Federal Fiscal Transfer Rules in Monetary Unions*

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Abstract

This paper considers simple rules for federal fiscal transfers that automatically redistribute funds among member states of a monetary union to counteract adverse idiosyncratic shocks. The transfer rules target regional differences in nominal GDP, consumption spending, labor income, and fiscal deficits. Targeting regional fiscal deficits is the only rule that reduces consumption fluctuations and that promotes interregional consumption risk sharing, but the overall welfare effect is negative. In contrast, targeting regional differences in labor income yields the largest welfare gains, but it also yields the largest fluctuations in consumption and real GDP. It is demonstrated that the welfare gains primarily stem from reducing the allocative inefficiency of input factors caused by nominal rigidities. The optimal transfer rule essentially implies a combination of consumption spending and labor income targeting, and it primarily targets the allocative inefficiency of factor inputs at the cost of lower interregional consumption risk sharing.

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1 Introduction

The continuing economic turbulence in the European Economic and Monetary Union (EMU) with the economic and political crises in Greece and Ireland has sparked off an unprecedented debate about the viability of the single currency in Europe. The concern is not merely about the success of EMU but about the success of European unification on the whole. There is no controversy about the exigency of new fiscal rules and automatic stabilization mechanisms such as federal fiscal transfers. In the view of many, EMU has already evolved into a transfer union without any formal foundation. This paper addresses the question of how a federal fiscal transfer scheme should be designed in monetary unions and at what transfer payments should be targeted.

The idea to complement EMU with a system of federal fiscal payment schemes is far from new and can be traced back to suggestions made by Meade (1957) and Ingram (1959). In a study on the feasibility of EMU, the so-called MacDougall Report (European Commission (1977)) recommended a system of built-in fiscal transfers that automatically redistribute funds among the member states in order to countervail the effects of asymmetric shocks. The transfers could be either between fiscal authorities or between private households. In a report on EMU, Delors (1989) advocated binding limits on national budget deficits and the coordination of national fiscal policies that establishes a union-wide federal fiscal adjustment mechanism that is able to absorb asymmetric shocks among the member states. Delors argued that the lack of such an arrangement would cause tensions within the monetary union that may even lead to a breakdown of the union. As is well known, the Maastricht Treaty took only the limits on national budget deficits and public debts into consideration which were anchored in the Stability and Growth Pact.

The basic argument for federal fiscal transfer arrangements builds on the theory of Optimum Currency Areas (OCA) pioneered by Mundell (1961), McKinnon (1963), and Kenen (1969). Creating a monetary union means the loss of national monetary policy instruments and flexible exchange rates among member states. According to OCA, this loss becomes severe if other economic adjustment mechanisms to idiosyncratic regional shocks also fail because prices or wages are sticky and production factors are immobile. As Kenen (1969) pointed out, a system of built-in fiscal transfers might then serve as an alternative adjustment mechanism in order to provide member states insurance against asymmetric shocks. In consideration of the relevance of that argument, it is surprising that it lacks a sound analysis within a modern quantitative business cycle model.

In this paper, I provide a quantitative analysis of federal fiscal transfer rules that target regional differences in (i) nominal GDP, (ii) consumption spending, (iii) labor income, and (iv) fiscal deficits. The purpose of the paper is to study the properties of the different trans-

fer rules with respect to stabilization of regional fluctuations, interregional risk-sharing, and welfare. I also consider the optimal simple transfer rule that maximizes union-wide welfare. The analysis of the federal fiscal transfer schemes is embedded into a dynamic stochastic general equilibrium model of a monetary union that consists of two regions and which follows closely Chari et al. (2002) and Kollmann (2001). The framework resembles the OCA environment in so far as the main features of the model are nominal price and wage rigidities, immobile factors, and incomplete financial markets. In this model, business cycle fluctuations are driven by shocks to regional total factor productivity and regional government spending. To facilitate the comparison of first moments of the equilibrium distribution, the computation of welfare, and the numerical calculation of the optimal simple transfer rule, I compute a second-order approximation to the solution of the model as described by Sims (2000) and Kim et al. (2008).

In the context of the model, a federal fiscal transfer scheme that strictly equalizes regional differences in fiscal deficits turns out to reduce consumption business cycle fluctuations and it also promotes interregional risk sharing. This conforms to the widespread opinion that constraining regional fiscal deficits constitutes an appropriate stabilization instrument. Targeting regional fiscal deficits, however, reduces average levels of GDP, consumption, physical capital and it increases the average level of labor. By implication, the welfare gains attained by reducing business cycle fluctuations are outweighed by lower average levels of consumption and leisure which lead to overall welfare losses. The quantitative results for strict nominal GDP targeting are rather ambiguous, though the welfare implications are negative. In contrast, federal fiscal transfers that strictly target regional differences in either consumption spending or labor income amplify business cycle fluctuations of consumption, GDP, investment, and employment. They also reduce the scope of interregional risk-sharing by a large amount, but they produce higher average levels of GDP, consumption, physical capital, and leisure. The overall welfare gains are positive. Targeting regional differences in labor income yields the largest fluctuations in consumption and GDP, but it also yields the largest average levels of GDP, consumption, physical capital, and leisure and thereby welfare.

The optimal transfer rule is a combination of consumption spending and labor income targeting, where more weight is attached to labor income targeting. The optimal transfer rule thus also amplifies business cycle fluctuations of GDP, investment, and consumption, but it reduces employment fluctuations. Virtually no weight is attached to regional differences in fiscal deficits. Regional differences in GDP are rather widened. These findings are seemingly contrary to the traditional notion of full stabilization of macroeconomic fluctuations that is underlying OCA and the debate over federal fiscal adjustment schemes. As it has been emphasized by the real business cycle literature (for example, Kydland and Prescott (1982),

Long and Plosser (1983), and King et al. (1988)), a presumably large fraction of business cycle fluctuations are efficient responses of the economy to exogenous fluctuations. Nominal price and wage rigidities turn out to dampen the equilibrium fluctuations of consumption and production whereas they increase employment fluctuations. As a consequence, compensating the loss of national monetary policy instruments and the exchange rate flexibility when prices and wages are sticky and production factors are immobile entails larger business cycle fluctuations for GDP and consumption and lower fluctuations for employment. Moreover, the presence of both nominal inertia and financial market incompleteness triggers a trade-off between offsetting the inefficiency caused by nominal rigidities and compensating the lack of interregional consumption risk sharing.[1] The quantitative analysis yields that the optimal transfer rule primarily targets the inefficiency caused by nominal rigidities at the cost of markedly larger consumption fluctuations. Put differently, the incompleteness of international financial markets seems to be of less importance than the implications of nominal rigidities. In this respect, the analysis reinforces the argument put forward in OCA.

Despite the repeatedly raised concerns over the lack of federal fiscal adjustment mechanisms in EMU, only little attention has been paid to the macroeconomic aspects of federal fiscal arrangements in monetary unions. The macroeconomic profession focussed on the analysis of deficit rules as implied by the Stability and Growth Pact (Maastricht Treaty, 1997), and appropriate institutional arrangements of fiscal policy coordination within monetary unions (e.g. Beetsma and Uhlig (1999), Dixit and Lambertini (2001, 2003), Uhlig (2002), Pappa and Vassilatos (2007), and Chari and Kehoe (2007)). More recently, attention has been drawn on the optimal fiscal policy of member states within a monetary union, as for example in Beetsma and Jensen (2005), Kirsanova et al. (2007), and Ferrero (2009). Evers (2010) provides an analysis of different forms of fiscal federalism within a monetary unions: fully decentralized regional fiscal authorities, fiscal equalization with nominal tax revenue sharing, and a common central fiscal authority. In the academic debate over EMU, the focus has been on the empirical assessment of federal fiscal arrangements in existing monetary unions.[2] The few macroeconomic studies of federal fiscal transfer arrangements in monetary

[1]The potential role of federal fiscal transfers for consumption risk sharing has been emphasized in the public finance perspective of fiscal federalism, eg. by Bucovetsky (1998), Lockwood (1999), Persson and Tabellini (1996a,b). Compare also the discussions in Boadway (2004) and von Hagen (2007).

[2]The seminal contributions of Sala-i-Martin and Sachs (1991) and von Hagen (1992) estimated that between 10% and 40% of regional income insurance can be attributed to the federal fiscal transfer payments in the U.S. Later studies include e.g. Atkeson and Bayoumi (1993), Goodhart and Smith (1993), Asdrubali et al. (1996), Sørensen and Yosha (1998), Obstfeld and Peri (1998), Athanasoulis and van Wincoop (2001), and Fatás (1998). Detailed overviews can be found in Mélitz and Zumer (2002), Kletzer and von Hagen (2001), and von Hagen (2007).

unions are Kletzer and Buiter (1997), Kletzer (1999), Kletzer and von Hagen (2001), and Evers (2006). The present paper studies different federal fiscal transfer schemes within a modern quantitative business cycle model. Thereby, the paper contributes to the literature along several dimensions. First, this paper provides a rigorous quantitative analysis of business cycle properties with respect to stabilization of regional fluctuations, interregional risk-sharing, the dynamics, and welfare properties of the transfers rules. Second, the paper assesses simple federal fiscal transfers that target differences in regional macroeconomic variables as discussed in the context of EMU: regional differences in (i) nominal GDP, (ii) consumption spending, (iii) labor income, and (iv) fiscal deficits. It also computes the optimal simple transfer rule as a combination of those targets. Third, this paper quantifies actual gains of the optimal transfer rule and relates them to the potential gains from increasing allocative efficiency of factor inputs and interregional consumption risk sharing.

The paper is organized as follows. The next section presents the two-country model of a monetary union. Section 3 presents the calibration and the computational details. Section 4 considers the different transfer rules with respect to first and second moments of the equilibrium distribution, dynamic responses, and welfare properties. Section 5 discusses the optimal federal transfer rule. The role of nominal rigidities and financial market incompleteness and their relevance for the optimal federal fiscal transfer scheme is discussed in Section 6. The paper concludes with Section 7.

2 A Two-country Monetary Union

There are two regions referred to as "home" (h) and "foreign" (f). In each region, there are an infinitely lived representative household, a regional fiscal authority, competitive final goods producers, and a continuum of monopolistic competitors that produce tradable intermediate goods. Final goods are produced using a combination of domestic and foreign intermediate goods as input factors and are used for either consumption or investment. Each producer of an intermediate good is a monopolistic supplier of a specific variety that is produced using capital and labor. It is assumed that intermediate goods producers charge the same price in the home and the foreign market. Price setting of intermediate goods and nominal wage setting are staggered as proposed by Calvo (1983). The market for rental capital is perfectly competitive, and input factors are immobile across regions. There is a common financial market where the households can trade a risk-free nominal bond, and the common central bank operates a nominal interest rate rule. Aggregate regional uncertainty stems from productivity shocks and government spending shocks.

I follow the standard notational convention to indicate foreign variables with a super-

scripted asterisk and the destination of traded variables with a subscripted h or f, respectively. Lower case letters denote real variables whereas upper case letters denote nominal variables. Where it is helpful, variables referring to the respective demand are indicated by superscripted d. All equations are developed for the home region only. The foreign counterparts are derived accordingly.

