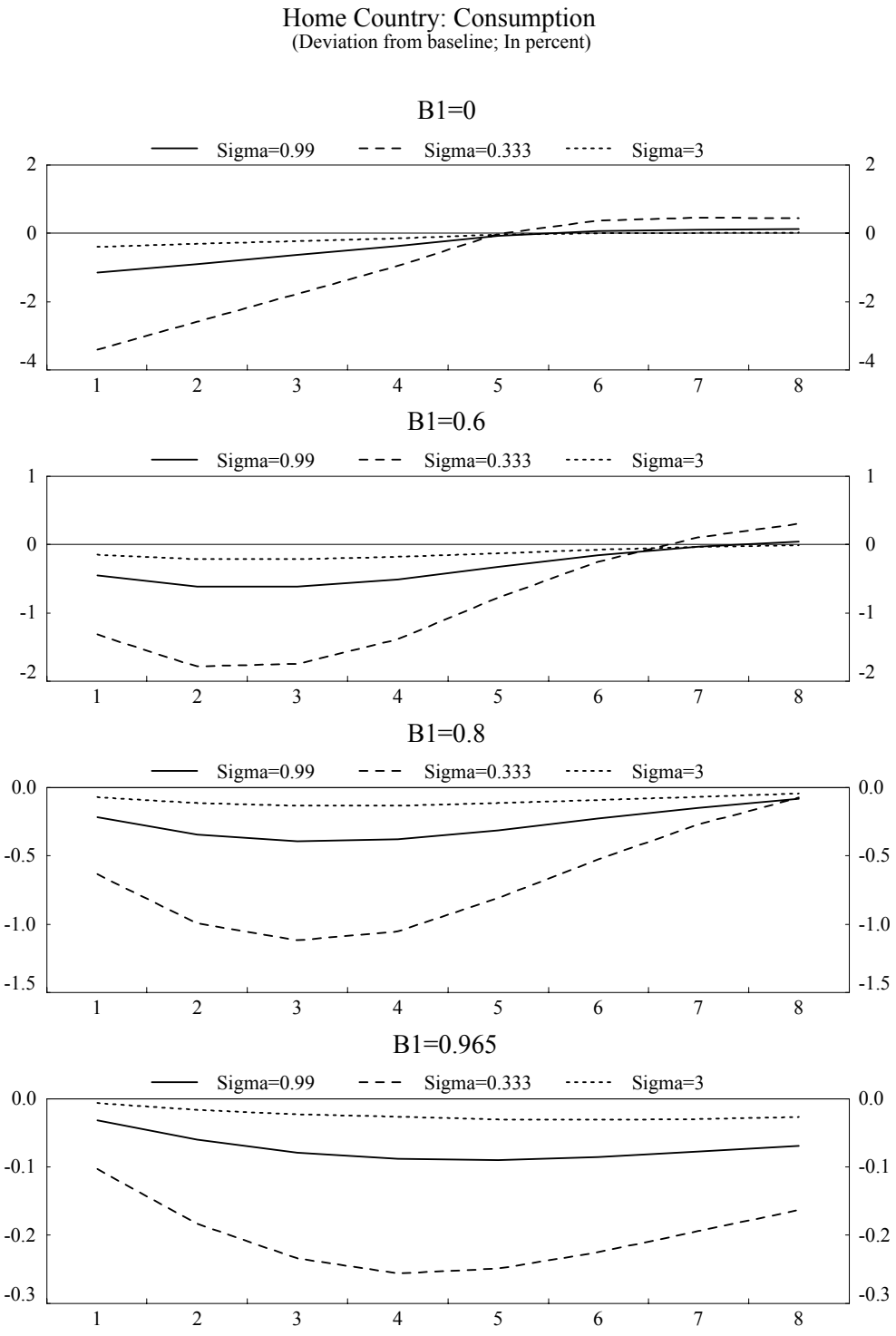


Figure 3: Output, consumption and labor effort responses to a disinflation shock under different assumptions about habit persistence in labor effort

