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Three Essays on Imbalances in a Monetary Union

Ida Maria Hjortsø

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

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Abstract

This thesis investigates the implications of imbalances within a monetary union.

In the first chapter, I study how international financial frictions lead to international imbalances and affect optimal fiscal policy in a two-country, two-good DSGE model of a monetary union. I show that the presence of international imbalances affects the optimal conduct of cooperative fiscal policies when the traded goods are complements. Government expenditures optimally play a cross-country risk sharing role which is in conflict with the domestic stabilization role: optimal fiscal policy consists in setting government expenditures such as to reduce international imbalances at the expense of higher domestic inefficiencies.

In the second chapter, I assess the implications of strategic fiscal policy interactions in a two-country DSGE model of a monetary union with nominal rigidities and international financial frictions. I show that the fiscal policy makers face an incentive to set fiscal policy such as to switch the terms of trade in their favour. This incentive results in a Nash equilibrium characterized by excessive inflation differentials as well as sub-optimally high current account imbalances within the monetary union. There are thus non-negligeable welfare losses associated with strategic fiscal policy making in a monetary union.

The third chapter investigates empirically the degree of risk sharing in the European Economic and Monetary Union (EMU), using two different methods. The first measure relates to the capacity of consumption smoothing. This measure indicates that risk sharing is rather low and that the introduction of the common currency did not lead to higher intra-EMU risk sharing. The second measure is based on the welfare losses associated with deviations from full risk sharing. These welfare losses have fallen since the introduction of the common currency. However, this is mostly due to changes in macroeconomic risk - not to changes in risk sharing per se.

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Introduction

This thesis investigates the implications of imbalances resulting from international financial frictions within a monetary union. Though this is a topic which has been on the research agenda in international macroeconomics since the emergence of the literature on Optimal Currency Areas, it has regained interest with the construction of the European Economic and Monetary Union (EMU), and the more so with the eurozone crisis.
Imbalances arising due to international financial frictions might have important welfare implications, and might affect the policy transmission mechanisms. Therefore, these imbalances might prove important for policy making. The focus of this thesis is on the implications for fiscal policy making within a monetary union. Indeed, the first two chapters of this thesis investigates the implications of international financial frictions respectively for union-wide optimal fiscal policy and for strategic interactions between fiscal policy makers. The third chapter investigates empirically the degree of risk sharing taking place within the EMU.

In the first chapter, I study how international financial frictions lead to international imbalances and affect the optimal conduct of fiscal policy in a two-country, two-good DSGE model of a monetary union. I show that the presence of international imbalances affects the optimal conduct of cooperative fiscal policies when the internationally traded goods are complements: Government expenditures optimally play a cross-country risk sharing role. The cross-country insurance role of fiscal policy is in conflict with the domestic stabilization role. That is, domestic macroeconomic stabilization is not sufficient for achieving international macroeconomic stabilization. Optimal fiscal policy consists in setting government expenditures such as to reduce international imbalances at the expense of higher domestic inefficiencies.

In the second chapter, I assess the economic consequences from conducting fiscal policy at the national level within a monetary union. This chapter investigates the consequences of strategic fiscal policy interactions in a two-country DSGE model of a monetary union with nominal rigidities and international financial frictions. I show that the fiscal policy makers in this framework face an incentive to set fiscal policy such as to switch the terms of trade in their favour. This incentive, the terms of trade externality, results in a Nash equilibrium where inflation differentials across countries and intra-union imbalances may be significantly larger than if the fiscal policy makers had cooperated. Indeed, the main results of the anal-

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ysis is that strategic interactions between national fiscal policy makers can lead to excessive inflation differentials across countries as well as sub-optimally high current account imbalances within the monetary union. When this is the case, there are non-negligeable welfare losses associated with strategic national fiscal policy making in a monetary union.

The third chapter is empirical, and attempts to measure the degree of risk sharing within the EMU. Though financial integration has accelerated in the last decades, the effects on the degree of risk sharing across countries remains an open question. The extent of risk sharing taking place within the European Economic and Monetary Union (EMU) and its evolution since the introduction of the common currency is of particular interest not only to evaluate financial integration and its benefits, but also because of policy implications. I measure the degree of risk sharing within the EMU using two different methods. The first measure is closely related to the capacity of consumption smoothing. This measure indicates that the degree of risk sharing is rather low and that the introduction of the common currency did not lead to higher intra-EMU risk sharing. The second measure is based on the welfare losses associated with deviations from full risk sharing. I show that these welfare losses have fallen since the introduction of the common currency. However, this is almost entirely due to changes in macroeconomic risk rather than changes in risk sharing per se.

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Chapter 1

Imbalances and Fiscal Policy in a Monetary Union

1.1 Introduction

The international imbalances within the European Economic and Monetary Union (EMU), illustrated by large current account imbalances and debt differences across countries, are widely seen as one of the main reasons for the Eurozone crisis. This crisis has pointed out the tensions between national and international policy objectives, and has recast the debate over fiscal policy making within monetary unions. In the absence of alternative, potentially more suitable policy instruments, it could be desirable to use national fiscal policies to address international imbalances. In this paper, I investigate whether it is indeed optimal to use national government spending to contain excessive international imbalances arising in the presence of international financial frictions within a monetary union. That is, I examine the potential cross-country insurance role of fiscal policies in a monetary union.

Within a two-country, two-good DSGE model of a monetary union, I show that the international transmission of productivity shocks and government spending as well as the resulting optimal fiscal policy are dependent on the structure of the international financial markets. Financial frictions are modelled in the spirit of Benigno (2001) who analyses the effects of international financial frictions for optimal monetary policy:[1] international financial mar-

[1] Note that on the contrary to Benigno (2001), I assume that the financial frictions are symmetric across countries. Furthermore, I allow for home bias in consumption, implying potential deviations from purchasing power parity.

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kets are incomplete in that only nominal bonds are traded across countries. Moreover, the yields on these bonds are debt-elastic, replicating the recent situation within the EMU. Government spending, the fiscal policy instrument, yields utility to agents and shifts demand towards the domestically produced good, thereby affecting output, inflation and international imbalances. Under complementarity of the internationally traded goods, I show that fiscal policy optimally adjusts such as to reduce international demand imbalances illustrating deviations from full risk sharing. That is, fiscal policy acts as a cross-country insurance tool. Higher consumption risk sharing is achieved through relative price movements: changes in government spending affect international prices by shifting relative demand, and thus affect the real exchange rate and relative consumption demand, the determinants of cross-country risk sharing.

The relative importance of the distortions arising due to internationally incomplete markets for fiscal policy making is shown to be very sensitive to the trade elasticity: the lower the trade elasticity, that is the less subsitutable are the goods, the more important is it for the policy maker to limit international demand imbalances. This is so because the trade elasticity determines the relative importance of the income and substitution effects of price changes. Hence, a change in prices in one country will either increase relative consumption demand or decrease it depending on the trade elasticity. As a result, the effects of fiscal policy on international imbalances, achieved through price changes, differ according to the trade elasticity.

For fiscal policy to effectively improve risk sharing across countries it must be able to affect relative consumption and the real exchange rate in opposite directions. Since these variables are affected in the same direction by fiscal policy under substitutability of the traded goods, decreasing the international demand imbalances requires large and costly changes in government spending in that deviations from the optimal spending composition need be large. Hence, under a high trade elasticity implying that the internationally traded goods are highly substitutable, the optimal response of government expenditures to a country-specific shock consists in stabilizing the national economies, not in redressing the cross-country demand imbalances arising due to international financial frictions. However, under a low trade elasticity, the fiscal policy maker optimally acts such as to reduce them; since government spending leads to changes in consumption and the real exchange rate which go in opposite directions, it is possible for the fiscal policy maker to improve risk sharing without too large costs in terms of deviations from the optimal spending composition. That is, when the internationally traded goods are complements, the fiscal policy maker optimally sets policy such

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as to avoid large deviations from full consumption risk sharing across countries: government expenditures play the role of a cross-country insurance tool. Interestingly, within a monetary union where the traded goods are complements, it is optimal to reduce cross-country imbalances at the expense of larger national inefficiencies, indicating that the best outcome for the union as a whole consists in stabilizing union-wide imbalances at the expense of national imbalances.

To my knowledge, the consequences for fiscal policy of cross-country imbalances resulting from international financial frictions has not been addressed in the literature. The New Open Economy Macroeconomic (NOEM) literature, initiated by Obstfeld and Rogoff (1995), has investigated the relation between international financial frictions and the international transmission of government spending shocks. Sutherland (1996) is the first to consider the effects of international financial frictions on the transmission of fiscal policy within a NOEM framework. He investigates the effects of international portfolio adjustment costs for the transmission of government spending shocks in a two-country model with flexible exchange rates. Pierdzioch (2004) and Koenig and Zeyneloglu (2010) carry out similar exercises within a currency union. These analyses focus on the international transmission of fiscal policy. However, incomplete financial markets across countries do not only affect the transmission of shocks and policies but also create inefficiencies. These inefficiencies potentially affect welfare, and might thus have important implications for optimal policy - also fiscal policy. Some recent contributions to the international literature, such as Obstfeld and Rogoff (2002), Benigno (2009), or Corsetti, Dedola, and Leduc (2010b) consider the effects of internationally incomplete markets for optimal monetary policy. However, these authors leave aside the analysis of the monetary and fiscal interaction, of the trade-off faced by the fiscal policy maker, and of the consequences for optimal fiscal policy, issues that I address here.

Within a monetary union where countries might be hit by asymmetric shocks, the implications of international financial frictions may be particularly important for the optimal conduct of fiscal policy because monetary policy is not available to address these shocks. Both Beetsma and Jensen (2005) and Gali and Monacelli (2008) point out the importance of the assumption of perfect risk-sharing within their analyses of optimal fiscal policy in a monetary union. However, they do not investigate the consequences of imperfect risk sharing in their research. I fill this gap in the literature and show that when national monetary policies cannot complement fiscal policies in redressing cross-country imbalances, the fiscal policy maker might face an important trade-off which cannot be characterized by domestic objectives: he must chose whether to stabilize output gaps, inflation, or limit the inefficiencies arising due to international financial frictions - thereby facing an additional objective, absent under complete markets. One implication of international financial frictions for the optimal conduct of fiscal policy within a monetary union is thus that optimal policies cannot be achieved by focusing on domestic targets exclusively.

My analysis has important implications for the conduct of fiscal policy within the EMU. I show that, under realistic assumptions, the optimal cooperative fiscal policy in a monetary union consists in reducing international imbalances, at the expense of larger domestic inefficiencies. Since reducing the latter constitutes the main objective of national fiscal policy makers in the EMU, this research indicates that rethinking fiscal policy could result in welfare gains for the union as a whole.

In the following section, I present the monetary union framework within which I assess the implications of international financial frictions for the conduct of fiscal policy. Then, in section 3, I describe the Ramsey policy problem and relate the Ramsey allocation to the efficient allocation. In section 4, I consider the implications of international financial frictions for optimal fiscal policy by investigating numerically the optimal response of government expenditures to a country-specific technology shock. The robustness of the results to different types of country-specific shocks and the sensitivity with respect to the chosen parameterization are investigated in section 5. Finally, I conclude the paper.

1.2 The Model

1.2.1 Households

The world is composed of two countries, denoted H (Home) and F (Foreign). There are respectively n and $1-n$ households in each of these countries. In the following, I will focus on the agents in the Home country.[2]

Households get utility from private consumption and government expenditures (respectively c and G), but disutility from work (l), and therefore a household's utility is given by

$$v = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left[U^C(c_t) + U^G(G_t) - U^L(l_t) \right] \tag{1.1}$$

[2]Analogous relations hold for the agents in the Foreign country, unless otherwise specified.

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where E_t denotes the expectations at time t, and β is the discount factor.
The functional forms are as follows:

$$U^C(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}$$
$$U^G(G_t) = \chi \frac{G_t^{1-\sigma} - 1}{1-\sigma}$$
$$U^L(l_t) = \frac{l_t^{1+\eta}}{1+\eta}$$

where $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution and the relative risk aversion coefficient, $\eta > 0$ is the inverse of the Frisch labor-supply elasticity, and χ is the weight given to public consumption relative to private consumption

The differentiated goods produced by firms h and f in country H and F respectively, $c_t(h)$ and $c_t(f)$, are assembled by a Dixit-Stiglitz aggregator into the composite goods denoted respectively $C_{H,t}$ and $C_{F,t}$:

$$C_{H,t} = \left[\int_0^n c_t(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}}, \quad C_{F,t} = \left[\int_n^1 c_t(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}}$$

such that θ denotes the elasticity of substitution between the differentiated goods produced within a country.
Consumption is a CES index of consumption of the goods produced at Home and the goods produced in the Foreign country

$$C_t = \left[a_H^{\frac{1}{\phi}} C_{H,t}^{\frac{\phi-1}{\phi}} + (1-a_H)^{\frac{1}{\phi}} C_{F,t}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}, \qquad 0 < a_H < 1, \quad \phi > 0, \tag{1.2}$$

where the constant elasticity of substitution between the home and foreign goods, also called the trade elasticity, is denoted ϕ. The trade elasticity is an important determinant of the transmission of shocks and policies across countries. It therefore plays a crucial role in determining optimal fiscal policy. a_H is the weight given to consumption of the Home goods, whereas $1 - a_H$ is the weight attached to consumption of the Foreign goods. If $a_H > n$, then a home bias in consumption is present. The presence of home bias results in deviations from purchasing power parity, even when the law of one price holds.
Given that households choose their relative consumption demand such as to maximize utility

for given expenditures, the domestic demand for respectively Home and Foreign goods are:

$$C_{H,t} = a_H \left(\frac{P_{H,t}}{P_t}\right)^{-\phi} C_t, \tag{1.3}$$

$$C_{F,t} = (1 - a_H) \left(\frac{P_{F,t}}{P_t}\right)^{-\phi} C_t. \tag{1.4}$$

where P_H and P_F respectively denote the price of the domestically produced generic good C_H and the foreign good C_F, whereas P and P^* denote the respective prices of the domestic and foreign consumption baskets C and C^*. The consumption-based price indices are defined analogously to the consumption bundles:

$$P_t = \left[a_H P_{H,t}^{1-\phi} + (1 - a_H) P_{F,t}^{1-\phi}\right]^{\frac{1}{1-\phi}}, \tag{1.5}$$

$$P_t^* = \left[(1 - a_H) {P_{H,t}^*}^{1-\phi} + a_H {P_{F,t}^*}^{1-\phi}\right]^{\frac{1}{1-\phi}}. \tag{1.6}$$

where

$$P_{H,t} = \left[\int_0^n p_t(h)^{1-\theta} dh\right]^{\frac{1}{1-\theta}}, \quad P_{F,t} = \left[\int_n^1 p_t(f)^{1-\theta} df\right]^{\frac{1}{1-\theta}}$$

The terms of trade are defined as the ratio between the price of imports and exports: $TOT_t \equiv \frac{P_{F,t}}{P_{H,t}^*}$, whereas the real exchange rate is defined as the price of the Foreign consumption bundle in terms of the Home consumption good:

$$Q_t \equiv \frac{P_t^*}{P_t} \tag{1.7}$$

Households face complete financial markets at the domestic level, and firms' profits are equally distributed among domestic households (because they all hold an equal share of each domestic firm) such that a representative household exists within each country. However, households are subject to frictions at the international level: only nominal one-period bonds with debt-elastic yields are traded across countries. The yields of the bonds are higher the higher is a country's external debt relative to the steady state level, as in Schmitt-Grohe and Uribe (2003). Apart from implying stationarity of the steady state, modelling financial frictions through a debt-elastic yield on bonds allows for yield differences across countries which mimic those recently observed across countries in the EMU.

