Budget-neutral fiscal rules targeting inflation differentials

by Maren Brede

June 1, 2016

Abstract

In light of persistent inflation dispersion and high debt levels in the EMU, this paper investigates budget-neutral fiscal policy rules to counteract inflation differentials. The paper employs a two-country DSGE model of a monetary union with traded and non-traded goods. National fiscal authorities are able to reduce welfare losses arising from asymmetric shocks by following a Taylor-type rule for consumption taxes while labour income taxes adjust to balance their budgets. Under technology and government spending shocks, the welfare costs of business cycle fluctuations can be reduced by up to 15% in the benchmark calibration.

Keywords: Inflation differentials, monetary union, fiscal rules, budget-neutral policy
JEL classification: E62, E63, F41, F45

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1 Introduction

During the last decade, European countries' inflation rates have been characterised by a high degree of heterogeneity. Prior to the introduction of the Euro, countries with traditionally higher inflation rates managed to lower their rates in order to comply with the Maastricht criteria. In the early years of the Euro, nominal convergence seemed to be attained. However, the years that followed showed a trend reversal as documented by Rabanal (2009). Specifically, inflation rates in the southern European periphery consistently exceeded the average Euro area inflation rate leading to significant real appreciations and the often-mentioned loss of competitiveness. Deviations of a domestic inflation rate from the union-wide average, or in other words inflation differentials, are not necessarily an undesirable phenomenon in a monetary union. Since the nominal exchange rate is fixed, inflation differentials are the by-product of asymmetric shocks and part of the adjustment mechanism. Crucial for the developments since the introduction of the Euro was not only the presence but also the persistence of observed inflation differentials.[1] The European Central Bank cannot address the heterogeneity across member countries' inflation rates. Hence, a number of articles consider the role of national fiscal policies to mitigate inflation differentials. In this context, this paper analyses the effectiveness of fiscal rules that strategically react to domestic inflation differentials as a stabilising policy.

Kirsanova et al. (2007) find that fiscal feedback to national differences in inflation rates are welfare-improving compared to fiscal rules responding to domestic output or the terms of trade only. In their New Keynesian model of a monetary union with two countries, feedback comes through government spending which is financed by government debt and constant taxes on labour income. Similarly, Beetsma and Jensen (2005) work with government purchases as the fiscal instrument financed by either lump-sum taxes or government debt. Moreover, Vogel et al. (2013) study various tax instruments in their fiscal rules also allowing for government debt. Both works find gains from responding to deviations in the terms of trade.

Positive analyses of Duarte and Wolman (2002, 2008) add to the discussion by including a non-tradeable goods producing sector in the model of the monetary union. Including non-traded varieties extends the scope for large and persistent price and thus inflation differentials. They show that a fiscal authority can successfully reduce inflation differentials via a fiscal rule for 'pro-cyclical' labour income taxes. A labour income tax that is lowered in response to a positive domestic inflation differential compresses inflation differentials, yet volatility of domestic inflation might increase.

Since the European periphery did not only face a deterioration of competitiveness over the past years but also a rise in the level of public debt, debt-financed policies that target the domestic inflation differential might not be attainable. In that respect, this paper adds to the existing literature by considering balanced-budget policies. Specifically, this paper analyses in how far fiscal policy should raise the consumption tax rate when domestic inflation is above the union average while labour income taxes balance the governmental budget. Consumption taxes in the form of value-added taxes have been one of the prominent fiscal instruments being adjusted during the Financial as well as the European crisis in several European countries and thus represent a natural candidate for a fiscal tax rule

[1] A large amount of research has been dedicated to identify the drivers of the inflation differentials across EMU countries. Prominent hypotheses were a catching-up process as described in Balassa (1964) and Samuelson (1964), differences in institutions/rigidities or demand-driven effects. A non-exhaustive overview of research in that field contains López-Salido et al. (2005), Canzoneri et al. (2006), Angeloni and Ehrmann (2007), Andrés et al. (2008), Rabanal (2009), Altissimo et al. (2011) and Morsy and Jaumotte (2012).

to examine. A welfare analysis allows to draw normative conclusions on the direction of the adjustment and the size of the gain.

The analysis works along the lines of a large body of research studying the optimal conduct of fiscal policy via simple rules in a monetary union.[2] Additionally, this paper is related to the literature concerned with fiscal devaluations as it considers budget-neutral policies which became explicitly relevant in the context of the European debt crisis. The most prominent work in this field has been conducted by Lipinska and Von Thadden (2012) who investigate the effectiveness of a unilateral tax shift to boost competitiveness of a member country of a monetary union. The distinguishing aspect between the literature on fiscal devaluations and the analysis performed in this paper is this paper's focus on temporary tax shifts in response to contemporaneous discrepancies in the domestic and the union-wide inflation rate instead of permanent tax shifts to boost competitiveness in the long run.

The paper proceeds as follows. Section 2 presents the set-up of the model and section 3 describes the baseline calibration as well as channels through which inflation differentials are generated. Section 4 compares the dynamics of the model with and without the fiscal rule via impulse-response functions. The welfare analysis is executed in section 5. Section 6 concludes.

2 The Model

The model is similar to that of Duarte and Wolman (2008) and consists of two countries of equal size, Home (H) and Foreign (F), which constitute a monetary union. Each country is populated by a measure one of households which have access to an internationally traded asset. In each country there is a sector producing tradeable goods which are traded within the monetary union. There is also a sector producing non-tradeable goods which can only be consumed by domestic households and the domestic government. Both countries are subject to nominal rigidities in the goods market in both sectors. The model abstracts from migration, i.e. labour is immobile across countries. Within a country though, labour is assumed to be perfectly mobile across sectors.

The following paragraphs describe the set-up of the Home economy. The structure of the Foreign economy is analogous. Foreign variables are denoted by an asterisk.

2.1 Households

Households maximise their expected lifetime utility

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left[U(C_{t+k}) - V(L_{t+k}) \right]$$

where $\mathbb{E}$ denotes the expectations operator and $\beta \in (0,1)$ the discount factor. Households derive utility from consumption C_t and disutility from supplying labour L_t.

The aggregate consumption index C_t is composed of consumption of tradeable, C_T, and non-tradeable, C_N, goods as in

$$C_t = \left[(1-\delta)^{\frac{1}{\iota}} C_{T,t}^{\frac{\iota-1}{\iota}} + \delta^{\frac{1}{\iota}} C_{N,t}^{\frac{\iota-1}{\iota}} \right]^{\frac{\iota}{\iota-1}} .$$

[2] Additional to the works mentioned above one has to name Lombardo and Sutherland (2004), Beetsma and Jensen (2004, 2005), Pappa and Vassilatos (2007), Gali and Monacelli (2008), Ferrero (2009) and Kirsanova and Wren-Lewis (2012) as notable advances in that research area.