2.1 Production and Goods Markets Structure

Final Goods. The final goods technology combines home and foreign intermediate goods according to

$$y_t = \left[\gamma^{\frac{1}{\theta}} y_{h,t}^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} y_{h,t}^{*\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{1}$$

where $y_{h,t}$ and $y^*_{h,t}$ are composites of home and foreign intermediate input goods. The parameters θ and γ capture the elasticity of substitution between home and foreign intermediates and the degree of home bias of intermediate goods demand. The composites of the respective home and foreign intermediate input goods are given by the aggregation

$$y_{h,t} = \left[\int_0^1 y_{h,t}(i)^{\frac{\mu-1}{\mu}} di\right]^{\frac{\mu}{\mu-1}} \qquad \text{and} \qquad y^*_{h,t} = \left[\int_0^1 y^*_{h,t}(i)^{\frac{\mu-1}{\mu}} di\right]^{\frac{\mu}{\mu-1}}, \tag{2}$$

where $y_{h,t}(i)$ denotes the home intermediate good i, $y^*_{h,t}(i)$ denotes the imported foreign intermediate good i, and μ captures the elasticity of substituting different intermediates from the same region. The representative final goods producer maximizes profits, ie. $\max\{P_t y_t - \left(\int_0^1 P_{h,t}(i) y_{h,t}(i) di + \int_0^1 P^*_{h,t}(i) y^*_{h,t}(i) di\right)\}$, by choosing inputs $y_{h,t}(i)$ and $y^*_{h,t}(i)$, $i \in [0,1]$, and output quantity y_t, subject to the technology constraint and taking prices as given. P_t is the price of the final good in period t, $P_{h,t}(i)$ denotes the price of home intermediate good i, and $P^*_{h,t}(i)$ denotes the prices of foreign intermediate good i. Factor cost minimization yields the optimal demands for home and foreign composites,

$$y^d_{h,t} = \gamma \left(\frac{P_{h,t}}{P_t}\right)^{-\theta} y_t \qquad \text{and} \qquad y^{*d}_{h,t} = (1-\gamma)\left(\frac{P^*_{h,t}}{P_t}\right)^{-\theta} y_t, \tag{3}$$

and the optimal demands for each individual home and foreign intermediate good $i \in [0,1]$,

$$y^d_{h,t}(i) = \left(\frac{P_{h,t}(i)}{P_{h,t}}\right)^{-\mu} y_{h,t} \qquad \text{and} \qquad y^{*d}_{h,t}(i) = \left(\frac{P^*_{h,t}(i)}{P^*_{h,t}}\right)^{-\mu} y^*_{h,t}, \tag{4}$$

respectively. The prices of home and foreign composites are given by $P_{h,t} = \left[\int_0^1 P_{h,t}(i)^{1-\mu} di\right]^{\frac{1}{1-\mu}}$ and $P^*_{h,t} = \left[\int_0^1 P^*_{h,t}(i)^{1-\mu} di\right]^{\frac{1}{1-\mu}}$. The price of the final good is given by

$$P_t = \left[\gamma P_{h,t}^{1-\theta} + (1-\gamma)(P^*_{h,t})^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{5}$$

Intermediate Goods. The technology for producing the intermediate good $i \in [0,1]$ is given by the Cobb-Douglas production function

$$y_t(i) = a_t k_t(i)^{\alpha} l_t(i)^{(1-\alpha)}, \tag{6}$$

where a_t measures regional productivity, $k_t(i)$ is the capital stock rented by firm i, and $l_t(i)$ is a composite of differentiated labor services. The technology is identical to all domestic intermediate goods producers. The labor composite is a combination over a continuum of different types of labor services $l_t(i,j)$, $j \in [0,1]$, within a region, i.e.

$$l_t(i) = \left[\int_0^1 l_t(i,j)^{\frac{\nu-1}{\nu}} dj \right]^{\frac{\nu}{\nu-1}}, \tag{7}$$

where ν is the elasticity of substitution between different types of labor services. Letting Q_t denote the home gross nominal rental rate of capital and W_t the nominal wage payment for one effective unit of the labor composite $l_t(i)$, factor cost minimization implies the optimal demands for capital and labor composite,

$$k_t^d(i) = \frac{1}{a_t} \left(\frac{\alpha}{1-\alpha} \frac{W_t}{Q_t} \right)^{(1-\alpha)} y_t(i) \quad \text{and} \quad l_t^d(i) = \frac{1}{a_t} \left(\frac{\alpha}{1-\alpha} \frac{W_t}{Q_t} \right)^{(-\alpha)} y_t(i). \tag{8}$$

The demand of intermediate good producer i for a specific labor service j is

$$l_t^d(i,j) = \left(\frac{W_t(j)}{W_t} \right)^{-\nu} l_t(i), \tag{9}$$

where $W_t(j)$ denotes the nominal wage of labor service j and $W_t = \left[\int_0^1 W_t(j)^{1-\nu} dj \right]^{\frac{1}{1-\nu}}$. Constant marginal production costs are in nominal terms $MC_t = \frac{1}{a_t} \frac{Q_t^{\alpha} W_t^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}$. Because the law of one price is assumed to hold, $P_{h,t}(i) = P_{f,t}(i)$, firm i's period nominal profit at time t can be written as

$$\Pi_t(i)(P_t(i)) = (P_t(i) - MC(i)_t)\,(y_{h,t} + y_{f,t})\,P_{h,t}{}^{\mu} P_t(i)^{-\mu}, \tag{10}$$

where total demand for the home intermediate good i, $(y_{h,t}(i) + y_{f,t}(i))$, is obtained by integrating over all individual demand schedules of home and foreign final goods producers (Equation (4) and corresponding foreign equation).

Price Determination of the Intermediate Good. The price setting of monopolistic intermediate goods producers is staggered as proposed by Calvo (1983). With a constant probability $(1-\xi)$ the firm is able to readjust its price to react to new information. Consequently, intermediate goods producer are assumed to set the price so as to maximize expected

discounted future real profits, ie.

$$\max_{P_t(i)} \sum_{s=0}^{\infty} \xi^s E_t \left(q_{t,t+s} \frac{\Pi_{t+s}(i)(P_t(i))}{P_{t+s}} \right), \tag{11}$$

where E_t denotes the expectations operator conditional on information available at time t and ξ^s denotes the probability that the price has not been reset for s periods. The discount factor $q_{t,t+s}$ equals the marginal rate of substituting consumption between periods t and $t+s$, ie. $q_{t,t+s} = \beta^s \frac{u_{c_{t+s}}}{u_{c_t}}$, where $0 < \beta < 1$ denotes the subjective discount factor and u denotes the instantaneous period utility function. The solution to the pricing problem in (11) reads

$$\tilde{P}_{h,t}(i) = \frac{\mu}{\mu - 1} \frac{\sum_{s=0}^{\infty} E_t \xi^s \Phi_{t+s} MC_{t+s}}{\sum_{s=0}^{\infty} E_t \xi^s \Phi_{t+s}}, \tag{12}$$

with $\Phi_{t+s} = \frac{q_{t,t+s}}{P_{t+s}} \left(y_{h,t} + y_{f,t} \right) \left(P_{h,t+s} \right)^{\mu}$. The optimal pricing decision is completely forward looking and it is independent of the firm's current state and thus identical across all firms that are able to change prices. As a consequence, a fraction $(1 - \xi)$ of home intermediate goods producers will post the new price $\tilde{P}_{h,t}$ according to (12). Following Yun (1996), the price index over home intermediate goods can be written recursively as

$$P_{h,t} = \left(\xi P_{h,t-1}^{(1-\mu)} + (1 - \xi) \tilde{P}_{h,t}^{(1-\mu)} \right)^{\frac{1}{(1-\mu)}}. \tag{13}$$

Aggregate demand for physical capital and specific labor services. The aggregate demand for physical capital in the home region is obtained by integrating over the individual factor demands in (8),

$$k_t^d = \int_0^1 k_t^d(i) di = \frac{1}{a_t} \left(\frac{\alpha}{1 - \alpha} \frac{W_t}{Q_t} \right)^{(1-\alpha)} \left(\frac{\mathcal{P}_{h,t}}{P_{h,t}} \right)^{-\mu} \left(y_{h,t} + y_{f,t} \right), \tag{14}$$

where the final goods producers' specific demand in (4) is used. The auxiliary price index $\mathcal{P}_{h,t}$ is defined as $\mathcal{P}_{h,t} = \left(\int_0^1 P_{h,t}(i)^{-\mu} di \right)^{\frac{1}{-\mu}}$. It follows the recursion

$$\mathcal{P}_{h,t} = \left(\xi \mathcal{P}_{h,t}^{-\mu} + (1 - \xi) \mathcal{P}_{h,t-1}^{-\mu} \right)^{\frac{1}{-\mu}} \tag{15}$$

and it captures the price dispersion among home intermediate goods producers.
The aggregate demand for the composite of differentiated labor services is similarly obtained and reads

$$l_t^d = \int_0^1 l_t^d(i) di = \frac{1}{a_t} \left(\frac{\alpha}{1 - \alpha} \frac{W_t}{Q_t} \right)^{(-\alpha)} \left(\frac{\mathcal{P}_{h,t}}{P_{h,t}} \right)^{-\mu} \left(y_{h,t} + y_{f,t} \right) = \frac{1 - \alpha}{\alpha} \frac{Q_t}{W_t} k_t^d. \tag{16}$$

The total demand for a specific labor service j is then

$$l_t^d(j) = \frac{1 - \alpha}{\alpha} Q_t k_t^d {W_t}^{\nu - 1} W_t(j)^{\nu}. \tag{17}$$

2.2 The Representative Household

The representative household is assumed to consist of a continuum of members named j, $j \in [0,1]$. Each member specializes in the supply of a particular differentiated labor service j. He sets his own nominal wage so as to maximize the overall utility of the household taking the wages of the other members as given. Household members are identical with respect to all variables except for their labor effort and their wages.[3]

Preferences. The preferences are described by

$$U_0 = \sum_{t=0}^{\infty} \beta^t E_0 u\left(c_t, m_t, (1-l_t)\right) \tag{18}$$
$$\text{with} \quad u\left(c_t, m_t, (1-l_t)\right) = \frac{1}{1-\varrho}\left[\chi c_t^{\epsilon} + (1-\chi)(\tfrac{M_t}{P_t})^{\epsilon}\right]^{\frac{1-\varrho}{\epsilon}} + \kappa\tfrac{(1-l_t)^{1-\eta}}{1-\eta}.$$

The representative household receives utility from per capita consumption, $c_t = \int_0^1 c_t(i)di$, from holding per capita real money balances, $m_t = \int_0^1 m_t(i)di$, and from per capita leisure, $(1-l_t) = (1-\int_0^1 l_t(i)di)$, where l_t denotes per capita labor.

