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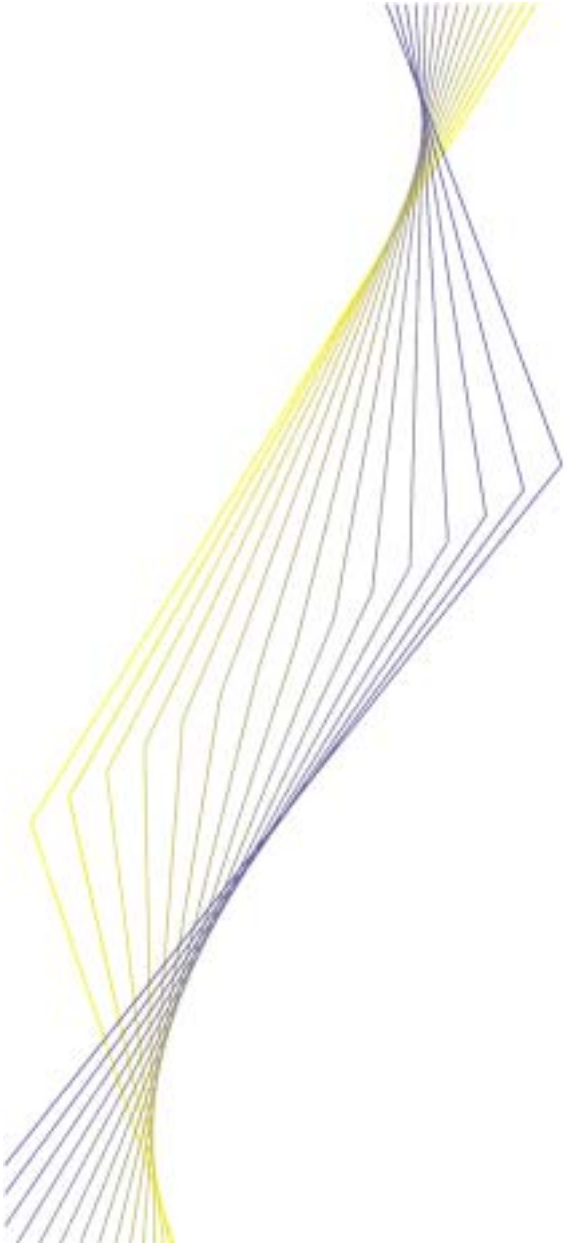

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REGIONAL INFLATION IN A CURRENCY UNION: FISCAL POLICY VS. FUNDAMENTALS[1]

BY MARGARIDA DUARTE[2] AND ALEXANDER L. WOLMAN[3]

INTERNATIONAL RESEARCH FORUM ON MONETARY POLICY

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2 *Federal Reserve Bank of Richmond, margarida.duarte@rich.frb.org*

3 *Federal Reserve Bank of Richmond, alexander.wolman@rich.frb.org*

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Address	**Kaiserstrasse 29** **D-60311 Frankfurt am Main** **Germany**
Postal address	**Postfach 16 03 19** **D-60066 Frankfurt am Main** **Germany**
Telephone	**+49 69 1344 0**
Internet	**http://www.ecb.int**
Fax	**+49 69 1344 6000**
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Abstract

We develop a general equilibrium model of a two-region currency union. There are two types of goods: non-traded goods, and traded goods for which markets are segmented. Monetary policy is set by a central monetary authority and is non-neutral due to nominal price rigidities. Fiscal policy is determined at the regional level by each region's government. We find that productivity shocks alone generate significant variation in inflation across the two countries. Government spending shocks, in contrast, do not account for a significant portion of inflation variation. Varying relative country size, we find that smaller countries experience higher variability of their inflation differential in response to shocks to productivity growth. Moreover, we show that regional governments can suppress incipient inflation differentials associated with shocks to productivity growth by letting the income tax rate respond negatively to inflation differentials.

Keywords: currency union, fiscal policy, inflation differentials, productivity differentials, nominal rigidities.

JEL classification: E31, E32, F41, H63.

Non-technical Abstract

Membership in the European Monetary Union is determined both by a limit on the deviation of a country's inflation rate from the union's average and by limits on the behavior of public deficits and debt. However, in the short time that the EMU has been in operation, inflation rates in some member countries have deviated from the limit imposed by the convergence criterion, and the European Commission appears willing to reproach these countries. It is important to understand whether such deviations are natural, given the variation in economic fundamentals across regions, or whether they reflect the behavior of regional fiscal policies and hence can be corrected. If large inflation differentials are natural, the question also arises of whether regional fiscal policies can be effective in mitigating them.

To study these questions, we develop a general equilibrium model of a two-region currency union. There are two types of goods in the model: nontraded goods, and traded goods for which markets are segmented. The coexistence of these two types of goods has the potential to generate two sources of inflation differentials in the model. First, inflation differentials can arise from deviations from the law of one price for traded goods. Second, inflation differentials can also arise from the differential behavior of the relative price of non-traded goods across countries. To the extent that these relative prices are affected by productivity differentials across countries, the model embeds the Balassa-Samuelson effect. Monetary policy is set by a central monetary authority and is non-neutral because prices are set for multiple periods. Fiscal policy is determined at the regional level by each region's government. The model is driven by shocks to productivity and regional fiscal policies.

Calibrating a symmetric version of the model to German data, we find that productivity shocks alone generate somewhat more variation in inflation across countries than has been observed between two European countries of roughly the same size, France and Germany. Government spending shocks, in contrast, do not account for a significant portion of inflation variation. In addition, in the simulations of the model, a 3% limit on the deficit to GDP ratio is violated regularly - about one third of the time; a 60% limit on the debt to GDP ratio, however, is violated only about 1% of the time. Finally, inflation differentials in the model are accounted for by differences in the relative price of traded to non-traded goods across regions; that is deviations from the law of one price are minimal.

We then vary the relative country size and focus on the behavior of regional in-

flation in response to shocks to productivity growth in the smaller country. We find that smaller countries experience higher variability in their inflation differential in response to these shocks. Finally, we show that regional governments are able to suppress incipient inflation differentials associated with shocks to productivity growth by letting the income tax rate respond negatively to inflation differentials. That is, a looser fiscal stance is associated with lower inflation differentials.

1. Introduction

Membership in the European Monetary Union is determined both by a limit on the deviation of a country's inflation rate from the union's average and by limits on the behavior of public deficits and debt. However, in the short time that the EMU has been in operation, inflation rates in some member countries have deviated from the limit imposed by the convergence criterion, and the European Commission appears willing to reproach these countries. It is important to understand whether such deviations are natural, given the variation in economic fundamentals across regions, or whether they reflect the behavior of regional fiscal policies and hence can be corrected. If large inflation differentials are natural, the question also arises of whether regional fiscal policies can be effective in mitigating them.

To study these questions, we develop a general equilibrium model of a two-region currency union. There are nontraded goods, and traded goods for which markets are segmented. The coexistence of these two types of goods has the potential to generate two sources of inflation differentials in the model. First, inflation differentials can arise from deviations from the law of one price for traded goods. Second, inflation differentials can also arise from the differential behavior of the relative price of non-traded goods across countries. To the extent that these relative prices are affected by productivity differentials across countries, the model embeds the Balassa-Samuelson effect. Monetary policy is set by a central monetary authority and is non-neutral because prices are set for multiple periods. Fiscal policy is determined at the regional level by each region's government. The model is driven by shocks to productivity and regional fiscal policies.

For a symmetric version of the model calibrated to Germany, we find that productivity shocks alone generate somewhat more variation in inflation across countries than has been observed between France and Germany. Government spending shocks do not account for a significant portion of inflation variation, and deviations from the law of one price are minimal, for reasons we will explain below. Varying relative country size, we find that small countries experience higher variability of their inflation differential. This leads us to ask whether there exist regional fiscal policies that can suppress incipient inflation differentials associated with shocks to productivity growth. Such policies do exist, but those that we have analyzed imply very large *negative* responses of labor income tax rates to inflation differentials.

This paper addresses the behavior of regional inflation in a currency union, and in particular the extent to which regional fiscal policy is able to influence

the behavior of regional inflation. It thus relates to research on the economics of currency unions, on inter-regional variation in inflation, and on the interaction between fiscal policy and inflation.

Early research on currency unions, dating back to Mundell (1961), concerns the optimal composition of a currency area. In modern dynamic equilibrium models, it has been difficult to find conditions under which it is optimal to relinquish monetary independence (see, for example, Monacelli, 2001). Thus, recent research has emphasized issues such as optimal monetary policy within a currency union (Benigno, 2001). We take as given that two regions comprise a currency union, and study the behavior of regional inflation. Our work is perhaps closest to Bergin (2001). He studies a model of a currency union in which firms price to market and face non-constant demand elasticities for the products they produce. These features lead to inflation differentials being associated with deviations from the law of one price, and to a potentially important role for demand shocks in driving inflation differentials. Our basic model assumes constant elasticities of demand, and therefore does not lead to large deviations from the law of one price.

The literature on regional variation in inflation is primarily empirical, focusing on the dynamics of price adjustment. See, for example, Rogers (2001), Cecchetti, Mark, and Sonora (2000), and Parsley and Wei (1996).

There is an extensive literature on the interaction between fiscal policy and inflation in closed economy models. Bergin (2000) and Sims (1999) consider implications of the fiscal theory of the price level for a monetary union. We focus on monetary and fiscal policy regimes in which there is a unique equilibrium. Nonetheless, the particular form of a region's fiscal policy rule has the potential to affect the equilibrium behavior of inflation.

The paper proceeds as follows. Sections 2 and 3 describe the model and calibration. Section 4 provides a nonquantitative discussion of how the model delivers variation in inflation across regions. Section 5 presents simulation results for the symmetric calibration, and section 6 analyzes the asymmetric case, focusing on the response to a persistent growth rate shock to tradables productivity; we describe the effect of country size on the inflation differential, and then we consider the ability of the regional fiscal authority to control its inflation differential. Section 7 concludes.

2. Model.

The currency union is composed of two regions, denoted home and foreign, that share the same currency. A central monetary authority issues the currency and conducts monetary policy. Each region has a fiscal authority, which is responsible for its region's fiscal policy.