The elasticity of substitution between traded and non-traded goods is expressed by ι and δ denotes the steady state share of non-tradeable goods in the aggregate consumption index. The price of the final consumption good is given by

$$P_t = \left[(1-\delta)P_{T,t}^{1-\iota} + \delta P_{N,t}^{1-\iota}\right]^{\frac{1}{1-\iota}}$$

where P_T and P_N denote the prices of traded and non-traded goods. Households choose the optimal allocation of consumption expenditures across different types of goods. The optimisation yields the following demand functions

$$\begin{aligned} C_{T,t} &= (1-\delta)\left(\frac{P_{T,t}}{P_t}\right)^{-\iota} C_t \\ C_{N,t} &= \delta\left(\frac{P_{N,t}}{P_t}\right)^{-\iota} C_t. \end{aligned}$$

Households have access to a riskless internationally traded bond B_t which pays out the gross nominal interest rate R_t in $t+1$. In line with Lipinska and Von Thadden (2012), households pay a consumption tax τ_t^C on their consumption and a labour income tax τ_t^L on their labour income. The intertemporal budget constraint expressed in real terms is given by

$$(1+\tau_t^C)C_t + \frac{B_t}{P_t} = R_{t-1}\frac{B_{t-1}}{P_t} + \Pi_t + (1-\tau_t^L)w_t L_t$$

where w_t stands for the real wage in the economy and Π_t for profit transfers from the ownership of domestic firms. The wage w_t is identical across sectors within the economy due to the assumption of perfect labour mobility across sectors and the absence of wage rigidities.

The optimal paths of C_t and L_t are described by the set of optimality conditions derived from the utility maximisation problem of the households. The labour supply decision and the intertemporal Euler equation are given by

$$\begin{aligned} \frac{(1-\tau_t^L)W_t}{(1+\tau_t^C)P_t} &= \frac{V'(L_t)}{U'(C_t)} \\ U'(C_t) &= \beta\mathbb{E}_t\left[U'(C_{t+1})\frac{R_t}{\pi_{t+1}}\frac{1+\tau_t^C}{1+\tau_{t+1}^C}\right] \end{aligned}$$

where $\pi_{t+1} = \frac{P_{t+1}}{P_t}$ denotes gross consumer price inflation net of taxes.

2.2 Firms

In both sectors, intermediate goods are produced by monopolistically competitive firms. Retailers use intermediate varieties as input for the production of final goods.

2.2.1 Retailers

Retailers in both sectors are perfectly competitive and combine intermediate goods to produce the final good. In the non-traded sector, the final good Y_N is produced with technology $Y_{N,t} = \left(\int_0^1 Y_{N,t}(i)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}$ where ϵ is the elasticity of substitution across different varieties $Y_N(i)$ of the non-tradeable good. Given the technology, retailers in the non-traded sector maximise their profit

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

which yields the demand function

$$Y_{N,t}(i) = \left(\frac{P_{N,t}(i)}{P_{N,t}}\right)^{-\epsilon} Y_{N,t}$$

where $P_{N,t}(i)$ is the price for variety i of the non-traded good and $P_{N,t} = \left(\int_0^1 P_{N,t}(i)^{1-\epsilon}di\right)^{\frac{1}{1-\epsilon}}$.
In the traded sector, retailers combine intermediate home and foreign produced traded goods, $Y_{H,t}(i)$ and $Y_{F,t}(i)$, to produce the final traded good Y_T consumed by domestic households. They choose their inputs to maximise

$$\max P_{T,t}Y_{T,t} - \int_0^1 P_{H,t}(i)Y_{H,t}(i)di - \int_0^1 P_{F,t}(i)Y_{F,t}(i)di$$

subject to technologies

$$\begin{aligned} Y_{T,t} &= \left[(1-\omega)^{\frac{1}{\varphi}}Y_{H,t}^{\frac{\varphi-1}{\varphi}} + \omega^{\frac{1}{\varphi}}Y_{F,t}^{\frac{\varphi-1}{\varphi}}\right]^{\frac{\varphi}{\varphi-1}}, \\ Y_{H,t} &= \left(\int_0^1 Y_{H,t}(i)^{\frac{\epsilon-1}{\epsilon}}di\right)^{\frac{\epsilon}{\epsilon-1}} \quad \text{and} \\ Y_{F,t} &= \left(\int_0^1 Y_{F,t}(i)^{\frac{\epsilon-1}{\epsilon}}di\right)^{\frac{\epsilon}{\epsilon-1}} \end{aligned}$$

where φ is the elasticity of substitution between final home and foreign traded goods in the production of Y_T and ω stands for the steady state share of imported goods in the final traded good. Home bias for home produced traded goods is present when $\omega < 0.5$.
The profit maximisation yields the demand functions

$$\begin{aligned} Y_{H,t}(i) &= (1-\omega)\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\epsilon}\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\varphi} Y_{T,t} \\ Y_{F,t}(i) &= \omega\left(\frac{P_{F,t}(i)}{P_{F,t}}\right)^{-\epsilon}\left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\varphi} Y_{T,t} \end{aligned}$$

where $P_{H,t}(i)$ and $P_{F,t}(i)$ are the prices of the home and foreign traded variety i and where the price indices are defined as $P_{H,t} = \left(\int_0^1 P_{H,t}(i)^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}$, $P_{F,t} = \left(\int_0^1 P_{F,t}(i)^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}$ and $P_{T,t} = \left[(1-\omega)P_{H,t}^{1-\varphi} + \omega P_{F,t}^{1-\varphi}\right]^{\frac{1}{1-\varphi}}$.

2.2.2 Intermediate goods producing firms

In each sector there is a continuum of monopolistically competitive firms indexed by i, $i \in [0,1]$, which set their prices in a Calvo fashion. The firms produce intermediate goods varieties using a linear production technology and sector- and country-specific technology Z_S, $S \in [T,N]$.
In the non-tradeable goods sector an intermediate goods producing firm i produces with

$$Y_{N,t}(i) = \exp(Z_{N,t})L_{N,t}(i)$$

and seeks to maximise its expected profit given that with probability θ the firm is not able to adjust its price $P_{N,t}(i)$ in a given period. Formally, it sets its price to solve the problem

$$\max \mathbb{E}_t \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} \left[Y_{N,t+k|t}(i) P_{N,t}(i) - W_{t+k} L_{N,t+k}(i) \right]$$

where $Q_{t,t+k} = \beta^k \frac{U'(C_{t+k})}{U'(C_t)} \frac{P_t}{P_{t+k}} \frac{1+\tau_t^C}{1+\tau_{t+k}^C}$ is the stochastic discount factor and W_t the nominal wage.