Optimal consumption and investment decisions. The household allocates resources between consumption c_t and investment into physical capital, x_t, money balances m_t, and nominal bonds B_t. It receives income from labor of all its members, $\int_0^1 W_t(i)l_t(i)di = W_t l_t$, from profits of intermediate goods production, $\int_0^1 \Pi_t(i)di = (y_{h,t} + y_{f,t})P_{h,t} - Q_t k_t - W_t l_t$, from gross interest payments on the stock of nominal bonds $(1+R_{t-1})B_{t-1}$, and from renting out the stock of physical capital, $Q_t k_t$. The law of motion for physical capital is

$$k_{t+1} = (1-\delta)k_t - \Psi_K(k_{t+1}, k_t) + x_t, \tag{19}$$

where x_t denotes gross investments, δ is the depreciation rate, and $\Psi_K(\cdot)$ denotes the costs of adjusting the capital stock. They are given by $\Psi_K(k_{t+1}, k_t) = \frac{\psi_K}{2}\frac{(k_{t+1}-k_t)^2}{k_t}$, where $\psi_K > 0$. Holding bonds incurs convex cost of $\Psi_B(B_t) = \frac{\psi_B}{2}(\frac{B_t}{P_t})^2$ with $\psi_B > 0$.[4] The regional fiscal authority levies proportional taxes on consumption and labor income, and also a lump-sum tax $T_{RF,t}$. The budget constraint in period t is

$$\begin{aligned} & B_t + M_t + P_t\left[(1+\tau_c)c_t + x_t + \Psi_B(B_t)\right] \\ = \;& (1+R_{t-1})B_{t-1} + M_{t-1} + Q_t K_t + \Pi_t + (1-\tau_l)W_t l_t + T_{RF,t}. \end{aligned} \tag{20}$$

The household's optimization problem is to choose $\{c_t, x_t, B_t, M_t, \{l_t(i)\}_{i\in[0,1]}\}_{s=0}^{\infty}$ so as to maximize expected life-time utility (19) subject to the flow budget constraint (20) and subject to a borrowing constraint $B_t \geqq -\bar{B}$ for some positive $\bar{B}$ to rule out Ponzi schemes.

[3] Compare Merz (1995) and Andolfatto (1996) on this modelling strategy.

[4] The convex bond holding costs $\Psi_B(\cdot)$ guarantee stationarity of the dynamic stochastic equilibrium system. See Schmitt-Grohé and Uribe (2003) for a discussion.

Taking prices, firms' profits and the initial conditions for $\{k_0, B_{-1}, M_{-1}\}$ as given, the corresponding first order conditions are

$$\frac{1+\psi_B \frac{B_t}{P_t}}{1+R_t} = E_t q_{t,t+1} \frac{P_t}{P_{t+1}} \tag{21}$$

for optimal bond holdings,

$$\left(1 - \frac{u_{m_t}}{u_{c_t}}\right) = \frac{1}{1+R_t} \tag{22}$$

for optimal real money balances, and

$$1 + \Psi_{K,k_{t+1}}(k_{t+1}, k_t) = E_t q_{t,t+1} \left(1 - \delta + \frac{Q_{t+1}}{P_{t+1}} - \Psi_{K,k_{t+1}}(k_{t+2}, k_{t+1})\right) \tag{23}$$

for optimal investment, where $\Psi_{K,k_{t+1}}(k_{t+1}, k_t) = \frac{\partial \Psi_K(k_{t+1},k_t)}{\partial k_{t+1}}$ and $\Psi_{K,k_{t+1}}(k_{t+2}, k_{t+1}) = \frac{\partial \Psi_K(k_{t+2},k_{t+1})}{\partial k_{t+1}}$. Recall the definition of the discount rate $q_{t,t+s} = \beta^s \frac{u_{c_{t+s}}}{u_{c_t}}$ in (11).

Labor supply and wage setting. Each member j sets the nominal wage of his specific labor service so as to maximize expected discounted future utility of the household (19). Similar to intermediate goods price setting, wage setting is staggered in the Calvo fashion where $(1-\zeta)$ denotes the probability that the provider is able to change his wage. The optimal wage satisfies the first-order condition

$$\widetilde{W}_t(j) = \frac{\nu}{\nu - 1} \frac{(1+\tau_c)}{(1-\tau_l)} \frac{E_t \sum_{s=0}^{\infty} \zeta^s \beta^s \Xi_{t+s} (-u_{l_{t+s}})}{E_t \sum_{s=0}^{\infty} \zeta^s \beta^s \Xi_{t+s} \frac{u_{c_{t+s}}}{P_{t+s}}}, \tag{24}$$

where $\Xi_{t+s} = \frac{1-\alpha}{\alpha} Q_t k_t {W_t}^{\nu-1}$. The aggregate wage level follows

$$W_t = \left(\zeta W_{t-1} + (1-\zeta)\widetilde{W}_t\right). \tag{25}$$

2.3 Market Clearing Conditions, Definitions and Equilibrium

The real exchange rate is defined as $rx_t = \frac{P_t^*}{P_t}$. Home real GDP is given by the final good output plus net exports, ie.

$$gdp_t = y_t + \frac{P_{h,t}}{P_t} y_{h,t}^* - \frac{P_{f,t}}{P_t} y_{f,t}. \tag{26}$$

Home real net exports are stated in terms of home GDP,

$$nx_t = \frac{P_{h,t}^* y_{h,t}^* - P_{f,t} y_{f,t}}{P_t gdp_t}. \tag{27}$$

In equilibrium, the following market clearing conditions and their foreign counterparts must hold: Each intermediate good producer $i \in [0,1]$ satisfies its specific demand and hence in the aggregate $y_{h,t} = y^d_{h,t} + y^{*d}_{h,t}$ holds. Likewise, each worker j satisfies the demand for his specific labor service for all intermediate firms $i \in [0,1]$ and hence in the aggregate $l_t = \int_0^1 l^d_{h,t}(i)di$ holds. The clearing condition for the rental market for physical capital reads $k_t = \int_0^1 k^d_{h,t}(i)di$. The home final good market clearing is $y_t = c_t + i_t + \Psi_t(B_t) + g_t$. Interregional bond market clearing implies $B_t + B^*_t = 0$, and money market clearing requires $M_t + M^*_t = M^{MU}_t$, where M^{MU}_t denotes the overall union-wide money supply.

2.4 The Central Monetary Authority

The central monetary authority operates its monetary policy by following the nominal interest rate rule (as in Clarida et al. (1998))

$$R_t = \lambda_R R_{t-1} + (1-\lambda_R)\left(\bar{R} + \lambda_\pi E_t \log \pi^{MU}_{t+1} + \lambda_{gdp}\left(\log gdp^{MU}_t - \log \overline{gdp}^{MU}\right)\right). \tag{28}$$

In (28), $E_t\pi^{MU}_{t+1} = \frac{1}{2}E_t(\pi_{t+1} + \pi^*_{t+1})$ denotes the expected average union-wide gross inflation and $gdp^{MU}_t = \frac{1}{2}(gdp_t + gdp^*_t)$ denotes the average union-wide GDP. The targets for the nominal interest rate, the inflation rate, and GDP are the respective zero inflation steady state levels. Seignorage is equally shared among the regional fiscal authorities,

$$M^{MU}_t - M^{MU}_{t-1} = T_{CB,t} + T^*_{CB,t}, \tag{29}$$

where M^{MU}_t is the union-wide money supply and $T_{CB,t} = T^*_{CB,t}$ for symmetric regions.

2.5 Regional Fiscal Authorities

The home fiscal authority levies taxes on consumption and on labor income and it collects a lump-sum tax $T_{RF,t}$. It receives seignorage from the central bank, $T_{CB,t}$, and a federal transfer $T_{CF,t}$. Taken together, total fiscal revenues FR_t of the home authority are given by

$$FR_t = \tau_c P_t c_t + \tau_l W_t l_t + T_{RF,t} + T_{CF,t} + T_{CB,t}. \tag{30}$$

Tax rates on consumption and labor income are assumed to be constant but tax receipts vary over the cycle because the tax bases, consumption expenditures and labor income, will change over time. Regional fiscal revenues are used to finance exogenous stochastic public goods demand g_t. The period budget constraint of the home fiscal authority thus implies

$$P_t g_t = FR_t. \tag{31}$$

Total revenues equal current regional government spending because the appropriate the lump-sum tax $T_{RF,t}$ ensures budget balance. However, because the Ricardian Equivalence

holds in this setup, the adjustment of lump-sum taxes can be used to express regional fiscal deficits. To be specific, the regional fiscal deficit D_t is defined as the sum of the primary deficit and interest payments on outstanding debt, where the primary deficit is given by the adjustment in lump-sum taxes. Formally,

$$D_t = (R_{t-1} - 1)\bar{\mathcal{B}} + (T_{RF,t} - P_t \bar{t}_{RF}), \tag{32}$$

where $\bar{\mathcal{B}}$ denotes the constant (steady state) nominal home public debt and $\bar{t}_{RF}$ denotes the lump-sum tax that implies zero fiscal deficit in steady state. Abstracting from the explicit analysis of the dynamic evolution of regional public debt is without loss of generality in this framework, but it keeps the structure of regional fiscal policy simple and transparent.

2.6 Federal Fiscal Authority

The federal fiscal authority collects transfers from one region and rebates the receipts to the other region. It serves as a balance sheet only and the central fiscal budget constraint is simply

$$T_{CF,t} + T^*_{CF,t} = 0. \tag{33}$$

The federal fiscal regime is specified by the respective transfer rule. Following the motivation in the introduction, I consider targeting rules that are aimed at closing regional differences of various macroeconomic variables: domestic income measured by nominal GDP, private consumption spending, labor income, and regional fiscal deficits. For instance, a transfer that targets regional differences in labor income equates home and foreign earned income, i.e. $W_t l_t = W^*_t l^*_t$ which is stated in real terms as $w_t l_t = w^*_t l^*_t rx_t$. Similarly, a transfer that equates home and foreign nominal consumption spending sets $c_t = c^*_t rx_t$. The general targeting rule is of the form

$$\left(\frac{gdp_t}{gdp^*_t rx_t}\right)^{\varphi_{gdp}} \left(\frac{c_t}{c^*_t rx_t}\right)^{\varphi_{con}} \left(\frac{w_t l_t}{w^*_t l^*_t rx_t}\right)^{\varphi_{lab}} \left(\frac{\exp\{d_t\}}{\exp\{d^*_t rx_t\}}\right)^{\varphi_{gov}} = 1. \tag{34}$$

The parameters φ_i capture the strength by which the transfers react to regional differences in the respective target $i \in \{gdp, con, lab, def\}$. Consequently, the transfer rule that strictly targets differences in nominal consumption spending is depicted by the parameter combination that sets $\varphi_{con} = 1$ and $\varphi_{gdp} = \varphi_{lab} = \varphi_{gov} = 0$. Note that the targeting rule is fully specified if three parameters are determined as there is one degree of freedom for the parameter choice.[5]

[5]Compare eg. Ferrero (2009) and Svensson (2003) on employing targeting rules instead of instrument rules in the analysis of fiscal and monetary policy.

The quantitative analysis considers the stabilization and welfare properties of rules that strictly target the regional differences in nominal GDP, consumption spending, labor income, and regional deficit. The strict targeting rules are compared to the benchmark scenario where no federal fiscal arrangement exists and to the optimal rule where the parameters φ_i are chosen so as to maximize union-wide welfare. In order to assess the extent to which simple federal transfer arrangements are capable to eliminate the effects of nominal rigidities and to provide interregional private insurance, I also compare the optimal rule to the scenario without nominal rigidities and complete financial markets.

3 Solution Method, Calibration and Simulation

The nonlinear stochastic rational expectations model is solved numerically computing a second-order approximation to the solution of the model about the deterministic zero inflation steady state. A first-order approximation ignores the interaction of nonlinearities and uncertainty. As Kim and Kim (2003) show, welfare comparisons based on linear solution methods may be highly misleading. To account for the insurance effect of federal fiscal transfers for both first moments of the equilibrium distribution as well as welfare, I compute the second-order approximation using the code provided by Sims (2000) which is explained in Kim et al. (2008).