The two regions share the same structure but may differ in size. Each region is specialized in the production of a continuum of varieties of a tradable and nontradable good. These goods are produced using labor, which is immobile internationally. Each region is populated by a continuum of households of measure x for home and $1-x$ for foreign. Households in each region supply labor to domestic firms and consume all varieties of both home and foreign tradable goods, as well as all varieties of the region's nontradable good. Households also demand real balances, which are an argument in their utility function.

Firms are monopolistically competitive, and prices are sticky in the sense that a goods price chosen in the current period is likely to be in place for several periods into the future. Knowing the pattern of price adjustment they will face, firms choose an optimal price when they do adjust.

We assume that asset markets are complete. Thus, in every state of the world the ratio of marginal utilities of per capita consumption across regions is equated to the ratio of consumption price levels across regions.

We describe only the home region's economy. An analogous description applies to the foreign region. The subscript f (or h) denotes a good's country of origin, whereas the superscript $*$ denotes a foreign region variable.

2.1. Households.

Households derive utility from consuming a composite good (c_t), leisure ($1-l_t$), and from holding real money balances ($\frac{M_t}{P_t}$). Households maximize the expected discounted value of the utility flow,

$$U_t = E_0\left[\sum_{t=0}^{\infty}\beta^t u\left(c_t, 1-l_t, \frac{M_t}{P_t}\right)\right] \tag{2.1}$$

where E_0 denotes the mathematical expectation conditional on information available in period $t=0$, $\beta\in(0,1)$ is the discount rate, and u is the momentary utility function, assumed to be concave and twice continuously differentiable.

2.1.1. The Composition of Consumption.

The composite consumption good is an aggregate of traded and nontraded goods as follows:

$$c_t = \left[a^{\frac{1}{\xi}} {c_t^T}^{\frac{\xi-1}{\xi}} + (1-a)^{\frac{1}{\xi}} {c_t^N}^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}. \tag{2.2}$$

The elasticity of substitution between the tradable and nontradable good is ξ, and a determines the agent's bias towards the tradable good. Consumption of traded goods is a similar aggregate of home- and foreign- produced traded goods:

$$c_t^T = \left[\omega^{\frac{1}{\gamma}} {c_{h,t}^T}^{\frac{\gamma-1}{\gamma}} + (1-\omega)^{\frac{1}{\gamma}} {c_{f,t}^T}^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}, \tag{2.3}$$

where $\gamma > 0$ denotes the elasticity of substitution between the home and foreign composite tradable goods, and the weight ω determines the agent's bias for domestic tradable good.

Each country produces a continuum of varieties of the tradable good, indexed by $i \in [0, T]$, and a continuum of varieties of the nontraded good, indexed by $j \in [T, 1]$. The local nontraded good and the local and imported traded goods in (2.2) and (2.3) are aggregates of these continua of varieties:

$$c_t^N = \left(\int_T^1 c_t^N(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{2.4}$$

$$c_{h,t}^T = \left(\int_0^T c_{h,t}^T(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}, \tag{2.5}$$

and

$$c_{f,t}^T = \left(\int_0^{T_f} c_{f,t}^T(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}, \tag{2.6}$$

where $\theta > 1$ is the elasticity of substitution between any two varieties of the same good, and the price elasticity of demand for a given variety.

2.1.2. Price Indices and Demands.

The numeraire we will work with is the common currency. Let $P_{h,t}^T(i)$, $P_{f,t}^T(i)$, and $P_t^N(i)$ denote the prices of the home and foreign tradable goods and of the local

nontradable good of type i, respectively. Given these prices, the consumption-based price index P_t is[1]

$$P_t = \left[a \left(P_t^T \right)^{1-\xi} + (1-a) \left(P_t^N \right)^{1-\xi} \right]^{\frac{1}{1-\xi}}, \tag{2.7}$$

and the price indices P_t^T and P_t^N for the tradable and nontradable composite goods are given by

$$P_t^T = \left(\omega \left(P_{h,t}^T \right)^{1-\gamma} + (1-\omega) \left(P_{f,t}^T \right)^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \tag{2.8}$$

and

$$P_t^N = \left(\int_T^1 P_t^N (i)^{1-\theta} \, di \right)^{\frac{1}{1-\theta}}. \tag{2.9}$$

In addition, the price indices $P_{h,t}^T$ and $P_{f,t}^T$ for the local and imported tradable goods are given by

$$P_{h,t}^T = \left(\int_0^T P_{h,t}^T (i)^{1-\theta} \, di \right)^{\frac{1}{1-\theta}} \quad \text{and} \quad P_{f,t}^T = \left(\int_0^T P_{f,t}^T (i)^{1-\theta} \, di \right)^{\frac{1}{1-\theta}}$$

Given the structure of preferences, the agent's demand functions for each variety of each good are given by

$$c_t^N (i) = (1-a) \left(\frac{P_t^N}{P_t^N (i)} \right)^{\theta} \left(\frac{P_t}{P_t^N} \right)^{\xi} c_t, \tag{2.10}$$

$$c_{h,t}^T (i) = a\omega \left(\frac{P_{h,t}^T}{P_{h,t}^T (i)} \right)^{\theta} \left(\frac{P_t^T}{P_{h,t}^T} \right)^{\gamma} \left(\frac{P_t}{P_t^T} \right)^{\xi} c_t, \tag{2.11}$$

and

$$c_{f,t}^T (i) = a (1-\omega) \left(\frac{P_{f,t}^T}{P_{f,t}^T (i)} \right)^{\theta} \left(\frac{P_t^T}{P_{f,t}^T} \right)^{\gamma} \left(\frac{P_t}{P_t^T} \right)^{\xi} c_t. \tag{2.12}$$

[1]Each price index is defined as the minimum expenditure necessary to buy one unit of the corresponding composite good.

2.1.3. The Budget Constraint.

The representative consumer in the home region holds currency, M_t, issued by the central monetary authority and trades a complete set of state contingent nominal bonds with the consumer in the foreign region. We denote the price at date t when the state of the world is s_t of a bond paying one unit of currency at date $t+1$ if the state of the world is s_{t+1} by $Q\left(s_{t+1}|s_t\right)$ and we denote the number of these bonds purchased by the home agent at date t by $D\left(s_{t+1}\right)$. The home consumer also holds a riskless nominal bond issued by the region's fiscal authority, B_t, paying $(1+R_t)$ currency units in period $t+1$.

The agent's intertemporal budget constraint, expressed in currency units, is

$$\begin{aligned} & P_t c_t + M_t + B_t + \sum_{s_{t+1}} Q\left(s_{t+1}|s_t\right) D\left(s_{t+1}\right) \qquad (2.13) \\ \leq \; & \left(1-\tau_t\right) P_t w_t l_t + M_{t-1} + D\left(s_t\right) + \Pi_t + \left(1+R_{t-1}\right) B_{t-1}, \end{aligned}$$

where Π_t represents profits of domestic firms (assumed to be owned by the domestic consumer) and $\left(1-\tau_t\right) P_t w_t l_t$ represents nominal labor earnings after tax.

The consumer chooses sequences for consumption, c_t, labor, l_t, state contingent bonds, $D\left(s_{t+1}\right)$, government bonds, B_t, and money holdings, M_t, in order to maximize the expected discounted utility (2.1) subject to the budget constraint (2.13).

2.2. The Regional Fiscal Authority.

The fiscal authority in the home region issues nominal debt, B_t, taxes labor income at rate τ_t, and receives seigniorage revenues from the central monetary authority, Z_t. These revenues are spent on public consumption, g_t, and interest payments on the debt. Public consumption does not yield utility to households in our model. The region's government budget constraint is given by

$$B_t + \tau_t P_t w_t l_t + Z_t = \left(1+R_{t-1}\right) B_{t-1} + P_t g_t. \qquad (2.14)$$

The government has the same preferences as the consumer for the different varieties of the local nontradable good and both tradable goods. Therefore, given a level of total government consumption g_t, government demands for individual goods are given by the same expressions as individual consumption demands (2.10), (2.11), and (2.12).

We are interested in studying the roles of both regional fiscal policy shocks and systematic fiscal policy in affecting inflation differentials across regions. Fiscal

policy shocks can be associated with either taxation or spending, and likewise systematic fiscal policy can be associated with either taxation or spending. We follow much of the literature in assuming that the ratio of government spending to output follows an exogenous stochastic process, whereas the labor income tax rate is determined by a feedback rule that incorporates a response to the stock of debt.[2] This response insures that the government will be able to pay the interest on its debts.

The share of total public consumption in output, $\frac{g}{y}$, is given by

$$\left(\frac{g}{y}\right)_t = c_g + \rho_g \left(\frac{g}{y}\right)_{t-1} + \varepsilon_{g,t}, \tag{2.15}$$

where $\left|\rho_g\right| < 1$ and $\varepsilon_{g,t} \sim N(0, \sigma_g)$. The tax rate τ_t on labor income is determined by a feedback rule that targets the debt/GDP ratio $\overline{b}$ according to

$$\tau_t = \tau_{t-1} + \alpha_{b,\tau}\left(b_t - \overline{b}\right) + \alpha_{\Delta b,\tau}\left(b_t - b_{t-1}\right) + \alpha_{\pi,\tau}\left(\pi_t - \pi_t^U\right). \tag{2.16}$$

Note that we have also allowed for a response of the tax rate to the inflation differential (π_t^U denotes union-wide inflation, to be defined below). This response is meant to capture the idea that in a currency union, fiscal policy is the only means that the local government has to affect inflation. In this paper we compare the implications for inflation of this benchmark fiscal policy rule with a fiscal environment in which the government funds its expenditures with lump sum taxes.

2.3. Firms and Market Structure.

There are two sectors of production in each region, the tradable, T, and nontradable, N, sector. The production function for each firm i in each sector is given by $z_t l_t(i)$, where $l_t(i)$ represents labor input and z_t is a sector- and country-specific productivity shock.

Firms are monopolistically competitive and prices are sticky. In particular, a firm's conditional probability of being able to adjust its price in period $t+j$ given that no adjustment occurred in period $t+j-1$ is α_j. It then follows that an adjusting firm in period t will face its next opportunity to adjust in period $t+j$ with probability $\vartheta_j \equiv \alpha_j \prod_{k=0}^{j}(1-\alpha_k)$, $j = 1, ...J$. By convention, $\alpha_N = 1$ and $\alpha_0 = 0$.