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In order to model the debt-dependent interest rates, I assume that bonds can only be traded internationally through intermediaries. These intermediaries demand a higher yield on bonds which are issued by countries with high external debt levels, for example because of an underlying risk of default that is increasing in debt.[3] For technical simplicity, the additional rent thus extracted by the intermediaries when lending to indebted countries (i.e. countries with a current account deficit) is assumed to be distributed to households within the current account surplus country as lump-sum transfers.[4]

To illustrate the mechanism of the debt-elastic yield, consider the situation in which Home real bond holdings, denoted $\frac{B_{H,t}}{P_t}$, are above their steady state level i.e. $\frac{B_{H,t}}{P_t} > \frac{\bar{B}_H}{P}$, that is, the Foreign country has issued (excessive) debt: $\frac{B_{F,t}}{P_t^*} < \frac{\bar{B}_F}{P^*}$. In that case, the Foreign yield is multiplied by a function $\Phi(B_{F,t}/P_t^*) > 1$ (the premium), and the domestic interest rate is decreased, since it is multiplied by $\Phi(B_{H,t}/P_t) < 1$. The function Φ is assumed to depend positively on the deviation of debt from its steady state level, $(\Phi'(.) < 0)$, and satisfies $\Phi(\frac{\bar{B}_F}{P^*}) = \Phi(\frac{\bar{B}_H}{P}) = 1$. Hence, a yield spread across the countries arise, and it is increasing in the difference between the countries' external debt levels, or current accounts. The yield premium associated with holding bonds is assumed to be linear in the excessive borrowing/lending (in deviations from the steady state value). An example of a function satisfying the requirements above is $\Phi(b_t) = 1 - \delta(b_t - \frac{\bar{B}}{P})$, with $\delta \geq 0$ and $\frac{\bar{B}_F}{P^*} \equiv \frac{\bar{B}_H}{P} \equiv \frac{\bar{B}}{P}$.

Labor is immobile between countries but perfectly mobile within countries such that wages are identical across households within a country. It follows that labor supply and consumption decisions are identical for all households within each country. Every period, the representative household uses its labor income, its wealth accumulated in bonds, profits of firms in the domestic economy, and the lump-sum transfers resulting from intermediation activities, to purchase consumption and bonds and pay lump-sum taxes. I assume that individual households do not internalize the effect of changes in their own bond holdings on the yield, i.e. they take the function $\Phi(.)$ as given.

In the Home country, the household budget constraint thus amounts to:

$$c_t + \frac{b_t}{P_t(1+i_t)\Phi(B_{H,t}/P_t)} + T_t = \frac{w_t}{P_t} l_t + \frac{b_{t-1}}{P_t} + [\frac{1}{\Phi(B_{F,t}/P_t^*)} - 1]\frac{B_{F,t}}{(1+i_t)P_t} + pr_t \qquad (1.8)$$

[3]This risk is not modelled explicitly, and in equilibrium default never occurs.

[4]This assumption could easily be replaced by the assumption of equal distribution of the rent across the whole union. The qualitative results would be unchanged by this alternative assumption.

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where c_t is consumption of the household considered such that $C_t \equiv \int_0^n c_t dh$, P_t is the CPI, i_t is the nominal interest set by the common central bank in period t, w_t is the wage rate, and l_t is the hours worked by the household, pr_t denote the profits, T_t denotes lump-sum taxes paid by the household, and b_t is the nominal bond holdings of a Home household such that $B_{H,t} \equiv \int_0^n b_t dh$, and similarly $B_{F,t} \equiv \int_n^1 b_t^* df$. The first-order conditions of the representative domestic household can be aggregated to yield:

$$\beta E_t[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}}\frac{1+i_t}{\pi_{t+1}}] = \frac{1}{\Phi(B_{H,t}/P_t)} \tag{1.9}$$

$$\frac{L_t^\eta}{C_t^{-\sigma}} = \frac{W_t}{P_t} \tag{1.10}$$

The first equation is the Euler equation, determining the inter-temporal allocation of consumption. The second equation is the labor supply equation stating that in equilibrium, the marginal utility of consumption obtained from an extra hour of work must equal the marginal disutility of working that extra hour.

1.2.2 Firms

Firms are monopolistically competitive and set prices in a staggered fashion a la Calvo-Yun. That is, they reset their price at a time-independent random frequency. More specifically, each firm faces the probability $1-\alpha$ of getting the possibility to reset their price every period. Firms are owned by domestic households, and all firms within a country are identical in that their technology is such that output is linear in labor, and depends on a country-specific productivity shock denoted A: $y_t(h) = A_t l_t(h)$, where h refers to a country H firm.
The optimisation problem of the firm producing good h and getting the opportunity to reset its price at time t consists in choosing a price $p_t(h)$ such as to maximize expected discounted future profits:

$$\max_{p_t(h)} E_t \sum_{s=0}^{\infty} \alpha^s \mu_{t,t+s}[((1-\tau)p_t(h) - \frac{W_{t+s}}{A_{t+s}})y_{t,t+s}(h)]$$

$$\text{subject to demand: } y_{t,t+s}(h) = (\frac{p_t(h)}{P_{H,t+s}})^{-\theta}(C_{H,t+s} + G_{t+s}) + (\frac{p_t(h)}{P_{H,t+s}})^{-\theta} C_{H,t+s}^*$$

where $\mu_{t,t+s}$ is the stochastic discount factor of the firm, and τ is a tax on production. Given that the firms are owned by the households their discount factor is identical to the discount factor of the representative household: $\mu_{t,t+s} = \beta^s \frac{U_{C,t+s}}{P_{t+s}} \frac{P_t}{U_{C,t}}$.
The resulting first order conditions imply that prices are set according to expectations of future marginal costs and demand in the following way:

$$p_t(h) = \frac{\theta}{(\theta-1)(1-\tau)} \frac{\sum_{s=0}^{\infty} (\alpha\beta)^s \frac{C_{t+s}^{-\sigma}}{P_{t+s}} \frac{W_{t+s}}{A_{t+s}} y_{t,t+s}(h)}{\sum_{s=0}^{\infty} (\alpha\beta)^s \frac{C_{t+s}^{-\sigma}}{P_{t+s}} y_{t,t+s}(h)} \tag{1.11}$$

Because all firms that get to reset their price in a given period face the same expectations of marginal costs and demand, they all set the same price. Hence the following condition holds:

$$P_{H,t} = [\alpha P_{H,t-1}^{1-\theta} + (1-\alpha) p_t(h)^{1-\theta}]^{\frac{1}{1-\theta}} \Leftrightarrow (\frac{p_t(h)}{P_{H,t}})^{1-\theta} = \frac{1-\alpha\pi_{H,t}^{\theta-1}}{1-\alpha} \tag{1.12}$$

where $\pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$.
Aggregating output across firms yields $Disp_t Y_{H,t} = A_t L_t$ where $Disp_t \equiv \int_0^n (\frac{p_t(h)}{P_{H,t}})^{-\theta} dh$ is a measure of the degree of price dispersion. This term is always larger or equal to unity[5]. The evolution of price dispersion is dependent on inflation in the following way:

$$Disp_t = (1-\alpha)[\frac{1-\alpha\pi_{H,t}^{\theta-1}}{1-\alpha}]^{\frac{-\theta}{(1-\theta)}} + \alpha\pi_{H,t}^{\theta} Disp_{t-1} \tag{1.13}$$

The price setting process of firms thus introduces a distortion in that price dispersion among firms with identical technologies result.

Note that if firms operate in an environment with perfectly flexible prices, the representative domestic firm sets its price to equal a constant markup over marginal costs illustrated by the real wage rate adjusted for productivity:

$$\frac{P_{H,t}}{P_t} = \frac{\theta}{(\theta-1)(1-\tau)} \frac{1}{A_t} \frac{W_t}{P_t}$$

[5]Proof: Let $v_t(h) = (\frac{p_{t,h}}{P_{H,t}})^{1-\theta}$, such that $Disp_t = \int_0^n (\frac{p_{t,h}}{P_{H,t}})^{-\theta} dh = \int_0^n v_t(h)^{\frac{\theta}{\theta-1}} dh$.
Recall that $P_{H,t} = [\int_0^n p_t(h)^{1-\theta}]^{\frac{1}{1-\theta}} dh$[6]. It follows that $\int_0^n (\frac{p_t(h)}{P_{H,t}})^{1-\theta} dh = 1 \Leftrightarrow [\int_0^n (\frac{p_t(h)}{P_{H,t}})^{1-\theta} dh]^{\frac{\theta}{\theta-1}} = 1$, or, equivalently that $[\int_0^n v_t(h) dh]^{\frac{\theta}{\theta-1}} = 1$.
Noting that $f(v(h)) = v(h)^{\frac{\theta}{\theta-1}}$ is a convex function we can apply Jensen's inequality, and thereby conclude that $Disp_t = \int_0^n v_t(h)^{\frac{\theta}{\theta-1}} dh \geq [\int_0^n v_t(h) dh]^{\frac{\theta}{\theta-1}} = 1$.

1.2.3 Monetary and fiscal policies

In this paper, I study the optimal monetary and fiscal policy mix. I thus assume fiscal and monetary policy to be set such as to maximize welfare from the view-point of the monetary union as a whole. More specifically, policies are set in a constrained Ramsey optimal way: A supranational policy maker sets a path for the common monetary policy instrument and for the fiscal policy instruments, government expenditures within each country, such as to maximize the population-weighted welfare of the monetary union, given the private sector's first order conditions and the national governments' budget constraints.

Fiscal policy

Fiscal policy is defined as the path of government expenditures. These are assumed to be financed by lump-sum taxation and (non state-contingent) bond issuance.[7] That is, I focus on the effects of government spending rather than on its financing in the present paper.[8]
Government demand is entirely directed towards domestically produced goods[9] which are assembled by the government into a composite public good denoted G:

$$G_t = \left[\int_0^n y_t(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}}$$

The technology used by the government in order to assemble the goods is different from the technology available to the private agents, and therefore the good G and the good C_H yield different levels of utility to households.
The fiscal authorities impose a subsidy on production which eliminates monopolistic distortions in the steady state: $\tau = \frac{1}{1-\theta}$. Hence, under appropriately chosen government expenditure levels and zero inflation, the steady state will be efficient. Note that the subsidy is fixed: though it does constitute an expenditure for the government, it does not constitute

[7] I abstract from any implications of fiscal policy that relates to distortionary taxation issues. This is reasonable if the path of government expenditures can be considered as independent of the financing of it.

[8] See e.g. Ferrero (2009) for the role played by distortionary taxation and government debt

[9] This assumption is not crucial per se. The important feature is that the degree of home bias in government spending is larger than the degree of home bias in private consumption.

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a policy instrument that can be changed in the face of shocks.
Imposing that in equilibrium, the bonds market must clear meaning that $nB_{H,t}+(1-n)B_{F,t} = 0 \ \forall t$, and using that $\int_0^n p_t(h)y_t(h)dh = P_{H,t}Y_{H,t}$ renders the government budget constraint:

$$\tau Y_{H,t} + T_t = G_t \tag{1.14}$$

A similar budget constraint holds for the Foreign government:

$$\tau^* Y_{F,t} + T_t^* = G_t^* \tag{1.15}$$

Monetary policy

Within the monetary union, the nominal exchange rate is normalized to unity and does therefore not constitute a policy instrument. The monetary policy instrument is the union-wide nominal interest rate paid on one-period bonds to the intermediaries, denoted i.[10]
I abstract from monetary frictions and can thus consider a "cashless economy" as in Woodford (2003). Hence, whereas monetary policy is neutral under flexible prices within the described framework, it affects the real economy in the presence of nominal rigidities, and through its effect on the debt burden of countries.

1.2.4 Market Clearing and Aggregation

Given the mentioned private and public demand, aggregate demand facing domestic producers amounts to:

$$Y_{H,t} = a_H \left(\frac{P_{H,t}}{P_t}\right)^{-\phi} C_t + \frac{1-n}{n} a_H^* \left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\phi} C_t^* + G_t \tag{1.16}$$

and aggregate demand for the foreign good amounts to:

$$Y_{F,t} = \frac{n}{1-n}(1-a_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\phi} C_t + a_H \left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\phi} C_t^* + G_t \tag{1.17}$$

[10] As explained in Woodford (2003) (p. 239, footnote 4), "In a cashless economy the central bank achieves its operating target for i_t by adjusting the interest rate i_t^m paid on the monetary base; an arbitrage relation then requires that $i_t = i_t^m$ in any equilibrium, given a positive supply of base money at all times. Here I simplify by supposing that the central bank can directly control the short-term market rate i_t..."

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Output is demand-determined in equilibrium, and, hence, the above equation can also be viewed as a goods market clearing condition.

Equilibrium on the financial markets requires that bonds and assets are in zero net supply:

$$nB_{H,t} + (1-n)B_{F,t} = 0 \tag{1.18}$$

When there is not complete trade in assets across countries, then consumption risk is not fully shared across countries. It is thus necessary to keep track of the evolution of the current account under incomplete markets. By combining the household's budget constraint and the government's budget constraint we obtain an aggregate resource constraint, characterizing the evolution of the current account. The Home aggregate resource constraint is:

$$C_t + \frac{B_{H,t}}{P_t(1+i_t)\Phi(B_{H,t}/P_t)} = \frac{P_{H,t}}{P_t}(Y_{H,t} - G_t) + \frac{1}{\pi_t}\frac{B_{H,t-1}}{P_{t-1}} + [\frac{1}{\Phi(B_{F,t}/P_t^*)} - 1]\frac{B_{F,t}}{P_t^*(1+i_t)}Q_t \tag{1.19}$$

Within the model developed above, optimal monetary and fiscal policy will depend on the trade-off facing the Ramsey policy maker. In the following section, I will describe the Ramsey policy maker's problem, define the efficient allocation, and characterize the trade-off faced by the Ramsey policy maker when deviations from this efficient allocation occur.

1.3 Ramsey Policy

1.3.1 The Ramsey policy maker's problem

I analyse the effects of international financial frictions and the resulting international imbalances for constrained Ramsey policy from a "timeless perspective".[11] The policy instruments available to the Ramsey policy maker are the union-wide nominal interest rate and Home and Foreign government spending. The Ramsey policy maker chooses a sequence of policies which maximize union-wide welfare subject to private sector optimization, the government budget constraints and the resource constraints, given the initial conditions (I_{t-1}) and the

[11] This implies that the policy maker cannot deviate from commitments made previously, cf. Woodford (2003).

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contemporaneous shocks (Ω_t).[12] The Ramsey problem thus is:

$$\max_{i(\Omega_t,I_{t-1}),G(\Omega_t,I_{t-1}),G^*(\Omega_t,I_{t-1})} E_t \sum_{s=0}^{\infty} \beta^{s-t}[nU(C_{t+s},G_{t+s},L_{t+s}) + (1-n)U^*(C^*_{t+s},G^*_{t+s},L^*_{t+s})]$$

$$s.t.\quad (1.5),(1.6),(1.7),(1.9),(1.10),(1.11),(1.12),(1.13),(1.14),(1.15),(1.16),(1.17),(1.18)$$

and Foreign counterparts

Solving the above problem corresponds to taking derivatives of the Lagrangian figuring in Appendix A with respect to all endogenous variables and lagrange multipliers.

The Ramsey allocation does generally not coincide with the first-best allocation. Only when competition is perfect, prices are flexible, and markets are complete can the Ramsey policy maker set policies which sustain the social planner's solution.[13] This efficient allocation constitutes a natural benchmark for evaluating different policies, and helps characterize the trade-off faced by the Ramsey policy maker.

1.3.2 The efficient allocation - a benchmark

In this subsection, I characterize the efficient allocation defined as the equilibrium which yields the highest possible union-wide welfare in the absence of any distortions. This allocation can be supported as a decentralized equilibrium under complete markets, flexible prices and appropriate subsidies eliminating monopolistic competition according to the second welfare theorem. The efficient allocation will serve as a benchmark in order to understand how the trade-off faced by the policy maker is affected by the international financial markets structure.