3.1 Calibration

The model is calibrated to quarterly data of a set of member countries of the European monetary union. The empirical statistics are computed using data from nine European countries (Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, and Spain) over the sample period 1999Q1-2007Q4. Relative variables are calculated using the respective remaining countries and weighted by time-varying tradeshares. For all variables, first logs (except for inflation rates) and then the HP-filter with smoothing parameter set to 1600 has been applied. The parametrization strategy follows standard procedures and it is summarized in Table 1A.

3.2 Exogenous Processes and Shock Decomposition

Home and foreign productivity follows an autoregressive process of the simple form

$$\begin{bmatrix} \log a_t \\ \log a_t^* \end{bmatrix} = \begin{bmatrix} \rho_a \\ \rho_{a^*} \end{bmatrix} \begin{bmatrix} \log a_{t-1} \\ \log a_{t-1}^* \end{bmatrix} + \begin{bmatrix} \epsilon_t^a \\ \epsilon_t^{a^*} \end{bmatrix}. \tag{35}$$

The innovations to productivity, ϵ_t^a and $\epsilon_t^{a^*}$, have zero mean, they are correlated with $corr_{a,a^*}$, and they have zero serial correlation. Following Backus et al. (1994), the process for regional government expenditures takes the form

$$\begin{bmatrix} g_t \\ g_t^* \end{bmatrix} = \begin{bmatrix} (1-\rho_g)\bar{g} \\ (1-\rho_{g^*})\bar{g}^* \end{bmatrix} + \begin{bmatrix} \rho_g \\ \rho_{g^*} \end{bmatrix} \begin{bmatrix} g_{t-1} \\ g_{t-1}^* \end{bmatrix} + \begin{bmatrix} \epsilon_t^g \\ \epsilon_t^{g^*} \end{bmatrix}. \tag{36}$$

The innovations to government spending, ϵ_t^g and $\epsilon_t^{g^*}$, have zero mean and zero serial correlation. In line with the data, they are mutually uncorrelated. The calibration of the shock processes are presented in Table 1B.

3.3 Shock Decomposition

The purpose of the paper is to study the properties of federal fiscal transfer arrangements that serve as automatic stabilizers responding to asymmetric shocks. To this end, shocks to home and foreign productivity and government expenditures are decomposed into common components and difference components. The aggregate (union-wide) component is defined as the weighted sum of home and foreign shocks, ie. $\epsilon_w = \frac{1}{2}(\epsilon+\epsilon^*)$. The difference (asymmetric) components are defined as $\epsilon_d = \frac{1}{2}(\epsilon-\epsilon^*)$. Difference components are perfectly negatively correlated across regions, but they are orthogonal to the common shocks. The vector of shocks can be expressed as

$$\begin{bmatrix} \epsilon \\ \epsilon^* \end{bmatrix} = \begin{bmatrix} \epsilon_w + \epsilon_d \\ \epsilon_w - \epsilon_d \end{bmatrix}, \tag{37}$$

where ϵ_w and ϵ_d have zero mean. The respective variances are given by

$$\sigma^2_{\epsilon_w} = \frac{1}{4}\left(\sigma^2_\epsilon + \sigma^2_{\epsilon^*} + 2\sigma_{\epsilon,\epsilon^*}\right) \quad \text{and} \quad \sigma^2_{\epsilon_d} = \frac{1}{4}\left(\sigma^2_\epsilon + \sigma^2_{\epsilon^*} - 2\sigma_{\epsilon,\epsilon^*}\right). \tag{38}$$

The covariance is zero, ie. $\sigma_{\epsilon_w,\epsilon_d} = 0$. The shock decomposition allows to extract business cycle statistics, welfare levels, and the dynamics for perfectly asymmetric shocks. This yields a clear view on the properties of different federal fiscal transfer arrangements. This analysis is conducted in the next section.

3.4 Welfare Measure

The different federal fiscal transfer arrangements are evaluated based on the welfare compensation of a permanent change of consumption relative to the steady state.[6] Home welfare

[6]Compare Lucas (1987, 2003).

is defined as

$$U = \sum_{t=0}^{\infty} \beta^t E u\left(c_t, (1 - l_t)\right), \tag{39}$$

where $u\left(c_t, (1 - l_t)\right)$ denotes the household's period instantaneous utility abstracting from real balances and E denotes the unconditional expectations operator. Let υ^A denote the welfare gain associated with transfer regime A. It is defined as the percentage change in permanent consumption relative to the deterministic steady state such that the representative household is indifferent between being in regime A or in the deterministic steady state. Formally,

$$U^A = \sum_{t=0}^{\infty} \beta^t E u\left(c_t^A, (1 - l_t^A)\right) = \sum_{t=0}^{\infty} \beta^t u\left((1 + \upsilon^A)\bar{c}, (1 - \bar{l})\right). \tag{40}$$

The welfare compensation υ^A can be decomposed into its mean and variance components, υ_M^A and υ_V^A where $(1 + \upsilon^A) = (1 + \upsilon_M^A)(1 + \upsilon_V^A)$. The change in the mean can be further decomposed into its two components, consumption $\upsilon_{M,c}^A$ and labor $\upsilon_{M,l}^A$, where $(1 + \upsilon_M^A) = (1 + \upsilon_{M,c}^A)(1 + \upsilon_{M,l}^A)$. Similarly, the variance part can be split up into the components accounting for consumption and labor variations, $(1+\upsilon_V^A) = (1+\upsilon_{V,c}^A)(1+\upsilon_{V,l}^A)$. The welfare compensations are computed consistently by a second-order Taylor expansion of the utility function about the deterministic steady state.[7]

3.5 Computation of the Optimal Transfer Rule

The optimal transfer rule is computed numerically by maximizing the expected union-wide welfare. To be specific, the sum of home and foreign welfare, $U + U^*$ is maximized with

[7] In terms of log-deviation, the second-order Taylor expansion of the period utility function yields

$$Eu(c_t, l_t) \approx \frac{\bar{c}^{1-\sigma}}{1-\sigma} + \frac{\kappa(1-\bar{l})^{1-\eta}}{1-\eta} + \bar{c}^{-\sigma} E\hat{c}_t - \kappa(1-\bar{l})^{-\eta} E\hat{l}_t - \frac{\sigma}{2\bar{c}^{(1+\sigma)}} E\hat{c}_t^2 - \frac{\kappa\eta}{2(1-\bar{l})^{(1+\eta)}} E\hat{l}_t^2,$$

where $\hat{c}_t$ and $\hat{l}_t$ denote the period log-deviation from the steady state level. Using $\log(1 + x) = x$ for small x, one obtains for the welfare compensation

$$\upsilon \;=\; \frac{1}{\bar{c}^{1-\sigma}} \left(\bar{c}^{-\sigma} E\hat{c}_t - \kappa(1-\bar{l})^{-\eta} E\hat{l}_t - \frac{\sigma}{2\bar{c}^{(1+\sigma)}} E\hat{c}_t^2 - \frac{\kappa\eta}{2(1-\bar{l})^{(1+\eta)}} E\hat{l}_t^2 \right).$$

The mean-variance decomposition yields

$$\upsilon_M = \frac{1}{\bar{c}^{1-\sigma}} \left(\bar{c}^{-\sigma} E\hat{c}_t - \kappa(1-\bar{l})^{-\eta} E\hat{l}_t \right) \quad \text{and} \quad \upsilon_V = \frac{1}{\bar{c}^{1-\sigma}} \left(-\frac{\sigma}{2\bar{c}^{(1+\sigma)}} E\hat{c}_t^2 - \frac{\kappa\eta}{2(1-\bar{l})^{(1+\eta)}} E\hat{l}_t^2 \right), \tag{41}$$

and the respective decompositions for consumption and labor are $\upsilon_{M,c} = \frac{1}{\bar{c}} \bar{c} E\hat{c}_t$, $\upsilon_{M,l} = -\frac{\kappa(1-\bar{l})^{-\eta}}{\bar{c}^{1-\sigma}} E\hat{l}_t$, $\upsilon_{V,c} = -\frac{\sigma}{2\bar{c}^2} E\hat{c}_t^2$, $\upsilon_{V,l} = -\frac{\kappa\eta}{2\bar{c}^{1-\sigma}(1-\bar{l})^{(1+\eta)}} E\hat{l}_t^2$.

respect to the parameters $\{\varphi_{gdp}, \varphi_{con}, \varphi_{lab}, \varphi_{gov}\}$ in the general targeting rule (34). The parameters are restricted to values for which a unique stationary rational expectations equilibrium exists. Specifically, I use the Matlab routine `fminunc` repeatedly over a grid of candidate coefficients.[8]

4 Business Cycle Properties of Strict Targeting Rules

The analysis of the different federal fiscal transfer regimes is based on business cycle statistics, dynamic impulse responses and welfare implications.

4.1 Business Cycle Statistics

Table 2 presents business cycle statistics for the data, the four different strict targeting rules, and the optimal transfer rule. The second column shows the statistics for the home region in the benchmark economy without federal fiscal transfers. Comparing the first and the second columns, the benchmark model performs reasonably well in matching the data both qualitatively and quantitatively. Columns 3 to 6 report the results for home region under the federal fiscal transfers that strictly target nominal GDP, consumption spending, labor income, and regional fiscal deficits. The numbers in parentheses are the percentage changes relative to the benchmark.

The first panel of Table 2 shows the standard deviations of the different scenarios. The transfers that strictly target consumption spending and labor income produce markedly larger fluctuations relative to the benchmark for all reported variables except for the real exchange rate and inflation. Nominal GDP targeting also results in higher fluctuations for consumption and employment. Targeting regional fiscal deficits, in turn, reduces the standard deviations of consumption. In terms of autocorrelations, both consumption spending targeting as well as regional deficit targeting reduce the persistence of real GDP, consumption, investment, and employment. Targeting labor income reduces the persistence of real GDP and investment most strongly, but at the same time it also increases the persistence of employment most strongly. The nominal GDP targeting rule increases the persistence of real GDP, consumption, investment, and employment. As a result, based on the analysis of standard deviations and autocorrelations, only the federal transfer scheme that targets regional fiscal deficits is capable of reducing business cycle fluctuations. In contrast, targeting regional differences in consumption spending and in labor income leads to a considerable

[8]Compare Kollmann (2004) and Schmitt-Grohé and Uribe (2007) for very similar approaches to compute optimal policy rules.

destabilization of regional real GDP, consumption, investment, and employment.

The effects of the different transfer schemes on the interregional risk-sharing can be measured by their implications on the regional cross-correlation which are reported in the third panel of Table 2. Importantly, federal fiscal transfers that target consumption spending and labor income lead to a remarkable decline in interregional risk-sharing as measured by the cross-correlations. Labor income targeting induces the strongest reduction in the cross-correlation of real GDP, consumption, and investment. The strongest reduction in the cross-correlation of employment is produced by nominal GDP targeting. Targeting regional deficit also reduces the cross-correlation of employment but it strongly promotes interregional consumption risk sharing.