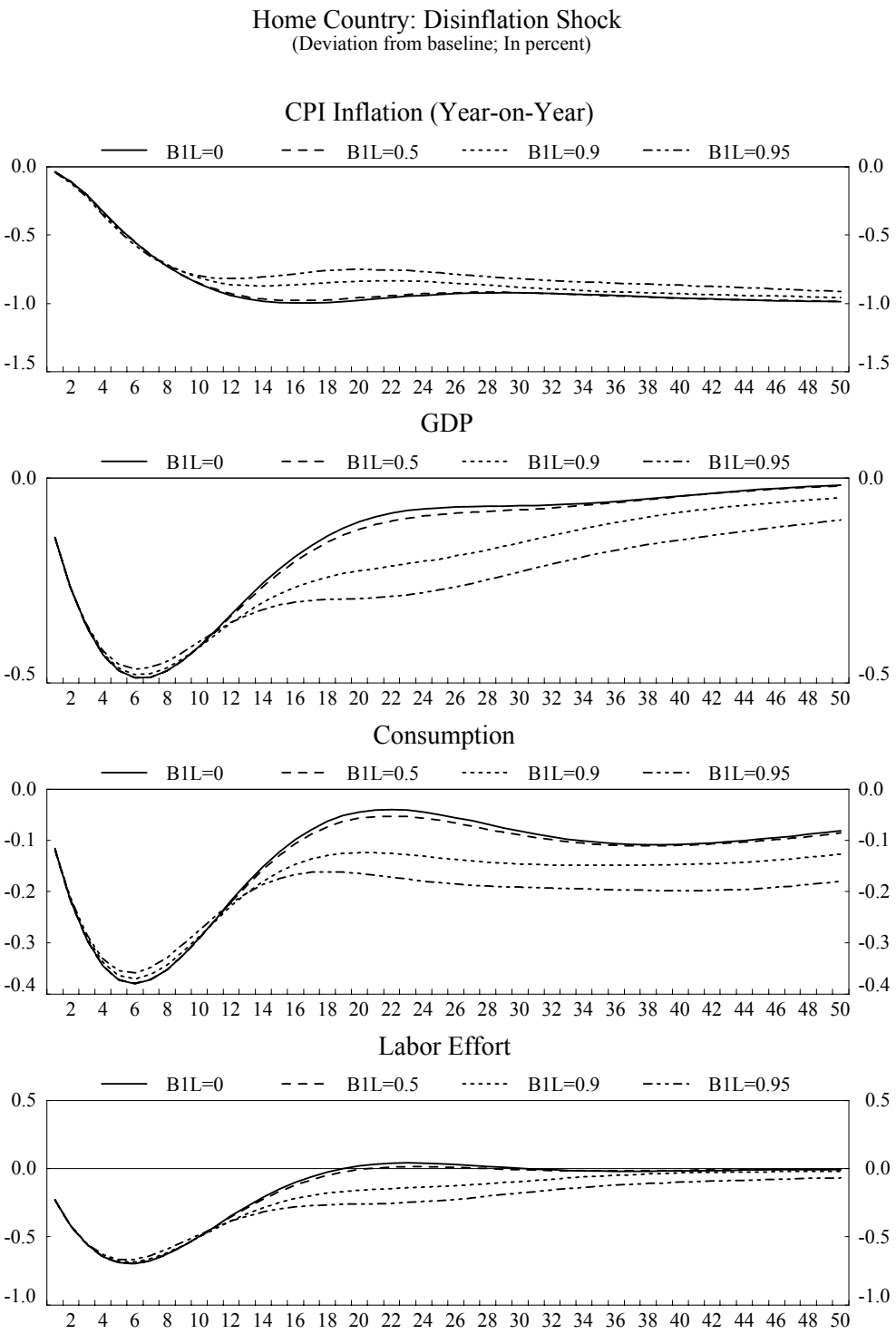


Figure 4: A comparison of an interest rate shock in GEM with VAR estimates by Altig and others (2003)