The efficient allocation derived from maximization of union-wide utility subject to private-sector optimization, government budget constraints, and firm technology, in the absence of distortions, is characterized by the following equations:

$$\chi G_t^{-\sigma} = \frac{P_{H,t}}{P_t} C_t^{-\sigma} \tag{1.20}$$

[12] I_{t-1} is composed of period $t-1$ prices and price dispersion as well as by the current account.

[13] The Ramsey policy maker sets the policy instruments such as to increase common welfare - constrained by private agents' behavior and national government budget constraints. That is, he cannot transfer funds from one country to the other directly. Could he do so, then the first-best allocation could be obtained at all points in time, whatever shocks hit. However, given that this is not possible, the first-best allocation can generally not be obtained when a country-specific shock hits.

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$$\chi G_t^{*-\sigma} = \frac{P_{F,t}^*}{P_t^*} C_t^{*-\sigma} \tag{1.21}$$

$$\frac{C_t^{-\sigma}}{C_t^{*-\sigma}} = \frac{P_t}{P_t^*} \tag{1.22}$$

That is, the policy maker aims at achieving the optimal composition of spending relating private and public consumption within each country (equations (1.20) and (1.21)) as well as full consumption risk sharing (equation (1.22)). Full risk sharing results from equalization of the marginal utility of consumption and its marginal cost, the latter being measured by the foreign marginal utility of consumption times the relative price.

It is useful to define deviations from the optimal spending composition and from full risk sharing by gaps. The spending composition gaps are defined as

$$Ggap_t \equiv \chi G_t^{-\sigma} - \frac{P_{H,t}}{P_t} C_t^{-\sigma} \quad \text{and} \quad Ggap_t^* \equiv \chi G_t^{*-\sigma} - \frac{P_{F,t}^*}{P_t^*} C_t^{*-\sigma} \tag{1.23}$$

The demand gap defining deviations from full risk sharing is described by the equation:

$$Dgap_t \equiv \frac{C_t^{-\sigma}}{C_t^{*-\sigma}} - \frac{P_t}{P_t^*} \tag{1.24}$$

When nominal frictions are present and markets are incomplete, the Ramsey policy maker faces a trade-off which can be characterized in terms of deviations from the efficient output level, from zero inflation, from the optimal spending composition level, and from full risk sharing, i.e. in terms of output gaps, inflation, spending composition gaps and demand gap.

1.3.3 Loss functions - an analytical characterization of optimal policy

The trade-off faced by the policy maker can be illustrated by his loss function. The loss function can be approximated by a quadratic function in which the relative weights attached to minimizing the different inefficiencies illustrate the relative importance of each inefficiency. In this subsection figures the quadratic loss function in the case where countries are symmetric, prices are flexible, and government spending is wasteful.[14] This simplification clarifies

[14] If prices were staggered as in the benchmark model presented in Section 2, producer price inflation rates would also enter the loss function. For simplicity, they do not figure in the loss function here. Similarly, was government spending not assumed to be wasteful, then government spending gaps would be present in the loss function to illustrate that welfare losses are associated with deviations from the optimal spending

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how the benevolent policy maker's loss function is affected by the introduction of market incompleteness in a relatively simple context, and whatever the potential instruments of the policy maker might be. In this case, the loss function can be written as:

$$\begin{aligned}\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & (\sigma+\eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] \\ & + 2a_H(1-a_H)\frac{(\phi\sigma - 1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H-1)^2]\hat{T}_t^2 \\ & - 4a_H(1-a_H)(\phi\sigma-1)\hat{T}_t(\hat{Y}_{H,t} - \hat{Y}_{F,t}) + \frac{2a_H(1-a_H)}{\sigma}Dgap_t^2\} + t.i.p. + (||\mathcal{O}||)^3\end{aligned} \tag{1.25}$$

where $t.i.p.$ denotes terms independent of policy, and $(||\mathcal{O}||)^3$ denote terms of order 3 or higher. A tilted variable denotes the efficient deviation of that variable from steady state:

$$\begin{aligned}\tilde{Y}_{H,t} \equiv & \frac{2(2a_H-1)^2(1+\eta)}{(2a_H-1)^2\eta + \sigma[1-2a_H(1-a_H)]}\hat{A}_t \\ \tilde{Y}_{F,t} \equiv & \frac{2(2a_H-1)^2(1+\eta)}{(2a_H-1)^2\eta + \sigma[1-2a_H(1-a_H)]}\hat{A}_t^*\end{aligned}$$

The quadratic loss function is exactly similar to the one derived under the assumption of complete markets, except for the introduction of demand imbalances into the loss function, see the Technical Appendix. As in Benigno and Benigno (2006), or Corsetti, Dedola, and Leduc (2010b), the quadratic loss function of the benevolent policy maker is increasing in output gaps and terms of trade movements. Moreover, the demand-gap appears in the loss function, illustrating that deviations from full risk sharing across countries are distortionary and reduce welfare.

The coefficients in front of the different policy objectives appearing in the loss function characterize the relative weights attached to those objectives. Notably, the relative weight attached to the demand gap is dependent on the degree of home bias, the steady state government spending to output ratios, as well as on the intertemporal elasticities of labor and consumption, and on the trade elasticity,[15] confirming the findings in Corsetti, Dedola, and Leduc (2010b): openness and elasticities play a key role in shaping the policy trade-offs in open economies with incomplete markets. More specifically, the relative weight of the demand gap is decreasing in the trade elasticity ϕ for a wide range of realistic parameter

composition. For details on the derivation of the loss function, please refer to the Technical Appendix.

[15] Even though the trade elasticity does not figure in the coefficient on the D-gap, it enters the coefficient on the terms of trade and thus affects the relative weight assigned to either of those objectives.

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combinations.[16] The reason for this relates to the fact that redirecting demand from one country to the other requires larger price deviations the lower the trade elasticity. Hence, it is optimal, in order to avoid large deviations from full risk sharing, to allow relative price changes to a larger degree the lower the trade elasticity. As a result the weight on the demand imbalances relative to the weight on the terms of trade falls with the trade elasticity.

As illustrated by the loss function, the relative importance of the different inefficiencies (or gaps) and the resulting trade-off faced by the policy maker differ according to the international financial markets structure and to the international goods market structure. In order to understand the implications for optimal policy, I engage in numerical analysis in the following sections. More specifically, I investigate the trade-off facing the fiscal policy maker within the specified framework by studying the impulse responses following a country-specific technology shock.

1.4 A Numerical Investigation of Optimal Policy in a Monetary Union

1.4.1 Solution method and Parameterization

The recursive solution to the Ramsey problem consists in policy functions describing the response of the nominal interest rate and the government spending levels to initial conditions and current disturbances. However, the form of the policy functions are undetermined and therefore a closed-form solution does not exist. We can nevertheless approximate the policy functions around some specified steady state. By using the method of undetermined coefficients, based on the knowledge of the derivatives of the equilibrium equations at the steady state, the model above can be solved by approximating the solution to the policy functions. The steady state around which the policy functions are approximated is the symmetric zero-inflation steady state in which monopolistic distortions are eliminated through appropriate subsidies. The approximated policy functions thus found are used for the numerical analysis carried out in this section.[17]

[16] See Proposition 1.1 in the Technical Appendix.

[17] I use code developed by Lopez-Salido and Levin (2004) to compute the approximated Ramsey optimal policies in Dynare.

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The parameter values used throughout this section figure in the Table 1. Most of them are quite standard in the business cycle literature, and realistic for the EMU.[18]
The population of each of the countries are assumed to be identical. The discount factor is set such that the steady state annual real interest rate is 4 percent. The Frisch elasticity of labor is set equal to 0.5. The inverse of the intertemporal elasticity of substitution, the risk aversion coefficient, is set to 1.5 in the benchmark calibration following Smets and Wouters (2003). χ is equal to 1/3 such that in steady state private consumption is more than twice as large as government consumption.
The degree of home bias is set to 0.9, implying that the steady state import ratio is 10 percent. The elasticity of substitution between goods produced within a country is set equal to 7.66 such as to ensure a mark-up of 15 percent. On average prices are sticky for a year: $\alpha = 0.75$. This value is in line with the GMM-estimates found by both Gali, Gertler, and Lopez-Salido (2001) and the Bayesian DSGE estimations carried out by Smets and Wouters (2003).[19]
Since the international trade elasticity is an important determinant of the equilibrium dynamics of the model presented in section 2, and thus of the trade-off faced by the policy maker, and since the empirical literature has not reached a consensus as to plausible values for that parameter, I consider different possible values for this elasticity. Whereas large values have been predicted by the international trade literature and by microeconomic studies, a relatively low trade elasticity, close to 1/2, corresponds to the estimates found in the international macroeconomic literature, see e.g. Hooper, Johnson, and Marquez (2000) or Corsetti, Dedola, and Leduc (2008). I thus consider values in the [0.5; 4] range for the trade elasticity.
In the incomplete markets model, δ, the sensitivity of the bond yield to debt is set such as to roughly mimic the observed yield differences across the EMU before the debt crisis.[20] The benchmark value of δ is such that for every ten percentage points increase in debt,[21] the annual interest increases by 0.5 percentage points.

[18]The parameter values used are within the range of estimates found by Smets and Wouters (2003) by engaging in Bayesian estimation of a DSGE model of the euro area, or follow Benigno (2004) who calibrates his model to the EMU. See also Gali and Monacelli (2008).

[19]The degree of price stickiness is assumed to be identical across countries in the benchmark calibration, but I also carry out an experiment in which price stickiness differs across countries, mimicking potential differences in price rigidities across regions within the EMU as noted inter alia by Benigno (2004). See Appendix C.

[20]The estimates vary quite a lot from country to country and from year to year. The benchmark parameterization of δ is a rather conservative value when comparing to recent years.

[21]this corresponds approximately to a similar increase in debt-to-steady state gdp.

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Table 1.1: Parameter values in benchmark case

Population in country H	n	0.5
Discount factor	β	$1.04^{-1/4}$
Inverse of the elasticity of labor supply	η	2
Risk aversion coefficient	σ	1.5
Degree of home bias	a_H	0.9
Price stickiness coefficient	α	0.75
Weight on government expenditures	χ	1/3
Intra-temporal elasticity of substitution	θ	7.66
Trade elasticity	ϕ	[0.5; 4]
Yield sensitivity to debt	δ	0.05

The following process is assumed for the technology shocks:

$$\begin{bmatrix} \log A_t \\ \log A_t^* \end{bmatrix} = \begin{bmatrix} 0.95 & 0 \\ 0 & 0.95 \end{bmatrix} \begin{bmatrix} \log A_{t-1} \\ \log A_{t-1}^* \end{bmatrix} + \begin{bmatrix} v_t \\ v_t^* \end{bmatrix} \tag{1.26}$$

where v_t and v_t^* are white noise processes with standard deviations 0.01.[22]

As compared to the previous literature on the fiscal and monetary policy interaction in a monetary union, the calibration here departs on several points: Both Gali and Monacelli (2008) as well as Beetsma and Jensen (2005) assume no home bias in consumption, and a unitary trade elasticity. The assumption of no home bias rules out deviations from PPP (and thus changes in the real exchange rate), whereas a unitary trade elasticity simplifies their models considerably. Furthermore, Gali and Monacelli (2008) consider the knife-edge case of log-utility in consumption, which together with a unitary trade elasticity implies that there are no spillovers across countries. The calibration chosen here can be considered as being somewhat better suited for considering realistic equilibrium dynamics within the EMU.

In the following, the parameter values listed above are used in order to investigate the effects of international financial frictions for the trade-off faced by the policy maker, and the resulting optimal monetary-fiscal policy mix. First, I analyse the optimal policy response to country-specific shocks when prices are flexible. Then, I show how the trade-off changes when nominal rigidities are present.

[22]In Appendix C, I consider the implications of technology spillovers across countries.

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1.4.2 Optimal policy under flexible prices

When prices are flexible and markets complete, then the efficient allocation can be implemented. In that case, fiscal policy does not play a stabilization role: government spending is set such as to satisfy the optimal spending composition. If, instead, international financial markets are incomplete, it might be optimal to use the fiscal policy instruments such as to reduce the distortions associated with international financial frictions. The derived loss function indeed showed the $Dgap$ to be an objective for the cooperative policy maker. The optimality of using fiscal policies for this objective, that is, to reduce international imbalances, depends on the fiscal transmission mechanism which crucially depends on the trade elasticity.

To understand the mechanism, consider the effect of government spending. A change in government spending affects marginal costs through its effect on aggregate demand and thus labor demand. Under flexible prices, producer prices are set at a constant mark-up over marginal costs, and thus the change in government spending affects prices. The induced change in the terms of trade affects relative income and thus relative consumption demand differently depending on whether the internationally traded goods are substitutes or complements in utility. Indeed, the trade elasticity determines the movements in income following a change in the terms of trade induced by fiscal policy.

Substitutable goods. Under a high trade elasticity the effects of government spending on relative consumption and price movements are such that large deviations of government spending from its optimal spending composition level are required in order to achieve a given reduction in international demand imbalances. Consider the effect of an increase in Home government spending, shifting demand towards the Home good, and thus increasing inflationary pressure at Home. The latter implies a fall in the real exchange rate and a fall in relative Home income. Since the demand gap is defined as $Dgap_t \equiv \left(\frac{C_t}{C_t^*}\right)^{-\sigma} - \frac{1}{Q_t}$, the fact that fiscal policy affects both of the terms defining the $Dgap$ in similar directions implies that it is rather difficult to narrow the demand gap using the fiscal policy instrument - at least without large costs in terms of government spending gaps. And, hence, it is not optimal to use the fiscal policy instruments to reduce the demand gap when the trade elasticity is large, as Figure 1.1 shows.

Figure 1.1 depicts the optimal policy response to a one standard deviation shock to productivity in country H. Due to the resulting fall in marginal costs, producer prices fall in the Home country. Since the substitution effect of the price change dominates the income effect,

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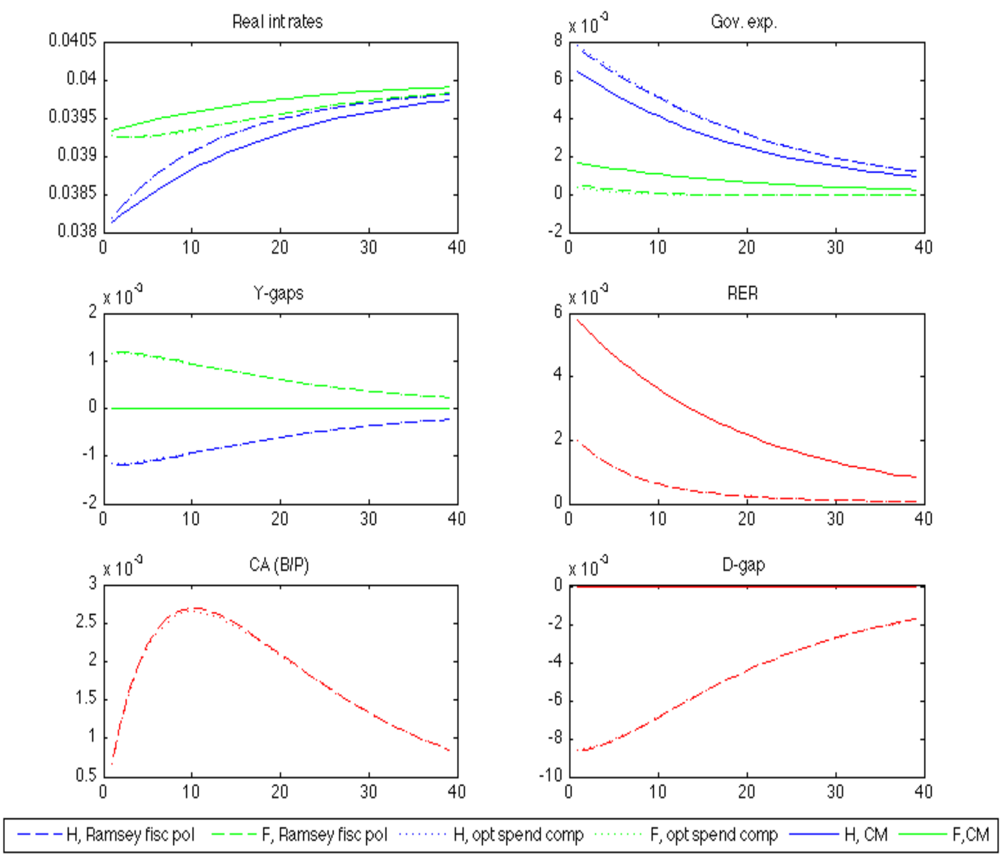
Home agents become temporarily richer and the current account turns positive. Prices move less than under complete markets in order to contain the rise in the current account at the expense of output gaps. This illustrates the fact that the efficient allocation, characterized by a zero demand gap and zero output gaps, cannot be achieved in the face of country-specific shocks. As already pointed out, optimal fiscal policy does not consist in reducing the demand gap since the costs associated with doing so, in terms of deviations from the optimal spending composition, are too large.