The last panel of Table 2 shows that the lower consumption risk under targeting regional fiscal deficits yields lower means of physical capital, real GDP, consumption, and leisure. Conversely, the destabilizing feature of consumption spending and labor income targeting actually implies higher means for real GDP, consumption, physical capital, and leisure. One basic intuition for this finding is precautionary saving in the absence of complete financial markets: the higher the consumption risk, the more the risk averse households save in form of physical capital. In fact, the larger the implied standard deviation of consumption, the larger the implied mean of physical capital. This leads to higher average output, consumption, and leisure.

A second intuition for this finding is the change in production efficiency: Nominal rigidities prevent the efficient allocation of factor inputs in response to disturbances. Federal fiscal transfers involve the reallocation of input factors (in particular of labor) between the two regions. The indirect reallocation of factor inputs to the region where it is more productive entails efficiency gains, whereas the reallocation to the region where it is less productive entails efficiency losses.

In case of nominal GDP targeting, precautionary saving still explains the rise in mean physical capital and also mean real GDP. Due to the inefficient reallocation of factor inputs implied by the transfer, mean consumption and leisure decline relative to the benchmark. Note that the implied consumption fluctuations are similar for nominal GDP targeting and consumption spending targeting. Precautionary saving alone should yield similar implications for the mean physical capital, too. Under GDP targeting, however, it is only half of that induced by consumption spending targeting. A furthers discussion of the role of nominal rigidities and financial market incompleteness follows in Section 6, where I compare the optimal rule to the scenarios without nominal rigidities and complete financial markets.

Taken together, federal transfers that equalize regional fiscal deficits are capable to stabilize business cycle fluctuations in particular of consumption and it also promotes interregional

risk sharing. Targeting fiscal deficits, however, reduce the means of real GDP, consumption, physical capital, and leisure. In contrast, federal fiscal transfer schemes that target regional differences in either consumption spending or labor income amplify business cycle fluctuations of real GDP, consumption, physical capital, and leisure. They also reduce the scope of interregional risk-sharing by a large amount, but they produce higher means of real GDP, consumption, physical capital, and leisure. The results for nominal GDP targeting are rather ambiguous.

4.2 Dynamic Responses to Asymmetric Shocks

For a better understanding of the strict targeting rules and the previous findings, Figures 1 and 2 present the dynamic impulse responses for selected variables of the home region to asymmetric productivity and government spending shocks. By the decomposition of the shocks, responses of foreign variables to asymmetric shocks display exactly the mirror images.

Figure 1 displays impulse responses to an asymmetric productivity shock that increases home productivity. In the benchmark case, real GDP, consumption, and investment increase on impact and then follow hump-shaped courses. Due to nominal rigidities, real wages cannot adjust immediately, which is why employment falls sharply on impact. Employment recovers swiftly for the most part with the increase in GDP and labor productivity following the investments into physical capital. In the short run, the sharp rise of GDP is driven by physical investment. In the medium-run, investment activity falls but the reversing of GDP turns out to be smoother because private consumption crowds in: consumption rises with increasing returns on investment and increasing labor income as employment picks up. The real exchange rate depreciates on impact and it then follows a hump-shaped pattern. The pattern of the impulse responses are in line with the empirical findings in Enders and Müller (2009) and Galí (1999). Regarding regional fiscal budgets, home experiences a deficit on impact because revenues on labor income taxes drop. With employment and hence tax revenues catching up, fiscal budget turns into a slight surplus from then on.

In case of nominal GDP targeting, the federal transfer moderates the sharp rise of real GDP in the short and medium run and also shifts the point when GDP falls again at a later date. This is achieved by reducing home private consumption and investment relative to the benchmark in the short and medium run and increasing them later on. Recall that the federal transfer affects private households through the adjusting changes of lump-sum taxes. The response of employment is also moderated in the short-run and shifted to the right. The response of the real exchange rate is lower and skewed to the right. Because changes in the regional fiscal deficit are mostly driven by transfer payments, looking at the response of home fiscal deficit reveals the difficulty of targeting nominal GDP through

shifting private demand of rational forward-looking households. As the shift in private demand would suggest, the home region is indeed the payer of the transfer in the short and medium run reducing consumption and investment and the recipient of transfer to increasing demand later on. Anticipating that it will become the recipient of transfers later on, however, further reduces the incentive for the home region to invest into physical capital in the short run. On impact, when overall income is lowest due to the drop in employment, investment and hence GDP would be too low as compared to the targeted levels. This anticipation effect implicates that the home region is the recipient of the transfer on impact. Moreover, the initial payment becomes the largest transfer of all because savings occur mostly through bonds and not through investment. The potential limitation of the federal fiscal transfers that target private demand is even more accentuated in case of direct consumption targeting.

In case of nominal consumption spending targeting, the federal fiscal transfer sets relative home and foreign changes in consumption equal to the changes in the purchasing power, or more formally, $\widehat{c} - \widehat{c^*} = \widehat{rx}$. When federal fiscal transfers are absent, relative changes in regional consumption are lower than the changes in relative prices. Accordingly, home should be the net recipient of federal transfers in order to increase the consumption response. The response of fiscal deficits confirms this intuition for all but the very first period. On impact, the home region is the payer of the largest transfer involved. Being the beneficiary of the federal transfer, the home region would smooth out the implications of the transfer receipts to the initial consumption response on impact. This would imply that both the initial response of home consumption as well as the response of the regional consumption difference were too large as compared to the targeted ones. The transfer scheme counteracts the intertemporal consumption smoothing by the large transfer payment of the home region on impact. The overall effect is that targeting consumption differences raises the response of consumption, investment, employment and GDP relative the benchmark scenario.

Accordingly, targeting private demand by fine-tuning consumption spending and saving behavior of rational forward-looking households requires not only rather complex transfer schemes, it also leads to comparatively large transfer volumes. As a result, the efficacy of federal fiscal transfers that target either nominal GDP or consumption spending is rather limited.

In contrast, targeting regional labor income aims the federal fiscal transfer at the difference of nominal income streams. The responses to a productivity shock look very different from the benchmark case and the federal fiscal transfers targeting nominal GDP or consumption spending: Investment and real GDP react most strongly on impact and then converge gradually to the benchmark responses. Consumption also reacts by more on impact and stays longer above the benchmark response. As a consequence, employment falls only slightly on

impact and displays an inverse hump-shape. It is important to stress that the federal fiscal transfer does not target employment directly. Instead, the transfer targets the differences in regional labor income. This has two important implications: First, the transfer compensates the initial loss of labor income caused by the sharp drop in employment. This compensation enhances both private consumption and in particular investment and results thereby to the strongest response of GDP to the shock on impact. Even though real wages cannot adjust immediately, the impact on employment is almost absorbed. Second, as the transfer targets regional differences in labor income in each period, the efficacy of the transfer is not diluted through intertemporal considerations of private households to smooth out transfer payments as it is the case with nominal GDP or consumption spending targeting. Instead, intertemporal considerations focus on the returns on physical investment: the higher the level of productivity, the stronger is the investment response. This will become clearer in Section 6.

The federal fiscal transfer that targets regional fiscal deficits displays responses to productivity shocks that look very similar to the benchmark responses. According to the home fiscal deficit in the benchmark case, home is the net recipient on impact. The sharp drop in employment and hence labor income tax revenues on impact outweighs the gains from higher consumption taxes and reduced government expenditures due to the changes in the final good price. As labor income tax revenues pick up, home region has a fiscal surplus and hence becomes the net payer of transfers from then on. As a result, consumption, investment, and hence GDP respond by less to productivity shocks as compared to the benchmark scenario.

Productivity shocks are the major force of business cycle fluctuations in the model. Consequently, the impulse response analysis of asymmetric productivity shocks already explains the main insights of the previous analysis of the business cycle statistics and also the mechanisms behind the different transfer schemes. Therefore, I dispense with a detailed discussion of the dynamic responses to a positive and asymmetric shock to home public spending which are displayed in Figure 2. Instead, I directly turn to the discussion of the welfare properties of the different strict targeting rules.

4.3 Welfare Results

The welfare results are reported in Table 3. The first panel shows the overall welfare effects measured by the permanent change of consumption relative to the steady state. The second and third panel show the decomposed welfare effects for the mean and the variance, respectively. As compared to the benchmark case, federal fiscal transfers that target nominal consumption spending or labor income lead both to overall welfare gains. The overall gains are quantitatively similar, but they differ with respect to the composition of mean

compensation and variance compensation: Targeting regional labor income yields higher mean compensation but also larger welfare losses due to higher volatility. In turn, targeting consumption spending yields lower welfare gains from increasing average consumption and leisure, but welfare losses due to uncertainty are also lower. The trade-off between welfare losses due to increased volatility and welfare gains due to higher means in particular of consumption reflects the findings on the business cycle implications of the respective targeting rules.

In contrast, the federal fiscal transfer schemes that target regional differences in nominal GDP and fiscal deficits both lead to overall welfare losses compared to the benchmark. In case of GDP targeting, even though the mean compensation indicates welfare gains due to higher average consumption and leisure, these gains are outweighed by welfare losses implied by the increased volatility. The consumption stabilizing property of targeting regional fiscal deficits in fact has positive welfare effects. However, the lower fluctuations also imply lower average levels of both consumption and leisure. As a result, overall welfare losses are largest relative to all other targeting rules.

5 The Optimal Simple Federal Fiscal Transfer Rule

The numerical optimization yields that the optimal welfare maximizing coefficients of the simple general targeting rule are

$$\varphi_{gdp} = -0.3290, \quad \varphi_{con} = 0.7917, \quad \varphi_{lab} = 1, \quad \text{and} \quad \varphi_{gov} = 0.0263. \tag{42}$$

The optimal transfer rule yields a combination of consumption spending and labor income targeting, where the optimal rule attaches more weight to labor income targeting. The coefficient on targeting regional differences in nominal GDP enters with the opposite sign which implies that the optimal targeting rule allows the regional nominal GDP gap to widen instead of closing it. The weight on GDP is, however, lower in absolute terms than the coefficients on consumption and labor income targeting. Virtually no weight is attached to regional differences in fiscal deficits which are left slack.[9] Intuitively, the optimal transfer rule trades the larger mean welfare compensation of strict labor income targeting off against the lower variance compensation losses of strict consumption spending targeting. The welfare compensation for the optimal transfer rule is shown in the last column of Table 3 and it confirms this trade-off. Comparing the business cycle statistics also reveals that the optimal

[9]Note that $\varphi_{lab} = 1$ does not mean that this is a corner solution of the maximization procedure. Instead, the degree of freedom to chose parameter values allows to normalize the parameter values with respect to the largest coefficient which is φ_{lab}.

transfer implies less consumption fluctuations than strict labor income targeting and it reduces employment fluctuations. The mechanism of the optimal combination of consumption spending and labor income targeting is best captured by looking at the impulse responses in Figure 1. Putting also weight on closing the regional consumption differences shifts the consumption response of the optimal transfer to the left of the response of strict labor income targeting. This is induced by slightly raising the overall net burden of transfers and bringing it forward: The home region pays larger transfers in the short and medium run and receives less transfers from then on. As a consequence, the home region saves and invests more in the very short-run and hence the initial responses of home investment, real GDP and employment are above the responses of strict labor income targeting. Furthermore, these initial implications are bolstered by further widening the regional GDP gap as induced by the coefficient on nominal GDP targeting. The last column in Table 2 shows that - relative to strict labor income targeting - the optimal transfer reduces the standard deviations of consumption and employment, but increases the standard deviations of real GDP and investment. In terms of autocorrelation, the optimal transfer implies lower persistence of all reported variables as responses are more accentuated. In accordance, the cross-correlations of GDP and investment are also smaller. Interregional consumption risk-sharing improves relative to strict labor income targeting, and employment cross-correlation turns positive.