[2] Johnson (2001) criticizes the arbitrariness of the approach taken by much of the literature (and by us). See Mitchell, Sault, and Wallis (2000) for a systematic study of different rules used in the literature.

Given that all firms face the same adjustment pattern, it is straightforward to compute the distribution of firms by time of last price adjustment. We denote by ω_j the fraction of firms in period t that last adjusted their price in period $t-j$, $j = 0, ..., J-1$.

2.3.1. The Nontradable Goods Sector.

The problem of a firm in the nontradable goods sector adjusting its price in period t is given by

$$\max_{P_t^N(0)} \sum_{j=0}^{J-1} \vartheta_j E_t \left[\rho_{t+j|t} \left(P_t^N(0) y_{t+j}^N(j) - P_{t+j} w_{t+j} l_{t+j}^N(j) \right) \right] \tag{2.17}$$

subject to

$$z_{t+j} l_{t+j}^N(j) = y_{t+j}^N(j). \tag{2.18}$$

The term $y_{t+j}^N(j)$ denotes the demand at date $t+j$ faced by a firm in this sector that has last adjusted its price in period t, and equals $c_{t+j}^N(j) + g_{t+j}^N(j)$. The term $\rho_{t+j|t}$ denotes the pricing kernel used to value date $t+j$ profits, which are random as of date t, and is given by $\beta^j \frac{U_{c,t+j}}{U_{c,t}} \frac{P_t}{P_{t+j}}$.

2.3.2. The Tradable Goods Sector.

We assume that home and foreign markets are segmented and that firms producing domestic tradable varieties can price discriminate across the two markets. Therefore, the law of one price need not hold for tradable goods.

Firms that adjust prices in period t choose $P_{h,t}^T(0)$ and $P_{h,t}^{*T}(0)$, the prices to charge in each market for its good. The firm's home demand in subsequent periods is given by $y_{t+j}^T(j) = c_{h,t+j}^T(j) + g_{h,t+j}^T(j)$, while its exports are given by $y_{t+j}^{*T}(j) = c_{h,t+j}^{*T}(j) + g_{h,t+j}^{*T}(j)$. The firm's optimal prices solve

$$\max_{P_{h,t}^T(0), P_{h,t}^{*T}(0)} \sum_{j=0}^{J-1} \vartheta_j E_t \left[\rho_{t+j|t} \left(P_{h,t}^T(0) y_{t+j}^T(j) + P_{h,t}^{*T}(0) y_{t+j}^{*T}(j) - P_{t+j} w_{t+j} l_{t+j}^T(j) \right) \right]$$

subject to

$$z_{t+j} l_{t+j}^T(j) = y_{t+j}^T(j) + y_{t+j}^{*T}(j). \tag{2.19}$$

Note that the subscripts h and f refer to the origin of the good; the superscript $*$ refers to a price defined for the foreign country.

We define the home region's nominal output in period t by aggregating each firm's output at its date t price,

$$y_t^n = \sum_{j=0}^{J-1} \vartheta_j \left\{ (1-T)\, y_t^N P_t^N(j) + T \left[y_t^T(j) P_t^T(j) + y_t^{*T}(j) P_t^{*T}(j) \right] \right\}.$$

Nominal output in the foreign region is defined similarly and denoted by y_t^{*n}.

2.4. The Central Monetary Authority.

The central monetary authority issues non-interest bearing money and allocates seigniorage revenue to the regions. Let the superscript U denote a *union-wide* variable; for example total nominal money balances in the union are $M_t^U = M_t + M_t^*$.

In period t, the monetary authority earns revenue from printing money equal to $M_t^U - M_{t-1}^U$ and it distributes this revenue among the regional fiscal authorities.[3] For now we will just note that the seigniorage has to add up; recalling that Z denotes seigniorage, we have

$$M_t^U - M_{t-1}^U \equiv Z_t^U = Z_t + Z_t^*. \tag{2.20}$$

We have to specify the rule for allocating seigniorage. For now we will assume that seigniorage is allocated according to each country's share of nominal consumption in the stationary steady-state, s_c, so that

$$Z_t = s_c Z_t^U. \tag{2.21}$$

[3] In the description of the problem of the central monetary authority we abstract, without loss of generality, from the central bank's balance sheet and from each government's borrowing from the central bank. Let B_t^{cb1} (B_t^{cb2}) denote the number of bonds issued by the home (foreign) government and held by the central monetary authority. Assuming that both governments' private borrowing is zero, the governments' budget constraints are

$$P_t^i g_t^i - T_t^i - \widetilde{Z}_t^i = \Delta B_t^{cbi} - R_{t-1} B_{t-1}^{cbi},\ i = 1, 2,$$

where T^i represents tax revenues received from consumers and $\widetilde{Z}^i$ represents transfers received from the central bank. The central bank buys government debt using money, $\Delta B_t^{f1} + \Delta B_t^{f2} = \Delta M_t^U$, and rebates back to the governments the interest income received on their debt, $\widetilde{Z}_t^1 + \widetilde{Z}_t^2 = R_{t-1}\left(B_{t-1}^{f1} + B_{t-1}^{f2}\right)$, where $B_{t-1}^{f1} + B_{t-1}^{f2} = M_{t-1}^U$. Let's define the *net* transfer from the central bank to each government as $Z_t^i = \Delta B_t^{fi} + \widetilde{Z}_t^i - R_{t-1} B_{t-1}^{fi}$, $i = 1, 2$. Note that $Z_t^1 + Z_t^2 = \Delta M_t^U$ and that Z_t^i is independent from the number of bonds issued by government i. By defining a rule that allocates seigniorage revenues across countries, we do not need to keep track of the central bank's balance sheet.

The monetary authority is assumed to follow an interest rate rule similar to the rules studied by Taylor (1993) and Clarida, Gali, and Gertler (1998). In particular, the nominal interest rate R_t is set as a function of the lagged nominal rate, next period's expected inflation rate in the union, and union-wide real output,

$$R_t = (1-\rho_R)\,\bar{R} + \rho_R R_{t-1} + (1-\rho_R)\left[\alpha_\pi\left(E_t\pi^U_{t+1} - \overline{\pi}^U\right) + \alpha_y \ln\left(y^U_t/\overline{y}^U\right)\right], \quad (2.22)$$

where a bar over a variable denotes its target value. In order to implement this rule, the central monetary authority needs a measure both for the price level and real output in the whole currency union, P^U_t and y^U_t, respectively.

We define the "union-wide" price level, P^U_t, as a weighted average of each region's price level, where the weight is determined by the region's share of nominal consumption in steady state. That is,

$$P^U_t = s_c P_t + (1-s_c)\,P^*_t.$$

In order to define "union-wide" real output, we first define union nominal output as the sum of each region's nominal output, $y^{Un}_t = y^n_t + y^{*n}_t$. Union real output is obtained by deflating union nominal output by the union price level, $y^U_t = \frac{y^{Un}_t}{p^U_t}$.

2.5. Equilibrium and Model Solution.

Equilibrium is defined by market clearing conditions and efficiency conditions for households and firms (first-order conditions for the maximization problems stated above), given the policy rules assumed for the monetary and fiscal authorities. We approximate the equilibrium linearly around its steady-state.

3. Calibration.

In this section we report the parameter values used in solving the model. Our benchmark calibration assumes that both regions in the currency union are symmetric and share the same structure and parameter values. The model is calibrated using German data and we assume that each time period in the model corresponds to one quarter.

3.1. Preferences.

We follow Chari, Kehoe and McGrattan (2000) closely in the preference specification. We consider a momentary utility function which is separable between a consumption-money aggregate and leisure and is given by

$$U\left(c, l, \frac{M}{P}\right) = \frac{1}{1-\sigma}\left(ac^{\eta} + (1-a)\left(\frac{M}{P}\right)^{\eta}\right)^{\frac{1-\sigma}{\eta}} + \psi\frac{(1-l)^{1-\nu}}{1-\nu}.$$

We set the curvature parameter, σ, equal to two. The parameters ψ and ν are set to 11 and 1.5, respectively, so that the elasticity of labor supply, with marginal utility of consumption held constant, is 2 and the fraction of working time in steady-state is 0.25.

The parameters a and η are obtained from estimating the money demand equation implied by the first-order condition for bond holdings. Using the utility function defined above, this equation can be rewritten as

$$\log\frac{M_t}{P_t} = \frac{1}{\eta-1}\log\frac{a}{1-a} + \log c_t + \frac{1}{\eta-1}\log\frac{R_t-1}{R_t}.$$

We ran a regression using German quarterly data from 1995:01 to 2000:01 for M1, CPI, real private consumption and the three-month Libor rate. We set $\frac{1}{\eta-1}$ equal to our estimate of the interest elasticity, -0.45, and obtain $\eta = -1.22$. The value for the weight coefficient a was set to 0.91 and it was derived from the estimate for the intercept, -1.026. The discount factor, β, is set to 0.99, implying a 4% annual real rate in the stationary economy.

For the consumption index c^T we need to assign values to γ, the elasticity of substitution between domestic and imported tradable goods, and to ω_T, the weight on consumption of domestic tradable goods. Collard and Dellas (2002) estimate γ for France and Germany using data from 1975:1 to 1990:4. Their estimate for France is 1.35 while their point estimate for Germany is substantially higher (2.33) but also very uncertain. In the benchmark calibration we set γ equal to 1.5, which is also the standard value used in models calibrated for US data. The weight ω_T is set to match the ratio of consumption of domestic goods to imported goods, $\frac{c_h^T}{c_f^T}$. In a symmetric steady-state, this ratio can be expressed as $\frac{\omega_T}{1-\omega_T}$ as well as $\frac{1-s_N-s_i}{s_i}$, where s_i is the share of imports in GDP and s_N is the share of nontradable goods in GDP. Stockman and Tesar (1995) report that nontraded goods account for about half of output in OECD countries and we set $s_N = 0.5$. We use an import share of 0.25, obtaining a value of ω_T equal to 0.5.