Figure 1.1: Optimal policy under substitutability ($\phi = 4$).



The impulse responses are those following a positive one-standard deviation shock to productivity in country H. "H, Ramsey fisc pol" refers to the response of Home variables under Ramsey fiscal and monetary policy. "H, opt spend comp" refers to the response of Home variables in the case where monetary policy is Ramsey optimal whereas government expenditures are set at their optimal spending composition level, i.e. such as to close the spending composition gap. "CM" refers to the case of complete markets. For all variables, except for the annualized real interest rates, deviations are shown relative to their steady state level. The real interest rates depicted are not identical to the international bond yields which depend on debt levels.

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The optimal fiscal policy response to a productivity shock to country H is in line with the predictions from the loss function derived in section 3.3. Indeed, the loss function indicates that the cross-country insurance role of fiscal policy might be rather small when the traded goods are substitutes. In combination with the limited effectiveness of fiscal policy in reducing international imbalances, this refrains fiscal policy from acting as a cross-country insurance tool. However, the derived loss function implies a larger risk-sharing role for fiscal policy when the traded goods are complements. The numerical exercise confirms this: The international imbalances affect the trade-off to a larger extent under a low trade elasticity, cf. Figure 1.2.

Complementary goods. Figure 1.2 depicts the optimal policy response to a positive one standard deviation Home TFP shock under complementarity of the traded goods. Whereas the Home agents were made relatively richer by the TFP shock under a high trade elasticity, the TFP shock makes them temporarily poorer under a low trade elasticity: the domination of the income effect implies that the fall in prices triggered by the TFP shock results in lower income. Hence, the current account is negative. Prices react more aggressively to a Home technology shock such as to retain international imbalances: The Home real interest rate falls further than under complete markets, thereby increasing demand for the Home good, and the Foreign real interest rate rises such as to decrease demand in country F. Price adjustments thus limit the current account imbalances but also increase Home output above the complete markets level and reduce Foreign output below its efficient level. The imbalances are thus curbed at the expense of output gaps which are of the opposite sign of those appearing under substitutability of the goods.

In a monetary union the fiscal policy maker faces a trade-off between using government spending such as to reduce the output gaps at the expense of higher international imbalances and using it in order to decrease international imbalances at the expense of higher output gaps. The trade-off faced by the policy maker is illustrated by the presence of domestic inefficiencies (the output gaps) and international imbalances (the $Dgap$) when government spending is set at the optimal spending composition levels (dotted lines in Figure 1.2).[23] On the one hand, closing the positive output gap in H and the negative output gap in F requires a decrease in relative Home government expenditures; on the other hand, closing the positive relative demand gap requires an increase in relative domestic government expenditures. As

[23] In the case where the countries do not form a monetary union, optimal fiscal policy leads to a reduction in all inefficiencies. Fiscal policy cannot achieve the same within a monetary union because the output gaps are of different signs than under flexible exchange rates, cf. Appendix D.

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the impulse responses below show, the trade-off facing the policy maker is optimally tilted towards correcting the relative demand imbalances arising due to international financial frictions: Government expenditures are optimally increased at Home (relative to the case where they are passively set to satisfy the optimal spending composition) and decreased in F such as to reduce the demand gap at the expense of larger output gaps and spending composition gaps. Hence, under a low trade elasticity, fiscal policy plays a risk-sharing role which clearly overshadows its stabilization role. Government expenditures thus optimally follow a very different path than they would were markets complete, or were they simply set at the optimal spending composition level.

The reason why it is optimal to use fiscal policy to reduce international imbalances rather than national inefficiencies is simple. Whereas the fiscal instruments, namely government spending, are rather ineffective in reducing inefficiencies associated with internationally incomplete markets under highly substitutable goods, they can improve risk sharing without high costs in terms of deviations from the optimal spending composition level under complementary goods. Indeed, a rise in government spending leads to a rise in relative prices and a rise in relative consumption (rather than a fall in relative consumption under substitutability). Hence, an improvement in risk sharing across countries can be obtained at the expense of rather small deviations from the optimal spending composition under complementarity of the internationally traded goods: fiscal policy is more effective in reducing international demand imbalances. Combined with a relatively large weight on the $Dgap$ in the loss function of the policy maker, the incentive to use fiscal policy for this purpose, rather than in order to stabilize domestic objectives, is thus high under complementarity of the internationally traded goods. And, indeed, optimal fiscal policy consists in reducing international imbalances at the expense of larger domestic output gaps as illustrated in Figure 1.2.

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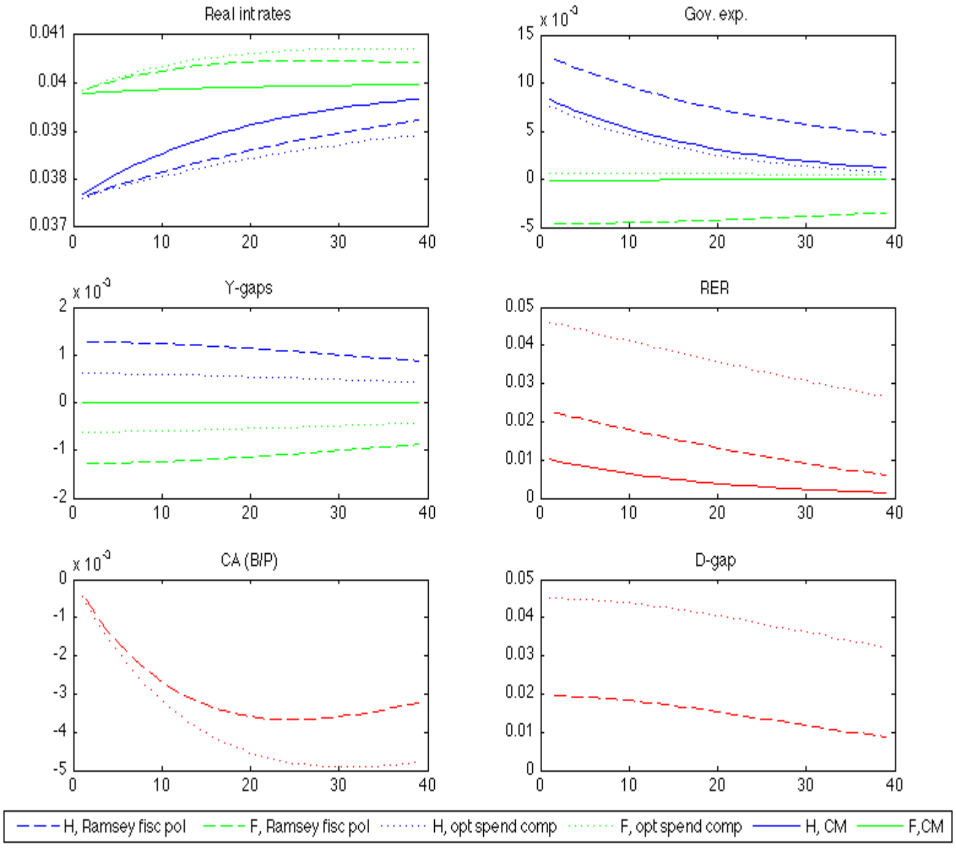
Figure 1.2: Optimal policy under complementarity ($\phi = 0.5$).



See notes for Figure 1.1.

The strand of the NOEM literature which considers the presence of international financial markets incompleteness has mostly come to the conclusion that the gains from taking into account the structure of international financial markets are rather small, cf. e.g. Benigno (2001).[24] As a result the policy maker need not care much about the international financial markets structure when setting policies, but should simply focus on domestic targets. Above, I have shown that this is not so under a low trade elasticity, in a monetary union with flexible prices: optimal policy consists in reducing the demand imbalances due to internationally incomplete markets at the expense of larger domestic inefficiencies (output gaps).

[24]The gains from taking into account financial markets have been shown to be non-existent in some special cases as pointed out by Cole and Obstfeld (1991) and Corsetti and Pesenti (2001). Recently, Corsetti, Dedola, and Leduc (2010b) is one among a few exceptions to point out that the international financial markets structure might have important consequences for optimal policy.

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Since inflation per se does not result in distortions which are relevant for the policy maker under flexible prices, it is optimal to let prices and government expenditures adjust such as to narrow a welfare-weighted combination of the output gaps, the relative demand gap and the optimal spending composition gaps. When prices are set in a staggered way as described in section 2, however, inflation leads to inefficient price dispersion across firms within a country. The New-Keynesian literature has emphasized the importance of stabilizing output gaps and inflation in this environment. More specifically, Beetsma and Jensen (2005) as well as Gali and Monacelli (2008) point out the output and inflation stabilization role of government expenditures within a monetary union with complete markets.
When prices are sticky and international financial frictions are present, there might be conflicts between achieving output stabilization, inflation stabilization, and cross-country insurance. In the following I study which policy objectives are conflicting, and which targets are the most important for a benevolent fiscal policy maker.

1.4.3 Optimal fiscal policy under sticky prices

The results found in the previous section go through in the presence of nominal rigidities: The trade-off faced by the fiscal policy maker is not very much affected by the structure of international financial markets under a high trade elasticity, and government spending continues to be inefficient as a cross-country insurance tool; However, when the trade elasticity is low, government expenditures play a risk-sharing role.

Substitutable goods. In order to understand the trade-off faced by the Ramsey policy maker, consider the effects of a positive Home TFP shock. The nominal interest rate is optimally decreased such as to ensure a union-wide increase in demand to counter-act the fall in prices due to the increased output supply. Since the real exchange rate is fixed and prices are sticky, relative prices will not adjust sufficiently to ensure the efficient level of output. Output gaps and inflation are thus non-zero.
Under complete markets, fiscal policy faces a trade-off between closing output gaps and reducing inflation, as emphasized in Beetsma and Jensen (2005). For example, by increasing Home government spending, the fiscal policy maker can reduce the deflationary pressure on Home prices resulting from the increase in TFP, but only at the expense of a higher output gap: the reduced fall in Home prices reduces the substitution towards the Home good, and since the substitution effect dominates the income effect of the price change, Home output falls further below its efficient level. A similar trade-off applies to the Foreign country's fiscal

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policy. Hence, when markets are complete, the optimal monetary-fiscal policy mix cannot achieve the first-best allocation under sticky prices, as illustrated in Figure 1.3.

In the presence of international financial frictions, the conduct of optimal policy is altered, showing the importance of the distortions stemming from incomplete markets. The main difference pertains to the fact that price changes are optimally much lower under incomplete markets implying higher output gaps, see Figure 1.3. The fact that prices fall less in country H following the TFP shock not only decreases distortions arising due to price changes, but also implies a lower substitution towards the Home good, thus lower income in country H. Since country H agents have become relatively rich following the positive Home TFP shock under a high trade elasticity, the current account has turned positive: Home agents lend to Foreign agents. The lower price changes, achieved at the expense of higher output gaps, ensure that current account imbalances leading to distortionary demand gaps do not become too large.

An active use of government spending only leads to minor changes, cf. Figure 1.3. This is so because government spending is a rather inefficient risk-sharing tool, as already noted in the case of flexible prices.[25]

[25]Indeed, domestic government expenditures are set to be above their optimal spending composition level in the first periods such as to decrease deflationary pressures at home, and vice-versa in country F. When inflation becomes positive, government expenditures fall below their optimal spending composition level such as to dampen inflationary pressures. Whereas the initial increase in home government spending and decrease in foreign government spending reduce the output gaps and the demand gap, the subsequent reversal has the opposite effect. This indicates that government expenditures are first and foremost set such as to stabilize inflation, under a high trade elasticity.

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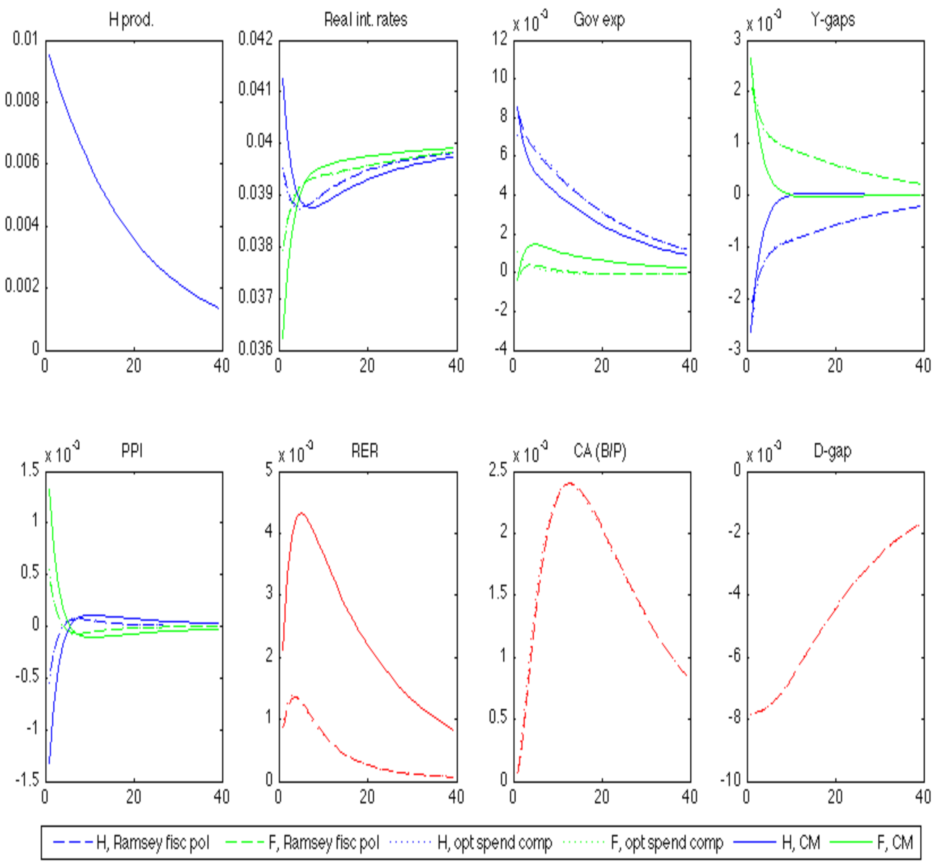
Figure 1.3: Optimal policy under sticky prices and high trade elasticity ($\phi = 4$).



See notes for Figure 1.1.

The impulse responses above show that financial market incompleteness only plays a minor role for optimal fiscal policy when the trade elasticity is high. However, this is not a general result. Indeed, as under flexible prices, the above result changes dramatically when the trade elasticity is low.