From a quantitative perspective, the differences between the optimal transfer rule and strict labor income targeting are small. The optimal rule, however, involves a rather complicated transfer scheme because it requires fine-tuning of private demand and hence expectations and inter-temporal decisions as in case of strict consumption targeting. In contrast, labor income targeting is comparatively simple. With regard to the implementability of the federal fiscal transfer scheme, the model suggests that welfare losses from simply following strict labor income targeting are minor.

6 The Role of Nominal Rigidities and Financial Markets Incompleteness

The finding that the optimal transfer rule yields a trade-off between targeting regional consumption spending differences and regional labor income differences motivates to further investigate the role of nominal rigidities and financial market incompleteness. On the one hand, nominal rigidities prevent the efficient equilibrium response of labor input and hence labor income. On the other hand, incomplete financial markets prevent interregional private consumption risk-sharing. The optimal transfer rule might thus reflect the trade-off between targeting inefficiencies resulting from nominal rigidities and incomplete consumption risk

sharing.

Next, I compare the optimal rule to the economy without nominal rigidities and the constrained efficient economy where prices and wages are flexible and financial markets are complete (but the economy is still subject to the monopolistic distortions). Table 4 reports the results for standard deviations, means, and welfare for the different scenarios. The comparison is restricted to perfectly asymmetric shocks, because removing nominal inertia also affects the equilibrium distribution for common aggregate shocks. To obtain unbiased statements, the appropriate comparison is conditioned on the stochastic environment with asymmetric shocks only under which the federal transfer rule is effective. The first column in Table 4 shows the figures for the benchmark economy. Columns 2-4 report the results for the optimal transfer rule, the economy without nominal rigidities, and the constrained efficient economy. The numbers in brackets in columns 2-4 denote the percentage changes relative to the benchmark scenario in column 1.

Consider first the role of nominal rigidities. When wages and prices are flexible, responses to shocks entail the efficient (abstracting from markups) reallocation of labor input such that the marginal rate of substituting leisure and consumption (MRS) equals the real wage which equals the marginal rate of transforming leisure into output (MRT, compare also equations (12) and (24)). Comparing columns 1 and 3 of Table 4 shows that without nominal rigidities the standard deviations of real GDP, consumption and investment are considerably larger whereas the standard deviation of employment is markedly smaller. The means of GDP, consumption, the stock of physical capital, and leisure increase by a large amount when wages and prices are flexible. Welfare is also larger than in the benchmark economy due to the increases in mean consumption and leisure, but higher volatility induces welfare losses as measured by the variance compensation. As a result, nominal rigidities dampen business cycle fluctuations of GDP, consumption and investment and they aggravate employment fluctuations. Because prices and wages adjust only sluggishly to shocks, the main ramification occurs on impact and in the short run. Figure 3 depicts the impulse responses to an asymmetric productivity shock that increases home productivity. Without nominal rigidities, the dynamic responses of GDP and investment are strongest on impact and decay gradually. Investment is largest when expected returns are largest, and GDP follows the pattern of investment in the short run. Employment is positive on impact, but it falls turning soon negative and it displays an inverse hump-shape. Consumption displays a hump-shape response similar to the benchmark response, but it reacts stronger on impact and also peaks earlier. In contrast, when wages and more importantly prices adjust sluggishly, prices do not equal marginal costs and hence the real wage is unrelated to the MRT. By implication, employment is laid off in response to the unexpected increase in home productivity which explains the sharp drop in employment on impact. As a consequence of the shortfall in labor

income, the initial responses of investment, consumption and hence GDP are dampened.

Consider next the constrained efficient economy. The last column in Table 4 shows that complete financial markets in fact reduce the standard deviation of consumption relative to the benchmark economy. It also reduces the standard deviation of employment but increases GDP and investment fluctuations. Welfare gains are largest for the constrained efficient economy because the reduction of consumption and employment fluctuations lead to welfare gains relative to the benchmark economy. Comparing columns 3 and 4 in Table 4 isolates the effect of perfect interregional risk sharing from the effects of removing nominal rigidities. In addition to the decline in consumption fluctuations, financial market completeness also further reduces employment fluctuations. The standard deviations of investment are almost identical and the standard deviation of GDP slightly falls. In accordance with the reduced fluctuations of consumption over the business cycle, perfect consumption risk-sharing reduces the means of consumption and leisure as the motive of precautionary saving into investment is reduced. In this respect, the large increase in the means of GDP, consumption, physical capital, and leisure must be attributed to efficiency gains from removing nominal rigidities. In terms of welfare, the additional gains implied by complete financial markets are rather small and they stem from reducing fluctuations in consumption and leisure. Figure 3 shows that the dynamic responses of the economy without nominal rigidities and the constrained efficient economy behave very similar except for consumption and the real exchange rate. Recall that when financial markets are complete, interregional consumption risk sharing implies that home marginal utility of consumption over foreign marginal utility of consumption equals the real exchange rate. The perfect risk-sharing condition implies that the consumption response is dampened and that the real exchange rate absorbs more of the shock.

These quantitative findings lead to the conjecture that the optimally designed transfer rule targets the inefficiency that stems from nominal rigidities rather than incomplete interregional risk sharing. Contrasting the optimal transfer rule with the scenario without nominal rigidities and the constrained efficient economy supports this conjecture. Looking at the standard deviations in Table 4, it strikes that the direction of changes relative to the benchmark case are identical to the economy without nominal rigidities. The standard deviations for GDP, investment, and in particulary for consumption and employment are, however, considerably larger.

The comparison of the means shows that under the optimal transfer rule the increase in the average stock of physical capital is comparable to the one achieved in the constrained efficient economy and it reaches three-quarters of the increase under flexible prices and wages. Relative changes in the means of GDP, consumption, and leisure are, however, much smaller

amounting to only less than half and roughly one-third, respectively. This indicates on the one hand that the optimal transfer still suffers losses due to the inefficient allocation of factor inputs caused by nominal rigidities even though it targets them. On the other hand, the large consumption fluctuations under the optimal transfer scheme induces precautionary saving into physical capital. In terms of welfare, the optimal transfer attains only one-quarter of the potential welfare gains. Mean compensation is roughly one-half of the potential which conforms to the relative changes in the means. The major drawback are the losses in the variance compensation due higher volatility.

Why is it then that the optimal transfer entails large consumption and employment fluctuations relative to the case without nominal rigidities and the constrained efficient economy? The reason is that the optimal transfer reallocates input factors indirectly by redistributing demand. This is best captured by the dynamic responses in Figure 3. The responses for GDP and investment are actually quite similar. The consumption response under the optimal transfer, however, lies above the responses when prices and wages are flexible and the constrained efficient economy, whereas the employment response is below the corresponding counterparts. Pushing the consumption response towards the efficient response requires to cut back the transfer payment. But the subsequent drop in private demand further depresses the response of employment. In turn, pushing the employment response to the efficient one requires a pro cyclical increase in transfer payments which causes private demand to increase. Put differently, further stabilizing either employment or consumption fluctuations aggravates the fluctuations of the other.

The preceding analysis discloses that the simple federal fiscal transfer scheme faces a trade-off between compensating the implications of nominal rigidities on production efficiency and interregional consumption risk sharing. The optimal transfer rule primarily targets the inefficient allocation of input factors as it puts up with markedly larger consumption fluctuations over the business cycle

7 Conclusion

In this paper, I studied simple federal fiscal transfer rules that automatically redistribute funds among the member states of a monetary union in order to counteract asymmetric shocks. In the absence of independent national monetary policy instruments and exchange rate flexibility, the basic rationale behind a built-in fiscal transfer scheme is that it might serve as an alternative policy instrument to dampen the effects of adverse regional shocks if other economic adjustment mechanisms fail. Within the framework of the analysis, the key adjustment frictions in the monetary union are nominal price and wage rigidities, immobile

factors, and incomplete financial markets. I examined stabilization properties, dynamics, and welfare properties of transfer rules that target regional differences in GDP, consumption, labor income and fiscal deficits.

In the context of the model, targeting regional fiscal deficits is the only rule that reduces consumption fluctuations and promotes interregional consumption risk sharing. This conforms to the popular view that keeping regional fiscal budgets balanced constitutes an appropriate federal fiscal rule. The overall welfare effect of fiscal deficit targeting, however, is negative. In contrast, targeting regional differences in labor income yields the largest welfare gains, but it also yields the largest fluctuations in consumption and GDP. It was demonstrated that the welfare gains stem mainly from reducing the allocative inefficiency of input factors caused by nominal rigidities. This, in turn, leads to the amplification of business cycle fluctuations as nominal rigidities dampen the efficient responses. Accordingly, the optimal transfer rule primarily targets the allocative inefficiency of factor inputs at the cost of lower interregional consumption risk sharing. It yields a combination of consumption and labor income targeting, where more weight is attached to labor income targeting. Regional differences in GDP are rather widened and virtually no weight is attached to regional differences in fiscal deficits.

The quantitative results suggest that differences between the optimal transfer rule and strict labor income targeting are minor. The optimal rule, however, involves a rather complicated transfer scheme because it requires fine-tuning of private demand and saving behavior of rational forward-looking households. In contrast, strict labor income targeting is fairly simple as it does not involve intertemporal considerations. From a practical perspective, the implementation of the strict labor income targeting rule thus appears to be more advantageous. From a political perspective, the implementability of simple federal transfer rules seems to be more realistic than imposing federal rules on national fiscal policymaking. Recent studies have focussed on the analysis of national fiscal policy and their role in stabilizing regional and union-wide macroeconomic fluctuations (as for example in Beetsma and Jensen (2005), Pappa and Vassilatos (2007), Kirsanova et al. (2007), Galí and Monacelli (2008), and Ferrero (2009)). Imposing federal rules on national fiscal policy conduct, however, inflicts the loss of fiscal autonomy on sovereign national governments and their prospects are therefore rather questionable.

In this paper, I concentrated on the quantitative analysis of the business cycle properties of the different transfer rules. I therefore restricted my attention to cases where national fiscal policies do not interact with the transfer schemes. A meaningful extension would be to consider the role of federal fiscal transfers if regional fiscal authorities have to meet financing requirements by adjusting either distortionary taxes or public debt. This extension would

also allow to reflect on the context of strict federal rules on national debt and deficits as in the Stability and Growth Pact. A second extension would be to examine strategic interaction among national fiscal authorities and the potential of federal fiscal transfer schemes to channel self-oriented and strategically motivated national fiscal policy conduct. A third extension would relax the assumption of a single instrument arrangement. In the present setup, nominal rigidities and incomplete financial markets are two adjustment frictions that amount to a trade-off for the single instrument rule. Along the lines of Evers (2006), including a second independent transfer might overturn the trade-off. Finally, monetary policy conduct was assumed to follow an exogenously specified Taylor rule. However, monetary policy and federal fiscal transfers do presumably interact in a non-trivial way. The optimal joint conduct of monetary policy and federal fiscal transfer schemes might be to have federal fiscal transfers synchronize regional macroeconomic variables to mimic common aggregate fluctuations which can then be effectively targeted by the common monetary authority. My conjecture is that in all suggested extensions, implementing a system of simple federal fiscal transfer arrangements turns out to be beneficial.

