Fiscal Policy and Regional Inflation in a Currency Union[*]

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Abstract

Substantial attention has been devoted to inflation differentials within the European Monetary Union, including suggestions that inflation differentials are a policy issue for national governments. This paper investigates the ability of a region participating in a currency union to affect its inflation differential with respect to the union through fiscal policy. In a two-region general equilibrium model with traded and nontraded goods, lowering the labor income tax rate in response to positive inflation differentials succeeds in compressing inflation differentials. Such policies can lead to higher volatility of domestic inflation while leaving the volatility of real output roughly unchanged. Regional fiscal policies also have spill-over effects on the volatility of union-wide and foreign inflation in our model.

Keywords: currency union, inflation differentials, fiscal policy

JEL classification: F33, F02, E62.

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1 Introduction

Regions participating in a currency union delegate monetary policy – the principal tool for controlling their inflation rate – to a central authority. Inevitably then, inflation rates vary across regions in a currency union. Some currency unions, such as the United States and Canada, are composed of relatively homogeneous, well-integrated regions with little attention paid to how inflation varies across regions: In the United States consumer price indices at the state level are not even constructed. The European Monetary Union, in contrast, is composed of heterogenous and less integrated countries. There, domestic inflation relative to the union-wide average continues to play an important role in discussions about the economic conditions of individual countries. News reports on releases of euro-zone inflation data typically mention at least the highest national inflation rate, as well as the euro-zone average.

Relative prices should fluctuate across regions – in response to asymmetric productivity shocks for example – when the regions' consumption baskets are not identical; in a currency union, these fluctuations are necessarily reflected in inflation differentials. Nonetheless, inflation differentials have received substantial attention in European economic policy discussions. In fact, instances in Europe of especially large inflation differentials have been accompanied by calls for a response from regional governments.[1] We study the implications of using domestic fiscal policy in an attempt to influence a region's inflation differential relative to the rest of the union. Our analysis is centered around the following questions: When fiscal policy is its only available instrument, can a regional government affect the inflation differential relative to the union? If so, what types of policies are effective, and what consequences do they have for real economic activity? To reiterate, inflation differentials in a currency union are not inherently "bad." Ours is a positive analysis aimed at understanding the macroeconomic consequences of countries acting on the suggestion that they direct fiscal policy at

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[1]In 2003, for instance, Pedro Solbes, then European Commissioner for Economic and Monetary Affairs, stated that for Ireland, "the inflation question, as in Spain, has to be tackled on the national level" (*Irish Times*, January 31, 2003, page 51). Most prominently, in 2001 Ireland was reprimanded by the European Commission for pursuing expansionary fiscal policy when its inflation rate was high relative to the European average. During 2001, average year-on-year monthly inflation rates were 4% in Ireland and 2.3% in the Eurozone. During 2002, these averages were 3.6% in Spain, 4.7% in Ireland, and 2.2% in the Eurozone.

the inflation differential.

Our analytical framework is a two-region model with both traded and nontraded goods, and with sticky prices. There is an exogenous stream of government expenditures, and the regional fiscal authority has access to a labor income tax and can issue bonds to finance these expenditures. The model is driven by shocks to government expenditures and to productivity in the traded and nontraded goods sectors. In our framework, price (and inflation) differentials across regions arise from movements in the relative price of nontraded goods across countries and from price differentials for traded goods. The mechanisms behind relative price differentials are independent of the presence of nominal price rigidities in the model. We include price stickiness, which affects the dynamic response of the economy to exogenous shocks since a large body of evidence suggests that prices do not adjust constantly.

There are a number of ways one could model fiscal policy attempting to influence the inflation differential: does the effect come through taxation or government spending? What kind of taxation? We maintain that government spending is exogenous, and study the implications of labor income tax rules that are aimed at influencing the region's inflation differential relative to the union-wide average. Treating government spending as exogenous is fairly standard for the purposes of macroeconomic analysis. The choice of tax rate is less obvious; our analysis could also be conducted using a consumption tax, and in section 2 we address this alternative.

The tax rate is distortionary, and therefore changes in its cyclical behavior alter the behavior of real variables, including the price of the home consumption basket relative to the foreign consumption basket. We find that regional fiscal authorities do have the ability to affect their inflation differential. Specifically, by lowering the distortionary tax rate in response to a positive deviation of inflation from the union-wide average (and raising the tax rate in response to a negative deviation), a regional fiscal authority can decrease the volatility of its inflation differential in response to the shocks driving the model. Regional fiscal policy that responds to deviations of the domestic inflation rate from the union-wide inflation average can lead to higher volatility of the domestic inflation rate, but it leaves the volatility of real output largely unchanged. These regional fiscal policies have spill-over effects and lead to higher volatility of union-wide and foreign inflation rates.

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 for a region to delegate its monetary policy.[2] Therefore, models of currency unions typically assume their existence. Altissimo, Benigno, and Rodriguez-Palenzuela (2004) provide an exhaustive empirical and theoretical study of consumer price and inflation differentials in a currency union.[3] They explore the role of structural differences across countries and the role of the common monetary policy in generating relative price differentials in response to different exogenous shocks in a two-region model. However, they do not consider the possibility of fiscal policy actively working to reduce inflation differentials across regions. Canzoneri, Cumby, and Diba (2005) study a model of a single country within a currency union. They address many questions related to asymmetric effects of monetary policy and, like us, they are interested in the interaction between monetary and fiscal policies. However, they consider only the effects of fiscal shocks on inflation differentials, as opposed to the effects of systematic fiscal policy on which we focus. Finally, there is a growing literature on optimal fiscal policy in regions of a currency union. Contributions include Beetsma and Jensen (2005), Galí and Monacelli (2004), Kirsanova, Satchi, and Vines (2004), Lambertini (2004), and Ferrero (2007). For the most part, this literature has studied models in which all goods are traded, whereas nontraded goods play an important role in our analysis. More importantly, our focus is on the *positive* implications of regional fiscal policy aimed at reducing the regional inflation differential. We leave to future research the welfare implications of the fiscal policy rules described here.

The paper proceeds as follows. In section 2 we present the model and in section 3 we describe the calibration. Section 4 is devoted to developing a basic understanding of the model; we describe the channels which lead to inflation rate differences across countries, and discuss the dynamic responses of the economy to productivity and government spending shocks. Section 5 contains our main results on the implications of using regional fiscal policy to affect the inflation differential with respect to the union. In section 6 we conclude.

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[2]Corsetti and Pesenti (2004) and Devereux and Engel (2003) are notable exceptions.

[3]There is an empirical literature documenting regional variation in inflation rates within currency unions. Cecchetti, Mark, and Sonora (2002), Parsley and Wei (1996), and Rogers (2001) study price level convergence, and Canova and Pappa (2003) study the effects of fiscal shocks on price dispersion.

2 The Model

We consider a currency union composed of two equally-sized 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 must finance an exogenous pattern of spending. The fiscal authority has access to a labor income tax and can issue nominal debt.

The two regions share the same structure. There are two sectors of production in each region, the traded and nontraded sectors. In each sector there are two types of firms, retailers and intermediate goods producers. Retailers produce final composite goods from intermediate varieties and can adjust prices costlessly.[4] A continuum of intermediate goods firms produce traded and nontraded varieties using labor, which is immobile across regions. These firms have market power and set prices in a staggered fashion. Given the exogenous price adjustment scheme, these firms choose an optimal price when they do adjust.

Each region is populated by a continuum of identical households of measure one. Households in each region supply labor to domestic firms and consume a traded composite good and a nontraded composite good. Households also demand real balances, which are an argument in their utility function. We assume that international asset markets are complete; consumers can trade internationally a complete set of state-contingent claims.

In what follows, we describe only the economy of the home region. An analogous description applies to the foreign region. The subscript f for foreign (or h for home) denotes the country of origin of a good, whereas the superscript $*$ denotes a foreign-region variable.

2.1 Households

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

$$U_0 = E_0 \left[\sum_{t=0}^{\infty} \beta^t u \left(c_t, 1 - l_t, \frac{M_t}{P_t} \right) \right], \tag{1}$$

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[4]The retail sector could be eliminated from the model. We include it in order to simplify the presentation of the model.