Complementary goods. Consider the effects of a temporary positive Home TFP shock, as depicted in Figure 1.4. Because aggregate Home producer prices do not fall sufficiently under sticky prices in the first periods, Home firms make large profits on aggregate during these first periods where firms readjust their prices. As a result, Home agents become relatively richer in the short term following a productivity shock. Only after prices have adjusted do their income fall and will they thus wish to borrow. The current account then

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turns negative. When the internationally traded goods are complements, the presence of international financial frictions leads to larger - but contained - price movements and thus more aggressive responses of the real interest rates. Prices vary more such as to contain international imbalances: the resulting short term increase in the Home real interest rate retains Home lending in the first periods. Following, the H real interest rate falls implying higher income in country H and thus less borrowing. Both in the short term and in the long term, prices thus adjust such as to retain current account imbalances, at the expense of higher but contained distortions associated with price changes and higher output gaps.
When fiscal policy is allowed to adjust optimally, government spending is increased in Home and decreased in the Foreign country, cf. Figure 1.4. This has the effect of increasing inflationary pressure in the Home country while reducing it in the Foreign country. As a result the real exchange rate is largely reduced - reducing the welfare losses associated with international imbalances and illustrated by the reduction in the demand gap. That is, optimal fiscal policy acts such as to reduce the demand imbalances through lower price changes. This is done at the expense of higher output gaps after the price adjustment has taken place. Fiscal policy thus simultaneously reduces distortionary inflation and the demand gap, at the expense of output stabilization, cf. Figure 1.4.

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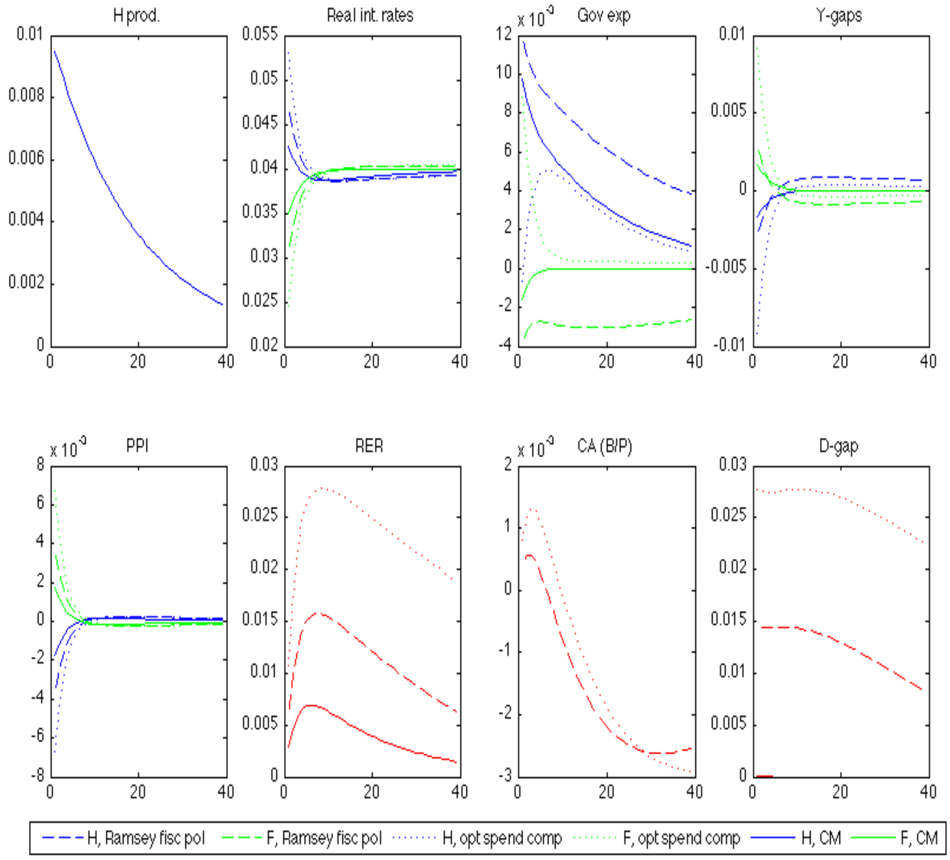
Figure 1.4: Optimal policy under sticky prices and complementarity ($\phi = 0.5$).



See notes for Figure 1.1.

On the contrary to the case where the traded goods are substitutes, fiscal policy plays an important role in reducing cross-country demand imbalances when the traded goods are complements - whether nominal rigidities are present or not.

The impulse responses figuring above show that optimal fiscal policy leads to a halvening of the relative demand imbalances. Indeed, setting government expenditures optimally decreases the welfare losses from incomplete markets arising within this model by 66 percent in the benchmark case, see Table 2. Hence, ignoring the financial markets structure can lead to policies that are very far from being optimal! This result contrasts with a large part of the earlier literature on the risk sharing role of optimal policies. Benigno (2001) e.g. concludes that "even if the costs of incomplete markets are non-negligible, the gains by using monetary policy optimally are always negligible." He finds that only when there are asymmetries across

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countries in initial net foreign asset positions do sizeable gains from optimal monetary policy arise as compared to policies of price stability.

In the following section, I assess the robustness of the results found above. First, I investigate whether the results found hinge on the specific kind of shocks hitting the economy. More specifically, I will consider whether the results go through in the face of news shocks, preference shocks, and mark-up shocks in order to exploit the generality of the results found for technology shocks. Following, I consider the sensitivity of the results to specific parameter values chosen in the numerical analysis above.

1.5 Robustness

1.5.1 News, preference and mark-up shocks

In order to check whether the cross-country insurance role of government expenditures hinges on the shocks affecting only technology, I consider the results' robustness to news shocks, preference shocks, and mark-up shocks. News shocks differ from productivity shocks in that they constitute anticipated technology shocks which affect forward-looking exchange rates and thereby the degree of risk sharing before the actual technology change occurs. Preference shocks have the particularity of affecting the risk sharing condition directly. Mark-up shocks differ from the two other types of shocks in that they are "inefficient", that is, imply inefficient movements in variables. Hence, by considering those three types of shocks, I make sure to consider a wide range of shocks. Details are available in the Appendix C.
The response of government expenditures to news shocks is of interest because news shocks emphasize the forward-looking features of the model: because prices are forward-looking, the exchange rate reacts to news about technology changes before they eventually take place. This affects the international demand imbalances directly. The optimality of fiscal policy as a cross-country insurance tool goes through in the face of news shocks, under complementarity of the traded goods: optimal fiscal policy consists in correcting the international imbalances at the expense of larger output gaps in the medium run.
The results found in the previous section also go through to a large extent in the presence of preference shocks: Under a low trade elasticity the international imbalances are corrected, at the expense of wider national output gaps in the medium term.
As a last check, I consider the presence of mark-up shocks e.g. induced by a change in the tax rate on production. In the face of mark-up shocks which are inefficient in their nature,

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the relevance of the cross-country demand imbalances for the fiscal policy maker is once again apparent in the case where the trade elasticity is low.
That is, the results for technology shocks go through for other kind of shocks as well, making clear that the concerns of the fiscal policy maker should depend on the international financial markets structure whenever the traded goods are complements.

1.5.2 Sensitivity analysis

I now consider the sensitivity of the risk-sharing role of fiscal policies in a monetary union to some important parameters, namely the trade elasticity, which plays a crucial role within this analysis, the debt-sensitivity of the yield which governs the international financial frictions, and the correlation of shocks and their spillover across countries.[26]

The trade elasticity

The elasticity of substitution between the domestically produced goods and the Foreign goods is a crucial determinant of the way in which fiscal policy should optimally be set. As noted previously a trade elasticity of 0.5 appears to be a reasonable value according to several studies such as Hooper, Johnson, and Marquez (2000) and Corsetti, Dedola, and Leduc (2008). While 0.5 remains in the confidence band of estimates found by Heathcote and Perri (2002) for the US, their point estimate is 0.9 - a little larger than the previous sources indicate, but still much lower than the trade literature indicates. In the following, I show that the results found for an elasticity of 0.5 go through qualitatively for an elasticity of 0.9 even though this implies that the internationally traded goods are substitutes. However, the optimal deviations of government expenditures from its optimal spending composition in order to reduce demand imbalances are dampened.
Figure 1.5 shows the impulse responses following a domestic technology shock, for the case of flexible prices. The important point is that - also for an elasticity of 0.9 - the trade-off between reducing demand imbalances or output gaps goes in the favour of reducing the demand imbalances at the expense of larger output gaps. That is, the qualitative result that welfare is maximized by reducing international demand imbalances rather than national output gaps goes through.

[26]In the Appendix C figure sensitivity analyses to the coefficient of relative risk aversion as well as to asymmetric degrees of price rigidities.

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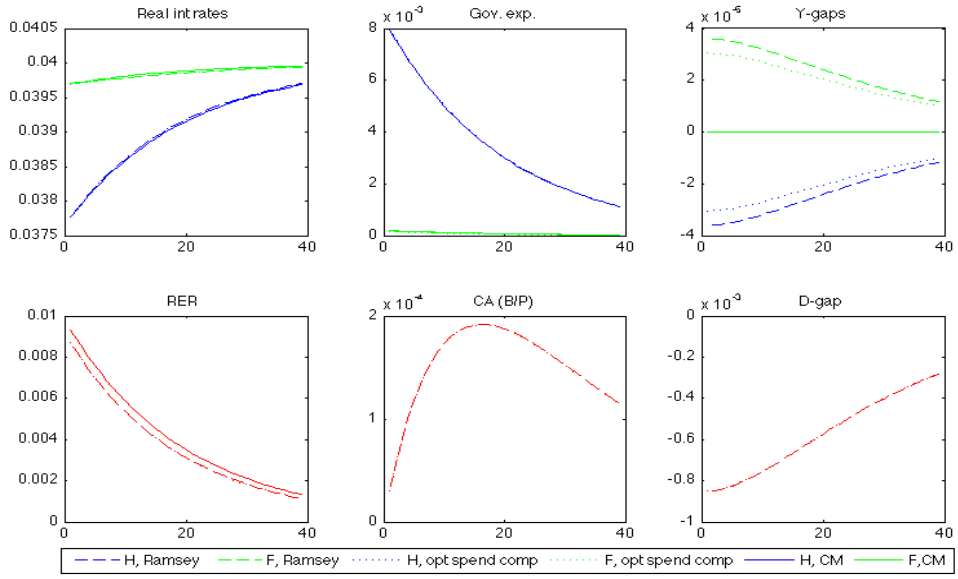
Figure 1.5: Optimal policies under flexible prices and $\phi = 0.9$.



See notes for Figure 1.1.

Debt-sensitivity of yield

The yield on bonds is a function of debt: the higher is a country's external debt, the higher will be the yield to be paid on this debt. This debt-sensitivity is modelled through the parameter δ. The benchmark value of δ is such that for every ten percentage points increase in debt,[27] the annual interest increases by 0.5 percentage points. The estimates obtained by regressing interest differentials between EMU-countries and Germany on deviations of debt-to-gdp ratios for the period 2001-2010 gives varying results depending on the country and the time period.[28] The benchmark value chosen is close to the average for all EMU-countries during the entire period considered, and the effects of deviations from this benchmark value have no effect on the main results of this paper. However, changes in δ do affect the magnitude of current account changes following shocks and have implications for the speed of transition to the steady state following shocks.

The main effect of an increase in δ is to restrict the optimal magnitude of current account imbalances, and, hence, the higher is the debt-sensitivity of the yield, the lower are the

[27]this corresponds approximately to a similar increase in debt-to-steady state gdp.

[28]The estimation relies on the steady state debt-to-gdp ratio being 60 percent, and the German interest rate being the interest rate set by the ECB.

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current account imbalances occurring. However, this does not imply that the resulting international demand imbalances are lower: indeed, in order to achieve the optimal real yield differences across countries in response to a country-specific shock, inflation differences are higher the higher is the debt-sensitivity of the yield. This ensures relative demand across countries to be closer to their efficient level, but also creates demand imbalances resulting from the higher real exchange rate movements.

Technology spillovers and correlation of shocks

The importance of the demand imbalances arising as a consequence of international financial frictions under a low trade elasticity depends on the cross-country correlation of shocks as well as on potential technology spillovers across countries. The higher is the correlation between the shocks and the technological spillovers across countries, the lower are the resulting international imbalances arising in the face of country-specific shocks. One might therefore suspect that the trade-off faced by the policy maker may tilt away from correcting the international imbalances towards correcting national inefficiencies as shocks become more correlated and technology is transferred across countries.

Allowing shocks to be correlated and technology to be shared across countries do not alter the qualitative conclusions reached for uncorrelated technology shocks and productivity processes. Even though the correlation between shocks is set to 0.3 and the productivity spillover across countries is 0.025 (replacing the zeros in the productivity transition matrix), as in Heathcote and Perri (2002), the optimal fiscal policy still consists in correcting the international demand imbalances at the expense of national inefficiencies under complementarity of the goods. Hence, even though the international imbalances are of a lower magnitude when shocks are correlated and technology spills over from one country to the other, they remain important for union-wide welfare, and the policy maker optimally corrects them.

Note however that given the smaller imbalances arising under correlation of technology shocks and productivity processes, the welfare gains from setting fiscal policy at its Ramsey optimal level rather than at its optimal spending composition level are smaller than in the benchmark case. Indeed, the welfare gains from Ramsey fiscal policy under incomplete markets under the Heathcote and Perri (2002) calibration for productivity processes and shocks correspond to 36 percent of the welfare costs of market incompleteness. This is considerably smaller than the 66 percent obtained in the benchmark case. Since this result implies that the welfare costs from conducting passive national fiscal policies are lower the higher the cross-country correlation of shocks, it is in line with the literature on Optimal Currency

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Areas which has emphasized that the more correlated are shocks across countries the higher is the rationale for forming a currency union with independent fiscal policy authorities.[29]

1.6 Conclusion

The analysis carried out in this paper shows the importance of international imbalances for the trade-off faced by the policy maker in a monetary union where the internationally traded goods are complements. The optimal path for government spending is dependent on the financial markets structure. In the monetary union framework with complementary traded goods, the optimal fiscal policy consists in setting government spending such as to decrease the international demand imbalances arising due to imperfect financial markets, even as this results in higher domestic inefficiencies. That is, fiscal policy optimally acts as a cross-country insurance tool rather than as a domestic stabilization tool.

National and international targets are shown to require conflicting fiscal policy movements within the monetary union framework. That is, it is not possible to set fiscal policies optimally by focusing solely on domestic targets such as output gaps. This is a particularity associated with the absence of national monetary policy instruments. This implication of the analysis is in line with a growing recognition that policy making needs to take into account the international environment in which it is to perform. The Committee on International Economic Policy and Reform note that monetary policy has been conducted following the "own house in order" doctrine, meaning that "national macroeconomic stability was seen as sufficient for international macroeconomic stability. The domestic and international aspects were essentially regarded as two sides of the same coin."[30], whether because of the alleged almost non-existent inefficiencies arising from incomplete markets as in Baxter and Crucini (1993), or because of the ability of other mechanisms to make up for missing markets as emphasized in Cole and Obstfeld (1991). The Committee concludes that central banks should go beyond their traditional emphasis on domestic objectives. Though these statements regard central banking, they are in line with the implications for fiscal policy making drawn from this paper.

The results of this paper have important implications for policy making within the EMU: since they indicate that it is optimal from the perspective of the monetary union to use fiscal policies such as to reduce deviations from perfect risk sharing rather than to address country-specific output gaps, the implications must be a rethinking of the way fiscal policy is

[29] Cooper and Kempf (2004) also make a similar argument.
[30] "Rethinking Central Banking", September 2011.

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to be conducted within the EMU. In particular, macro-prudential policies aiming at reducing current account imbalances might prove welfare-increasing.
Furthermore, the results naturally raise the issue of potential welfare gains from fiscal policy cooperation in monetary unions. Indeed, the results show that optimal fiscal policy cannot be attained by focusing on domestic targets, but instead requires international objectives to enter into the loss function of the policy maker. Further research on the extent to which independent strategically competitive fiscal policy authorities deviate from the cooperative allocation is needed in order to address this question.
Another interesting question - also related to recent debates about fiscal policies in the EMU - is whether fiscal rules might prove beneficial within a monetary union. This paper indicates that if the internationally traded goods are complements, then debt-dependent fiscal rules and austerity measures associated with external debt may lead to higher international imbalances and deteriorate risk sharing across countries.