The consumption index for c depends on ξ, the elasticity of substitution between tradable and nontradable goods, and ω, the weight on consumption of tradable goods. Mendoza (1995) estimates ξ using data for industrialized countries and obtains $\xi = 0.74$.[4] In a symmetric steady state across countries with $P^N/P^T = 1$, the ratio $\frac{c^T}{c^N}$ can be expressed as $\frac{\omega}{1-\omega}$ as well as $\frac{1-s_N}{s_N}$. A share of nontradable goods in GDP of 0.5 implies that ω equals 0.5.

3.2. Production.

The elasticity of substitution between different varieties of a given good, θ, is related to the markup chosen when firms adjust their prices. If inflation were zero, the steady state markup would simply be $\theta/(\theta-1)$ (with low but nonzero inflation the steady state markup differs insignificantly from $\theta/(\theta-1)$). We set $\theta = 10$, which is a representative value in the literature. It implies a markup of 1.1 in steady state, which is consistent with the empirical work of Basu and Fernald (1997) and Basu and Kimball (1997).

The nature of price stickiness is determined by the vector $\alpha = \{\alpha_j\}_{j=1}^{J-1}$, with $\alpha_J = 1$ and J the largest number of periods any firm goes without adjusting its price. The most common assumption in the literature is $\alpha_j = \alpha$ for all $j = 1, 2, ...$, that is, Calvo pricing. Kiley (1998) and Wolman (1999) have shown that the inflation dynamics associated with Calvo pricing differ dramatically from those associated with more realistic patterns of price adjustment, in which firms adjust their price with probability one after a relatively small number of periods. We therefore choose a finite pattern of price adjustment that has the following features: (i) the conditional adjustment probabilities (α_j) are increasing: the longer a firm has gone without adjusting its price, the higher is the probability that it will adjust in the current period, and (ii) the expected duration of a price is approximately five quarters. These two assumptions do not pin down α; we choose the pattern of adjustment used in Wolman (1999), shown in Table 1.

Table 1. Conditional Adjustment Probabilities.

α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8
0.015	0.056	0.125	0.224	0.352	0.506	0.684	0.897

[4]This estimate is bigger than the one found by Stockman and Tesar (1995), who use data from both developing and industrialized countries.

The relative size of the tradable sector, T, is set to 0.5 so that in steady state the price of tradables relative to nontradables is one.

3.3. Monetary and Fiscal Policy Rules.

The parameters of the nominal interest rate rule are taken from the estimates in Clarida, Gali, and Gertler (1998, Table I) for the Bundesbank. We set $\rho_r = 0.91$, $\alpha_{\pi,r} = 1.31$, and $\alpha_{y,r} = 0.25/4$, where this last term is converted for quarterly data. The target values for R, π^U, and y^U are their steady-state values. We assume that in steady-state prices grow at 2% per year (or 0.5% per quarter).

The parameters for the tax rule are taken from Mitchell, Sault, and Wallis (2000). We convert their values for quarterly data and set $\alpha_{b,\tau} = 0.04/16$ and $\alpha_{\Delta b,\tau} = 0.3/4$.

3.4. Exogenous processes.

The technology shocks to the two industries are assumed to follow an $AR\,(1)$ process $z_{t+1} = A^z z_t + \varepsilon_t^z$, where z_t is the vector $\left[z_t^T, z_t^N, z_t^{*T}, z_t^{*N}\right]$ and A^z is a 4×4 matrix. The vector ε_t^z represents the innovation to z. Stockman and Tesar (1995) provide estimates for a joint productivity process such as this one, but that process is annual, and the home and foreign countries are interpreted as symmetric and together comprising the entire industrialized world. Our model is quarterly, and the home and foreign countries are loosely interpreted as Germany and France, which likely experience higher correlation of productivity shocks. We adjust the Stockman and Tesar process to account for these two differences, and end up with

$$A^z = \begin{bmatrix} 0.199 & 0.249 & -0.010 & 0.094 \\ 0.176 & 0.593 & 0.036 & 0.044 \\ -0.010 & 0.094 & 0.199 & 0.249 \\ 0.036 & 0.044 & 0.176 & 0.593 \end{bmatrix}$$

and

$$\varepsilon_t^z = \begin{bmatrix} \epsilon_t^{T,h} \\ \epsilon_t^{N,h} \\ \epsilon_t^{T,f} \\ \epsilon_t^{N,f} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \epsilon_t^{T,c} \\ \epsilon_t^{N,c} \end{bmatrix},$$

with each ϵ is independently distributed across both time and sectors and $\sigma^2_{\epsilon^{T,i}} = 0.289^2$, $\sigma^2_{\epsilon^{N,i}} = 0.147^2$, and $\frac{\sigma^2_{\epsilon^c}}{\sigma^2_{\epsilon^i}} = 0.3636$, for $i = h, f$.[5]

Shocks to government expenditures in each country are assumed to follow the same independent $AR(1)$ process $g_{t+1} = c + A^g g_t + \varepsilon^g_t$, where g_t represents the share of government expenditures in GDP. We estimated this process using quarterly data for Germany from 1991:2 to 2001:3. The estimate for A^g is 0.42 and the estimate for $\sigma^2_{\varepsilon^g}$ is 0.000214.

4. Sources of Regional Inflation Differentials.

The model contains two general mechanisms which can create inflation differentials across regions. First, there are nontraded consumption goods, so the consumption price indices in the two countries correspond to distinct baskets of goods. Differential behavior of the relative price of home and foreign nontraded goods – perhaps due to variation in productivity – will lead to differential behavior of inflation in the two regions. Second, producers of traded goods can price discriminate across markets; if they choose different prices for the two markets this will lead to differential behavior of inflation. We start by investigating these two sources of inflation differentials analytically when prices are flexible. We then study the interaction of sticky prices with these two mechanisms, and illustrate the potential for regional fiscal policy to affect regional inflation.

For simplicity, we assume in this section that the two regions are of equal size. While this assumption can affect the magnitude of the differential between a country's inflation rate and the union average, it does not affect the results qualitatively. Later we will focus exclusively on the role of country size for inflation differentials.

[5] We arrived at this representation for productivity in two steps. First, we computed a quarterly productivity process that came close to replicating the Stockman-Tesar process when it was time-aggregated. Next, we imposed the common shock structure of Collard and Dellas, who estimate a joint AR(1) process for aggregate productivity for Germany and France. We assumed that the variance ratio of common to idiosyncratic shocks was as they report for Germany. We chose the levels of idiosyncatic shock variances so that, when combined with our A^z matrix, the own variances of traded and non-traded productivity were close to those implied by the original Stockman and Tesar process. Ideally we would estimate this process directly.

4.1. Nontraded Goods (the Balassa-Samuelson effect).

If prices are flexible ($\alpha_j = 1 \ \forall j$), consumers place equal weight on home and foreign traded goods ($\omega = 0.5$) and producers of traded goods set a common price across regions then the ratio of home to foreign price levels can be expressed as

$$\frac{P^*}{P} = \left[\frac{1 - (1-a)\left\{(1-T)\frac{\theta}{\theta-1}\frac{w}{z^N}\right\}^{1-\xi}}{1 - (1-a)\left\{(1-T)\frac{\theta}{\theta-1}\frac{w^*}{z^{N*}}\right\}^{1-\xi}} \right]^{\frac{1}{1-\xi}}. \tag{4.1}$$

Thus, if nontraded goods productivity is the same in the two countries, then regional price level differentials (and hence inflation differentials) are associated entirely with regional wage differentials. Wages are of course endogenous, so (4.1) should properly be thought of as an equilibrium condition relating several endogenous variables. However, to the extent that the wage in the home country is related in equilibrium to traded goods productivity in the home country, then (4.1) illustrates the classical Balassa-Samuelson effect: higher productivity in traded goods at home leads to a higher real wage at home, driving up the relative price of non-traded goods. With traded goods prices common across countries, the price level at home rises relative to that abroad.

Pricing-to-market by some firms and sticky prices for all firms mean that the ratio of foreign to domestic price levels is not given by (4.1). Sticky prices, in particular, generate transitory dynamics that complicate the relationship between relative price levels and wage rates. We will investigate the effect of adding sticky prices below.

4.2. Deviations from the Law of One Price.

If prices are flexible and the demand elasticity is the same in both countries, then pricing-to-market firms will choose to set the same price in both countries. Even though these firms have the ability to price discriminate across countries, it is optimal not to do so and to set the home and foreign prices as the same markup over marginal cost. Therefore, the law of one price holds for all tradable goods. If there are no nontradable goods and if home and foreign agents consume the same basket of tradable goods ($\omega = 0.5$), then the price levels in the two countries are identical.

If we allow the elasticity of substitution to differ across countries (reflecting different tastes across countries), then pricing-to-market firms will optimally choose

to set different prices in the two markets and the law of one price will not hold for these goods.[6] In the case with no nontradable goods and in which all firms price-to-market, the ratio of home to foreign price levels can be expressed as

$$\frac{P^*}{P} = \frac{\theta^*/(\theta^* - 1)}{\theta/(\theta - 1)}. \tag{4.2}$$

That is, the country where agents have a higher elasticity of substitution among varieties of goods has a lower price level.

4.3. The Role of Sticky Prices.

Price stickiness complicates the nontraded goods effect on inflation differentials, and expands slightly the model's ability to generate inflation differentials through deviations from the law of one price. We illustrate the interaction of nontraded goods with price stickiness using an impulse response function. We then show the implications of price stickiness for the price setting problem of a firm that can price discriminate across countries.

Figure 1 displays the responses of selected variables to a permanent increase in traded goods productivity with sticky prices, when government spending is financed by lump sum taxes. For the purpose of generating these figures, monetary policy is assumed to be given by a constant growth rate for the money supply. In the flexible price case, the home wage, price level and price of nontraded goods – all relative to their foreign counterparts, jump on impact to their new steady state levels. In the sticky price model, these same higher ratios are achieved after about ten quarters, but on impact of the shock the relative effects are reversed. On impact of the shock, the inflation differential is smaller in the sticky price model, but a significant inflation differential persists for several periods, whereas it is quickly dissipated in the flexible price model.

We turn now to the implications of price stickiness for deviations from the law of one price. Above we concluded that when prices are flexible, a firm with the ability to price discriminate across markets would find it optimal to do so if the demand elasticity differs across countries. If prices are sticky, a price discriminating firm may charge different prices across markets even if demand elasticities are identical. This will occur if there are anticipated changes in marginal cost, together with quantities demanded that differ across markets.