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, Demands, and the Price Index

The composite consumption good c_t is an aggregate of traded and nontraded composite goods ($c_{T,t}$ and $c_{N,t}$) as follows:

$$c_t = \left[\omega^{\frac{1}{\rho}} c_{T,t}^{\frac{\rho-1}{\rho}} + (1-\omega)^{\frac{1}{\rho}} c_{N,t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}. \tag{2}$$

The elasticity of substitution between the traded and nontraded good is ρ, and ω is the expenditure share on traded goods when the prices of traded and nontraded goods are equal.

We use the common currency as the numeraire. Let $P_{T,t}$, and $P_{N,t}$ denote the prices of the traded and nontraded composite goods in the home region. Given the consumer's demand for the composite consumption good, the demand for the traded and nontraded goods can be determined by solving a cost minimization problem. The resulting demand functions are given by

$$c_{T,t} = \omega \left(\frac{P_t}{P_{T,t}} \right)^{\rho} c_t, \tag{3}$$

and

$$c_{N,t} = (1-\omega) \left(\frac{P_t}{P_{N,t}} \right)^{\rho} c_t, \tag{4}$$

where P_t is the price index for consumption.[5] Substituting these demands into the consumption aggregator (2) yields an expression for the price index:

$$P_t = \left[\omega P_{T,t}^{1-\rho} + (1-\omega) P_{N,t}^{1-\rho} \right]^{\frac{1}{1-\rho}}. \tag{5}$$

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[5] For a formal statement and solution of this cost minimization problem, see Obstfeld and Rogoff (1996), pages 226-228.

2.1.2 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 $Q(s_{t+1}|s_t)$ and we denote the number of these bonds purchased by home households at date t by $D(s_{t+1})$. The home consumer also holds riskless nominal bonds issued by the home and foreign fiscal authorities, $B_{h,t}$ and $B_{f,t}$, both paying $(1+R_t)$ currency units in $t+1$.

The intertemporal budget constraint of the household, expressed in currency units, is given by

$$
\begin{aligned}
P_t c_t + M_t + B_{h,t} + B_{f,t} + \sum_{s_{t+1}} Q(s_{t+1}|s_t) D(s_{t+1}) & \qquad (6) \\
\leq \; (1-\tau_t) P_t w_t l_t + M_{t-1} + (1+R_{t-1})(B_{h,t-1} + B_{f,t-1}) + D(s_t) + \Pi_t,
\end{aligned}
$$

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

The consumer chooses sequences for consumption c_t, labor l_t, state-contingent bonds $D(s_{t+1})$, government bonds, $B_{h,t}$ and $B_{f,t}$, and money holdings M_t, in order to maximize the expected discounted utility (1) subject to the budget constraint (6).

2.2 The Regional Fiscal Authority

The fiscal authority in the home region taxes labor income at the rate τ_t, issues nominal debt B_t, and receives seigniorage revenues Z_t from the central monetary authority. These revenues are spent on public consumption of the composite good, g_t, and interest payments on outstanding debt.[6] The region's government budget constraint is given by

$$
\tau_t P_t w_t l_t + B_t + Z_t = P_t g_t + (1+R_{t-1}) B_{t-1}. \qquad (7)
$$

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[6]Public consumption does not yield utility to households in our model. We assume that public consumption g_t is given by the same aggregate of traded and nontraded composite goods as in equation (2).

We are interested in studying the role 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 assume that the ratio of government spending to output follows an exogenous stochastic process. In turn, the labor income tax rate is determined by a feedback rule that incorporates a response to the stock of government debt. This response ensures that the government will be able to pay the interest on its debts.

The share of total public consumption in output, g/y, is given by

$$\left(\frac{g}{y}\right)_t = c_g + \rho_g \left(\frac{g}{y}\right)_{t-1} + \varepsilon_{g,t}, \tag{8}$$

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

$$\tau_t = \tau_{t-1} + \alpha_{\tau,b}\left(b_t - \bar{b}\right) + \alpha_{\tau,\Delta b}\left(b_t - b_{t-1}\right) + \alpha_{\tau,\pi}\left(\pi_t - \pi_t^U\right). \tag{9}$$

Our specification of the feedback rule also allows for a response of the labor income tax rate to the difference between domestic inflation π_t and union-wide average inflation π_t^U. By varying the tax response parameter $\alpha_{\tau,\pi}$ we can study the regional fiscal authority's ability to affect the inflation differential.

We restrict distortionary taxation to a labor income tax, abstracting from other sources of distortionary taxation, namely taxes on consumption.[7] Like a labor income tax, a consumption tax works through its effect on the household's consumption-leisure optimality condition.[8] However, a consumption tax also directly affects the consumer price index, and if the consumption tax varies over time it shifts the consumption Euler equation.[9] These effects make it is less straightforward to interpret our results in the case of the consumption

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[7]Both these taxes are important sources of tax revenue. In Germany, for instance, personal income taxes accounted for 25 percent of total tax receipts in 2002 while taxes on goods and services accounted for 29 percent.

[8]This optimality condition equates the after-tax real wage rate $(1 - \tau_t)w_t/(1 + \tau_{c,t})$ to the marginal rate of substitution between labor and consumption $u_{l,t}/u_{c,t}$, where τ denotes that tax rate on labor income and τ_c denotes the tax rate on consumption.

[9]The European Harmonised Indices of Consumer Prices include sales taxes.

tax. In Section 5 we briefly discuss the implications of using a consumption tax instead of a labor income tax.

2.3 Firms

There are two sectors of production in each region: traded (T) and nontraded (N). In each sector, intermediate goods firms produce a continuum of differentiated varieties and retail firms produce a final composite good. In the traded sector, the final good is a composite of traded home and foreign intermediate inputs and the final nontraded good. In the nontraded sector, the final good is a composite of domestic nontraded intermediate inputs.

2.3.1 Retailers

We start by describing the problem of retailers in each sector. Producers of the final non-traded good combine a continuum of intermediate nontraded varieties, $y_{N,t}(i)$, $i \in [0,1]$, to produce the composite good $y_{N,t}$. These firms are perfect competitors and each period choose inputs $y_{N,t}(i)$ and output $y_{N,t}$ to maximize profits

$$\max P_{N,t} y_{N,t} - \int_0^1 P_{N,t}(i) y_{N,t}(i) di,$$

subject to the production function $y_{N,t} = \left(\int_0^1 y_{N,t}(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}$. The parameter θ is the elasticity of substitution between any two varieties of the nontraded good and $P_{N,t}(i)$ represents the price of home nontraded variety i in period t. This problem yields the demand functions

$$y_{N,t}(i) = \left(\frac{P_{N,t}}{P_{N,t}(i)} \right)^{\theta} y_{N,t}.$$

Profit maximization by retail firms implies that the price of the nontraded composite good is given by

$$P_{N,t} = \left(\int_0^1 P_{N,t}(i)^{1-\theta} di \right)^{\frac{1}{1-\theta}}.$$

Retailers of the final composite traded good $y_{T,t}$ combine home and foreign traded inter-mediate varieties, $y_{Th,t}(i)$ and $y_{Tf,t}(i)$, $i \in [0,1]$, to produce the (wholesale) tradable good

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$\widetilde{y}_{T,t}$. They then combine each unit of this good with ϕ units of the nontraded composite good $(y^d_{N,t})$ in order to produce one unit of the final (retail) composite traded good $y_{T,t}$.[10] Retail firms choose inputs $y_{Th,t}(i)$, $y_{Tf,t}(i)$, $y^d_{N,t}$, and output $y_{T,t}$ to maximize profits

$$\max P_{T,t}y_{T,t} - \int_0^1 P_{Th,t}(i)y_{Th,t}(i)di - \int_0^1 P_{Tf,t}(i)y_{Tf,t}(i)di - P_{N,t}y^d_{N,t},$$

subject to

$$y_{T,t} = \min\left(\widetilde{y}_{T,t}, \frac{y^d_{N,t}}{\phi}\right), \tag{10}$$

$$\widetilde{y}_{T,t} = \left[\omega_T^{\frac{1}{\gamma}} y_{Th,t}^{\frac{\gamma-1}{\gamma}} + (1-\omega_T)^{\frac{1}{\gamma}} y_{Tf,t}^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}, \tag{11}$$

$$y_{Tj,t} = \left(\int_0^1 y_{Tj,t}(i)^{\frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}}, \quad j = h, f. \tag{12}$$