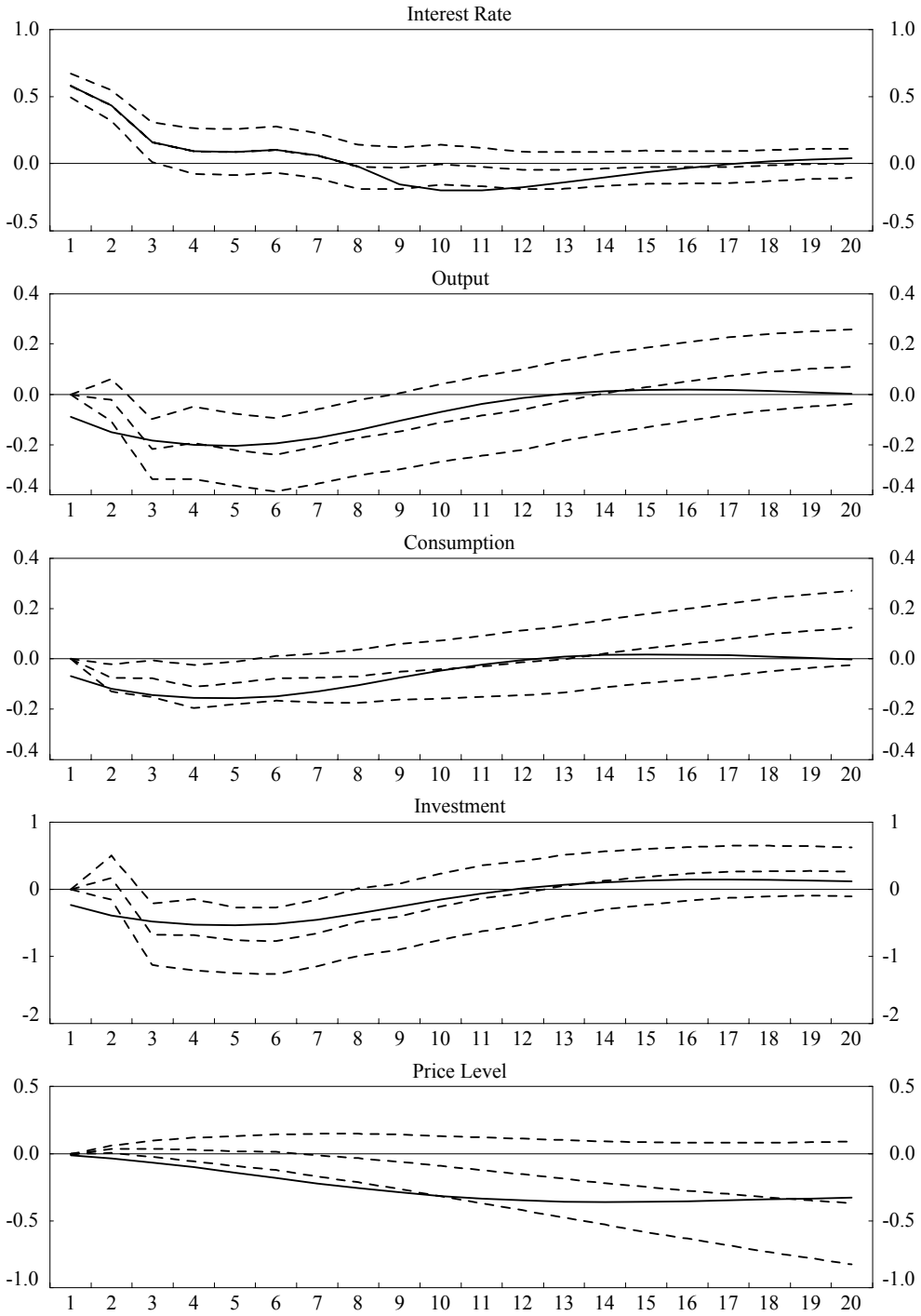
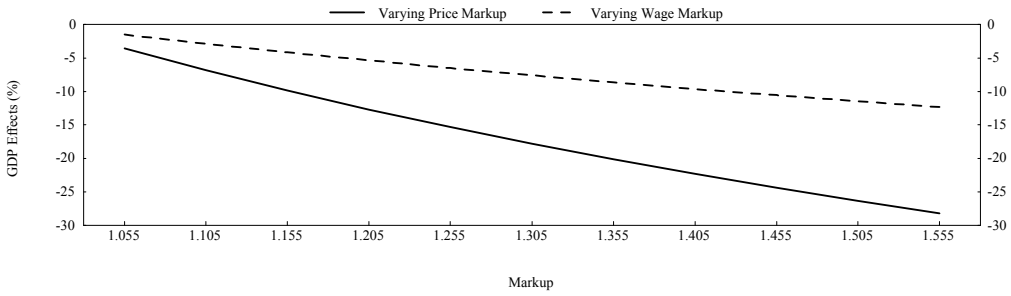