The set-up and maximisation problem of an intermediate goods producing firm in the traded sector is analogous. Intermediate goods in the traded sector in the home economy are produced by some firm i via the production function

$$Y_{H,t}(i) = \exp(Z_{T,t}) L_{T,t}(i).$$

Firm i in the tradeable sector sets its price $P_{H,t}(i)$ to maximise

$$\max \mathbb{E}_t \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} \left[Y_{H,t+k|t}(i) P_{H,t}(i) - W_{t+k} L_{T,t+k}(i) \right].$$

given that with probability θ the firm cannot readjust its price.

2.2.3 Terms of trade

Due to the presence of the non-traded goods sector, the model includes external and internal terms of trade. The external terms of trade T_t are defined as the price of foreign produced traded goods relative to home produced traded goods, i.e.

$$T_t = \frac{P_{F,t}}{P_{H,t}}.$$

A rise in the terms of trade ameliorates the trade position of the home economy as the foreign produced traded goods become relatively more expensive. The internal terms of trade $T_{N,t}$ are defined as

$$T_{N,t} = \frac{P_{N,t}}{P_{T,t}} \quad \text{and}$$
$$T_{N,t}^* = \frac{P_{N,t}^*}{P_{T,t}^*}$$

and measure the internal competitiveness across sectors within a country. They capture the price of the non-traded good relative to the final traded good within a member country of the union.

2.3 Policy makers

2.3.1 Central monetary authority

Monetary policy is conducted at the union-level. Following Lipinska and Von Thadden (2012), the central bank sets the union-wide gross nominal interest R_t in response to union-wide average inflation net of taxes $\pi_t^U = 0.5\pi_t + 0.5\pi_t^*$. The Taylor-type interest rate rule reads

$$R_t = \frac{1}{\beta} \left(\pi_t^U \right)^{\phi}$$

where ϕ captures the rigorousness of the central bank.

2.3.2 Fiscal authority

Fiscal policy is conducted on the country-level and is assumed to be symmetric for both countries. The government consumes non-tradeable varieties and the stream of public consumption relative to total GDP within a country follows an exogenous process of the form

$$(G_t/Y_t) = (\bar{G}/\bar{Y}) + \rho_g(G_{t-1}/Y_{t-1}) + \epsilon_{G,t}$$

where $|\rho_G| < 1$ and $\epsilon_{G,t} \sim \mathcal{N}(0, \sigma_G^2)$. The government uses its of tax income to finance its expenditures. The budget constraint of the fiscal authority reads

$$\tau_t^C C_t + \tau_t^L w_t L_t = G_t.$$

Since the present analysis is concerned with budget-neutral policies, the government does not have the possibility to issue debt to finance its expenditures.
The inflation differential is defined as the domestic consumer price inflation net of taxes, π_t, relative to the union-wide consumer price inflation net of taxes, π_t^U, that is $\pi^{diff} = \frac{\pi_t}{\pi_t^U}$. This paper considers a fiscal rule such that the consumption tax rate responds to deviations of the inflation differential from its steady state of one while the labour income tax balances the fiscal budget. The fiscal feedback rule is given by

$$1 + \tau_t^C = (1 + \bar{\tau}^C) \left(\pi_t^{diff}\right)^{\zeta}.$$

where ζ is a measure of the tax elasticity with respect to the inflation differential. The benchmark is set at $\zeta = 0$, so that the consumption tax rate is constant at its steady state level $\bar{\tau}^C$. The goal of the welfare analysis is to quantify the gains in welfare for values of ζ different from zero.

2.4 Market clearing and equilibrium

The market clearing conditions for traded and non-traded goods, the labour market and the international bond market are given by

$$\begin{aligned} Y_{T,t} &= C_{T,t}, \\ Y_{N,t} &= C_{N,t} + G_t, \\ L_t &= \int_0^1 L_{T,t}(i) + L_{N,t}(i)di, \\ B_t &= -B_t^*. \end{aligned}$$

To close the model, a debt-elastic interest rate as proposed by Schmitt-Grohé and Uribe (2003) is incorporated to induce stationarity on private debt. For the impulse-responses the equilibrium is approximated linearly around a zero-inflation steady state.

2.5 Sources of inflation differentials

From the definition of the price of consumption in H, P_t, and its analogue for country F, P_t^*, one can decompose the different sources of consumer price differentials which translate to differences in inflation rates. To begin with, the ratio of aggregate consumer prices of both countries is given by

$$\frac{P_t}{P_t^*} = \frac{P_{T,t}}{P_{T,t}^*} \left[\frac{1 - \delta + \delta T_{N,t}^{1-\iota}}{1 - \delta + \delta T_{N,t}^{*1-\iota}}\right]^{\frac{1}{1-\iota}}.$$

Neglecting the ratio of traded goods prices for a moment, it is easily seen that the presence of non-traded goods ($\delta \neq 0$) is an essential source for price (inflation) differentials. Non-traded goods prices are not in direct competition across countries. Hence, different prices for non-tradeable goods translate into differing internal terms of trade across countries. These lead to price differentials even if the price indices for the final traded good would be identical across countries, i.e. $P_{T,t} = P^*_{T,t}$.
Going one step further one can analyse in how far inflation differentials might arise from the traded goods sector. One can express the ratio of traded goods prices as

$$\frac{P_{T,t}}{P^*_{T,t}} = \left[\frac{(1-\omega)P_{H,t}^{1-\varphi} + \omega P_{F,t}^{1-\varphi}}{(1-\omega)P_{F,t}^{1-\varphi} + \omega P_{H,t}^{1-\varphi}}\right]^{\frac{1}{1-\varphi}}$$

which shows in how far the presence of home bias is essential in creating price differentials. Under $\omega = 0.5$, when home bias is absent, traded goods price indices would be identical across countries. With home bias, price (and inflation) differentials work through the external terms of trade, i.e. the relative price of foreign to home produced traded goods. Note that neither of the two channels described above rely on the inclusion of rigid prices.

3 Calibration

This section presents the benchmark parameter values of the model. The calibration is symmetric across countries and one model period corresponds to one quarter.