Equation (10) describes the production function of the final traded good y_T, which requires the use of the wholesale traded good $\widetilde{y}_T$ and the nontraded composite good in fixed proportions. The parameter ϕ determines the amount of the nontraded composite good needed to produce each unit of the final traded composite good. Equations (11) and (12) describe the production function of $\widetilde{y}_{T,t}$. The parameter $\gamma > 0$ denotes the elasticity of substitution between home and foreign traded goods $y_{Th,t}$ and $y_{Tf,t}$ used in the production of $\widetilde{y}_{T,t}$, and the weight ω_T determines the bias for the domestic traded input. Finally, $P_{Th,t}(i)$ and $P_{Tf,t}(i)$ denote the price of home and foreign traded variety i, respectively. The solution to this

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[10]This assumption reflects the need to use distribution services (intensive in local nontraded goods) in the production of final traded goods. The importance of distribution services in explaining consumer-price differentials of traded goods across countries has been emphasized by Burstein, Neves, and Rebelo (2004) and Corsetti and Dedola (2005).

problem implies the following conditions

$$y_{Th,t}(i) = \omega_T \left(\frac{P_{Th,t}}{P_{Th,t}(i)} \right)^{\theta} \left(\frac{\widetilde{P}_{T,t}}{P_{Th,t}} \right)^{\gamma} y_{T,t}, \tag{13}$$

$$y_{Tf,t}(i) = (1 - \omega_T) \left(\frac{P_{Tf,t}}{P_{Tf,t}(i)} \right)^{\theta} \left(\frac{\widetilde{P}_{T,t}}{P_{Tf,t}} \right)^{\gamma} y_{T,t}, \tag{14}$$

$$y_{N,t}^{d} = \phi y_{T,t}, \tag{15}$$

$$P_{T,t} = \widetilde{P}_{T,t} + \phi P_{N,t}, \tag{16}$$

where $P_{Tj,t} = \left(\int_0^1 P_{Tj,t}(i)^{1-\theta} di \right)^{\frac{1}{1-\theta}}$, $j = h, f$, and $\widetilde{P}_{T,t} = \left(\omega_T P_{Th,t}^{1-\gamma} + (1 - \omega_T) P_{Tf,t}^{1-\gamma} \right)^{\frac{1}{1-\gamma}}$.

Equations (13) and (14) represent the demand functions for home and foreign intermediate varieties and equation (15) represents the demand function for the nontraded input used for distribution, y_N^d. Equation (16) determines the final (retail) price of the traded composite good, $P_{T,t}$, as a function of its price before distribution, $\widetilde{P}_{T,t}$, and the price of distribution services, $P_{N,t}$.

2.3.2 Intermediate Goods Producers

We now turn to the problem of intermediate goods producers. In each sector there is a continuum of monopolistically competitive firms indexed by i, $i \in [0, 1]$, that produce differentiated varieties of a traded and nontraded good. The production function for each firm i in each sector $k = N, T$ is given by $z_{k,t} l_{k,t}(i)$, where $l_{k,t}(i)$ represents labor input and $z_{k,t}$ is a sector- and country-specific productivity shock. We denote the real marginal cost of production by $\psi_{k,t} = w_t / z_{k,t}$. Note that marginal cost is specific to the sector and country: two firms in the same country and in the same sector have the same level of productivity and hence (since they face the same wage) the same marginal cost. Firms producing intermediate goods set prices for J periods in a staggered way; in each period t, a fraction $1/J$ of firms in each sector chooses optimally prices that are set for J periods.

In the nontraded goods sector, a firm adjusting its price in period t chooses price $X_{N,t}$ in

order to solve the following problem:

$$\max_{X_{N,t}} \sum_{j=0}^{J-1} E_t \left[\vartheta_{t+j|t} \left(X_{N,t} - P_{t+j} \psi_{N,t+j} \right) y_{N,t+j}(j) \right].$$

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

In the traded-goods sector, a firm adjusting its price in period t chooses $X_{Th,t}$ and charges this price in both markets.[11] This firm's problem is

$$\max_{X_{Th,t}} \sum_{j=0}^{J-1} E_t \left[\vartheta_{t+j|t} \left(X_{Th,t} - P_{t+j} \psi_{T,t+j} \right) \left(y_{Th,t+j}(j) + y^*_{Th,t+j}(j) \right) \right] \tag{17}$$

where $y_{Th,t+j}(j)$ $\left(y^*_{Th,t+j}(j) \right)$ denotes home (foreign) demand in period $t+j$ faced by a firm in this sector that has last adjusted its price in period t.

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.[12] Recalling that

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[11]It should be noted that, in our setup, the presence of distribution services does not generate an incentive for traded intermediate goods producers to price discriminate across markets. In contrast, in Corsetti and Dedola (2005), the presence of distribution services affects the price elasticity of demand faced by these firms and, thus, can generate an incentive for price discrimination across countries.

[12]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. To solve the model, we need to specify how the revenue from money creation is allocated across regions. We do this by choosing a rule for the allocation of the change in the monetary base. This choice eliminates the need to keep track of the central bank's balance sheet. If we were, instead, to specify the allocation rule in terms of the central bank's interest revenues, we would need to keep track of its balance sheet.

Z denotes seigniorage, we have

$$M_t^U - M_{t-1}^U \equiv Z_t^U = Z_t + Z_t^*. \tag{18}$$

We assume that seigniorage is allocated according to each country's share of nominal consumption in the stationary steady-state, s_c, so that

$$Z_t = s_c Z_t^U. \tag{19}$$

The monetary authority is assumed to follow an interest rate rule similar to the rules studied by Taylor (1993) and Clarida, Galí, 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,

$$R_t = \rho_R R_{t-1} + (1 - \rho_R) \left[\bar{R} + \alpha_{R,\pi} \left(E_t \pi_{t+1}^U - \bar{\pi}^U \right) + \alpha_{R,y} \ln \left(y_t^U / \bar{y}^U \right) \right], \tag{20}$$

where a bar over a variable denotes its target value, which we treat as its steady-state. In order to implement this rule, the central monetary authority needs a measure for the inflation rate and real output in the whole currency union, π_t^U and y_t^U, respectively.

We define the "union-wide" inflation rate, π_t^U, as a weighted average of each region's inflation rate, where the weight is determined by the region's share of nominal consumption. That is,

$$\pi_t^U = s_c \pi_t + (1 - s_c) \pi_t^*.$$

In order to define "union-wide" real output, we first define union nominal output as the sum of each region's nominal output, $Y_t^U = Y_t + Y_t^*$. Nominal output in the home region is given by

$$Y_t = P_t (c_t + g_t) + P_{Th,t} y_{Th,t}^* - P_{Tf,t} y_{Tf,t},$$

where $P_{Th,t} y_{Th,t}^*$ and $P_{Tf,t} y_{Tf,t}$ represent the value of exports and imports in period t, respectively. Union-wide real output is obtained by computing the Fisher Ideal quantity index

and normalizing its level to one in steady-state.[13]

2.5 Market Clearing Conditions

The market clearing conditions for labor, traded goods, and nontraded goods are given by

$$
\begin{aligned}
l_t &= \int_0^1 \left(l_{T,t}(i) + l_{N,t}(i) \right) di, \\
y_{T,t} &= c_{T,t} + g_{T,t}, \\
y_{N,t} &= c_{N,t} + g_{N,t} + y_{N,t}^d.
\end{aligned}
$$

Note that the market clearing condition for nontraded goods reflects the three uses of these goods: private consumption, public consumption, and distribution services. Note also that the market clearing condition for traded goods reflects only local demand: This good is *traded* in the sense that it is produced using traded inputs, but consumers must buy it from the local retailer. The market clearing condition for government bonds is given by $B_t = B_{h,t} + B_{h,t}^*$, while state-contingent bonds traded between home and foreign households are in zero net supply.