Figure 5: Effects of different price and wage markups on sacrifice ratios and the long-run levels of economic activity (BASE-CASE PARAMETERS WITH LOWER STRUCTURAL INFLATION PERSISTENCE AND IDENTICAL NOMINAL ADJUSTMENT COSTS IN THE HOME AND FOREIGN COUNTRY)

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	-3.5	-6.8	-9.9	-12.7	-15.3	-17.8	-20.1	-22.3	-24.4	-26.3	-28.2
Consumption	-2.0	-3.9	-5.9	-7.7	-9.6	-11.4	-13.1	-14.8	-16.5	-18.1	-19.6
Investment	-7.2	-13.7	-19.4	-24.6	-29.2	-33.4	-37.2	-40.7	-43.9	-46.8	-49.5
Labor Effort	-2.1	-4.0	-5.9	-7.6	-9.2	-10.8	-12.2	-13.6	-14.9	-16.2	-17.4
Real Exchange Rate (- appreciation)	-1.8	-3.6	-5.1	-6.6	-8.0	-9.3	-10.5	-11.6	-12.7	-13.8	-14.7
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.3	-0.5	-0.8	-1.0	-1.2	-1.3	-1.5	-1.7	-1.8	-2.0	-2.1
Consumption	-0.4	-0.9	-1.2	-1.6	-1.9	-2.2	-2.5	-2.8	-3.0	-3.2	-3.5
Investment	-0.2	-0.4	-0.6	-0.8	-0.9	-1.1	-1.2	-1.4	-1.5	-1.6	-1.7
Labor Effort	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-1.5	-2.8	-4.1	-5.3	-6.5	-7.6	-8.6	-9.6	-10.5	-11.4	-12.3
Consumption	-1.4	-2.6	-3.8	-5.0	-6.0	-7.1	-8.0	-9.0	-9.9	-10.7	-11.5
Investment	-1.5	-2.8	-4.1	-5.3	-6.5	-7.6	-8.6	-9.6	-10.6	-11.5	-12.4
Labor Effort	-1.5	-2.9	-4.2	-5.5	-6.7	-7.8	-8.9	-9.9	-10.9	-11.8	-12.7
Real Exchange Rate (- appreciation)	-0.5	-0.9	-1.4	-1.8	-2.2	-2.5	-2.9	-3.2	-3.6	-3.9	-4.2
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6
Consumption	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-0.9	-1.0
Investment	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5
Labor Effort	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1

Long-Run Effects of Different Price Markups and Wage Markups



Sacrifice Ratios for Home Country Under Different Markups

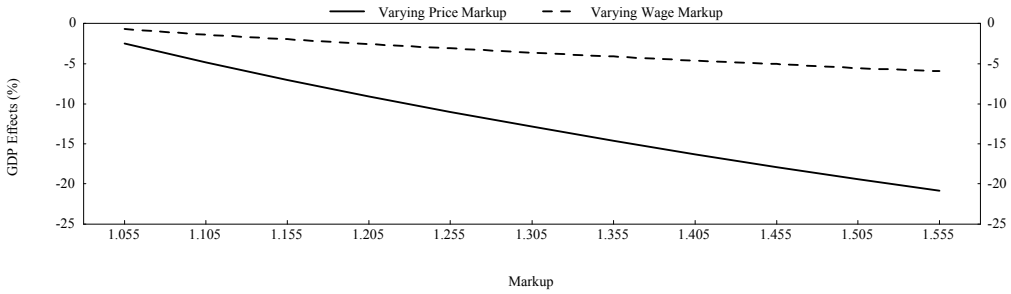
	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.2	0.3	0.4	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.9
Sacrifice Ratio (Varying Wage Markup)	0.2	0.5	0.8	0.9	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8

Figure 6: Effects of different price and wage markups on sacrifice ratios and the long-run levels of economic activity (BASE-CASE PARAMETERS WITH FRISCH ELASTICITY OF LABOR SUPPLY EQUAL TO MEAN ESTIMATE FROM MICRO STUDIES ($\zeta = 1/.15 = 6.7$)