3.1 Private sector

The household's utility is governed by

$$U(C_t) = \frac{C_t^{1-\sigma} - 1}{1-\sigma} \quad \text{and}$$
$$V(L_t) = \frac{L_t^{1+\kappa}}{1+\kappa}$$

where σ denotes the coefficient of relative risk aversion and κ the inverse of the Frisch elasticity of labour supply. The discount factor β takes a standard value of 0.99 while the coefficient of relative risk aversion σ as well as the inverse of the Frisch elasticity of labour supply κ is set equal to one (log-utility in consumption).
As in Duarte and Wolman (2008) the share of non-tradeable goods in the consumption basket δ takes a value of 0.4 and the elasticities of substitution ι, φ and ϵ are set to 0.74, 1.5 and 10 respectively. In contrast to these authors, the benchmark allows for home bias in the production of the final traded good and sets $\omega = 0.4$. The Calvo parameter θ is assumed to be identical across sectors and countries. The benchmark assumes an expected price lifetime of 3 quarters such that $\theta = 2/3$ which is close to estimates by Druant et al. (2012) who find for a sample of 17 European countries that on average prices remain unchanged for around 10 months.

3.2 Public sector

Monetary policy is characterised by a standard Taylor coefficient of $\phi = 1.5$. For the fiscal side this work follows Lipinska and Von Thadden (2012) by assuming a steady state consumption tax rate $\bar{\tau}^C$ of 15%. The steady state share of public consumption relative to domestic GDP is taken to be 25%. In order to comply with the budget constraint of the government, the steady state of the labour income tax rate $\bar{\tau}^L$ is set to be 15.3%.

3.3 Shock processes

The analysis uses the estimated shock processes and variance-covariances matrices of Duarte and Wolman (2008) for the technology and government spending processes. Technology shocks follow an AR(1) process $Z_t = AZ_{t-1} + \epsilon_{Z,t}$ with covariance matrix Ω, where $Z_t = [Z_{T,t}, Z_{N,t}, Z^*_{T,t}, Z^*_{N,t}]$,

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

and

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

Shocks to the share of government consumption of output follow independent AR(1) processes with persistence ρ_g of 0.42 and variance $\sigma^2_G = 0.000214$.

4 Mechanism of the fiscal rule

This section briefly shows how stochastic disturbances to technology and government spending create inflation differentials. In order to illustrate the mechanism of the responsive consumption tax rule, this section compares the dynamics of the model under a responsive fiscal rule ($\zeta > 0$) to the benchmark in which the consumption tax rate is constant ($\zeta = 0$).

4.1 Government spending shocks

Figure 1 displays impulse-response functions to an increase in the share of government spending of 1% point which is entirely financed by higher labour income taxes in the case of constant consumption taxes. The blue line displays the dynamics under constant consumption taxes and the red dotted line the dynamics under responsive consumption taxes. The increase in government spending raises demand for non-traded goods and firms in that sector increase their production. With higher production, marginal costs increase and firms in the non-traded sector raise their prices. Relative to traded goods, non-traded goods become more expensive such that the internal terms of trade increase. Due to higher labour demand in the non-traded sector, the wage in the economy increases and thus also marginal costs for firms in the traded sector. Consequently, home-produced traded goods become relatively more expensive and the external terms of trade deteriorate. CPI inflation in the home economy increases relative to the union and the home economy faces a positive inflation differential. Domestic consumption falls due to the higher prices. The differential reverses as the shock feeds through the home economy's traded sector to the foreign economy via the external terms of trade. Qualitatively, the dynamics of the model remain unchanged when consumption taxes strategically respond to the domestic inflation differential. The increase in government spending still triggers an increase in domestic inflation. The increase in the consumption tax though lowers domestic demand of households which lowers the increase in production and thus dampens the response of the terms of trade and inflation. The rise in consumption taxes compresses the inflation differential but at the costs of a larger drop of domestic consumption.

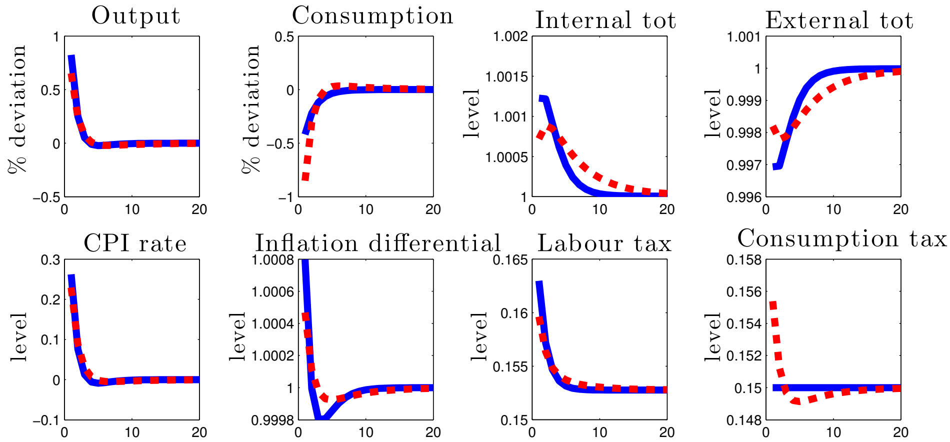


Figure 1: Impulse-response functions to a 1% point increase in G/Y with constant consumption taxes (blue, solid) and responsive consumption taxes (red, dotted).

4.2 Technology shocks

Figure 2 displays the dynamics of the model in response to a 1% point increase in productivity in the non-traded sector Z_N.[3] The increase in technology lowers marginal costs for firms in the non-traded sector causing them to lower their prices. Non-traded goods become relatively cheaper and the internal terms of trade fall. The decrease in the wage also lowers marginal costs in the traded sector leading to a decline in home-produced traded goods and the displayed increase in the external terms of trade. Since consumer prices drop consumption increases. Relative to the union, the domestic inflation rate falls and results in a negative inflation differential. Under a responsive consumption tax one can

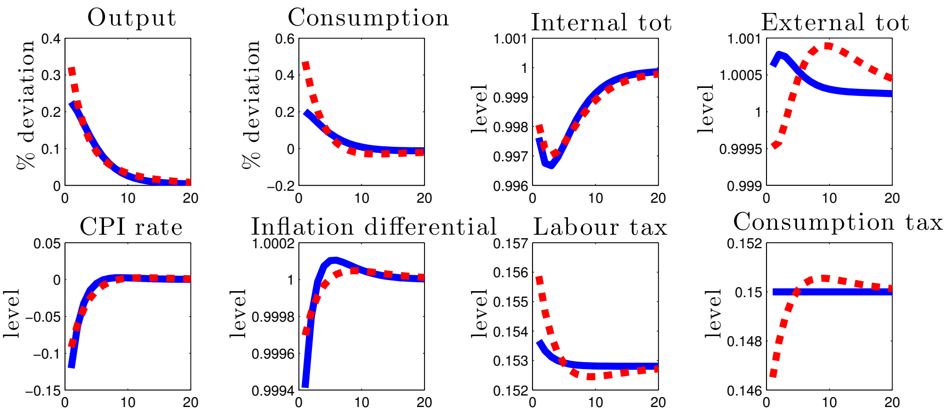


Figure 2: Impulse-response functions to a 1% point increase in Z_N with constant consumption taxes (blue, solid) and responsive consumption taxes (red, dotted).