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1.7 Appendix A. The Ramsey problem

The Lagrangian of the Ramsey planner's problem is:

$$
\begin{aligned}
\mathcal{L} =& E_t \sum_{s=0}^{\infty} \beta^{t+s} \Bigg([nU(C_{t+s}, G_{t+s}, L_{t+s}) + (1-n)U^*(C^*_{t+s}, G^*_{t+s}, L^*_{t+s})] \\
&+ \lambda_{1,t+s} \left[Y_{H,t+s} - a_H \left(\frac{P_{H,t+s}}{P_{t+s}} \right)^{-\phi} C_{t+s} - \frac{1-n}{n}(1-a_H) \left(\frac{P_{H,t+s}}{P_{t+s}} \right)^{-\phi} Q^{\phi}_{t+s} C^*_{t+s} \right] \\
&+ \lambda_{2,t+s} \left[Y_{F,t+s} - a_H \left(\frac{P^*_{F,t+s}}{P^*_{t+s}} \right)^{-\phi} C^*_{t+s} - \frac{n}{1-n}(1-a_H) \left(\frac{P^*_{F,t+s}}{P^*_{t+s}} \right)^{-\phi} Q^{-\phi}_{t+s} C_{t+s} \right] \\
&+ \lambda_{3,t+s} \left[[\frac{1-\alpha\pi^{\theta-1}_{H,t+s}}{1-\alpha}]^{\frac{1}{1-\theta}} - \frac{\theta}{(\theta-1)(1-\tau)} \frac{x^1_{t+s}}{x^2_{t+s}} \right] \\
&+ \lambda_{4,t+s} \left[x^1_{t+s} - D^{\eta}_{t+s} A^{-(1+\eta)}_{t+s} Y^{1+\eta}_{H,t+s} - \alpha\beta\pi^{\theta}_{H,t+s+1} x^1_{t+s+1} \right] \\
&+ \lambda_{5,t+s} \left[x^2_{t+s} - C^{-\sigma}_{t+s} p_{H,t+s} Y_{H,t+s} - \alpha\beta\pi^{\theta-1}_{H,t+s+1} x^2_{t+s+1} \right] \\
&+ \lambda_{6,t+s} \left[D_{t+s} - (1-\alpha)[\frac{1-\alpha\pi^{\theta-1}_{H,t+s}}{1-\alpha}]^{\frac{-\theta}{1-\theta}} - \alpha\pi^{\theta}_{H,t+s} D_{t+s-1} \right] \\
&+ \lambda_{7,t+s} \left[[\frac{1-\alpha\pi^{\theta-1}_{F,t+s}}{1-\alpha}]^{\frac{1}{1-\theta}} - \frac{\theta}{(\theta-1)(1-\tau)} \frac{x^{1*}_{t+s}}{x^{2*}_{t+s}} \right] \\
&+ \lambda_{8,t+s} \left[x^{1*}_{t+s} - D^{*\eta}_{t+s} A^{*-(1+\eta)}_{t+s} Y^{*1+\eta}_{F,t+s} - \alpha\beta\pi^{\theta}_{F,t+s+1} x^{1*}_{t+s+1} \right] \\
&+ \lambda_{9,t+s} \left[x^{2*}_{t+s} - C^{*-\sigma}_{t+s} p_{F,t+s} Y^*_{F,t+s} - \alpha\beta\pi^{\theta-1}_{F,t+s+1} x^{2*}_{t+s+1} \right] \\
&+ \lambda_{10,t+s} \left[D^*_{t+s} - (1-\alpha)[\frac{1-\alpha\pi^{*\theta-1}_{F,t+s}}{1-\alpha}]^{\frac{-\theta}{1-\theta}} - \alpha\pi^{*\theta}_{F,t+s} D^*_{t+s-1} \right] \\
&+ \lambda_{11,t+s} \left[C_{H,t+s} - a_H \left(\frac{P_{H,t+s}}{P_{t+s}} \right)^{-\phi} C_{t+s} \right] + \lambda_{12,t+s} \left[C_{F,t+s} - (1-a_H) \left(\frac{P^*_{F_{t+s}}}{P^*_{t+s}} \right)^{-\phi} Q^{-\phi}_{t+s} C_{t+s} \right] \\
&+ \lambda_{13,t+s} \left[C^*_{H,t+s} - (1-a_H) \left(\frac{P_{H,t+s}}{P_{t+s}} \right)^{-\phi} Q^{\phi}_{t+s} C^*_{t+s} \right] + \lambda_{14,t+s} \left[C^*_{F,t+s} - a_H \left(\frac{P^*_{F,t+s}}{P^*_{t+s}} \right)^{-\phi} C^*_{t+s} \right] \\
&+ \lambda_{15,t+s} \left[a_H (\frac{P_{H,t+s}}{P_t})^{1-\phi} + (1-a_H)(\frac{P^*_{F,t+s}}{P^*_{t+s}})^{1-\phi} Q^{1-\phi}_{t+s} - 1 \right] \\
&+ \lambda_{16,t+s} \left[\frac{a_H (\frac{P^*_{F,t+s}}{P^*_{t+s}})^{1-\phi} Q^{1-\phi}_{t+s} + (1-a_H)(\frac{P_{H,t+s}}{P_{t+s}})^{1-\phi}}{a_H (\frac{P_{H,t+s}}{P_{t+s}})^{1-\phi} + (1-a_H)(\frac{P^*_{F,t+s}}{P^*_{t+s}})^{1-\phi} Q^{1-\phi}_{t+s}} - Q^{1-\phi}_{t+s} \right] \\
&+ \lambda_{17,t+s} \left[\frac{p^*_{F,t+s}}{p_{H,t+s}} \frac{p_{H,t+s-1}}{p^*_{F,t+s-1}} \frac{Q_{t+s}}{Q_{t+s-1}} - \frac{\pi^*_{F,t+s}}{\pi_{H,t+s}} \right] \\
&+ \lambda_{18,t+s} \left[\beta E_{t+s} [\frac{C^{-\sigma}_{t+s+1}}{C^{-\sigma}_{t+s}} \frac{1+i_{t+s}}{\pi_{t+s+1}}] - \frac{1}{\Phi(\frac{B_{H,t+s}}{P_{t+s}})} \right] + \lambda_{19,t+s} \left[\beta E_{t+s} [\frac{C^{*-\sigma}_{t+s+1}}{C^{*-\sigma}_{t+s}} \frac{1+i_{t+s}}{\pi^*_{t+s+1}}] - \frac{1}{\Phi(\frac{B_{F,t+s}}{P^*_{t+s}})} \right] \\
&+ \lambda_{20,t+s} \left[C^*_{t+s} + \frac{B_{F,t+s}}{P^*_{t+s}(1+i_{t+s})} \frac{1}{\Phi(\frac{B_{F,t+s}}{P^*_{t+s}})} - \frac{P^*_{F,t+s}}{P^*_{t+s}} (Y_{F,t+s} - G^*_{t+s}) - \frac{B_{F,t+s-1}}{P^*_{t+s}} - \left[\frac{1}{\Phi(\frac{B_{H,t+s}}{P_{t+s}})} - 1 \right] \frac{\frac{n}{1-n} B_{H,t+s}}{(1+i_{t+s}) P^*_{t+s}} \right] \\
&+ \lambda_{21,t+s} \left[nB_{H,t+s} - (1-n) B_{F,t+s} \right] \Bigg)
\end{aligned}
$$

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where $\pi_{H,t+s} \equiv \frac{P_{H,t+s}}{P_{H,t+s-1}}$, $\pi^*_{F,t+s} \equiv \frac{P^*_{F,t+s}}{P^*_{F,t+s-1}}$, $p_{H,t+s} \equiv \frac{P_{H,t+s}}{P_{t+s}}$, and $p^*_{F,t+s} \equiv \frac{P^*_{F,t+s}}{P^*_{t+s}}$.

The constraints relating to λ_1 and λ_2 are the aggregate demand equations, (1.16) and its foreign counterpart, $\lambda_3 - \lambda_{10}$ are associated with the pricing equations, $\lambda_{11} - \lambda_{14}$ are associated with the demand functions, $\lambda_{15} - \lambda_{16}$ are associated with equations relating the prices to each other and to the real exchange rate, λ_{17} relates to the evoluation of the terms of trade, $\lambda_{18} - \lambda_{19}$ are associated with the consumption Euler equations, and finally λ_{20} relates to the resource constraint and λ_{21} to bond market clearing.

1.8 Appendix B. Welfare results

I compute the consumption-equivalent welfare loss of having incomplete markets in the form specified in this paper, under optimally set fiscal policy and under the optimal spending composition. The welfare gains from setting fiscal policy optimally can thus be deducted.
I follow Schmitt-Grohe and Uribe (2004) and Devereux, Lane, and Xu (2006) in computing the second order consumption-equivalent welfare measure. I define the consumption-equivalent welfare cost of having incomplete markets and adopting the optimal spending composition, as compared to complete markets, λ^{OSC}, as to satisfy the equation:

$$
\begin{aligned}
&E_0 \sum_{t=0}^{\infty} \beta^t \left\{ nU((1-\lambda^{OSC})C_t^{CM}, G_t^{CM}, L_t^{CM}) + (1-n)U((1-\lambda^{OSC})C_t^{*CM}, G_t^{*CM}, L_t^{*CM}) \right\} \\
=&E_0 \sum_{t=0}^{\infty} \beta^t \left\{ nU(C_t^{OSC}, G_t^{OSC}, L_t^{OSC}) + (1-n)U(C_t^{*OSC}, G_t^{*OSC}, L_t^{*OSC}) \right\} \equiv W_0^{OSC}
\end{aligned}
$$

Using the functional forms specified in section 2, the above can be rewritten in the following way:

$$
\lambda^{OSC} = 1 - \left\{ \frac{(1-\sigma)(1-\beta)\left[W_0^{OSC} - W_0^{CM} + \sum_{t=0}^{\infty} \beta^t \frac{C_t^{CM1-\sigma} + C_t^{*CM1-\sigma}}{(1-\sigma)(1-\beta)}\right]}{\sum_{t=0}^{\infty} \beta^t \left(C_t^{CM1-\sigma} + C_t^{*CM1-\sigma}\right)} \right\}^{\frac{1}{1-\sigma}} \tag{1.27}
$$

The measure is computed conditionally on being in the deterministic steady state at time zero. A second-order approximation to the above welfare measure requires second-order approximations to welfare and consumption under the different financial market structures and fiscal policy regimes. These approximations are a function of the steady state values and the second derivative of the relevant policy functions, see Schmitt-Grohe and Uribe (2004).

For example, given the approximation to the policy function under incomplete markets and optimal spending composition, h^{OSC}, the welfare measure can be computed in the following way

$$W_0^{OSC} = \bar{W}^{OSC} + h_{\epsilon\epsilon}^{OSC}(W^{OSC})\frac{var(\epsilon_t)}{2} + h_{\epsilon^*\epsilon^*}^{OSC}(W^{OSC})\frac{var(\epsilon_t^*)}{2} + h_{\epsilon\epsilon^*}^{OSC}(W^{OSC})cov(\epsilon_t, \epsilon_t^*)$$

where $h_{\epsilon\epsilon}^{OSC}(W^{OSC})$ denotes the second derivative of the policy function for W^{OSC} with respect to the technology shock to country H.
Similarly, in order to get a measure of the welfare cost of incomplete markets under Ramsey optimal fiscal policy:

$$\lambda^R = 1 - \left\{ \frac{(1-\sigma)(1-\beta)\left[W_0^R - W_0^{CM} + \sum_{t=0}^{\infty}\beta^t \frac{C_t^{CM1-\sigma} + C_t^{*CM1-\sigma}}{(1-\sigma)(1-\beta)}\right]}{\sum_{t=0}^{\infty}\beta^t\left(C_t^{CM1-\sigma} + C_t^{*CM1-\sigma}\right)} \right\}^{\frac{1}{1-\sigma}} \tag{1.28}$$

The difference between those two welfare costs constitutes the welfare gains from implementing optimal fiscal policy as opposed to satisfying the optimal spending composition:

$$\lambda^{OPT,IM} = \lambda^{OSC} - \lambda^R \tag{1.29}$$

Welfare gains are reported in the table below. They are correct up to second order.

Table 1.2: Welfare gains from Ramsey optimal policy

	Low trade elasticity (0.5)	High trade elasticity (4)
Welfare gains from Ramsey optimal fiscal policy in percent of welfare costs of incomplete markets under optimal spending composition	66	1.26

To complete the welfare analysis, the welfare losses associated with the different fiscal policy regimes, and according to the financial markets structure, with respect to the efficient allocation figure below.

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Table 1.3: Welfare losses with respect to the efficient allocation ($\phi = 0.5$)

Optimal fiscal policy under complete markets, and sticky prices	0.0040
Optimal spending composition under complete markets, and sticky prices	0.0071
Optimal fiscal policy under incomplete markets, and sticky prices	0.0828
Optimal spending composition under incomplete markets, and sticky prices	0.2377

The welfare loss is computed in percent of steady state consumption.

1.9 Appendix C. Robustness and Sensitivity

In this appendix figures a more detailed robustness and sensitivity analysis than the one figuring in the paper "Imbalances and Fiscal Policy in a Monetary Union". First, I investigate the robustness of the results found in that paper with respect to different kinds of shocks. Thereafter figure some sensitivity analyses which are only mentioned briefly in the paper.

Robustness

News shocks. A news shock is defined as in Devereux and Engel (2006) and Corsetti, Dedola, and Leduc (2010a) and corresponds to an anticipated technology shock. The process of productivity is modelled as a sum of two processes: a technology process and a news process, i.e.

$$A_t = \frac{U_t}{V_t} \tag{1.30}$$

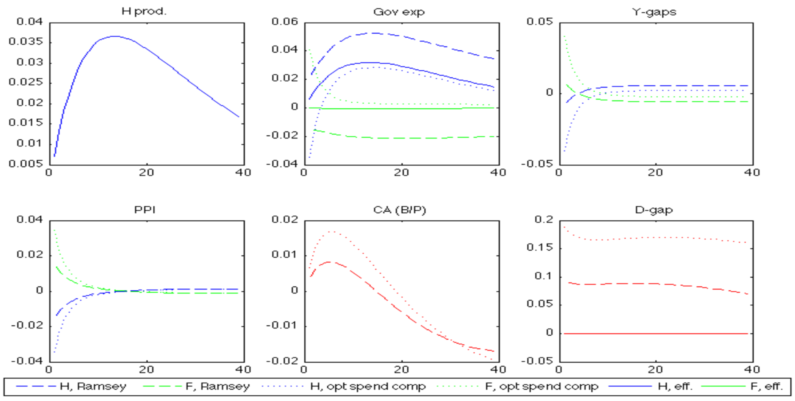
$$\log U_t = \rho_u \log U_{t-1} + \epsilon_{u,t} + \epsilon_{v,t} \tag{1.31}$$

$$\log V_t = \rho_v \log V_{t-1} + \epsilon_{v,t} \tag{1.32}$$

where $\rho_u > \rho_v$ and ϵ_u and ϵ_v represent white noise technology and news shocks respectively. I follow Corsetti, Dedola, and Leduc (2010a) in setting the standard deviation of ϵ_v to $\sqrt{0.02}$ such that the unconditional variance of productivity is similar to the case where there are no news shocks and the standard deviation of ϵ_u is 0.01 as in the benchmark numerical

exercise. I also follow them in setting $\rho_v = 0.9$. When a news shock hits ($\epsilon_{v,t} \neq 0$), then productivity starts increasing the period after the shock hits - not immediately. Given the parameterization, productivity only reaches its peak 13 quarters after a news shock has hit. Figure 1 shows the optimal policy response to a news shock of one standard deviation, assuming that no technology shock hits simultaneously, that is $\epsilon_{u,t} = 0$ for all t.
The optimal fiscal policy in the face of a news shock is very similar to the one following a technology shock. Under complementarity of the internationally traded goods, the optimal fiscal policy combination ensures a reduction in the international imbalances at the expense of higher output gaps. This is illustrated in the impulse responses following a domestic news shock below.