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	-2.5	-4.8	-7.0	-9.1	-11.0	-12.9	-14.6	-16.3	-17.9	-19.4	-20.9
Consumption	-1.0	-2.0	-3.0	-4.1	-5.2	-6.3	-7.4	-8.5	-9.6	-10.7	-11.7
Investment	-6.2	-11.8	-16.8	-21.4	-25.6	-29.4	-32.9	-36.1	-39.0	-41.8	-44.3
Labor Effort	-1.0	-1.9	-2.8	-3.6	-4.4	-5.2	-5.9	-6.6	-7.3	-7.9	-8.5
Real Exchange Rate (- appreciation)	-1.5	-2.9	-4.2	-5.4	-6.6	-7.6	-8.6	-9.6	-10.5	-11.3	-12.1
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.2	-0.4	-0.6	-0.7	-0.9	-1.0	-1.1	-1.3	-1.4	-1.5	-1.6
Consumption	-0.3	-0.7	-1.0	-1.2	-1.5	-1.7	-1.9	-2.1	-2.3	-2.5	-2.7
Investment	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-0.9	-1.0	-1.1	-1.2	-1.2
Labor Effort	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-0.7	-1.3	-1.9	-2.5	-3.1	-3.6	-4.1	-4.6	-5.0	-5.5	-5.9
Consumption	-0.6	-1.2	-1.8	-2.3	-2.9	-3.4	-3.8	-4.3	-4.7	-5.1	-5.5
Investment	-0.7	-1.3	-1.9	-2.5	-3.1	-3.6	-4.1	-4.6	-5.1	-5.5	-6.0
Labor Effort	-0.7	-1.4	-2.0	-2.6	-3.2	-3.7	-4.2	-4.7	-5.2	-5.7	-6.1
Real Exchange Rate (- appreciation)	-0.2	-0.4	-0.6	-0.8	-1.0	-1.2	-1.4	-1.5	-1.7	-1.8	-2.0
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3
Consumption	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.5
Investment	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
Labor Effort	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0

Long-Run Effects of Different Price Markups and Wage Markups



Sacrifice Ratios for Home Country Under Different Markups

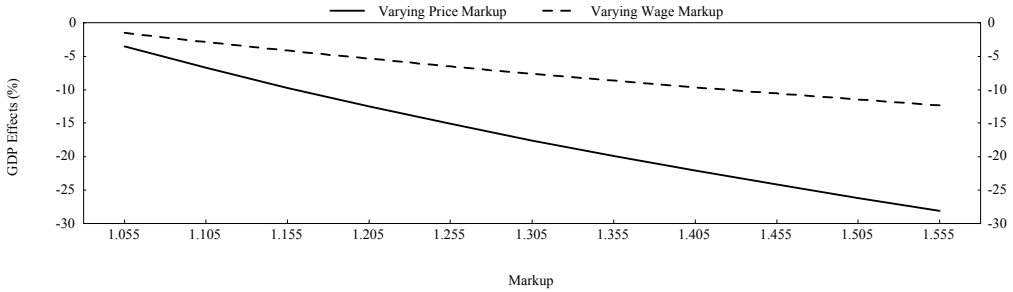
	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.2	0.3	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6
Sacrifice Ratio (Varying Wage Markup)	0.1	0.3	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2

Figure 7: Effects of different price and wage markups on sacrifice ratios and the long-run levels of economic activity (BASE-CASE PARAMETERS WITH ELASTICITY OF SUBSTITUTION BETWEEN CAPITAL AND LABOR REDUCED BY 0.10)