observe quantitative differences. The fall in the domestic inflation rate below the union average causes a fall in consumption taxes when the fiscal rule is responsive. The lower tax allows a larger rise in consumption which already increased due to lower consumer

[3] The dynamics for a technology shock in the traded sector are qualitatively equivalent to those presented for the shock to technology in the non-traded sector and are thus not displayed and discussed here explicitly.

prices without the responsive tax. The stronger increase in domestic demand relative to constant consumption taxes allows firms to raise their production by more which causes a faster increase in marginal costs. Relative to constant consumption taxes firms lower their prices by less which is displayed by the dampened response of inflation and the inflation differential.

This section examined the model's dynamics in response to government spending as well as technology shocks. By comparing the impulse response functions under constant and responsive consumption taxes one can observe that the response of inflation as well as the inflation differential is dampened when the fiscal rule is responsive while the response of consumption is more pronounced.

5 Welfare analysis

In order to understand whether the fiscal rule can be welfare-improving, this section determines and compares the welfare loss of business cycle fluctuations under constant and responsive consumption taxes for a given union-wide monetary policy. The welfare analysis follows the framework of Lucas (1987, 2003) and computes a consumption compensation v that a household would be willing to pay to avoid moving from being in the deterministic steady state to being in the stochastic environment. Formally, the consumption compensation v solves

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t[U(C_t)-V(L_t)]=\sum_{t=0}^{\infty}\beta^t[U((1+v)\bar{C})-V(\bar{L})]$$

where bar-variables denote the deterministic steady state of the model's variables. The unconditional expectation of the household's utility in the ergodic distribution of the model must be equal to the utility of the household in the deterministic steady state paying the consumption compensation v. Using a second-order Taylor approximation on both sides one can express v as a function of first and second order moments of the ergodic distribution. Also, one can decompose v into four components as given by

$$v=v_{meanC}+v_{meanL}+v_{volatilityC}+v_{volatilityL}.$$

This allows to inspect the contributions of differences between the unconditional expectation and the deterministic steady state (mean effects v_{meanC} and v_{meanL}) and differences between the volatility in the ergodic distribution and the volatility in the deterministic steady state (volatility effects $v_{volatilityC}$ and $v_{volatilityL}$) of consumption and hours. In order to accurately calculate the moments of the ergodic distribution the model is written recursively and solved in Dynare using a second-order accurate perturbation. This paper employs the method developed by Lan and Meyer-Gohde (2013) to find accurate first- and second-order moments analytically.

First, the welfare loss for the benchmark calibration is computed, i.e. for constant consumption taxes ($\zeta = 0$) and the shock processes specified in section 3. Subsequently, the loss under the responsive consumption tax rate that reacts with different sensitivities ($\zeta \in [0, 50]$) to the domestic inflation differential is calculated and compared to the loss of the benchmark. The lower panel in figure 3 displays the welfare loss for different sensitivities of the fiscal rule relative to constant consumption taxes given the shock processes presented in section 3. The upper panels repeat the exercise for the model without government spending shocks (left) and without technology shocks (right). For positive values of ζ welfare losses are consistently and significantly lower than under constant consumption taxes. On first examination, it is evident that a responsive fiscal rule reduces welfare

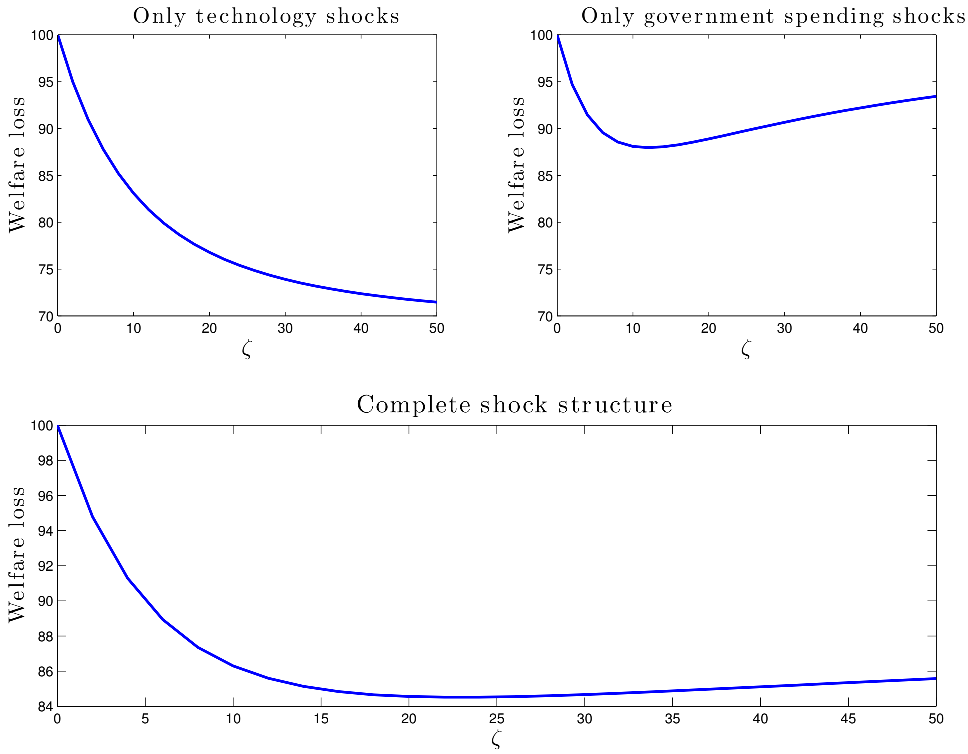


Figure 3: Welfare losses for different values of ζ relative to constant consumption taxes (=100).

losses even for large values of ζ relative to constant consumption taxes. Marginal gains are specifically pronounced in the low-sensitivity segment.[4] The upper graphs in figure 3 reveal that the large gains from a fiscal rule for consumption taxes largely stem from the presence of technology shocks. Nonetheless, it should be noted that the fiscal rule does not face a trade-off when stabilising inflation differentials arising from either technology shocks of government spending shocks. The upper right graph clearly shows that even without technology shocks, significant gains in welfare are realised under the responsive fiscal rule for consumption taxes.