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TABLE 1A

Parameters Values: Structural parameters and monetary and regional fiscal policies.

Parameter	Value	Description (Source/Target)
Structural Parameters		
β	.99	Discount Rate (4% s.s. annual interest rate)
ϱ	2	Coefficient of Risk Aversion
χ	.81	Preference weight on real balances (Duarte and Wolman (2008))
ϵ	-2.66	Interest rate elasticity of money demand is $\frac{\epsilon-1}{\epsilon}$ (Duarte and Wolman (2008))
κ	2.4	Preference weight on labor (Hours worked in s.s. 0.3)
η	ϱ	Balanced growth path (Labor supply elasticity is 1.17)
ϕ_k	1.09	Capital adj. costs (matches $\frac{std(inv)}{std(gdp)}$ to the data)
ϕ_b	0.0434	Bonds adj. costs (sets $\frac{.0038}{\bar{y}_h^*}$, Kollmann (2003, 2004))
ξ	0.75	Calvo parameter prices (avg. duration is four quarters)
ζ	0.75	Calvo parameter wages (avg. duration is four quarters)
γ	.85	Trade share (S.s. ratio to GDP is 30%)
θ	.9	Price elasticity of traded goods (Heathcote and Perri (2002))
α	0.26	Capital share (S.s. total value added to labor is 2/3)
δ	.025	Capital depreciation rate (S.s. rate of 2.5 % per quarter
μ	10	Subst. ela. of intermediates (11% price mark-up, Basu and Kimball (1997))
ν	7.6	Subst. ela. of labor (15% wage mark-up is, Chari et al. (2002))
Monetary Policy		
λ_R	0.91	Weight on lagged interest rate (Clarida et al. (1999))
λ_π	1.31	Weight on inflation targeting (Clarida et al. (1999))
λ_{gsp}	0.0625	Weight on output targeting (Clarida et al. (1999))
Regional Fiscal Policy		
τ_c	0.15	Consumption tax rate
τ_l	0.25	Labor income tax rate
$\frac{\bar{g}}{\bar{y}}$	0.2	Government spending (S.s. ratio to output)
$\frac{\bar{\mathcal{B}}}{\bar{y}}$	0.6	Government debt (S.s. ratio output)

TABLE 1B
Parameters Values: Shock processes.

Parameter	Value	Description (Source/Target)
Technology		
$\rho_a = \rho_{a^*}$	0.95	Persistence of technology shock (Chari et al. (2002))
$corr_{a,a^*}$	0.25	Correlation of technology shock (Chari et al. (2002))
$\sigma_a = \sigma_{a^*}$	0.00355	Std. deviation of technology shock (matches $std(y)$ to the data)
Government Spending		
$\rho_g = \rho_{g^*}$	0.66	Persistence of gov. spending shock ((matches $\frac{std(g)}{std(gdp)}$ to the data))
$\sigma_g = \sigma_{g^*}$	0.0015	Std. deviation of gov. spending shock (matches $std(gdp)$ to the data)

TABLE 2: Business cycle statistics for the different federal fiscal transfer rules.

Statistic	Data†	Bench-mark‡	Transfers Targeting‡: Nominal GDP		Consumption Spending		Labor Income		Regional Deficit		Optimal Transfer‡	
Standard Deviations												
GDP	0.87	0.87	0.87	(0.03)	0.90	(3.15)	0.91	(4.68)	0.87	(-0.05)	0.92	(5.12)
Consumption	0.73	0.82	0.84	(3.42)	0.85	(3.62)	0.89	(9.11)	0.78	(-3.83)	0.87	(7.18)
Investment	3.03	3.03	3.01	(-0.66)	3.30	(8.99)	3.44	(13.60)	3.01	(-0.51)	3.52	(16.29)
Employment	0.69	0.65	0.68	(5.29)	0.67	(2.87)	0.66	(1.93)	0.66	(1.02)	0.65	(-0.10)
Gov. Exp.	0.83	0.83	0.83	(0.00)	0.83	(0.00)	0.83	(0.00)	0.83	(0.00)	0.83	(0.00)
Net Exports	0.39	0.06	0.04	(-32.27)	0.10	(65.43)	0.12	(95.92)	0.10	(67.72)	0.12	(106.08)
Real E.R.	0.42	0.98	0.78	(-20.42)	0.85	(-13.61)	0.66	(-32.55)	1.20	(22.38)	0.77	(-21.75)
Inflation	0.42	0.20	0.20	(-0.02)	0.19	(-1.49)	0.19	(-2.03)	0.20	(0.97)	0.19	(-1.97)
Autocorrelation												
GDP	0.89	0.97	0.97	(0.38)	0.96	(-0.44)	0.95	(-1.47)	0.96	(-1.00)	0.95	(-1.93)
Consumption	0.74	0.99	0.99	(0.01)	0.99	(-0.00)	0.99	(-0.20)	0.99	(0.00)	0.99	(-0.23)
Investment	0.90	0.93	0.93	(0.03)	0.92	(-0.58)	0.87	(-5.90)	0.91	(-1.49)	0.86	(-7.14)
Employment	0.85	0.77	0.80	(3.77)	0.75	(-2.13)	0.84	(9.85)	0.72	(-5.96)	0.84	(8.92)
Cross Country Correlation												
GDP	0.86	0.60	0.60	(-0.15)	0.50	(-16.09)	0.46	(-23.34)	0.60	(0.27)	0.45	(-25.38)
Consumption	0.72	0.61	0.50	(-17.21)	0.50	(-18.17)	0.35	(-42.33)	0.74	(21.52)	0.40	(-34.28)
Investment	0.85	0.50	0.52	(4.01)	0.26	(-47.34)	0.16	(-67.33)	0.52	(3.10)	0.11	(-77.94)
Employment	0.68	0.48	0.34	(-30.09)	0.40	(-16.93)	0.43	(-11.56)	0.45	(-6.17)	0.49	(0.61)
Means§												
GDP	-	-0.23	-0.23	(0.49)	-0.22	(4.41)	-0.21	(7.51)	-0.24	(-4.46)	-0.22	(6.77)
Consumption	-	-0.30	-0.31	(-1.30)	-0.29	(3.92)	-0.28	(6.91)	-0.32	(-4.91)	-0.28	(6.67)
Phys. Capital	-	-0.56	-0.54	(4.39)	-0.50	(11.05)	-0.44	(21.11)	-0.61	(-9.44)	-0.46	(18.29)
Employment	-	0.18	0.19	(1.80)	0.18	(-4.42)	0.18	(-3.91)	0.19	(3.59)	0.18	(-4.10)

† The empirical statistics (left column 'data') are based on data on nine European countries (Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, and Spain) over the sample period 1999Q1-2007Q4. Relative variables are computed towards the remaining countries, weighted by time-varying tradeshares. For all variables, first logs (except inflation rates) and then the HP-filter with smoothing parameter set to 1600 has been applied.

‡ The statistics of all model variants are the computed theoretical moments. Standard deviations are stated in percent. The numbers in parentheses are the percentage changes relative to the benchmark.

§ Means are stated as the relative per mill change from the deterministic steady state.

TABLE 3: Welfare comparisons of the different federal transfer arrangements

Statistic	Bench-mark‡	Transfers Targeting‡								Optimal Transfer‡	
		Nominal GDP		Consumption Spending		Labor Income		Regional Deficit			
Welfare Compensation†	-0.073	-0.084	(-15.81)	-0.062	(15.02)	-0.061	(16.39)	-0.086	(-18.93)	-0.058	(19.45)
Mean Compensation	-0.057	-0.063	(-10.14)	-0.041	(28.74)	-0.032	(43.80)	-0.076	(-32.55)	-0.033	(41.35)
Consumption	-0.045	-0.049	(-8.80)	-0.033	(26.45)	-0.024	(46.58)	-0.060	(-33.12)	-0.025	(43.60)
Labor	-0.012	-0.014	(-15.27)	-0.007	(37.48)	-0.008	(33.18)	-0.015	(-30.38)	-0.008	(32.74)
Variance Compensation	-0.016	-0.021	(-36.50)	-0.021	(-35.13)	-0.029	(-83.75)	-0.011	(30.83)	-0.025	(-60.54)
Consumption	-0.013	-0.018	(-35.45)	-0.018	(-37.56)	-0.026	(-97.02)	-0.008	(38.32)	-0.023	(-72.65)
Labor	-0.003	-0.004	(-41.95)	-0.003	(-22.52)	-0.003	(-15.10)	-0.003	(-7.92)	-0.002	(2.12)

† Welfare compensations are stated in per mill. They are computed for asymmetric shocks only. Numbers in parentheses are the percentage changes relative to the benchmark.

TABLE 4: Business cycle statistics and welfare comparison of the optimal transfer rule with scenarios without nominal rigidities under incomplete and complete financial markets.

Statistic†	Benchmark Economy‡	Optimal Transfer Rule		No Nominal Rigidities		No Nom. Rig. and Complete Fin. Markets	
Standard Deviations							
GDP	0.39	0.48	(23.40)	0.47	(19.54)	0.46	(17.99)
Consumption	0.36	0.48	(32.60)	0.40	(11.36)	0.34	(-7.28)
Investment	1.51	2.35	(55.43)	2.13	(41.18)	2.15	(41.98)
Employment	0.33	0.33	(-0.38)	0.26	(-21.43)	0.20	(-40.61)
Means§							
GDP	-0.03	-0.02	(45.94)	-0.00	(96.42)	-0.00	(97.04)
Consumption	-0.05	-0.02	(44.97)	0.00	(102.12)	-0.00	(98.90)
Phys. Capital	-0.06	0.04	(159.23)	0.06	(200.31)	0.05	(176.84)
Employment	0.02	0.01	(-34.72)	-0.00	(-104.27)	0.00	(-95.07)
Welfare¶							
Overall	-0.073	-0.058	(20.01)	-0.016	(77.54)	-0.013	(81.80)
Mean	-0.057	-0.033	(42.85)	0.001	(102.56)	-0.001	(98.10)
Variance	-0.016	-0.026	(-63.42)	-0.018	(-13.92)	-0.012	(22.25)

† The statistics of all model variants are the computed theoretical moments conditional on perfectly asymmetric shocks. Standard deviations are stated in percent. The numbers in parentheses are the percentage changes relative to the scenario without federal arrangements.

‡ The benchmark denotes the decentralized fiscal regime with nominal rigidities.

§ Means are stated as the relative per mill change from the deterministic steady state.

¶ Welfare compensations are stated in per mill. Numbers in parentheses are the percentage changes relative to the benchmark.