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	-3.5	-6.7	-9.7	-12.5	-15.1	-17.6	-19.9	-22.1	-24.2	-26.2	-28.1
Consumption	-2.1	-4.1	-6.1	-8.0	-9.9	-11.7	-13.5	-15.3	-16.9	-18.6	-20.2
Investment	-6.7	-12.7	-18.1	-23.0	-27.5	-31.5	-35.2	-38.6	-41.7	-44.6	-47.2
Labor Effort	-2.1	-4.1	-6.0	-7.8	-9.4	-11.0	-12.5	-13.9	-15.3	-16.6	-17.8
Real Exchange Rate (- appreciation)	-1.7	-3.4	-4.9	-6.3	-7.6	-8.9	-10.1	-11.2	-12.3	-13.3	-14.2
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.3	-0.5	-0.7	-0.9	-1.1	-1.3	-1.4	-1.6	-1.7	-1.8	-2.0
Consumption	-0.4	-0.8	-1.2	-1.5	-1.8	-2.1	-2.4	-2.6	-2.9	-3.1	-3.3
Investment	-0.2	-0.4	-0.5	-0.7	-0.8	-0.9	-1.0	-1.1	-1.3	-1.3	-1.4
Labor Effort	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4
Home Country Long-run Effects of Higher Wage Markups (In percent)											
GDP	-1.5	-2.8	-4.1	-5.3	-6.5	-7.6	-8.6	-9.6	-10.5	-11.4	-12.3
Consumption	-1.4	-2.6	-3.8	-5.0	-6.0	-7.1	-8.0	-9.0	-9.9	-10.7	-11.5
Investment	-1.5	-2.8	-4.1	-5.4	-6.5	-7.6	-8.7	-9.7	-10.6	-11.5	-12.4
Labor Effort	-1.5	-2.9	-4.2	-5.5	-6.7	-7.8	-8.9	-9.9	-10.9	-11.8	-12.7
Real Exchange Rate (- appreciation)	-0.5	-0.9	-1.4	-1.8	-2.2	-2.5	-2.9	-3.2	-3.6	-3.9	-4.2
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6
Consumption	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-0.9	-1.0
Investment	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4
Labor Effort	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1

Long-Run Effects of Different Price Markups and Wage Markups



Sacrifice Ratios for Home Country Under Different Markups

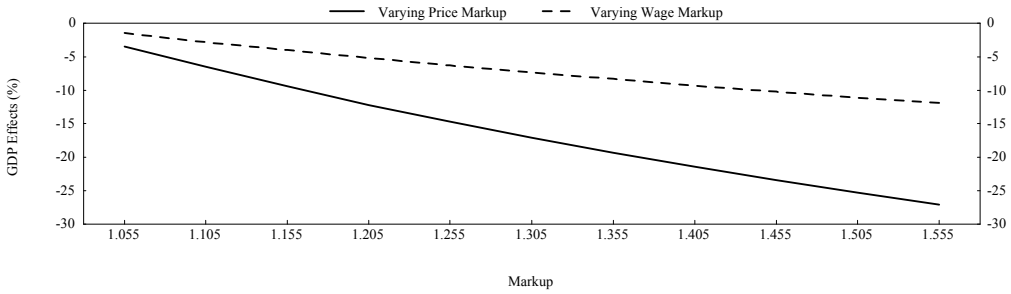
	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.1
Sacrifice Ratio (Varying Wage Markup)	0.2	0.6	0.8	1.0	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.0

Figure 8: Effects of different price and wage markups on sacrifice ratios and the long-run levels of economic activity (BASE-CASE PARAMETERS WITH SMALLER IMPORT DEMAND ELASTICITIES (μ_A and $\mu_E = 1.5$)

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	-3.4	-6.5	-9.4	-12.1	-14.7	-17.1	-19.3	-21.4	-23.4	-25.3	-27.1
Consumption	-1.5	-3.0	-4.6	-6.2	-7.8	-9.4	-10.9	-12.5	-14.0	-15.5	-16.9
Investment	-7.1	-13.4	-19.1	-24.2	-28.8	-32.9	-36.7	-40.1	-43.3	-46.2	-48.9
Labor Effort	-2.1	-4.0	-5.8	-7.5	-9.1	-10.7	-12.1	-13.5	-14.8	-16.0	-17.2
Real Exchange Rate (- appreciation)	-3.7	-7.0	-10.0	-12.7	-15.2	-17.6	-19.7	-21.7	-23.6	-25.3	-26.9
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.6	-1.1	-1.5	-2.0	-2.4	-2.7	-3.1	-3.4	-3.7	-4.0	-4.3
Consumption	-0.9	-1.7	-2.5	-3.2	-3.9	-4.5	-5.1	-5.6	-6.1	-6.6	-7.0
Investment	-0.4	-0.9	-1.2	-1.6	-1.9	-2.2	-2.5	-2.8	-3.0	-3.2	-3.5
Labor Effort	-0.1	-0.2	-0.3	-0.4	-0.4	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8
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	-1.2	-2.3	-3.4	-4.4	-5.4	-6.3	-7.2	-8.0	-8.8	-9.6	-10.3
Investment	-1.4	-2.7	-4.0	-5.2	-6.3	-7.4	-8.4	-9.3	-10.3	-11.1	-12.0
Labor Effort	-1.5	-2.9	-4.2	-5.5	-6.6	-7.8	-8.8	-9.9	-10.8	-11.7	-12.6
Real Exchange Rate (- appreciation)	-0.9	-1.8	-2.7	-3.5	-4.2	-5.0	-5.6	-6.3	-6.9	-7.5	-8.1
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	-0.8	-0.9	-1.0	-1.1	-1.2	-1.2
Consumption	-0.2	-0.5	-0.7	-0.9	-1.0	-1.2	-1.4	-1.6	-1.7	-1.9	-2.0
Investment	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-0.9	-1.0
Labor Effort	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2