[6] Pricing-to-market firms would also choose to set different prices across countries if supply conditions, instead of demand conditions, differed across markets.

Suppose pricing-to-market firms set the home and foreign prices of its good for two periods. Denote the firm's nominal marginal cost at date t by $mc_t = P_t w_t / z_t$ and denote the firm's demand at date t in country j, $j = h, f$, by $c_t^j(0)$ if it has adjusted its price in the current period, or by $c_t^j(1)$ if it has adjusted its price in the previous period. The optimal prices set at date t are then given by

$$P_t^j(0) = \frac{\theta}{(\theta-1)} \frac{c_t^j(0)\, mc_t + \beta \rho_{t+1|t} c_{t+1}^j(1)\, mc_{t+1}}{c_t^j(0) + \beta \rho_{t+1|t} c_{t+1}^j(1)}, \tag{4.3}$$

where $\rho_{t+1|t}$ is defined above. These prices can be rewritten as

$$P_t^j(0) = \frac{\theta}{(\theta-1)} \left\{ \varphi_t^j mc_t + \left(1 - \varphi_t^j\right) mc_{t+1} \right\}. \tag{4.4}$$

That is, the optimal prices are a constant markup over a weighted average of current and next period's marginal costs, where the weights φ_t^j are given by $\frac{\lambda_t c_t^j(0)}{\lambda_t c_t^j(0) + \beta \lambda_{t+1} c_{t+1}^j(1)}$ and depend on the structure of the relevant country's demand across the two periods. If marginal cost is the same in both periods, the optimal prices set by the firm depend only on marginal cost; even if demand differs across countries, the firm will choose to set a common price. If marginal cost is not constant across periods, then different demand conditions at home and abroad will imply different weights φ_t^j and different optimal prices $P_t^h(0)$ and $P_t^f(0)$. In principle then, (4.4) makes clear that price stickiness can lead to deviations from the law of one price in a currency union. Quantitatively however, if the inflation rate is low then these deviations will necessarily be small. To see this, note that (4.4) can be rewritten as

$$P_t^j(0) = \frac{\theta}{(\theta-1)} \left\{ \Delta mc_t \cdot \varphi_t^j + mc_{t+1} \right\}.$$

The difference in prices charged across regions is due to differences in φ_t^j. However, local to a steady state with low inflation, any differences in φ_t^j will be multiplied by a small number – the steady state change in nominal marginal cost. In contrast, the above expressions make clear that variation in the demand elasticity across countries will have a first-order effect on deviations from the law of one price, whether or not prices are sticky.

4.4. The Role of Fiscal Policy.

Fiscal policy in each region is summarized by an exogenous process for government expenditures and by a feedback rule for the labor income tax. Both shocks to government expenditure and the nature of the tax rule can affect the behavior of inflation differentials, through their interaction with the two mechanisms just discussed. Here we illustrate the influence of fiscal shocks and systematic fiscal policy by presenting impulse response functions to government spending shocks.

Figure 2 plots the responses of selected variables to a one standard deviation shock to the home country process for the share of government consumption in output. In this experiment we focus on the effect of government spending on inflation by assuming that the government finances increases in public consumption by adjusting lump-sum taxes. The shock generates an increase in government spending of 10% on impact; domestic real output increases by slightly more than 1%, while the transmission to foreign output is less than 1%. The negative effect on private consumption is small (-0.016% on impact in the home country). In response to this shock, home demand for home goods and for foreign tradable goods increases. The impact increase in prices is small but they adjust more in the home country than in the foreign country. The home country temporarily experiences marginally higher inflation than the foreign country: in the period of the shock, the difference between inflation in the home country and the union average is 0.02 percentage points. The main lesson that we take away from this figure is that with lump sum taxes, government spending shocks have very little effect on inflation differentials.

We now investigate the effect on the inflation differential of the feedback rule for the labor income tax. Figure 3 plots the response to the same shock to government expenditures assuming now that the tax rate τ responds both to the change and the level of the debt to GDP ratio. In this case, the government finances the increase in government spending partly by borrowing from households, and partly by an increase in the tax rate on labor income. The response to the government spending shock is more persistent in this environment and the adjustment of prices and inflation is bigger compared to the previous case with lump-sum taxation. Nonetheless, in absolute terms these effects remain small.

It is tempting at this point to focus on the magnitudes of inflation differentials in figures 2 and 3. This would lead one to conclude that fiscal policy has little ability to affect the behavior of regional inflation differentials. We wish to instead focus on the fact that the nature of the tax policy can in principle affect the behavior of inflation differentials. Our analysis below of a small country will

convince the reader that this is also true in practice.

5. Quantitative Variation in Inflation Across Regions.

We now begin to quantify the role of fiscal policy for the variation in inflation across regions. We simulate the model with and without government spending shocks, to determine the contribution of government spending shocks to inflation variation. The tax feedback rule can also have implications for the variation in inflation; we report results on inflation variation with lump sum taxes and then with the benchmark income tax feedback rule described above.

5.1. Productivity Shocks as the Prime Mover of Inflation Differentials.

The non-traded goods channel for inflation variation is quite strong in the model, so the calibrated productivity process alone generates significant variation in inflation across regions: the standard deviation of the inflation differential between the two countries is 0.67%. With government spending shocks as well, the standard deviation only rises slightly, to 0.68%. These numbers are for the case with distortionary taxes responding to the debt. When lump sum taxes are available, the corresponding numbers are 0.71% and 0.72%.

For France and Germany from 1995 through 2001, the corresponding number is 0.23%. Thus, productivity shocks alone generate more variation in inflation in the model than has been observed between France and Germany.

Even though the primary surplus is positive in steady-state, in the presence of both productivity and government spending shocks, a limit on the deficit of 3% of GDP is violated roughly one third of the time. A limit of 60% on the debt to GDP ratio, however, is violated only about 1% of the time, reflecting the discipline imposed on this ratio by the income tax feedback rule. This behavior of primary surpluses and debt reflects the effects of the shocks to productivity and is barely affected by the presence of government spending shocks. If one views the income tax feedback rule as representing a "sound" fiscal policy, then our results provide more of an argument for the EU's debt limit than for its deficit limit; even with sound fiscal policy, a country should be expected to violate the deficit limit regularly.

5.2. A Digression on Deviations from the Law of One Price.

As we saw above, our basic model does not generate significant deviations from the law of one price. Furthermore, given the size of the inflation differentials generated by productivity shocks alone, through the non-traded goods channel, there seems to be little room in the model for deviations from the law of one price. Nonetheless, in the interest of learning about the model's behavior, we report here on the results of one modification which essentially imposes deviations from the law of one price. We assume that there are region-specific shocks to θ, the elasticity of demand for individual goods. Referring to (4.2), these shocks cause price-discriminating firms to charge different prices in the two markets. If the shocks to θ are independent both over time and across regions, then a standard deviation of just 0.23 generates the level of inflation variability observed between France and Germany. While it is surely unrealistic to imagine this type of shock as being responsible for all of the variation in inflation across regions, the fact that small variation in the demand elasticity delivers significant inflation differentials is interesting.

6. Asymmetric Regions.

In this section we allow for the two regions to differ in size, and we focus on the behavior of inflation in the small country relative to the union average. This interest reflects a broad pattern in the observed behavior of inflation rates across countries of different sizes in Europe: the standard deviations of small countries' inflation differentials are bigger than the standard deviations of large countries' inflation differentials, where the differential is measured as the difference between home country inflation and union-wide inflation. Figure 4 plots the HICP inflation rate as well as the inflation rates for two large countries (France and Germany) and two small countries (Ireland and Portugal) in the Euro area. This graph shows that the inflation rate is more volatile relative to HICP inflation in both small countries than in the two big countries.

These deviations of inflation from the union-wide average are not without consequences: in February 2001, after Ireland's inflation rate had reached 7%, the European Commission reprimanded Ireland for its loosening of fiscal policy. The Commission implied that, in the presence of high inflation rates, Ireland should pursue tighter fiscal policy to bring inflation back down. In the popular-academic press, it has been common to interpret the recent Irish experience as a classic

example of the Balassa-Samuelson effect in action: high productivity growth in traded goods drives up wages for all sectors, the price of nontraded goods must rise, and with traded goods prices set in world markets, the price level rises. With a persistent increase in the growth rate of productivity in the traded-goods producing sector, there can be a persistent increase in inflation. Our model can be used to ask whether, in the presence of a Balassa-Samuelson effect on inflation differentials, fiscal policy can in fact significantly mitigate that effect.

With these points in mind, we perform two experiments with the model. First, we ask how country size affects the size of inflation differentials, for a given shock to the growth rate of productivity in the tradable sector. Next, we ask what leverage a small country has over its inflation rate, when its only tool is fiscal policy. As described above, we model country size as simply the number of households in the country, and we hold all other parameters of the model constant when we vary country size.

6.1. Country Size and Inflation Differentials.

We first look at the response to a persistent shock to the growth rate of productivity in the home tradable sector assuming equal size countries. Figure 5 plots the response of selected variables to this shock. In this experiment we assume that government spending in each region is a constant share of output and is funded through lump-sum taxes, and that the monetary authority follows the interest rate rule described above.[7] This shock increases real output and consumption permanently in both countries. The price of the composite tradable good decreases permanently while the price of the composite nontraded good increases more in the home country than abroad, reflecting the permanently higher home wages. Therefore, in response to the persistence shock to productivity in the tradable sector, the home country experiences a persistent increase in inflation relative to foreign inflation.

The relative country sizes have a substantial effect on the difference between the home country's inflation rate and the union's average in response to this shock. Figure 6 plots this inflation differential for different sizes of the home country. In the symmetric case, the inflation differential reaches its peak of 0.75 percentage points five quarters after the shock. However, if the small country represents one

[7]Because this shock has a permanent level effect on real output, the interest rate rule is assumed to depend on the growth rate of output instead of depending on the deviation of output from its steady-state level as in (2.22).

forth of the currency union, this same shock leads to an inflation differential of 1.3 percentage points after five quarters. While the effect of this shock on real output dies out approximately after five quarters, its effect on the inflation differential is more persistent and dies out approximately after ten quarters. The persistence of this shock's effect on the inflation differential, however, is not affected by country size.