In order to understand the origins of the welfare gains, table 1 decomposes the computed welfare loss into mean and volatility components of consumption and labour for the complete shock structure, technology shocks and government shocks only. The columns headed 'baseline' denote the scenario of constant consumption taxes. The gains in welfare are calculated for the consumption tax rule for which welfare losses are minimised under the complete shock structure ($\zeta = 22$). Consider the first row of table 1. Under the responsive consumption tax rule, welfare losses are reduced by a little more than 15% relative to the baseline model with constant consumption taxes. A little less than two thirds of the welfare loss is attributed to government spending shocks. Given the policy rule, welfare losses are also reduced under either only technology or only government spending shocks, whereas the gains are much larger for technology shocks. The decomposition of the wel-

[4] Note that under the complete shock structure welfare losses could be reduced by a little more than 15% with a value for ζ of 22. However, even with a value of 5 for ζ welfare losses are reduced by around 10% relative to the benchmark.

	Complete shock structure			Technology shocks only			Government spending shocks only		
	baseline	responsive	Δ%	baseline	responsive	Δ%	baseline	responsive	Δ%
Welfare loss of fluctuations	-1.3107	-1.1026	15.88	-0.4821	-0.3429	28.89	-0.8278	-0.7262	12.28
Decomposition:									
mean consumption	-1.1764	-0.8384	25.79	-0.4316	-0.2534	36.97	-0.7448	-0.5812	19.77
mean hours:	0.0174	0.0015	-1.22	-0.0090	-0.0030	1.25	0.0264	0.0078	-2.25
volatility cons.:	-0.0641	-0.2166	-11.63	-0.0295	-0.0776	-9.97	-0.0342	-0.1073	-8.83
volatility hours:	-0.0876	-0.0490	2.94	-0.0121	-0.0090	0.64	-0.0752	-0.0455	3.59
Moments:									
mean consumption	0.7044	0.7046	0.03	0.7049	0.7050	0.02	0.7047	0.7048	0.02
mean hours	0.9402	0.9402	0.00	0.9403	0.9402	-0.00	0.9402	0.9402	0.00
std. dev. consumption	0.0079	0.0147	84.66	0.0054	0.0088	62.43	0.0058	0.0103	77.68
std. dev. hours	0.0132	0.0099	-25.19	0.0049	0.0042	-13.73	0.0123	0.0095	-22.24
std. dev. CPI inflation	0.0051	0.0048	-7.24	0.0024	0.0022	-7.68	0.0045	0.0043	-5.88
std. dev. inflation diff.	0.0020	0.0007	-65.57	0.0010	0.0002	-78.35	0.0018	0.0009	-47.51
std. dev. cons. tax	0.0000	0.0203	.	0.0000	0.0122	.	0.0000	0.0135	0.00

Table 1: Welfare loss $\times 10^{-3}$, theoretical moments and % gains under the welfare-maximising consumption tax rule (responsive) relative to constant consumption taxes (baseline).

fare losses reveals several interesting facts. First, mean as well as volatility components associated with hours do not play an important role in explaining the gains in welfare under the responsive consumption tax. Second, the gains in welfare clearly originate from a higher mean of consumption in the ergodic distribution of the model under a responsive consumption tax compared to the baseline. The larger welfare loss under the responsive consumption tax in the volatility component of consumption is easily explained by the higher volatility of the consumption tax itself. The higher volatility in consumption under the responsive fiscal rule has been displayed by the stronger responses of consumption to the stochastic disturbances in the previous section. The larger loss in this component however is significantly outweighed by the gain in mean consumption. Note that these findings are irrespective of the specified shock structure.

One needs to address the origin of welfare losses in the mean consumption component, i.e. the difference between the unconditional expectation of the ergodic distribution and the deterministic steady state of consumption. Section 4 presented in how far the specified shocks are natural drivers of inflation and especially inflation differentials. Due to the Calvo pricing set-up however, only a fraction of firms can actually adjust their prices after a shock leading to price dispersion across different varieties of goods produced by the continuum of intermediate goods producing firms. The larger the response of inflation the wider is the underlying dispersion across prices. Price dispersion causes an inefficient allocation of resources as retailers use different quantities of the available varieties to produce the final good. The inefficiency in the production process of the final good ultimately results in a lower mean of consumption in the ergodic distribution of the model.[5] The proposed budget-neutral tax shift in response to the domestic inflation differential reduces the welfare loss originating in the mean component of consumption by actively compressing domestic inflation and hence the underlying price dispersion.

[5] Note that this mechanism not only holds true for shocks originating in the domestic economy but also for shocks that originate in the foreign economy. The internal and external terms of trade ensure that also foreign shocks feed through to the domestic economy.

6 Robustness of the results

This section deals with assessing the robustness of the findings presented in the previous section. In the following figures the benchmark results will be depicted by a solid red line. In terms of model parameters, sensitivity checks are performed for the steady state share of non-traded goods in the consumption aggregate (δ), the steady state import share in the production of the final traded good (ω) and the degree of the nominal rigidity (θ). The mentioned parameters govern the scope and persistence of inflation differentials as well as price dispersion and are consequently of specific interest. Additionally, the robustness analysis includes an examination of the results when the two countries in the union are not of equal size and lastly when the policy is only adopted by the home economy (unilateral policy).

6.1 Sensitivity to model parameters

In the baseline calibration the steady state share of non-traded goods in the final consumption aggregate, δ, has been set to 0.4. Stockman and Tesar (1995) argue that the share of non-traded goods ranges roughly between 0.3 and 0.5 across OECD countries. Accordingly, figure 4 displays the welfare loss for different policy sensitivities ζ relative to constant consumption taxes for the respective values for δ. It is evident that the gains

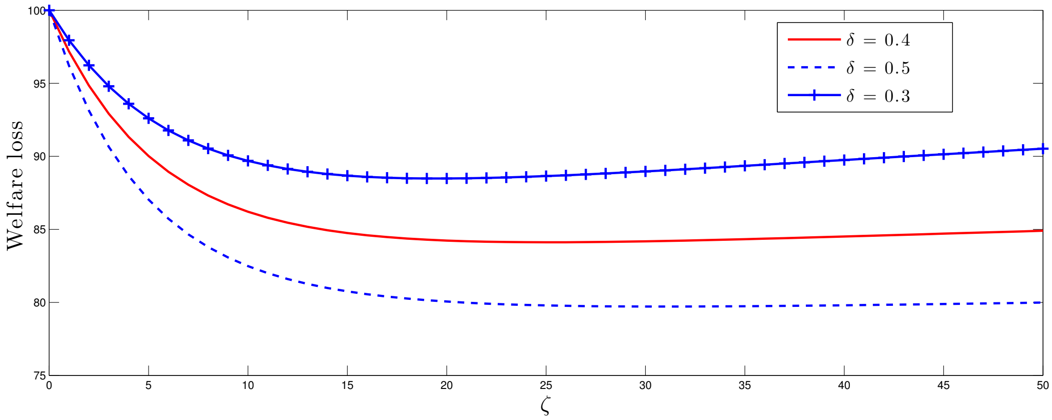


Figure 4: Welfare losses for different values of ζ relative to constant consumption taxes (=100) for different steady state shares δ of non-traded goods.