Long-Run Effects of Different Price Markups and Wage Markups



Sacrifice Ratios for Home Country Under Different Markups

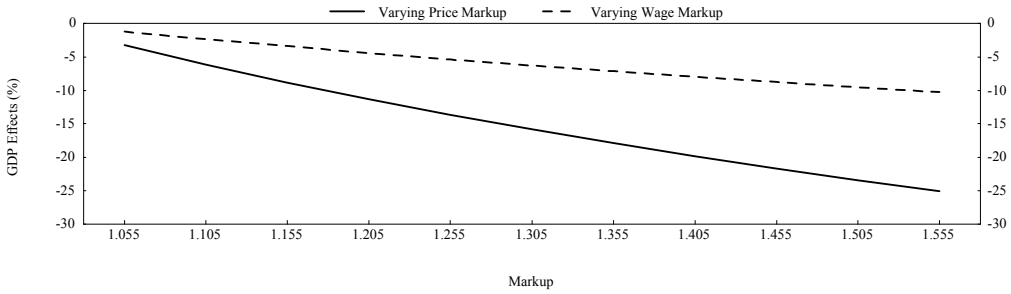
	1.005	1.055	1.105	1.155	1.205	1.255	1.305	1.355	1.405	1.455	1.505	1.555
Sacrifice Ratio (Varying Price Markup)	0.1	0.3	0.4	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.7	1.8
Sacrifice Ratio (Varying Wage Markup)	0.1	0.5	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7

Figure 9: 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 $(1/\sigma) = 1/0.99$)

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	-11.3	-13.6	-15.8	-17.9	-19.9	-21.7	-23.4	-25.1
Consumption	-1.6	-3.2	-4.8	-6.3	-7.9	-9.4	-10.8	-12.2	-13.6	-14.9	-16.3
Investment	-6.9	-13.0	-18.4	-23.4	-27.8	-31.8	-35.5	-38.8	-41.9	-44.7	-47.3
Labor Effort	-1.7	-3.3	-4.7	-6.1	-7.4	-8.6	-9.7	-10.8	-11.8	-12.8	-13.7
Real Exchange Rate (- appreciation)	-1.7	-3.4	-4.8	-6.2	-7.5	-8.7	-9.9	-10.9	-11.9	-12.9	-13.8
Spillover Effects on Foreign Country of Higher Price Markups in Home Country (In percent)											
GDP	-0.2	-0.3	-0.5	-0.6	-0.7	-0.9	-1.0	-1.1	-1.2	-1.2	-1.3
Consumption	-0.3	-0.7	-0.9	-1.2	-1.4	-1.7	-1.9	-2.1	-2.3	-2.4	-2.6
Investment	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.8	-0.9	-0.9
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	-1.2	-2.3	-3.4	-4.4	-5.3	-6.2	-7.1	-7.9	-8.7	-9.5	-10.2
Consumption	-1.1	-2.2	-3.1	-4.1	-5.0	-5.8	-6.6	-7.4	-8.1	-8.8	-9.5
Investment	-1.2	-2.3	-3.4	-4.4	-5.4	-6.3	-7.1	-8.0	-8.8	-9.5	-10.2
Labor Effort	-1.2	-2.4	-3.5	-4.5	-5.5	-6.4	-7.3	-8.2	-9.0	-9.8	-10.5
Real Exchange Rate (- appreciation)	-0.4	-0.8	-1.1	-1.5	-1.8	-2.1	-2.4	-2.7	-3.0	-3.2	-3.5
Spillover Effects on Foreign Country of Higher Wage Markups in Home Country (In percent)											
GDP	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4
Consumption	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7
Investment	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3
Labor Effort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1