2.6 Equilibrium and Model Solution

An equilibrium for this economy is defined as a collection of allocations for home and foreign consumers, allocations and prices for home and foreign firms (retailers and intermediate goods producers), composite goods prices, real wages, and bond prices that satisfy the efficiency conditions for households and firms (first-order conditions for the maximization problems stated above) and market clearing conditions, given the policy rules assumed for the monetary and fiscal authorities. We approximate the equilibrium linearly around its steady-state.

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[13]The Fisher Ideal quantity index is computed as the geometric mean of the fixed-weighted Paasche and Laspeyres indices. This index is used by the Bureau of Economic Analysis to construct real series in the National Income and Product Accounts.

3 Calibration

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

3.1 Preferences and Production

We follow Chari, Kehoe, and McGrattan (2002) 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. As in Chari, Kehoe, and McGrattan (2002) we set $\nu = \sigma$. The parameter ψ is set to 7.5, so that the fraction of working time in steady-state is 0.3. Given these parameter choices, the implied elasticity of labor supply with marginal utility of consumption held constant is 1.2.

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

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

and we estimate it by OLS on quarterly German data for M1, CPI, real private consumption and the three-month Libor rate, from 1991:1 to 2001:4. This yields $\frac{1}{\eta-1} = -0.27$, which implies $\eta = -2.66$, and an intercept of 0.39, which implies an estimate of the weight coefficient a of 0.81.[14] The discount factor β is set to 0.99, implying a 4% annual real rate in the

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[14]It has been suggested to us that MZM may be a better measure of money in the 1990s for Germany. We constructed an approximate measure of MZM and re-estimated the money-demand equation. This yielded estimates $a = 0.81$ and $\eta = -0.9393$. Qualitatively our results below are unchanged if we use these parameter

stationary steady-state economy.

The consumption aggregate depends on ρ, the elasticity of substitution between traded and nontraded goods, and on ω, the weight on consumption of traded goods. We use Mendoza's (1995) estimate of the elasticity of substitution between traded and nontraded goods for industrialized countries and set ρ equal to 0.74.[15] To set the weight ω we refer to Stockman and Tesar (1995) who report that nontraded goods account for about half of consumption in OECD countries. We set $\omega = 0.6$ to match this ratio.

For the production function of composite traded goods $\tilde{y}_T$ we need to assign values to γ, the elasticity of substitution between domestic and imported traded goods, and to ω_T, the weight on home traded 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 whereas their estimate for Germany is substantially higher, at 2.33, but imprecise. 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 equal to 0.5, implying that the import share in steady state is 18% of GDP.

Finally, we need to choose the values for the distribution parameter ϕ, the elasticity of substitution across varieties of goods θ, and the number of periods for which prices are set, J. We follow Burstein, Neves, and Rebelo (2004) in setting ϕ equal to 0.82 so that distribution services represent 45% of the retail price of traded goods in steady state. 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 non-zero 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 1.11 in steady state, which is consistent with the empirical work of Basu and Fernald (1997) and Basu and Kimball (1997). We assume that firms set their price for 3 quarters ($J = 3$).

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values, although output and inflation become somewhat more volatile.

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

3.2 Monetary and Fiscal Policy Rules

The parameters of the nominal interest rate rule are taken from the estimates in Clarida, Galí, and Gertler (1998, Table I) for the Bundesbank. We set $\rho_r = 0.91$, $\alpha_{R,\pi} = 1.31$, and $\alpha_{R,y} = 0.25/4$, 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 $\alpha_{\tau,b} = 0.04/16$ and $\alpha_{\tau,\Delta b} = 0.3/4$. The target value for the debt-to-quarterly GDP ratio $\bar{b}$ is set to one. This value corresponds to an average debt-to-annual GDP ratio of 25 percent, which is the average stock of German central government debt to GDP between 1991:4 and 2001:4. The response of the tax rate to the inflation differential $\alpha_{\tau,\pi}$ is set to zero in the benchmark calibration.

We set the government spending share of output, g/y, in steady-state to Germany's average share of central government expenditures in GDP between 1991:4 and 2001:3, 16 percent. The tax rate on labor income in steady-state is set to 18 percent, in order to balance the government budget in steady state given the other parameter choices.[16]

3.3 Exogenous processes

The technology shocks are assumed to follow an $AR(1)$ process $z_{t+1} = Az_t + \varepsilon_{z,t+1}$, where z_t is the vector $\left[z_t^T, z_t^N, z_t^{*T}, z_t^{*N}\right]$ and A is a 4×4 matrix. The vector ε_z represents the innovation to z and has variance-covariance matrix Ω. We identify technology shocks in the traded goods sector with Solow residuals in the manufacturing sector, and technology shocks in the nontraded goods sector with Solow residuals in the service sector. We estimated the stochastic process for technology shocks using quarterly data for Germany and France from 1992:1 to 2000:4 for hours worked and for GDP in the manufacturing and service sectors. Since we assume a symmetric economic structure across countries, we impose cross-country symmetry on the auto-correlation and variance-covariance matrices A and Ω. The estimates

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[16]Carey and Tchilinguirian (2000) estimate an average effective tax rate on labor income in Germany between 1991 and 1997 which is higher (36 percent). This difference reflects our simplified specification of the government sector. Most importantly, we abstract from transfer payments.

are

$$A = \begin{bmatrix} 0.708 & 0.169 & 0.006 & -0.435 \\ -0.023 & 0.707 & -0.061 & -0.038 \\ 0.006 & -0.435 & 0.708 & 0.169 \\ -0.061 & -0.038 & -0.023 & 0.707 \end{bmatrix}$$

and

$$\Omega = \begin{bmatrix} 0.16 & 0.05 & 0.03 & 0 \\ 0.05 & 0.06 & 0 & 0 \\ 0.03 & 0 & 0.16 & 0.05 \\ 0 & 0 & 0.05 & 0.06 \end{bmatrix} \times 10^{-3}.$$

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

4 Mechanisms Behind Regional Price Differentials

In general, price level differentials across countries in a currency union can be decomposed into the differential in the price of a traded goods basket, and the differential between the relative price of nontraded to traded goods across countries. Since nontraded goods have two distinct uses in our model (as final consumption and as an input into the production of final traded consumption goods), the model contains three mechanisms that can generate price (and inflation) differentials across regions in a currency union. Two of these mechanisms work through the presence of local nontraded goods and the third works through movements in the relative price of imports in terms of exports (the country's terms of trade) when agents have a home bias for the local traded good. We emphasize that these three mechanisms are independent of the presence of nominal price rigidities.

To see these three mechanisms, we express regional price differentials in our model as a function of price differentials for nontraded goods across countries and the country's terms

of trade, $P_{Tf,t}/P_{Th,t}$. In log-linear terms we have:

$$\hat{P}_t - \hat{P}_t^* = [(1-\omega)\Omega_1 + \phi\omega\Omega_2]\left(\hat{P}_{N,t} - \hat{P}_{N,t}^*\right) - \omega(2\omega_T - 1)\Omega_3\left(\hat{P}_{Tf,t} - \hat{P}_{Th,t}\right), \qquad (21)$$

where a hat variable represents its deviation from the steady-state value and the constants Ω_1, Ω_2, and Ω_3 are positive functions of relative prices in steady-state.[17] This equation highlights the three mechanisms behind regional price differentials: consumption of local nontraded goods (ω), use of local distribution services in the production of traded goods (ϕ), and home bias in the production of traded goods (ω_T). When households do not consume nontraded goods ($\omega = 1$ in equation 2), when there are no distribution costs ($\phi = 0$ in equation 10), and when retailers of the traded good place equal weight on home and foreign traded inputs ($\omega_T = 0.5$ in equation 11), the model does not generate regional price differentials in response to exogenous shocks. In this case, consumers in both countries have identical preferences defined over the same basket of (traded) goods and the law of one price holds. Hence, the price level in both countries responds identically to (country-specific) exogenous shocks.