in welfare from a responsive consumption tax increase in δ. A larger share of non-traded goods allows for larger differences in the domestic inflation rates of the two member countries and hence increase the scope for persistent inflation differentials in the monetary union as discussed in section 2.5. Larger (smaller) inflation differentials make the responsive consumption tax rule more (less) favourable from a welfare perspective explaining the observed pattern in figure 4.

Similarly, figure 5 repeats the previous analysis for different steady state import shares, ω. The baseline calibration allowed for home bias by setting $\omega = 0.4$. Figure 5 displays the gains in welfare for the scenario when home bias is absent ($\omega = 0.5$) and for a stronger home bias than in the baseline calibration ($\omega = 0.3$). In line with the previous observation concerning the steady state share of non-traded goods, the gain from the responsive policy increases in the size of the home bias, i.e. the larger the home bias the larger the gain from the responsive consumption tax rule. A larger home bias allows for larger differences

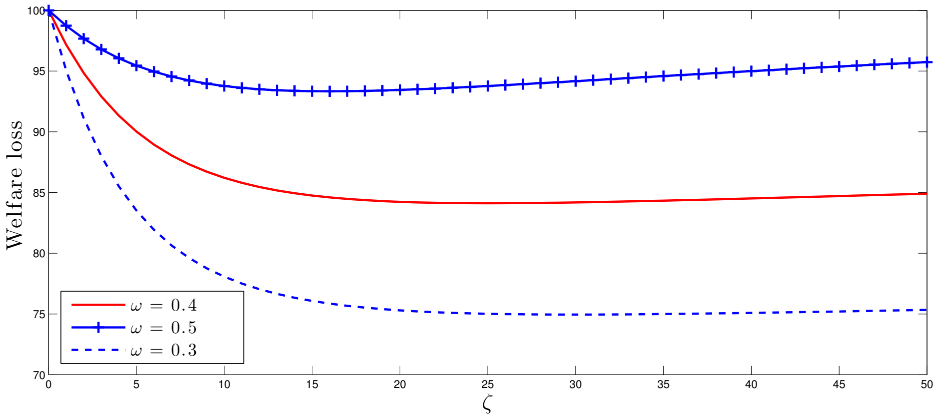


Figure 5: Welfare losses for different values of ζ relative to constant consumption taxes (=100) for different steady state import shares ω.

in domestic inflation rates and the fiscal rule is able to reduce welfare losses to a larger extent for a given ζ.
Lastly, figure 6 illustrates the sensitivity of the results with respect to the degree of the nominal rigidity, θ. The benchmark took an average price lifetime of three quarters ($\theta = 2/3$). The robustness analysis considers an average price lifetime of two ($\theta = 1/2$)

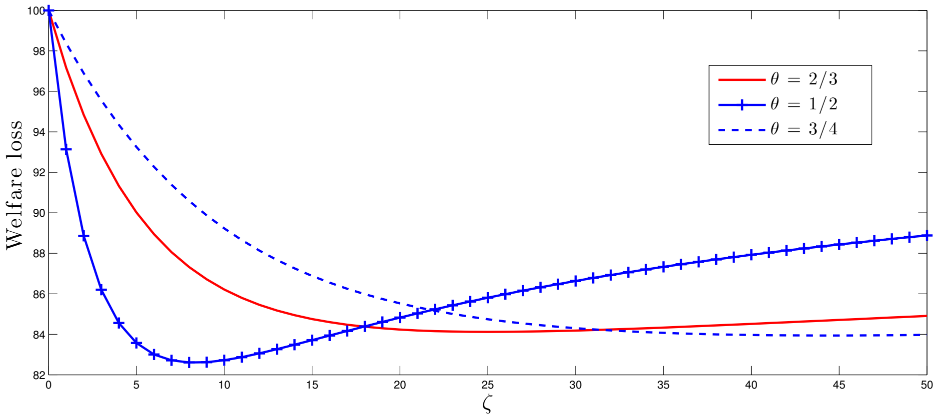


Figure 6: Welfare losses for different values of ζ relative to constant consumption taxes (=100) for different degrees of the nominal rigidity θ

and four ($\theta = 3/4$) quarters. Generally, gains in welfare remain sizeable for less as well as for more rigid prices. In the case of less rigid prices ($\theta = 1/2$) the responsive policy performs better for low values of ζ than the benchmark while the opposite is true for more rigid prices. The degree of the nominal rigidity governs the scope as well as the persistence of price dispersion. Under less rigid prices, a larger fraction of firms can adjust their prices after an exogenous disturbance, causing a rise in price dispersion. However, the persistence of price dispersion is lower when a larger fraction of firms can adjust their prices each period. Consequently, large sensitivities of the consumption tax rule are less favourable from a welfare perspective relative to the benchmark where price dispersion is more persistent. The opposite logic applies to the case of a higher nominal rigidity.

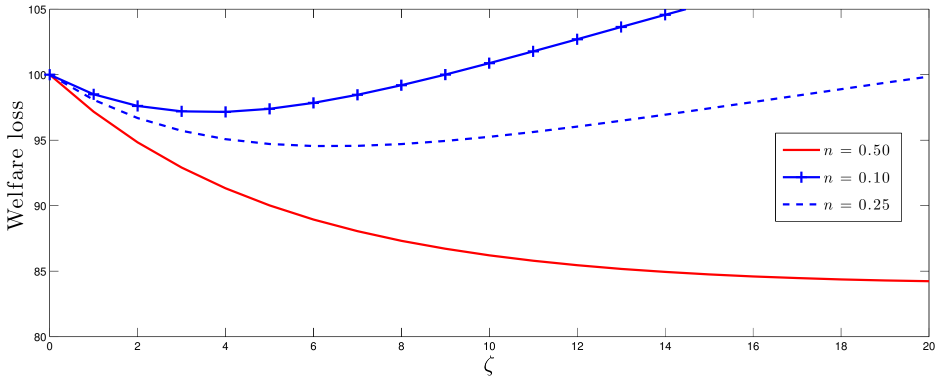
6.2 Sensitivity to the setting of the union