6.2. Fiscal Policy and Inflation Differentials.

We have just seen that for a persistent shock to productivity growth in the tradables sector, the inflation differential between the home country and union is higher for a small country than for a large country. Given the EC's criticism of Ireland, it is important to understand to what extent, and how, a small country experiencing high productivity growth in tradable goods can influence its inflation rate through fiscal policy alone. We answer this question by supposing that a small country augments its tax feedback rule by responding not only to the behavior of debt, but also to the behavior of the country's inflation differential with respect to the entire union. We ask what the relationship is between the coefficient on the inflation differential and the behavior of the inflation differential. Our results are displayed in figure 7, for the case in which the small country represents approximately one third of the currency area. We assume the same monetary policy rule as above.

We find that, in the presence of shocks to the growth rate of productivity, the small country's fiscal authority is able to influence the inflation differential by making use of its tax rate instrument. In particular, the more negative is the coefficient on the inflation differential, the smaller is the response of the inflation differential to this shock. With the benchmark feedback reaction rule, the inflation differential reaches a peak of approximately 1.2 percentage points after five quarters. If, however, the tax rate also depends on the inflation differential with a coefficient of -10 (that is, if positive inflation differentials are associated with a looser fiscal stance), this same shock leads to a peak inflation differential of about 0.5 percentage points after five quarters.

As shown before, in response to a positive shock to home tradable productivity growth, the price of composite tradable goods decreases permanently in both countries, and the home price of composite nontradable goods and the overall home price level increase permanently. This increase reflects the permanently higher wages in the home country in response to the shock. If the tax rate on labor

income responds to the inflation differential with a negative coefficient then the tax rate decreases with the productivity shock. Therefore, in order to make workers willing to supply a given amount of labor (and for a given level of consumption and real money balances) the before tax wage rate w does not need to increase by as much in response to the shock as when the tax rate does not respond to the inflation differential. Since firms set prices as a mark-up over marginal cost, it follows that when the tax rate responds negatively to the inflation differential prices do not increase by as much as when the tax rate does not respond. Thus, a looser fiscal stance is associated with lower inflation differentials.

7. Conclusion.

This paper addresses the behavior of regional inflation in a currency union and the extent to which regional fiscal policy is able to influence the behavior of regional inflation. We develop a general equilibrium model of a two-region currency union with both traded and non-traded goods. Monetary policy is set by a central monetary authority and is non-neutral due to nominal price rigidities. Fiscal policy is decided at the regional level by each region's government. The model is driven by shocks to productivity and to regional fiscal policies.

For a symmetric version of the model calibrated to Germany, we find that productivity shocks alone generate somewhat more variation in inflation across countries than has been observed between Germany and France. Government spending shocks, in contrast, do not account for a significant portion of inflation variation. Varying relative country size, we find that smaller countries experience higher variability in their inflation differential in response to shocks to productivity growth. Moreover, we show that regional governments can suppress incipient inflation differentials associated with shocks to productivity growth by letting the income tax rate respond negatively to inflation differentials.

The response of fiscal policy to inflation differentials raises the question of whether this policy is consistent with the deficit and debt limits imposed by the European Commission. In future work we will explore the budget and debt implications of fiscal policies that react to inflation differentials.

Finally, this paper addressed solely positive issues. Whether it is desirable for regional governments to respond to inflation differentials is an open question.

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Figure 1. Permanent Shock to Home Traded Productivity