The first mechanism behind regional price differentials is associated with the consumption of nontraded goods. When households consume both traded and nontraded goods ($\omega < 1$), the consumption price indices in the two countries correspond to distinct baskets of goods. Hence, movements in the relative price of nontraded goods across countries generates price level differentials. The second mechanism behind regional price differentials is associated with the use of local nontraded goods in the production of the final traded composite good ($\phi > 0$), which implies that the consumer price of the traded good P_T depends on the price of the local nontraded composite good. Movements in the relative price of nontraded goods across countries thus imply consumption price index differentials. Finally, when retailers of traded goods have a bias towards the local traded input ($\omega_T > 0.5$), the price of the traded composite good $\widetilde{P}_T$ disproportionately reflects the price of the local traded good.[18]

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[17] Equation (21) is obtained from (the log-linearized versions of) equation (5) for the price level P, equation (16) for the consumer price of traded goods P_T, and the equation for the price of the composite traded good before distribution $\widetilde{P}_{T,t}$. In deriving this expression we make use of the fact that the model is symmetric in steady-state.

[18] By setting $\omega_T = 0.5$ we eliminate this mechanism in our model. That is, $\widetilde{P}_{T,t} = \widetilde{P}_{T,t}^*$.

Our model is driven by exogenous shocks to government spending and productivity and each of these shocks generates equilibrium price differentials across countries. To gain some insight into the dynamics associated with the exogenous shocks in our model, we now look at the equilibrium responses to shocks to productivity and government spending. In these experiments we assume that monetary policy is given by a constant money growth rate.

Government Expenditure Shock   Fiscal policy in each region is summarized by an exogenous process for government expenditures as a share of output and by a feedback rule for the labor income tax. Here we illustrate the effects of a persistent shock to home government spending (the auto-regression coefficient is set to 0.42, as in the estimated process in Section 3) on price differentials when the tax response parameter $\alpha_{\tau,\pi}$ is zero. Recall that in our setup government spending is a pure resource drain on the economy. Figure 1 displays the response of selected variables to a one percentage point increase in the share of government spending in output. This shock generates an increase in government spending of about 7% on impact and it falls gradually to zero. This temporary increase in government spending is financed through the issuance of government debt and an increase in the tax rate on labor income. After the adjustment to this shock, both the stock of government debt and the tax rate return to their original steady-state values.

[Figure 1 about here]

The increase in government spending implies an increase in demand for both home and foreign traded goods as well as for the local nontraded good (partly to be used for the distribution of traded goods). Domestic real output increases by less than 1% on impact and the transmission of the shock to foreign output is even smaller.[19] The shock has a negative effect on private consumption, bigger in the home country than in the foreign country. As firms readjust prices, consumption falls further for three periods and then returns gradually to zero. This shock generates a positive price differential with respect to the foreign region of about 0.05 percentage points on impact. As domestic firms raise prices more than their

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[19]Betts and Devereux (1999) find identical responses of home and foreign output to government spending shocks. In our model the responses of home and foreign outputs are not identical because there are nontraded goods.

foreign counterparts, the positive price differential widens for three periods and afterwards gradually returns to zero.[20] In response to the increase in government spending, the home household works more hours. The foreign household also works more, but less so than the household in the home country. The real wage in the home country jumps on impact and decreases as hours fall.

The relative price of home traded goods to foreign traded goods increases reflecting the bigger price increases in the home country than abroad, and all agents substitute consumption away from home traded goods towards foreign traded goods. This substitution effect leads to the relative expansion of the traded goods sector in the foreign country, while the nontraded goods sector expands relatively more in the home country.

Productivity Shocks Figure 2 plots the response to a 1% increase in productivity in the home nontraded goods sector. We set the auto-regression coefficient to 0.71, as in the estimated process in Section 3, but we set all spill-over effects (across sectors and countries) to zero. On impact, this shock generates a negative price differential, with the home price level decreasing about 0.2 percentage points and the foreign price level remaining roughly unchanged. The price differential widens for three periods, as domestic firms lower their prices, and then gradually returns to zero. With optimal risk sharing, the fall in the home relative price is associated with a fall in the ratio of marginal utilities of consumption across countries and an increase in home relative consumption.

[Figure 2 about here]

In response to this shock, home producers of nontraded goods gradually lower their prices. Due to the presence of distribution costs, the fall in nontraded goods prices also reduces the consumer price of the composite traded good in the home country, but relatively less than the fall in the price of nontraded goods. Home consumption increases for all goods and real output increases in the home country; increased home demand for foreign traded goods also

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[20]The assumption of complete asset markets implies the optimal risk sharing condition $u_{c,t}/P_t = u_{c,t}^*/P_t^*$. This condition implies that the ratio of price levels moves together with the ratio of marginal utilities of consumption. Abstracting from the presence of money in the utility function, this condition implies a negative relationship between price differentials and consumption differentials.

raises foreign real output. Together with output, government spending also rises in response to this shock, maintaining the share of government spending in output unchanged. The increase in government spending is financed through a temporary increase in government debt and the tax rate on labor income. Hours worked by the foreign household remain roughly unchanged and the home household works less by substituting hours away from the relatively more productive sector.

[Figure 3 about here]

In contrast to the shock to nontraded goods productivity, a productivity shock to the traded goods sector generates almost no price differential across countries (Figure 3). This effect contrasts with the textbook Balassa-Samuelson effect, where, in response to higher productivity in the traded goods sector, a country experiences an increase in its price level relative to the foreign country.[21] However, as discussed in Duarte and Wolman (2003), the sign of the relative price differential in response to a traded-goods productivity shock depends on the elasticity of substitution γ between home and foreign traded goods. Altissimo, Benigno, and Rodriguez-Palenzuela (2004) contains a more extensive discussion of the conditions under which the textbook Balassa-Samuelson effect holds.

5   Fiscal Policy and Regional Inflation

Because we model the government spending process as exogenous, if a regional fiscal authority wishes to influence the behavior of the region's inflation differential, its sole means for doing so is to move the labor income tax. We study a fiscal policy rule whereby the regional government moves the tax rate in response to the differential between the domestic inflation rate and the union-wide inflation rate. Specifically, we vary the parameter $\alpha_{\tau,\pi}$ in the policy rule in equation (9), which represents the feedback from the regional inflation differential to

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[21]See, for example, Obstfeld and Rogoff (1996), page 210. Note that in Figure 3, the price levels fall. The Balassa-Samuelson effect is typically thought of as involving an increase in the home price level. In fact, the Balassa-Samuelson effect refers only to *relative* price behavior; monetary policy should be viewed as determining whether the price level rises or falls.

the tax rate.[22] To summarize the effects of changes in the policy rule, we simulate the model using the shock processes described in section 3, and illustrate the relationship between the volatility of the inflation differential and that of other endogenous variables.

The results are presented in Figure 4. Panel A displays the relationship between $\alpha_{\tau,\pi}$ and the endogenous volatility of the inflation differential, as measured by its standard deviation in percentage points.[23] This plot shows that a region within a currency union can reduce the volatility of its inflation differential relative to the rest of the union by responding to the inflation differential with a negative coefficient in the tax rule. Panel B displays the relationship between the volatility of the inflation differential and the volatility of inflation in both countries and union-wide inflation. Rules that reduce the volatility of the inflation differential reduce the volatility of domestic inflation locally but increase the volatility of both foreign and union-wide inflation. Furthermore, as Panel C shows, rules that reduce the volatility of the inflation differential also reduce locally the volatility of output, but to a small extent. Finally, the use of tax policy to stabilize the inflation differential leads to substantially greater volatility of the distortionary tax rate and tax revenues.