6.2.1 Size of the home economy

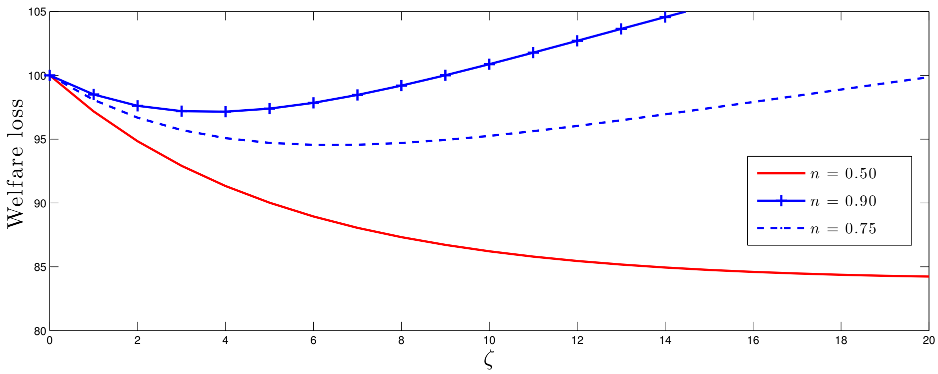
In the baseline calibration both countries were of equal size, i.e. a country's mass in the monetary union was 0.5. In order to determine the role of a country's size for the welfare analysis the model can be modified to allow for different sizes of the home (n) and foreign economy ($1-n$) while maintaining an equal steady state per-capita-output across the two countries. Relevant changes materialise in the demand for traded goods where foreign demand has to be weighted according to the relative size of the foreign to the home economy. Similarly, the parameter governing the home bias has to be adjusted to account for the relative size of the domestic to the foreign economy. Lastly, the definition of union-wide inflation takes the more general form of

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

which feeds into the Taylor rule for the union-wide nominal interest rate.[6]
Figure 7 presents the results of the welfare analysis when the home economy is smaller or larger than the foreign economy. It is evident that welfare gains under a responsive



(a) Small home economy



(b) Large home economy

Figure 7: Welfare losses of the home economy for different values of ζ relative to constant consumption taxes (=100) for different sizes n of the home economy.

consumption tax rule are largest when the countries are of equal size. The larger the

[6] A formal derivation of the changes in the model's equations is available from the author upon request.

asymmetry in the size of the two member countries of the union, the smaller are the welfare gains from the responsive consumption tax for a given sensitivity ζ. This finding is symmetric across sizes, i.e. the larger economy is not better off than the smaller and vice versa. When the home economy is relatively larger than the foreign economy, union-wide inflation is largely driven by the inflation rate of the home economy. The responsive consumption tax becomes less advantageous when ones impact on the union-wide inflation rate is relatively larger (smaller) than the one of the other country because the stabilisation is not carried out symmetrically. A relatively small country would need to adjust its consumption tax by a larger amount than the larger foreign economy to drive the inflation differentials back to their steady state. Given symmetric sensitivities, welfare gains are smaller compared to the benchmark the larger the discrepancy in size of the two countries in the union.

6.2.2 Unilateral policy

The preceding analysis has been conducted under the assumption of symmetry, specifically that both member countries of the union adopt the consumption tax rule that responds to the domestic inflation differential. Figure 8 displays the results of the welfare analysis for the home economy when the foreign economy holds its consumption tax rate constant and both countries are of equal size. The graphs indicate that welfare gains remain substantial for large sensitivities ζ of the fiscal rule. However, the graph also reveals that the domestic government could increase welfare losses by reacting too strongly to the inflation differential as displayed by the blue dotted line crossing the threshold of 100. Welfare

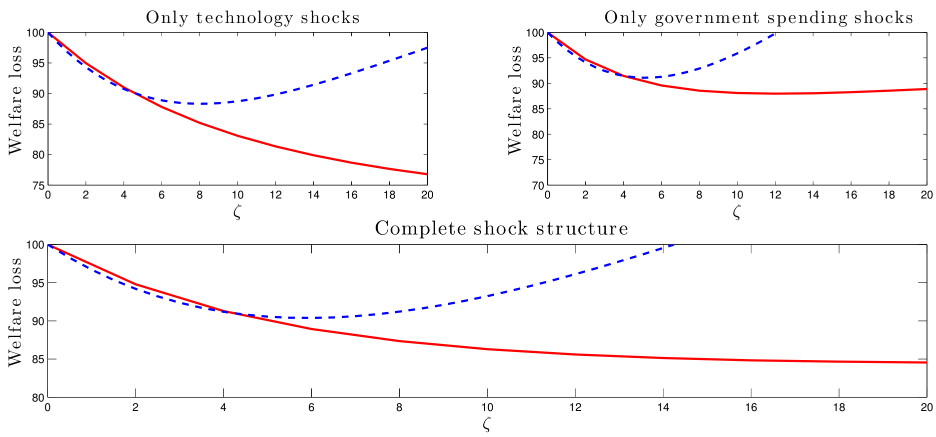


Figure 8: Welfare losses of the home economy for different values of ζ relative to constant consumption taxes (=100) when only the foreign economy features constant consumption taxes.

gains are larger when both countries actively try to stabilise their domestic inflation differential which illustrates the desirability of an alignment of fiscal policies in the monetary union. This result underlines the benefits from fiscal policy coordination in the presence of asymmetric shocks when the union-wide monetary policy remains largely inactive. Given the country-specific technology and government spending shocks a symmetric fiscal policy set-up is more favourable than a unilateral fiscal policy for a given sensitivity ζ.

7 Conclusion

This paper investigates in how far national fiscal authorities should strategically react to the domestic inflation differential. In a two-country DSGE model with traded and non-traded goods, the analysis focuses on a fiscal rule that prescribes a raise in the consumption tax in response to a positive domestic inflation differential while labour income taxes balance the governmental budget. The welfare analysis shows that large gains in the mean component of consumption largely outweigh the higher volatility of consumption under the responsive fiscal rule. The gain in mean consumption stems from a lower degree of price dispersion when the fiscal authority actively compresses domestic inflation. The decomposition of the welfare loss also shows that the large gains materialise under both technology as well as government spending shocks. The results are robust to variations in the key parameters driving inflation differentials and price dispersion. Concerning the setting of the union, the paper finds that the gains in welfare are largest when the countries both adopt the responsive fiscal rule and are of equal size.

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