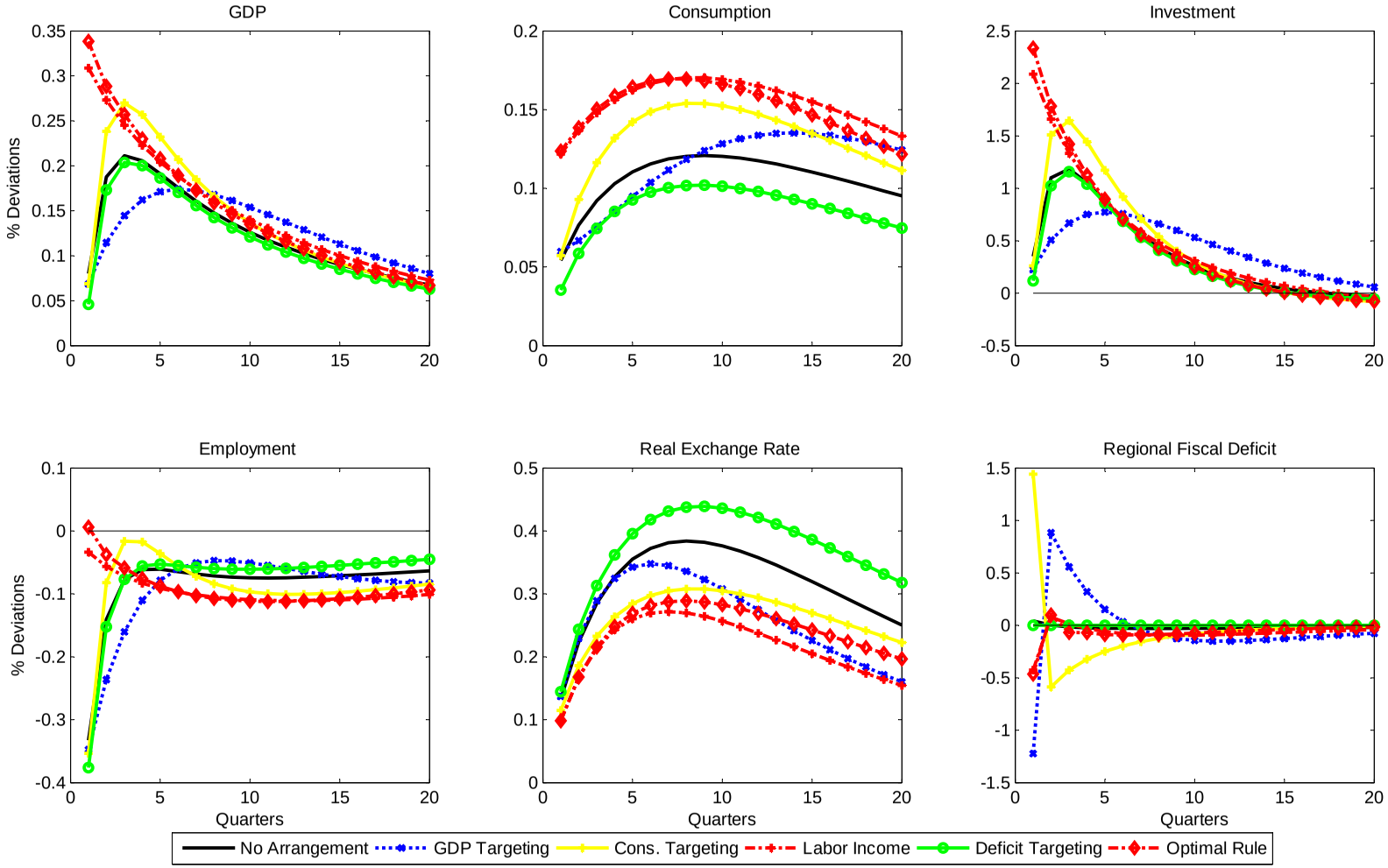

FIGURE 1. Impulse responses for selected variables of the home region to a positive and asymmetric one-standard-deviation innovation to home productivity. All variables are in terms of steady state percentage deviations.

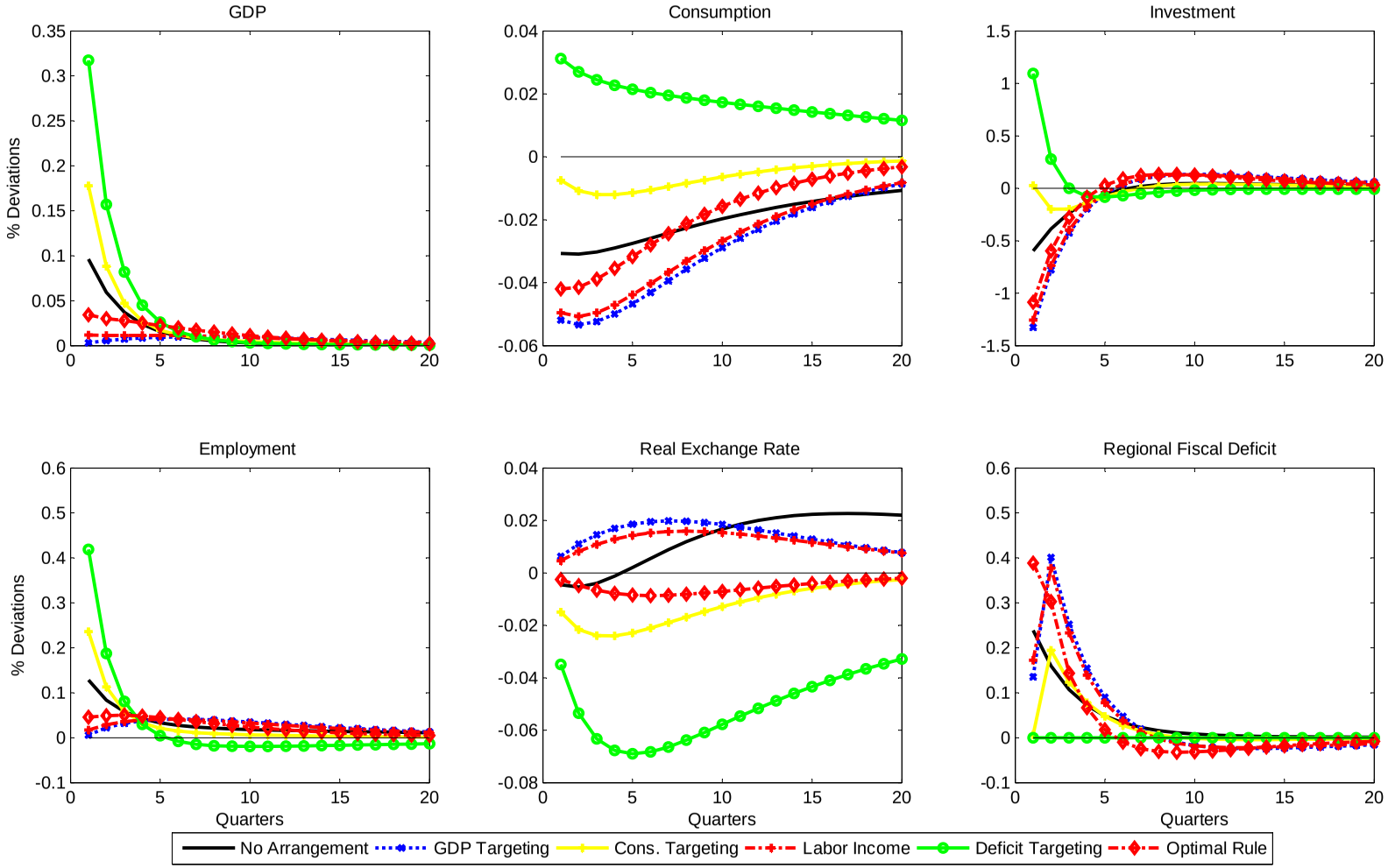

FIGURE 2. Impulse responses for selected variables of the home region to a positive and asymmetric one-standard-deviation innovation to home government expenditure. All variables are in terms of steady state percentage deviations.

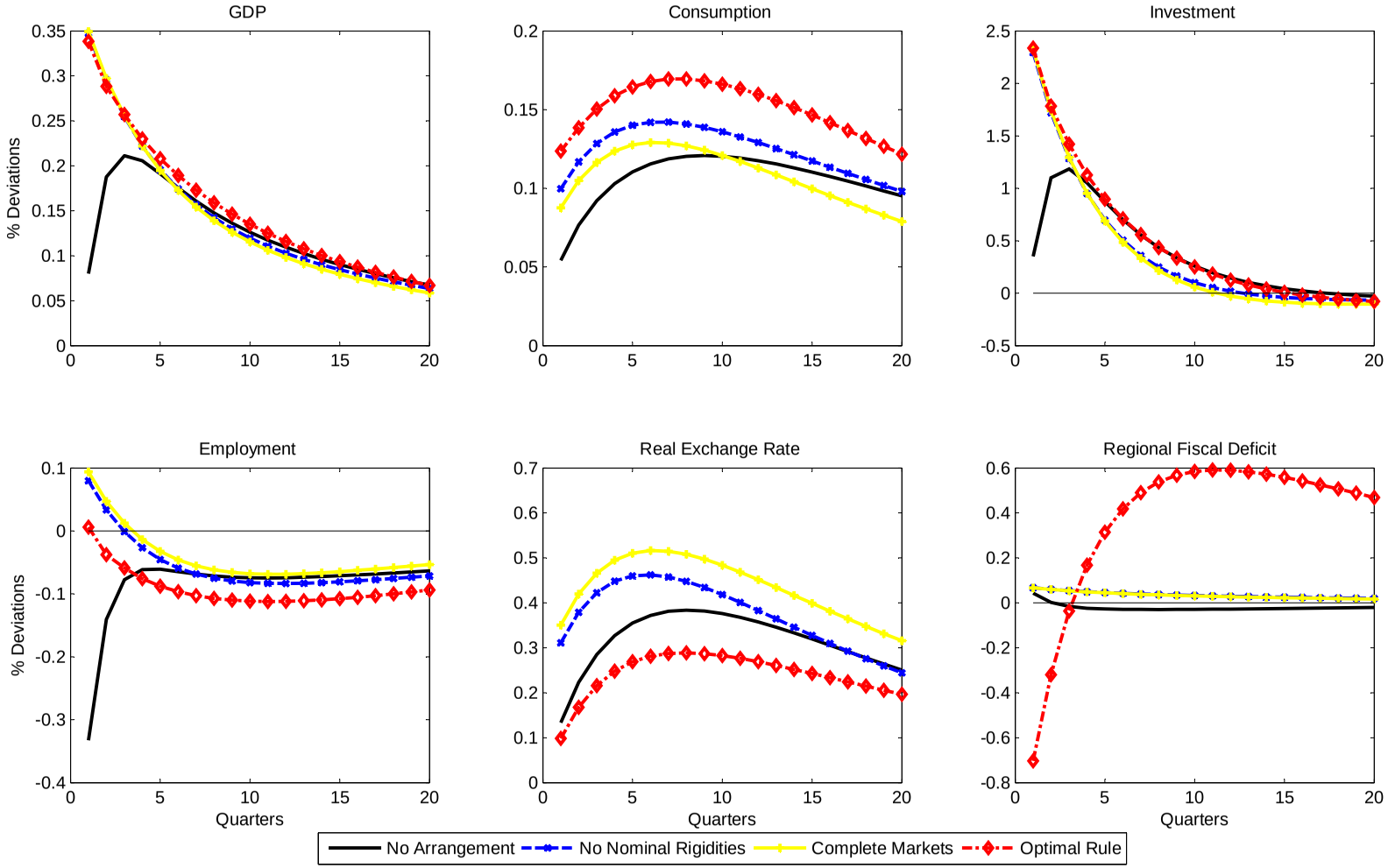

FIGURE 3. Impulse responses for selected variables of the home region to a positive and asymmetric one-standard-deviation innovation to home government expenditure. All variables are in terms of steady state percentage deviations.