[Figure 4 about here]

Fundamentally, volatility in any of the endogenous variables in the model is a result of volatility in productivity and government spending. Thus, the tax rule alters endogenous volatility by altering the response of the economy to productivity and government spending shocks. As indicated by Panel A of Figure 4, a country can reduce the volatility of its inflation differential with respect to union-wide inflation by responding to this differential with a negative coefficient in the tax rule. Recall that the consumer's problem implies that the after-tax wage rate $(1 - \tau_t)w_t$ equals the marginal rate of substitution between labor and consumption $u_{l,t}/u_{c,t}$. Now, consider the price-setting problem of firms. When prices are flexible, firms set their relative price as a constant markup $\theta/(\theta - 1)$ over marginal cost

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[22]In terms of units, $\alpha_{\tau,\pi}$ is the level derivative of the tax rate with respect to the inflation differential. For instance, if $\alpha_{\tau,\pi} = -1.0$, then an inflation differential of one percentage point would decrease the tax rate by one percentage point compared to a situation with zero inflation differential.

[23]We plot this relationship with the inflation volatility on the horizontal axis, instead of the tax rule parameter, because the other panels relate inflation volatility to other statistics involving endogenous variables. In this figure, the inflation differential and all inflation rates are annualized quarterly rates.

$\psi_{k,t} = w_t/z_{k,t}$, $k = N, T$. If the fiscal authority lowers the labor income tax rate in response to a shock that generates a positive price differential, then, all else equal, the wage rate w_t needs to increase less (or decrease more) in order to satisfy the consumer's optimality condition. Since the wage rate increases less, firms increase their relative price less and, in equilibrium, the price level increases less. Therefore, when prices are flexible, the fiscal authority can reduce the inflation differential associated with exogenous shocks by lowering (increasing) the tax rate on labor income in response to shocks that generate a positive (negative) inflation differential. When prices are sticky, the price set by firms depends not just on current marginal cost but also on future expected marginal costs and demand. The intuition above still holds, however, and a "pro-cyclical" distortionary tax rate is associated with lower inflation differentials.

By using fiscal policy, a region in a currency union can reduce the extent to which its inflation rate deviates from the union-wide average. As Panel B in Figure 4 shows, this stabilization of the inflation differential is associated with stabilization of the domestic inflation rate locally. However, by responding *strongly* to inflation differentials, the fiscal authority may increase the volatility of its domestic inflation rate. In addition, both the volatility of union-wide inflation and foreign inflation increase as the domestic fiscal authority responds to the inflation differential.[24]

When a regional fiscal authority responds to its inflation differential, it responds to any shock that affects its inflation rate relative to the union-wide inflation rate. In our model, the domestic (foreign) inflation rate in a country is mostly affected by domestic (foreign) shocks while union-wide inflation is the average of the inflation rates in the two countries. Therefore, all shocks in the union affect the inflation differential of a region with respect to the union-wide inflation rate. That is, a regional fiscal authority responding to its inflation differential will implicitly respond to all shocks, regardless of their origin. These effects are illustrated in Figure 5, for the case of productivity shocks to the home and foreign nontraded

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[24]Note that in our model regional fiscal policy affects union-wide inflation. Alternatively, we could consider an inflation targeting rule which would make union-wide inflation less sensitive to regional fiscal policy. We adopt the specification for monetary policy in equation (20) since we limit ourselves to a positive analysis of fiscal policy and regional inflation in a currency union, and this specification has been shown to approximate reasonably well the behavior of some central banks in developed economies (see, for instance, Clarida, Galí, and Gertler, 1998).

goods sectors.[25] This figure plots the response of domestic and foreign inflation and domestic real output when $\alpha_{\tau,\pi}$ equals 0 and -6. The graphs on the left report the response to shocks originating in the home country while the graphs on the right report the responses to shocks originating in the foreign country.

[Figure 5 about here]

The response of the fiscal authority to the inflation differential (with $\alpha_{\tau,\pi} < 0$) dampens the response of domestic inflation to the shocks that affect domestic inflation more than union-wide inflation (*i.e.*, shocks originating in the home country). However, the response of fiscal policy magnifies the response of domestic inflation to the shocks that affect union-wide inflation more than domestic inflation (*i.e.*, shocks originating in the foreign country). Intuitively, in order to stabilize the inflation differential, the home country effectively "imports" union-wide inflation when responding to shocks that originate in the foreign country. For small negative values of $\alpha_{\tau,\pi}$, the response of the domestic fiscal authority to shocks originating in the home country (which matter the most for home inflation volatility) dominates and the volatility of domestic inflation decreases. However, as $\alpha_{\tau,\pi}$ falls and the response to inflation differentials becomes stronger, the response of the domestic fiscal authority to shocks originating in the foreign country dominates and the volatility of domestic inflation increases. With respect to the behavior of foreign inflation, the response of the domestic fiscal authority to its inflation differential magnifies the response of foreign inflation to those shocks that matter the most for foreign inflation volatility (*i.e.*, shocks originating in the foreign country). By forcing the domestic inflation rate to replicate the behavior of union-wide inflation, the domestic fiscal authority magnifies the response of the price of home traded goods which, in turn, magnifies the response of foreign inflation.[26] As Figure 4 shows, the

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[25]These effects are qualitatively similar for shocks to productivity of the traded goods sector or shocks to government spending.

[26]In the case of a productivity shock to the foreign nontraded goods sector, the domestic fiscal authority responds to the the initial inflation differential by lowering the tax rate on labor income. This response leads the before-tax wage rate in the home country to fall relative to the case in which the fiscal stance does not respond to the inflation differential. Since the wage rate falls, the price of home traded goods does not rise as much and the price of traded goods does not rise as much in the foreign country. In equilibrium, thus, the foreign price level falls more in response to a productivity shock to the foreign nontraded goods sector when the home fiscal authority responds to its inflation differential.

volatility of foreign (and union-wide) inflation increases as the response of the home region to its inflation differential becomes stronger.

Regional fiscal policy that responds to the inflation differential lowers the volatility of real output slightly. Because prices adjust slowly to exogenous shocks, output responds gradually to exogenous shocks as well. The response of the labor income tax to inflation differentials makes the response of output more sluggish, lowering its volatility.[27]

Figure 4 also shows that regional fiscal policy that responds to the inflation differential has spill-over effects in a currency union of two equally-sized regions. By affecting the volatility of foreign and union-wide inflation, these regional fiscal policies thus would affect the desired behavior of foreign regional fiscal policy and the common monetary policy.

It is straightforward to conduct the same analysis with a consumption tax replacing the labor income tax. As was mentioned earlier, because a (time-varying) consumption tax adds (i) an intertemporal distortion through the Euler equation, and (ii) a direct effect on consumer price inflation to the sole intratemporal distortion present with the labor income tax, it is less straightforward to interpret the results in the case of the consumption tax. Notably, for a wide range of parameters the model's dynamics exhibit damped oscillations under a consumption tax, and for strong negative feedback on the inflation differential in the tax rule the oscillations are no longer damped – the economy cycles permanently in response to a shock. Nonetheless, the frontiers in Figure 4 share the same broad features regardless of whether we use a labor income tax or a consumption tax; most importantly, the Panel A locus is downward sloping, meaning that compressing the inflation differential is associated with decreasing the tax rate in response to a positive inflation differential.

6   Conclusion

This paper investigates the extent to which regional fiscal policy can affect the behavior of a region's inflation differential relative to the union in a general equilibrium model of a two-

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[27]In the case of a productivity shock to the home nontraded good depicted in Figure 5, the tax rate increases more and returns gradually to its steady-state value in response to the negative inflation differential associated with this shock. The behavior of the tax rate is associated with a more sluggish adjustment of hours worked, and thus a more sluggish response of real output compared to the case in which the tax rate does not respond to the inflation differential.

region currency union. Our emphasis on a positive approach is motivated by the attention that has been focused on inflation differentials in EMU member countries and, specifically, by suggestions that countries should pursue policies aimed at affecting their national inflation rates when those deviate greatly from the union-wide average.

We consider fiscal policy rules that make the labor income tax rate respond to the inflation differential. A regional fiscal authority can decrease the absolute value of its inflation differential in response to the shocks driving the model by lowering (raising) the tax rate in response to positive (negative) inflation differentials. Fiscal policies that greatly lower the volatility of the inflation differential may raise the volatility of domestic inflation and unambiguously raise the volatility of foreign and union-wide inflation. The volatility of output remains largely unchanged by these policies.