Figure 1.6: Optimal policy under sticky prices and complementarity ($\phi = 0.5$).



"H, Ramsey" refers to the response of Home variables under Ramsey fiscal and monetary policy. "H, opt spend comp" refers to the response of Home variables in the case where monetary policy is Ramsey optimal whereas government expenditures are set at their optimal spending composition level, i.e. such as to close the spending composition gap. "eff" refers to the case of complete markets with a zero inflation rate. For all variables, except for the annualized real interest rates, deviations are shown relative to their steady state level. The real interest rates depicted are not identical to the international bond yields which depend on debt levels.

Preference shocks. Whereas Beestma and Jensen (2005) find that preference shocks do not imply any trade-off for the policy maker within their complete markets framework,[31] they point out that under incomplete markets such shocks affect the cross-country demand

[31]Their results hinge on PPP holding. Hence, their results do not go through in my model under complete markets in the presence of home bias in consumption. Without home bias in consumption implying that PPP holds, my results are identical to Beetsma and Jensen (2005). Note that Gali and Monacelli (2008) ignore demand shocks, whereas Corsetti et al. (2011) consider the effects of preference shocks, and find results that are similar to those arising within this monetary union framework.

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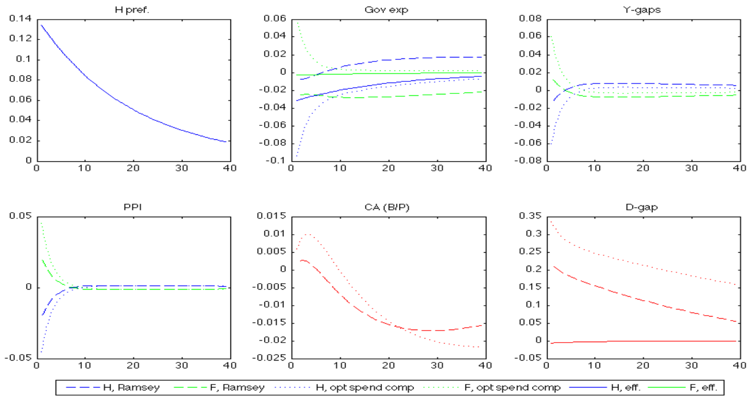
imbalances directly, potentially creating a risk-sharing role for government expenditures. Indeed, I find that country-specific preference shocks lead to movements in demand imbalances, which are optimally corrected by government expenditures - but only when the trade elasticity is low.

Figure 1.7: Optimal policy under sticky prices and complementarity ($\phi = 0.5$).



See notes for Figure 1.

As Figure 2 shows, the results found for technology shocks go through to a large extent in the presence of preference shocks as well: Under a low trade elasticity the international imbalances are corrected, at the expense of wider national output gaps in the medium term.

Mark-up shocks. Markup shocks are modeled as changes in the production tax. Making the tax rate time-varying, the maximisation problem of the firm producing good h becomes:

$$\max_{p_t(h)} E_t \sum_{s=0}^{\infty} \alpha^s \mu_{t,t+s} \{[(1-\tau_{t+s})p_t(h) - \frac{W_{t+s}}{A_{t+s}}] y_{t,t+s}(h)\} \tag{1.33}$$

The resulting first order conditions imply that prices are set according to expectations of future marginal costs, demand, and tax rates in the following way:

$$p_t(h) = \frac{\theta}{\theta-1} \frac{\sum_{s=0}^{\infty} (\alpha\beta)^s \frac{\zeta_{C,t} C_{t+s}^{-\sigma}}{P_{t+s}} \frac{W_{t+s}}{A_{t+s}} y_{t,t+s}(h)}{\sum_{s=0}^{\infty} (\alpha\beta)^s (1-\tau_{t+s}) \frac{\zeta_{C,t} C_{t+s}^{-\sigma}}{P_{t+s}} y_{t,t+s}(h)} \tag{1.34}$$

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This in turn implies that the price dynamics can be written in the following way under a time-varying tax rate:

$$[\frac{1-\alpha\pi_{H,t}^{\theta-1}}{1-\alpha}]^{\frac{1}{1-\theta}} = \frac{\theta}{(\theta-1)}\frac{x_t^1}{x_t^2} \tag{1.35}$$

$$\begin{aligned} x_t^1 &\equiv \sum_{s=0}^{\infty}(\alpha\beta)^s(\frac{P_{H,t+s}}{P_{H,t}})^{\theta}A_{t+s}^{-(1+\eta)}Disp_{t+s}^{\eta}Y_{H,t+s}^{1+\eta} \\ &= A_t^{-(1+\eta)}Disp_t^{\eta}Y_{H,t}^{1+\eta} + \alpha\beta\pi_{H,t+1}^{\theta}x_{t+1}^1 \end{aligned} \tag{1.36}$$

$$\begin{aligned} x_t^2 &\equiv \sum_{s=0}^{\infty}(\alpha\beta)^s(1-\tau_{t+s})(\frac{P_{H,t+s}}{P_{H,t}})^{\theta-1}\frac{P_{H,t+s}}{P_{t+s}}\zeta_{C,t}C_{t+s}^{-\sigma}Y_{H,t+s} \\ &= (1-\tau_t)\zeta_{C,t}C_t^{-\sigma}p_{H,t}Y_{H,t} + \alpha\beta\pi_{H,t+1}^{\theta-1}x_{t+1}^2 \end{aligned} \tag{1.37}$$

Note that if firms operate in an environment with perfectly flexible prices, the representative domestic firm sets its price to equal a constant markup over after-tax marginal costs:

$$\frac{P_{H,t}}{P_t} = \frac{\theta}{(\theta-1)(1-\tau_t)}\frac{1}{A_t}\frac{W_t}{P_t}$$

Markup shocks e.g. induced by a change in the tax rate on production differ from technology and preference shocks in that they are inefficient, meaning that they do not result from a change in fundamentals (such as productivity), and any change in production that follows such shocks is thus inefficient. Hence, under complete markets, government expenditures are optimally used to contain the output deviations resulting from the mark-up. That is, the optimal response of government expenditures to a mark-up shock does not decrease the inflationary pressures, nor does it ensure the optimal spending composition - but it does imply lower deviations of output.

Under incomplete markets and a high trade elasticity, the same pattern is observed as under complete markets. Again, this results from the output distortion impeding much more on welfare than any of the other distortions: under optimal government expenditures, output deviations are decreased at the expense of higher inflation, a wider demand gap, and optimal spending composition gaps.

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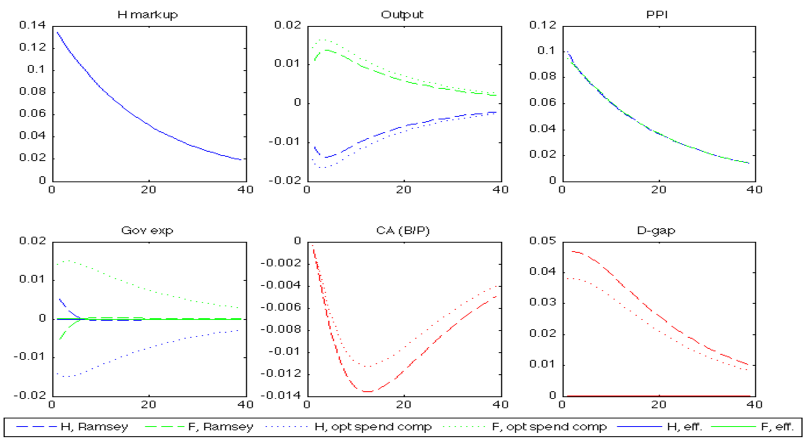
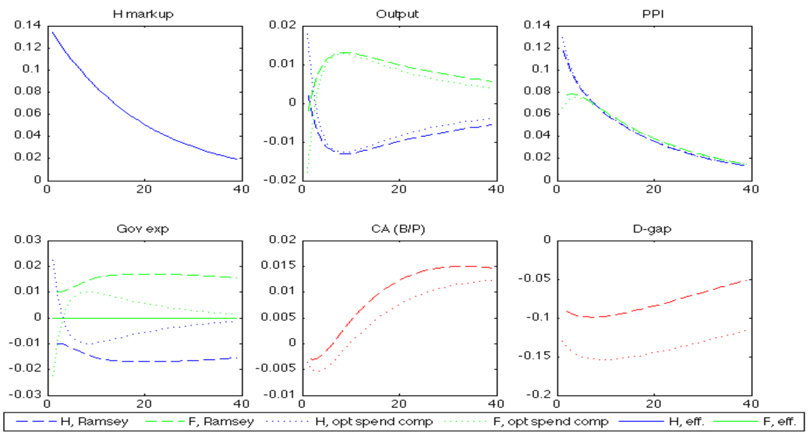
Figure 1.8: Optimal policy under sticky prices and substitutability ($\phi = 4$).



See notes for Figure 1.

Under complementarity of the internationally traded goods, optimal fiscal policy does not consist in counteracting output distortions and disregarding demand imbalances. Instead, the national fiscal policy instruments are optimally used such as to diminish the demand imbalances, at the expense, this time, of output distortions and deviations from optimal spending compositions.

Figure 1.9: Optimal policy under sticky prices and complementarity ($\phi = 0.5$).



See notes for Figure 1.

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The relevance of the cross-country demand imbalances for the fiscal policy maker is apparent when the internationally traded goods are complements - whether the shocks hitting the economy are technology shocks, news shocks, preference shocks or mark-up shocks.

Sensitivity

Risk aversion. The results are somewhat sensitive to the degree of risk aversion since it determines the importance of the substitution effect relative to the income effect of relative price changes, in combination with the trade elasticity.
For lower values of risk aversion, e.g. a risk aversion coefficient of 1/5 which is close to P. Benigno (2004)'s calibration, I find that though optimal fiscal policy still consists in reducing demand imbalances this is not done at the expense of other objectives. Notably, under flexible prices, the decrease in the international imbalances which is achieved by adjusting government expenditures optimally is not obtained at the expense of larger output gaps.

Different degrees of price rigidities. Earlier literature has pointed out that if the degree of price rigidity differs across countries, then the scope for using country-specific policy tools within a monetary union is enhanced, see e.g. Benigno P. (2004). That is, in the specified framework, the stabilization role of fiscal policy would increase under asymmetric price rigidities across the union. In order to assess the importance of such asymmetries for the tradeoff faced by the policy maker, I investigate the case where prices are less rigid in country H than in country F.[32]
Under a high trade elasticity, the impulse responses show that the tradeoff faced by the policy maker is almost independent of the presence of asymmetry in price rigidities. However, under a low trade elasticity, when price rigidities are asymmetric, government expenditures are used to a much larger extent to stabilize the output gap in the country with most sluggish price adjustment, and to stabilize inflation. That said, its role in closing the demand gap remains important. All in all, the results maintain the importance of the demand imbalances arising under incomplete markets for the tradeoff faced by the policy maker, when the trade elasticity is low.

[32]Specifically, I study the case where the firms in country H face a probability of 50 percent of being allowed to change their price each period, whereas the firms in country F only face a similar probability of 25 percent.

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1.10 Appendix D. Optimal Policy under Flexible Exchange Rates

In this appendix, I show the optimal policy response to a country-specific technology shock in a two-country model with flexible exchange rates. Hence, this section points out the differences for policy makers of being in a monetary union as opposed to having national monetary policy instruments. I first point out the transmission of shocks and policies under complete markets, and then turn to the incomplete markets case. Since the degree of substitutability of the goods matters for the transmission of shocks and policies, I consider both the case where the goods are substitutes in utility and the case where they are complements.

Complete markets

Consider the case where TFP and thus the marginal product of labor increases temporarily in the Home country. Under complete markets, the only distortion results from price dispersion following producer price changes, and it is thus optimal to avoid changes in producer prices. Given the increase in Home aggregate supply (for given prices) which results from the TFP shock, it is necessary to increase aggregate demand proportionally if price changes are to be avoided. Hence, optimal monetary policy consists in reducing Home interest rates such as to increase aggregate demand for the Home good.

The resulting depreciation of the Home currency, and worsening of the terms of trade, affects the Foreign country differently according to the degree of substitutability between the Home and Foreign goods. Indeed, because the response of real variables to price changes is very sensitive to the trade elasticity governing the relative importance of the substitution and income effects, we shall consider two scenarios: the case where the trade elasticity is high (as in the trade literature), and the case where the trade elasticity is rather low, in line with the international macroeconomic business cycle estimates. Under a relatively large trade elasticity, the substitution effect of a change in relative prices dominates the income effect such that demand for the Home good increases following a decrease in domestic prices. On the contrary, under a lower trade elasticity the income effect dominates, creating different dynamics between relative prices and output. These dynamics affect the transmission of shocks and policies, and thus the optimal conduct of policy.

If the degree of substitutability is high such that the internationally traded goods are substitutes in utility, then the nominal exchange rate depreciation affects output in the Foreign country negatively: demand for the Foreign goods fall. In order to avoid distortionary price movements - the optimal objective given that price dispersion is the only distortion under complete markets - the monetary authority decreases the Foreign interest rate thus increasing demand for the Foreign good. The interest rate is decreased exactly so much as to ensure that producer prices are constant, see Figure 1.10. At that point, Foreign output is lower than initially because of the terms of trade change, but producer prices are the same.

If the internationally traded goods are instead complements in utility, meaning that the trade elasticity is rather low, the effects of the exchange rate depreciation are different. First, the exchange rate depreciation leads to an increase in aggregate demand for the Foreign good because of the domination of the income effect: The exchange rate depreciation increases the relative value of the Foreign currency and thus the income of Foreigners. Due to home bias in consumption the relative demand for the Foreign good thus increases following a depreciation, and not the other way around. The optimal F real interest rate response consists in a decrease to offset the effects of the Home depreciation on Foreign producer prices, see Figure 1.11.

As a result of monetary policy being able to achieve the first best allocation under sticky prices and complete markets, fiscal policy does not play a stabilization role. Instead, government spending is optimally set such as to satisfy the optimal spending composition.

Incomplete markets

When international financial frictions are present, the interest rate and nominal exchange rate movements ensuring the efficient expenditure-shifting under complete markets are no longer optimal. As noted by Corsetti, Dedola, and Leduc (2010b), under incomplete markets "the economy will generally be away from its first-best allocation in response to efficient shocks"[33]. The impulse responses to a Home TFP depicted in Figure 1.10 and 1.11 illustrate that optimal monetary and fiscal policies cannot ensure zero producer price inflation (PPI), zero output gaps and a zero demand gap simultaneously.

Substitutability. Figure 1.10 depicts the impulse responses following a Home technology shock in the case where the traded goods are substitutes, under complete and incomplete international financial markets. Whereas government spending does not serve as a stabilization tool under complete markets, it does play a role under incomplete markets.

[33] This is so except for in the special case of only technology shocks and macroeconomic independence ($\sigma\phi = 1$).