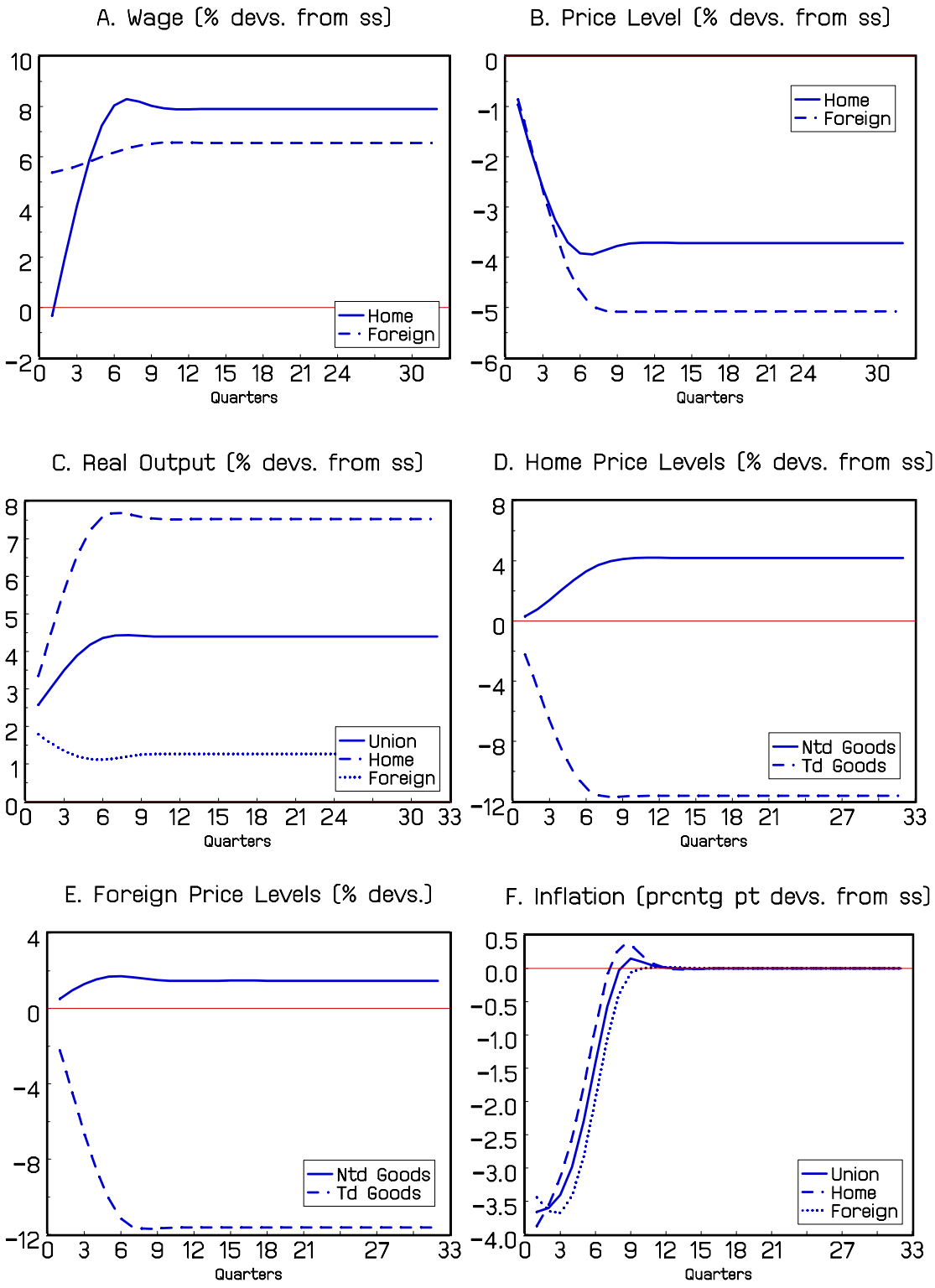


Figure 2. Shock to g/y, with lump sum taxes

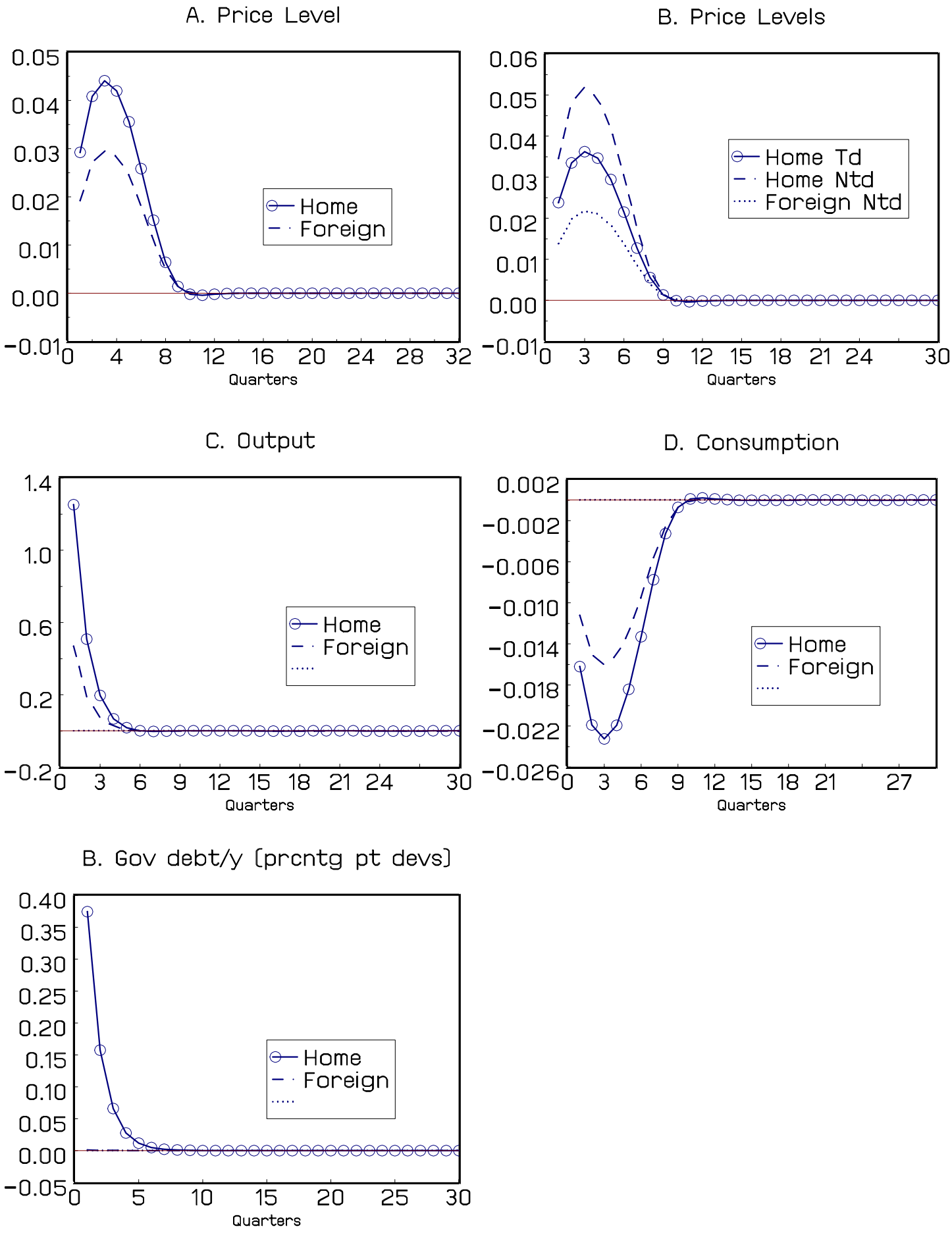


Figure 3. Shock to g/y, with distortionary tax

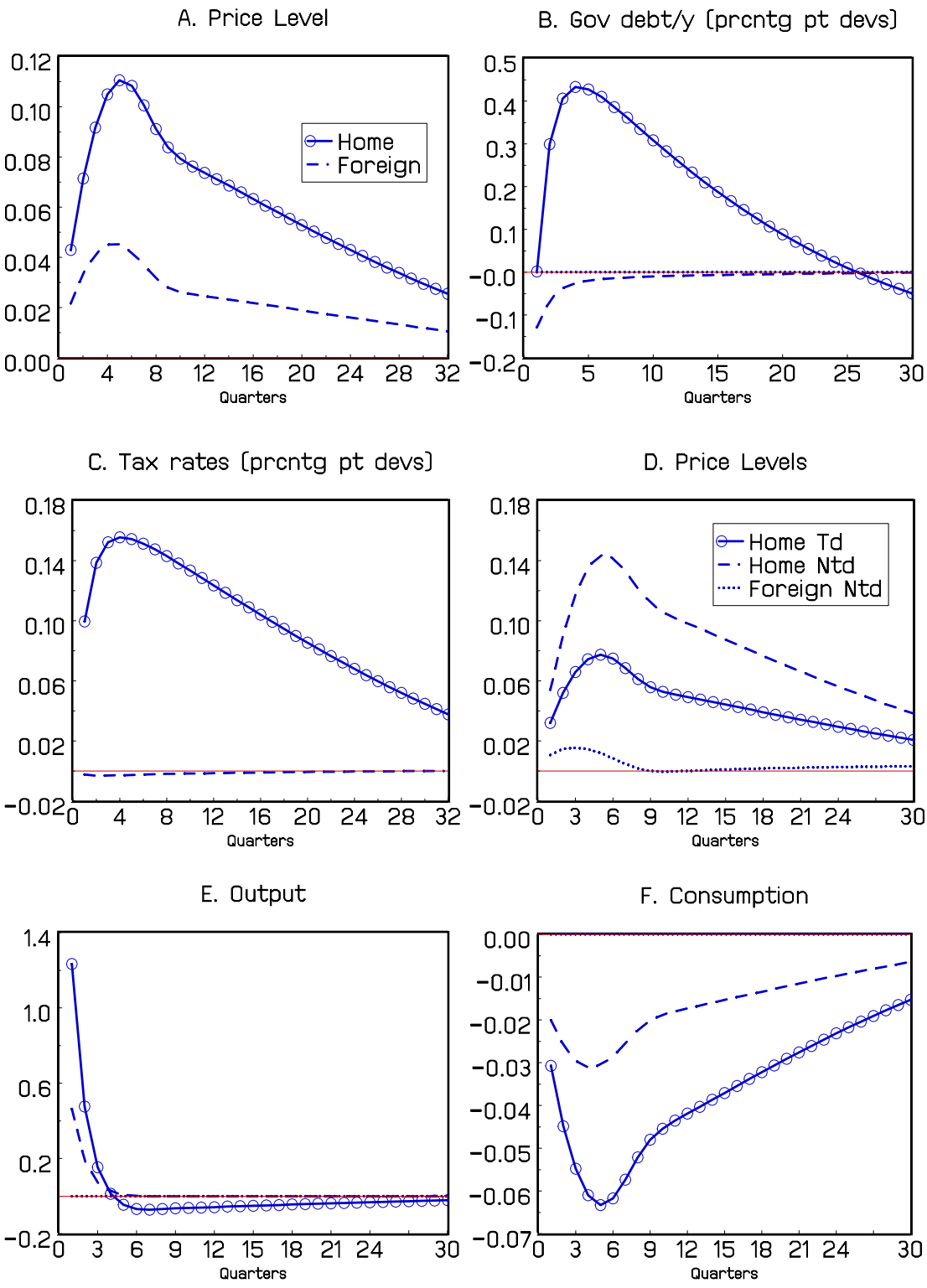
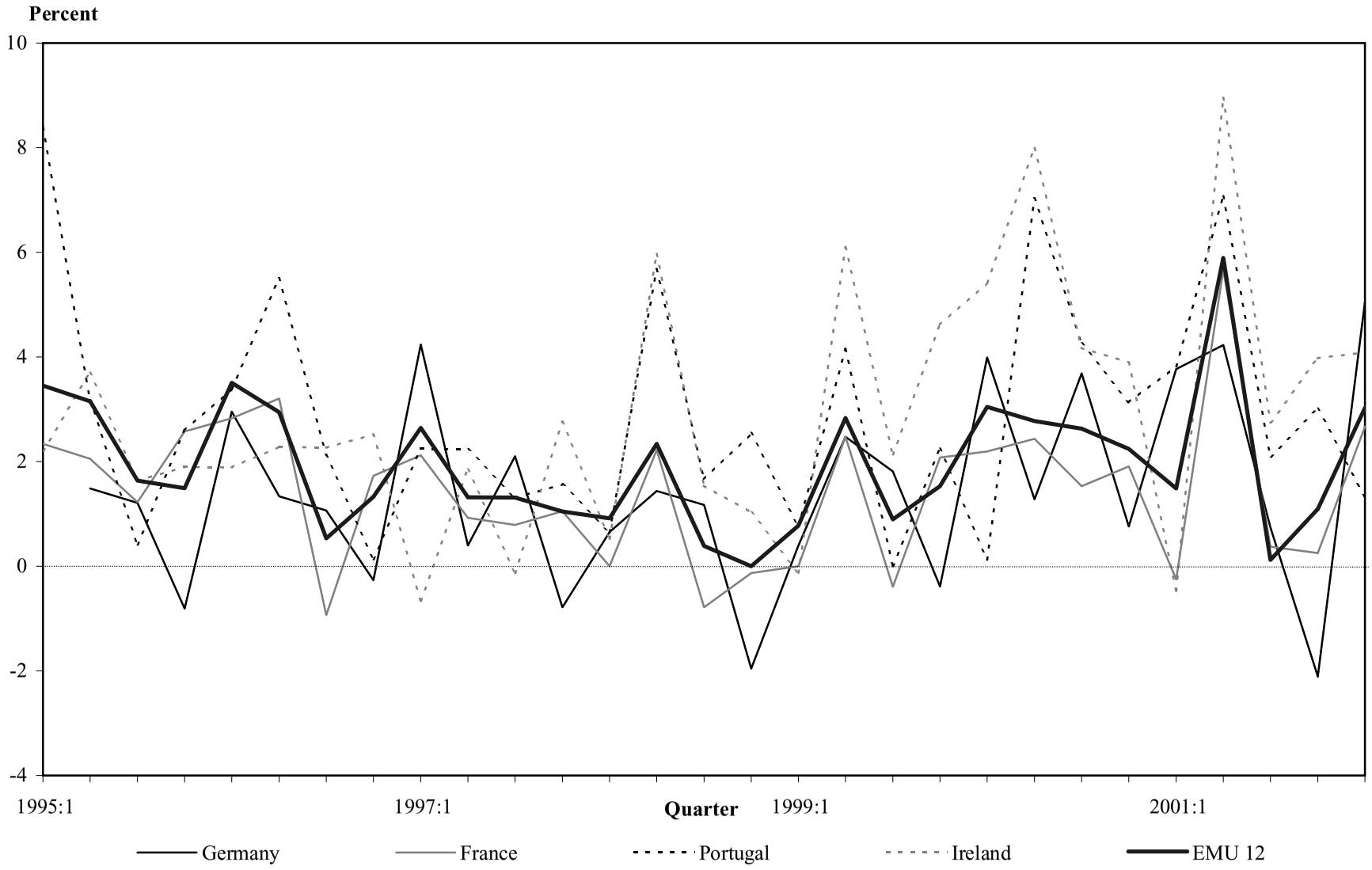


Figure 4. Inflation Rates.



Note: All series are annualized percent changes from the previous period. Source: DRI International Economic Database