In the case of a currency union of two equally-sized regions, regional fiscal policies that affect the inflation differential can have spill-over effects on foreign and union-wide inflation rates. Regional fiscal policy can then affect the desired behavior of fiscal policy in the foreign country or of monetary policy by the central monetary authority. It is thus important to study the coordinated and uncoordinated optimization problems between regional fiscal authorities and between the central monetary authority and regional fiscal authorities. The papers cited in the introduction have taken initial steps along these lines and a natural extension of our work would involve studying the welfare implications of fiscal rules that respond to the inflation differential.

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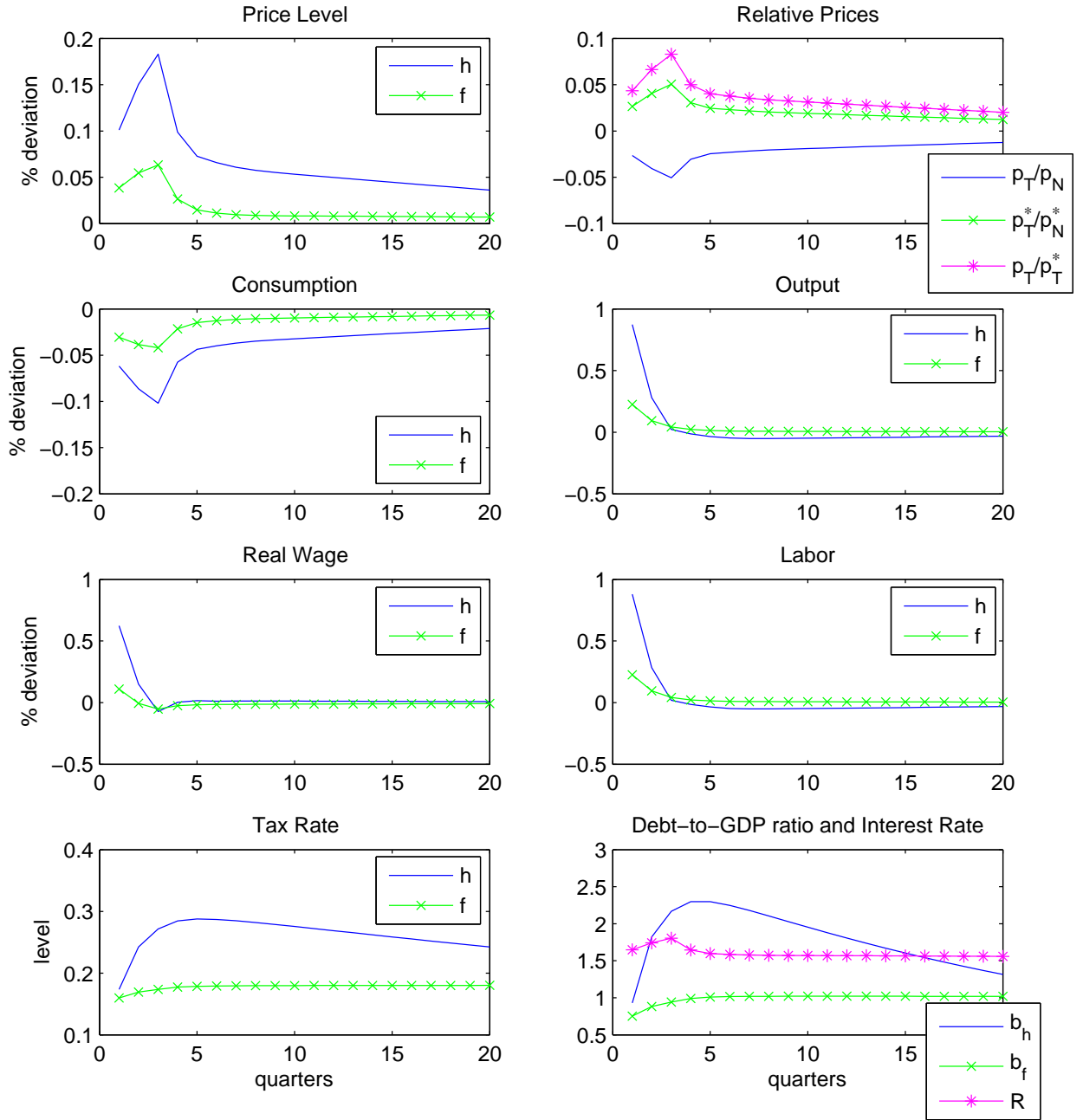
Figure 1: Government Spending Shock
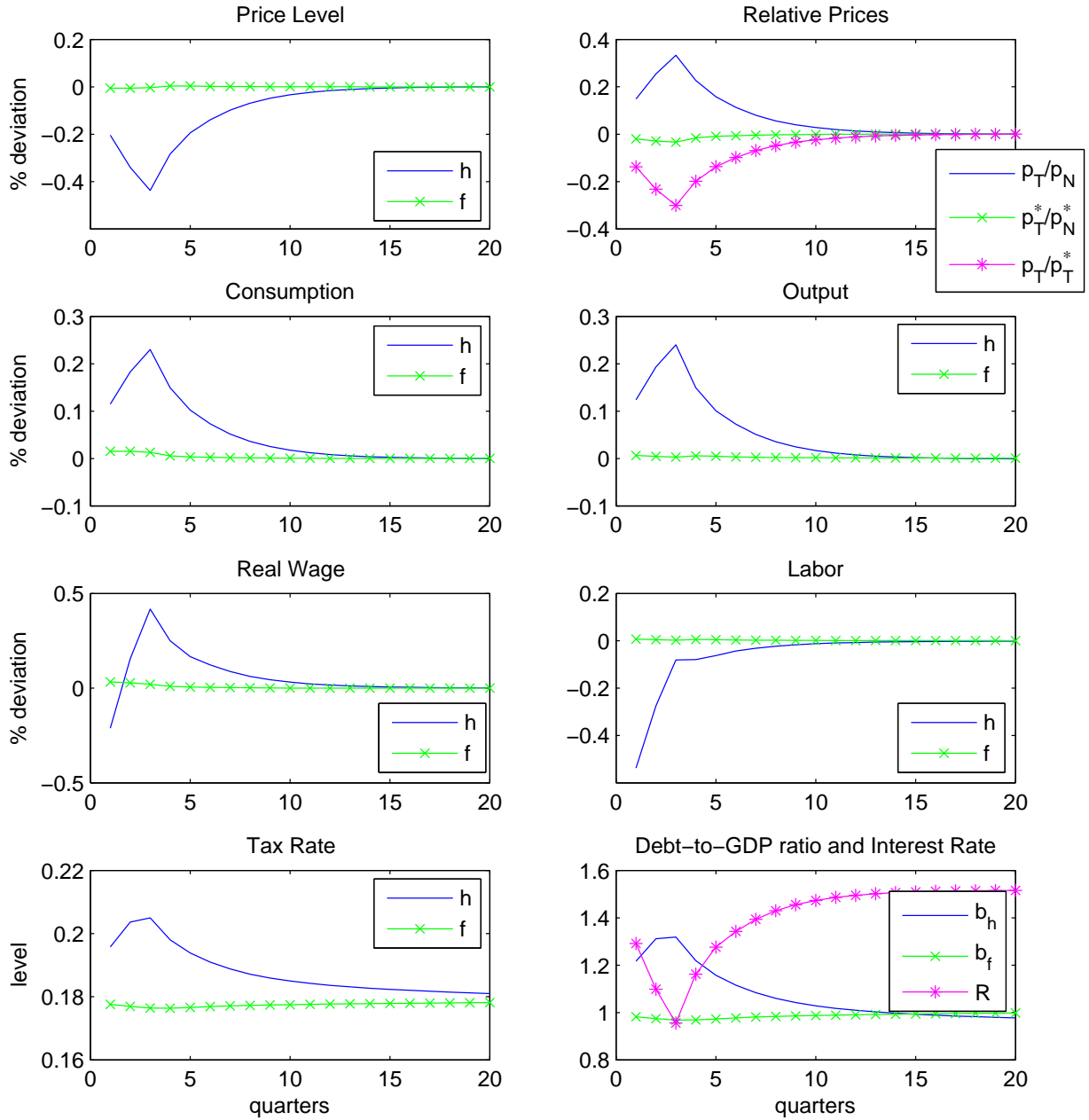
Figure 2: Productivity Shock to Nontraded Goods Sector
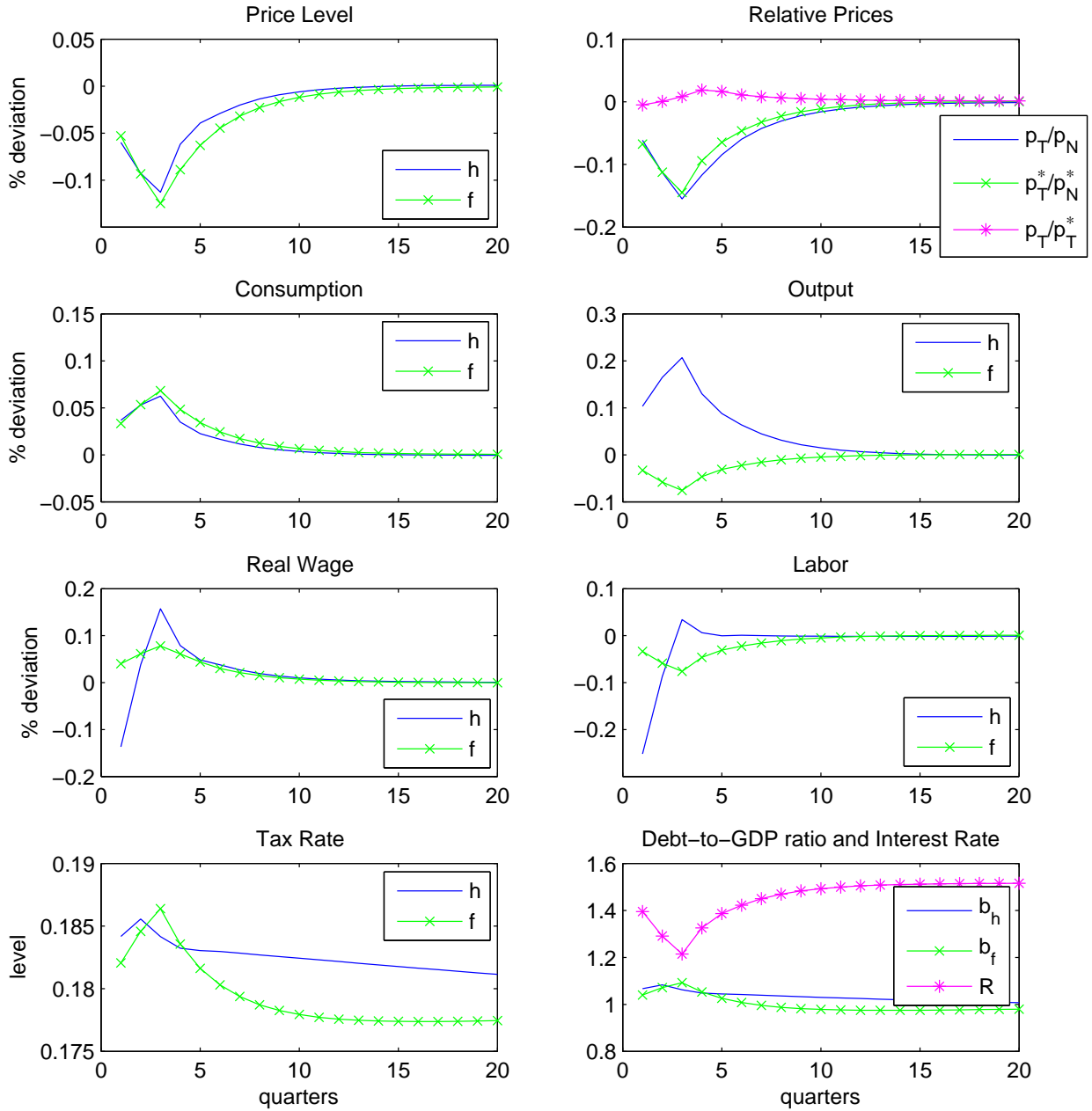
Figure 3: Productivity Shock to Traded Goods Sector