Long-Run Effects of Different Price Markups and Wage Markups



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)	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2
Sacrifice Ratio (Varying Wage Markup)	0.2	0.6	0.8	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9

Figure 10: Dynamic effects of more competition-friendly policies in the euro area (anticipated and perfectly credible)

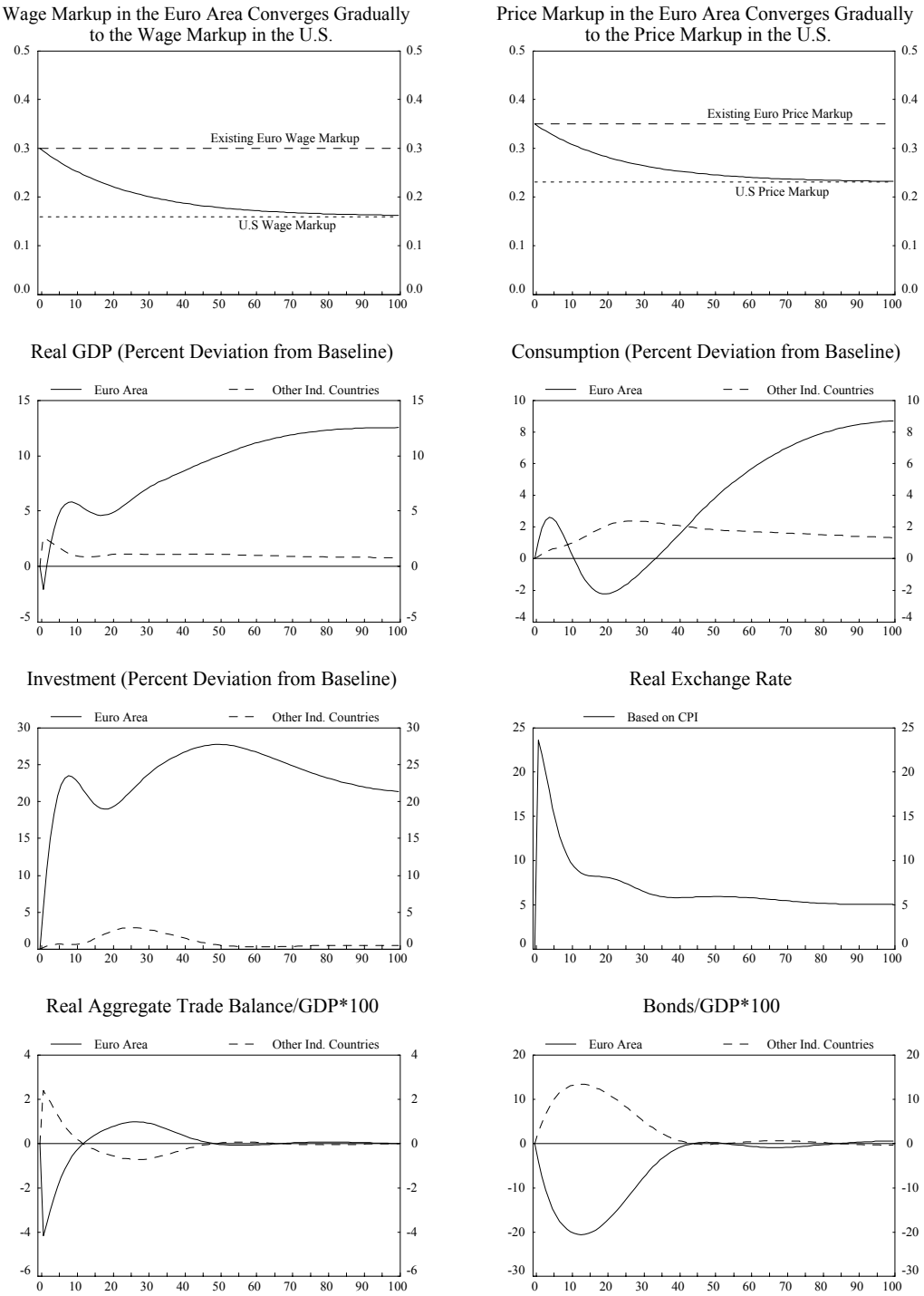


Figure 11: Dynamic effects of more competition-friendly policies in the euro area (unanticipated)