Figure 5. Growth rate shock to trad. prod., w/ lump sum taxes

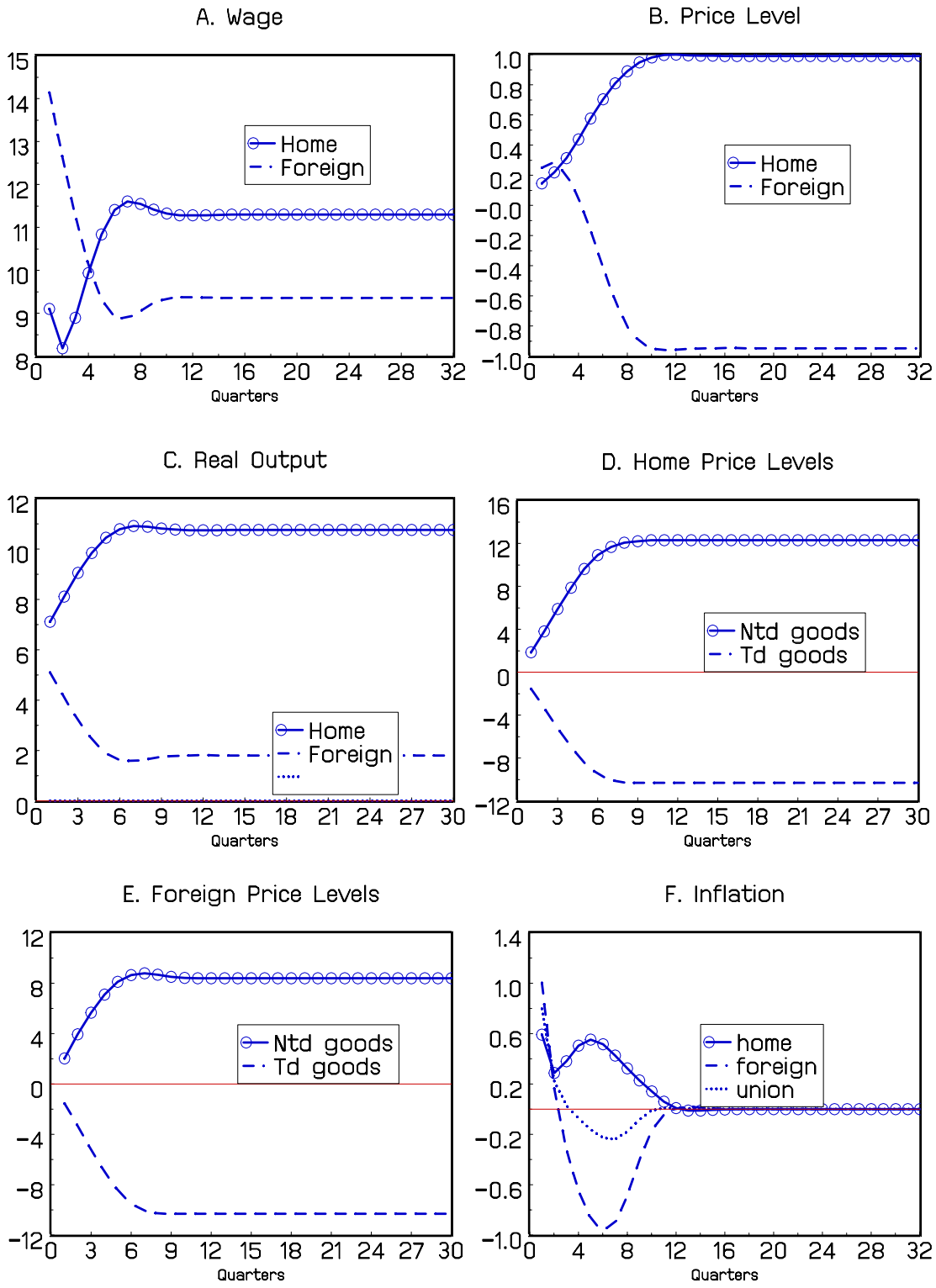


Figure 6. Country Size and Inflation Differentials.

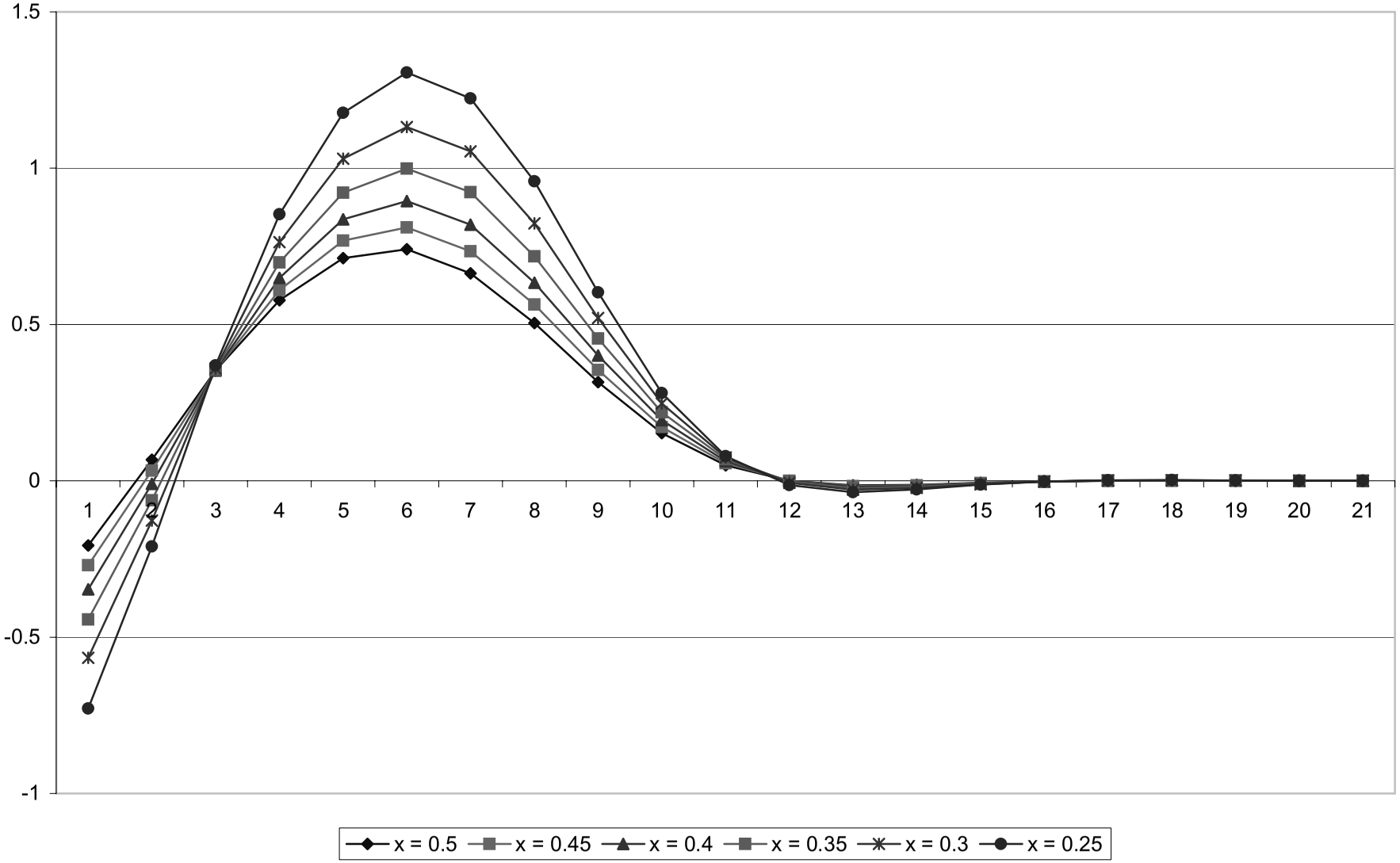
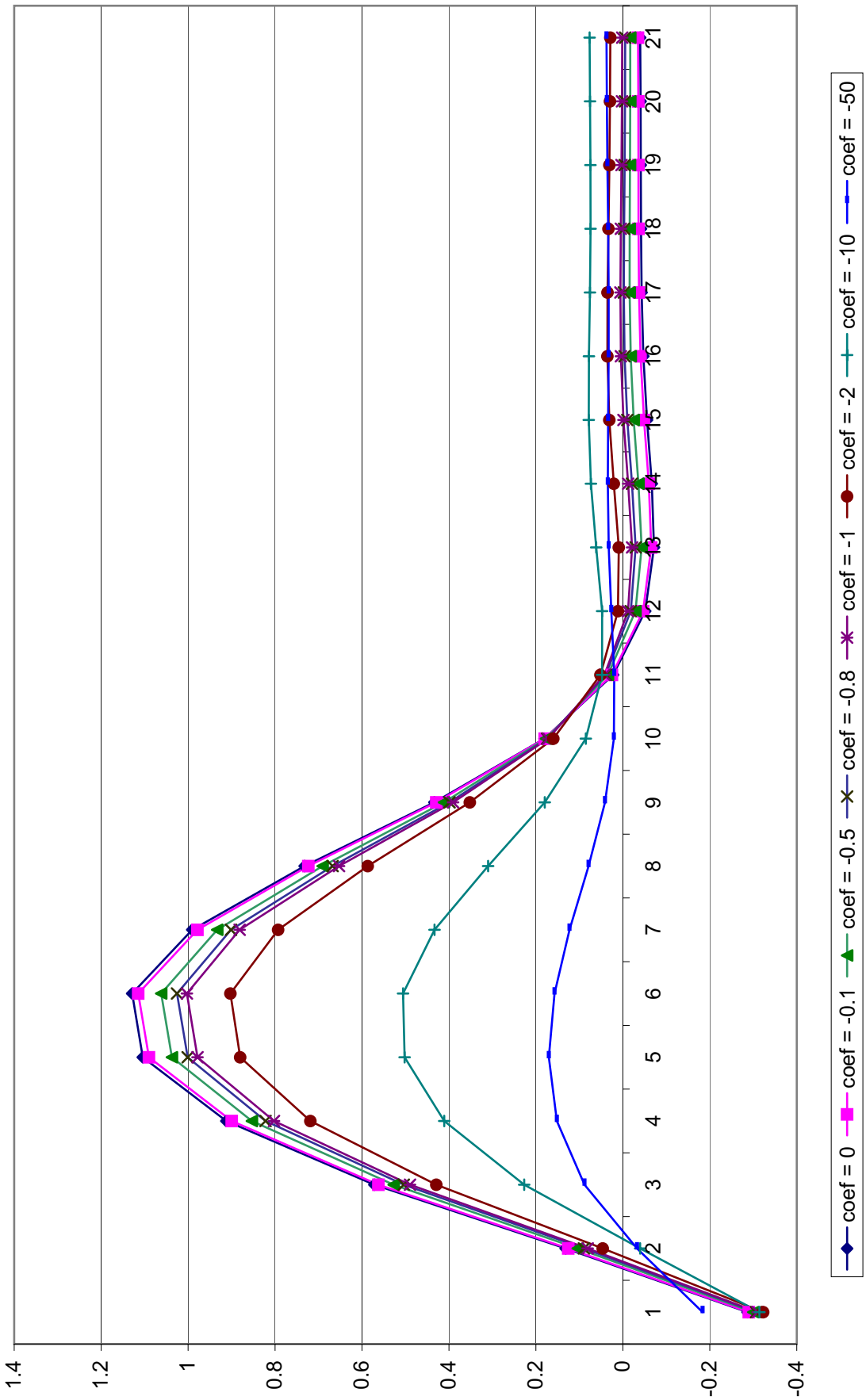


Figure 7. Fiscal Policy and Inflation Differentials.



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