Figure 4: Home Country Responds to the Inflation Differential

A. Tax Response Parameter

B. Inflation Volatility
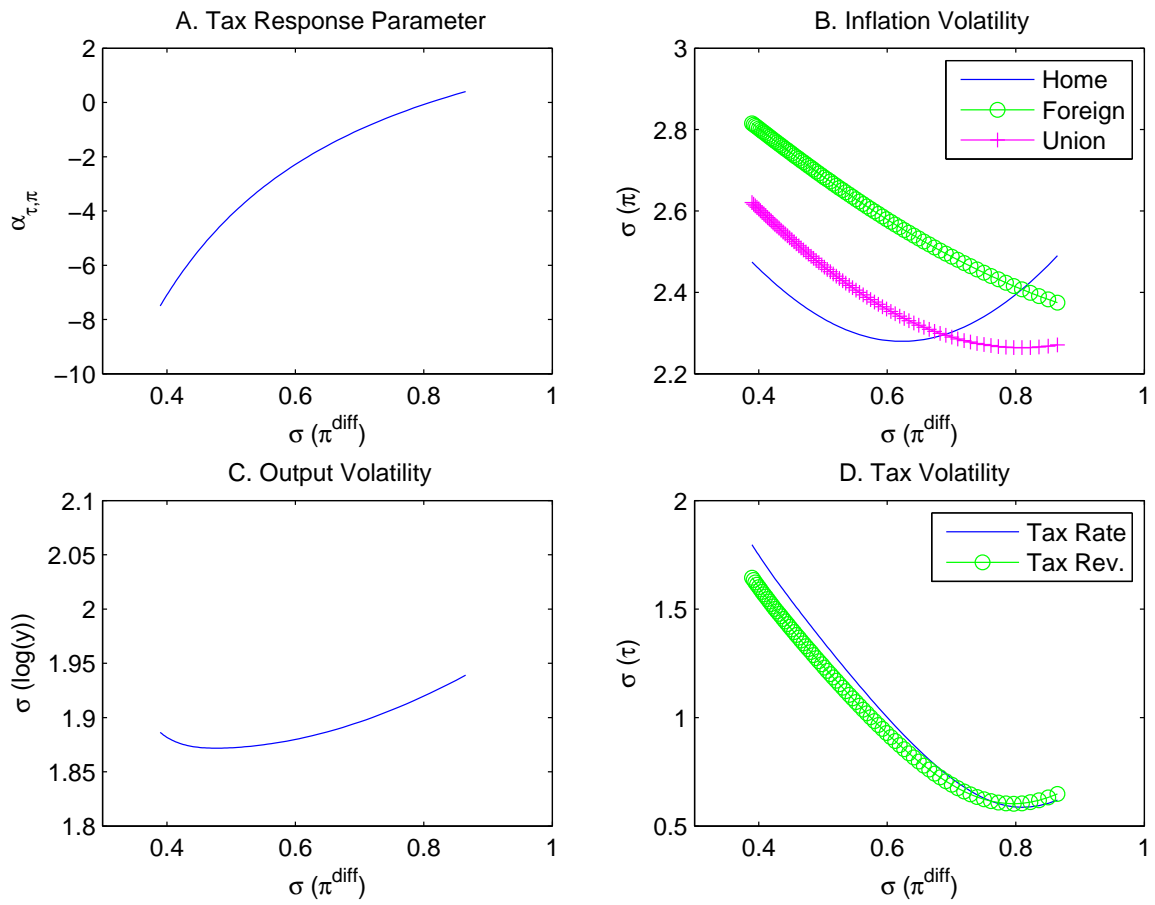
C. Output Volatility

D. Tax Volatility

Figure 5: Productivity Shock to Nontraded Goods Sector (home vs. foreign)