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Consider the effect of a domestic productivity shock, leading to a fall in prices.[34] Due to the domination of the substitution effect over the income effect, Home agents experience an increase in income following the shock. Since they wish to smooth consumption over time, they lend funds to the Foreign agents. As under complete markets, the shock requires a decrease in interest rates in order to increase demand towards the zero-inflation output level. However, a fall in interest rates not only decreases the deflationary pressure, but also increases income through the increase in demand, thereby increasing Home wealth and creating a current account surplus. Hence, to avoid large current account imbalances associated with financial distortions, it is optimal to have the interest rate fall less than under complete markets. As a result both output and prices will be lower than under complete markets. Given that the efficient allocation cannot be achieved through monetary policy, it is optimal to complement it by using fiscal policy as a stabilization tool. The optimal fiscal policy consists in decreasing Home government spending with respect to its optimal spending composition level, thus putting further deflationary pressure on domestic prices, thereby switching demand towards the Home good. Optimal fiscal policy thus ensures a lower output gap (with respect to the complete markets level), but increases deflationary pressures and the demand imbalances thus increasing the distortions arising due to financial frictions. The interest rate and government spending lead complementary roles: monetary policy reduces inefficiencies arising from inflation and international imbalances, whereas fiscal policy increases welfare by reducing the output gap.

The Home TFP shock affects the Foreign economy through its effect on the nominal exchange rate: the demand for the Foreign good decreases. In order to avoid large output and price fluctuations in country F, it is optimal to decrease the Foreign interest rate such as to increase demand - but the movements will be lower than under complete markets because the exchange rate shock to the Foreign country is lower. Indeed, the fall in the Foreign interest rate leads to an increase in demand for the Foreign good in the presence of home bias in consumption, and thus to an increase in Foreign income. This is desirable in order to avoid large current account fluctuations. This is why the policy maker will decrease the Foreign interest rate more than he would have done under complete markets for a similar exchange rate shock, making the Foreign output gap positive. Under these circumstances,

[34]Note that the nominal depreciation, through the increase in the domestic consumer price level due to rising import prices, leads to an increase in marginal costs at first and thus to a positive PPI inflation rate initially. Since producer prices relative to consumer prices are set at a mark-up over marginal costs, the increase in domestic consumer prices resulting from the nominal exchange rate depreciation is consistent with rising producer prices (though relative producer prices fall) in the first periods. Over time, as prices adjust, producer price inflation turns negative.

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it is optimal to increase Foreign government spending such as to decrease the output gap, at the expense of higher inflation and a higher debt burden i.e. higher imbalances across countries. That is, also in country F does monetary policy decrease inflationary pressures and frictions due to international imbalances, and also does government spending decrease the output gap.

As Figure 1.10 shows, the optimal conduct of monetary policy is dependent on the financial markets structure and contributes to limiting the demand imbalances arising due to international financial markets: a higher Home real interest rate decreases Foreign debt and thus deviations from full risk sharing. That is, optimal monetary policy simultaneously decreases distortionary price movements and plays a risk-sharing role. On the contrary, optimal fiscal policy does neither decrease price movements nor reduce the cross-country demand imbalances resulting from internationally incomplete markets under a high trade elasticity; it does not play a risk-sharing role. This conclusion, however, does not hold when the internationally traded goods are complements.

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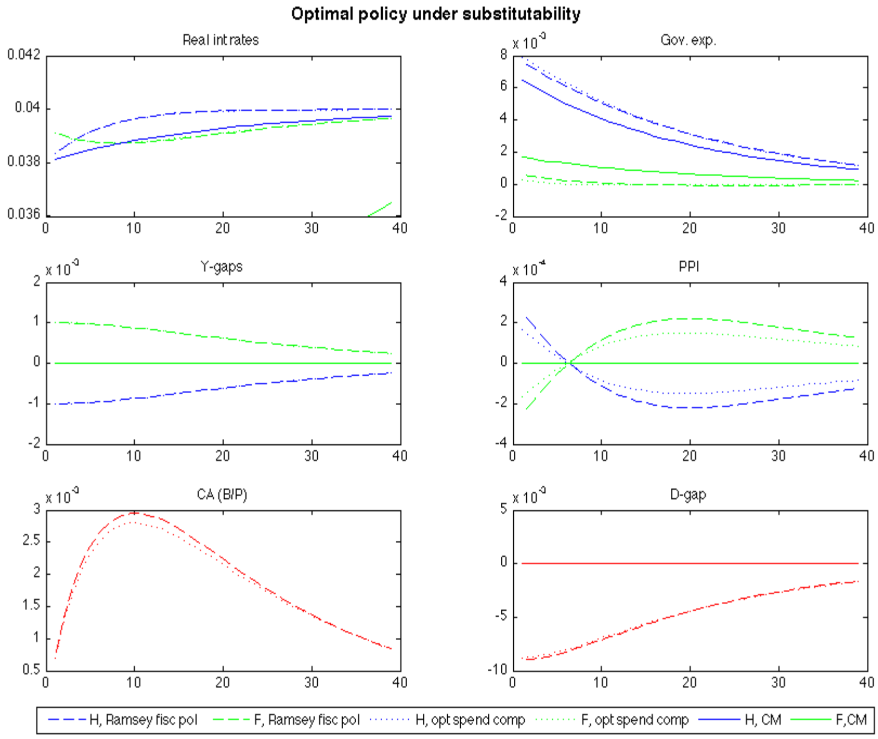
Figure 1.10: Flexible exchange rates and high trade elasticity ($\phi = 4$).



The impulse responses are those following a one-standard deviation shock to productivity in country H. "H, Ramsey fisc pol" refers to the response of Home variables under Ramsey fiscal and monetary policy. "H, opt spend comp" refers to the response of Home variables in the case where monetary policy is Ramsey optimal whereas government expenditures are set at their optimal spending composition level, i.e. such as to close the spending composition gap. "CM" refers to the case of complete markets with a zero inflation rate (the sticky-price allocation and the flexible-price allocation are identical). For all variables, except for the annualized real interest rates, deviations are shown relative to their steady state level. The real interest rates depicted are not identical to the bond yields which depend on debt levels.

Complementarity. Consider now the case where the traded goods are complements, illustrated in Figure 1.11. In that case, the Home TFP shock leads to a temporary fall in domestic income: the lower price of the Home good decreases income because the substitution effect is weak. Home agents thus wish to borrow from Foreign agents in order to smooth their consumption over time. We have seen that under complete markets, it is optimal to decrease the interest rate to the point where demand ensures that the firms do not have any incentive to change their prices. Under incomplete markets, it is optimal to decrease the Home interest rate further, thus putting inflationary pressure on Home producer prices, and thereby increasing Home income, and thus reducing the debt of Home agents. As a

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result, monetary policy is more aggressive under incomplete markets, and leads to a nominal exchange rate appreciation. However, the resulting nominal exchange rate appreciation implies large deviations from full risk sharing unless Home prices fall and Foreign prices rise such that the real exchange rate appreciates less than the nominal exchange rate. Hence, in order to avoid large deviations from full risk sharing the fall in Home interest rates must be accompanied by falling Home prices and rising Foreign prices. Due to the domination of the income effect, this in turn implies that the Home output gap is negative and the Foreign output gap is positive.

Since the substitution effect is weaker than the income effect, the decrease in Home interest rates appreciating the Home currency decreases Foreign income and demand. The optimal monetary response to this shock is different than under complete markets because a fall in Foreign interest rates not only brings the economy closer to its unconstrained efficient allocation, but also increases international imbalances through its positive effect on prices and thus income in country F. Hence, the Foreign interest rate is decreased less than under complete markets.

Whereas monetary policy has adverse effects on output and demand gaps, government spending can reduce these inefficiencies simultaneously. Indeed, a rise in domestic government spending has inflationary effects on Home goods, thus increasing Home income. That is, an increase in government spending lowers price distortions and the output gap and simultaneously reduces Home debt thus decreasing international imbalances. Note however that it is not optimal to increase Home government spending so much as to eliminate any of the distortions totally since the welfare costs in terms of deviations from the optimal spending composition would be too large. Similarly, it is optimal to decrease Foreign government spending. Indeed, through its deflationary effects it reduces inflation and Foreign income and reduces demand thus reducing the output gaps. As in the Home country, government spending thus plays a role in reducing all distortions at the cost of deviations from the optimal spending composition level.

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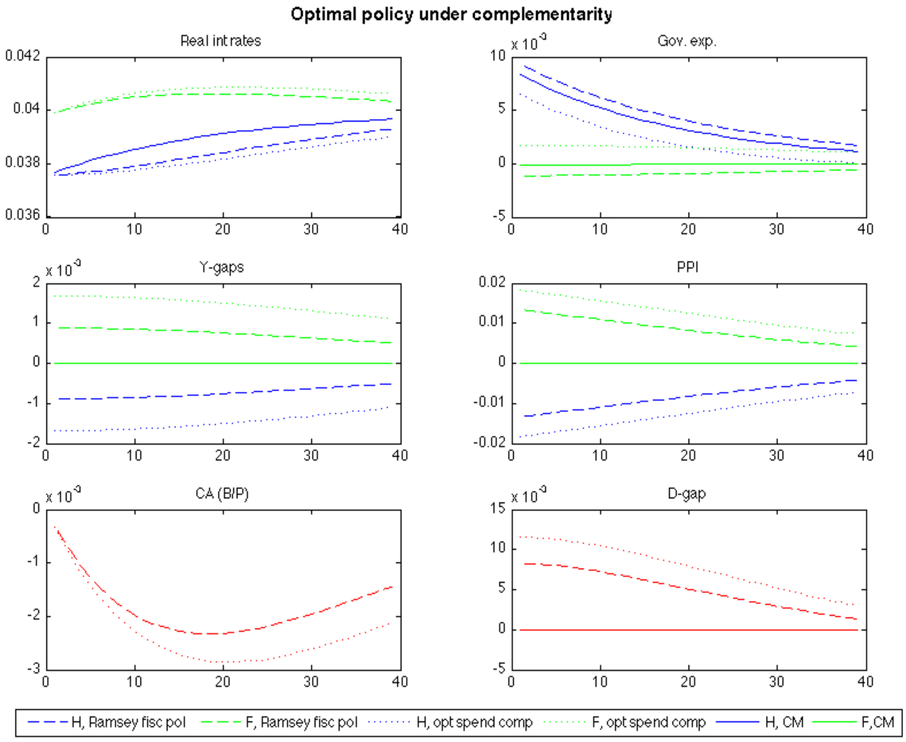
Figure 1.11: Flexible exchange rates and low trade elasticity ($\phi = 0.5$).



See notes for Figure 1.10.

Under a low trade elasticity, optimal government expenditures do not only correct output gaps, but also inflation and cross-country demand imbalances: It takes on both a stabilisation and a risk-sharing role. However, whether the reduction in the international imbalances occurs explicitly such as to reduce the distortions resulting from financial frictions, or whether it is simply the bi-product of an optimal reduction of output gaps and inflation cannot be seen here. Indeed, since there is no fiscal policy trade-off between domestic and international objectives, the importance of the cross-country insurance role with respect to the domestic stabilization role of government expenditures cannot be determined. Since this trade-off is present within a monetary union, fiscal policy making differs according to the monetary framework, i.e. whether the two countries form a monetary union or have different monetary policy instruments: Under flexible exchange rates, "keeping one's own house in order", i.e. targeting domestic objectives is sufficient to achieve the optimal fiscal policy - this is not so within a monetary union!

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1.11 Technical appendix to Chapter 1

Loss functions under Complete and Internationally Incomplete Markets

Introduction

In the following, I will explain how to derive the quadratic approximation to the loss function as figuring in Chapter 1 entitled "Imbalances and Fiscal Policy in a Monetary Union". This is done by approximating the world welfare function; the resulting loss function is correct up to second-order. I followed Benigno and Benigno (2006), or Ferrero (2009).
The steps to derive the loss function, explained for the model used in Chapter 1 in the remainder of this appendix, are:

1. First, I derive the second-order approximation to the welfare function. The approximation to the welfare function can be written as $W = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ z_x' x_t + x_t' Z_{xx} x_t + \epsilon_t' Z_{\epsilon x} x_t + z_\epsilon' \epsilon_t + \epsilon_t' Z_{\epsilon\epsilon} \epsilon_t \right\}$ where x denotes a vector of variables which will only appear quadratically in the derived loss function, and ϵ denotes the vector of (exogenous) variables which will not be replaced by quadratic terms.

2. Second, I take a second-order approximation of the equilibrium equations: the AD-equations, the AS-equations, the real exchange rate (RER) definition and the resource constraint. These approximations can be expressed as systems of the form $r_x^i x_t + \frac{1}{2} x_t' R_{xx}^i x_t + \epsilon_t' R_{\epsilon x}^i x_t + r_\epsilon^i \epsilon_t + \frac{1}{2} \epsilon_t' R_{\epsilon\epsilon}^i \epsilon_t = 0$ where i refers to equilibrium equation i.

3. In order to get a loss function which is quadratic in the vector x, I replace all the linear terms in x appearing in the welfare approximation by quadratic terms. The following steps explain how to achieve this. I compute the vector ζ which satisfies the equation $\Lambda_x \zeta = z_x$ where $\Lambda_x \equiv [r_x^{1'} \;\; r_x^{2'} \;\; ...]$ is a matrix containing the linear terms in the equilibrium equations as specified above and z_x is the vector containing the linear terms of the welfare function approximation to be replaced. Replacing $z_x' x_t$ by $\zeta' \Lambda_x' x_t = \zeta' \begin{bmatrix} -\left[\frac{1}{2} x_t' R_{xx}^1 x_t + \epsilon_t' R_{\epsilon x}^1 x_t + r_\epsilon^1 \epsilon_t + \frac{1}{2} \epsilon_t' R_{\epsilon\epsilon}^1 \epsilon_t\right] \\ -\left[\frac{1}{2} x_t' R_{xx}^2 x_t + \epsilon_t' R_{\epsilon x}^2 x_t + r_\epsilon^2 \epsilon_t + \frac{1}{2} \epsilon_t' R_{\epsilon\epsilon}^2 \epsilon_t\right] \\ ... \end{bmatrix}$ corresponds to using the second-order approximations to the equilibrium equations to replace the linear terms in x in the welfare function. This yields a loss function which is quadratic in x (the endogenous variables of the system).

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4. Following, I reduce the loss function such as to include only deviations in a limited amount of variables, by using first-order approximations to the equilibrium equations.[35]

In the following the method described above is applied to the model figuring in Chapter 1.

Method

The following vectors of variables will be used throughout this appendix:

$$x'_t = \begin{bmatrix} \hat{Y}_{H,t} & \hat{C}_t & \hat{Y}^*_{F,t} & \hat{C}^*_t & \hat{T}_t & \hat{Q}_t \end{bmatrix}$$

$$\epsilon'_t = \begin{bmatrix} \hat{A}_t & \hat{A}^*_t & \hat{CA}_t & \hat{G}_t & \hat{G}^*_t \end{bmatrix}$$

Second-order Approximation to the Welfare function

Assuming that the countries are symmetric, the second order approximation to the common welfare function is

$$\begin{aligned} W = E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ & \Big\{ U_C \bar{C}[\hat{C}_t + \frac{1}{2}(1-\sigma)\hat{C}_t^2] + U_G \bar{G}[\hat{G}_t + \frac{1}{2}(1-\sigma)\hat{G}_t^2]. \\ & - \bar{Y}_H^{1+\eta} \hat{Y}_{H,t}[1 + \frac{1}{2}(1+\eta)\hat{Y}_{H,t} - (1+\eta)\hat{A}_t)] - \frac{1}{2}\bar{Y}_H^{1+\eta} \frac{(1+\eta\theta)\alpha\theta}{(1-\alpha)(1-\alpha\beta)} \pi_{H,t}^2 \Big\} + \\ & \Big\{ U_C^* \bar{C}^*[\hat{C}^*_t + \frac{1}{2}(1-\sigma)\hat{C}_t^{*2}] + U_G^* \bar{G}^*[\hat{G}^*_t + \frac{1}{2}(1-\sigma)\hat{G}_t^{*2}] \\ & - \bar{Y}_F^{1+\eta} \hat{Y}_{F,t}[1 + \frac{1}{2}(1+\eta)\hat{Y}_{F,t} - (1+\eta)\hat{A}^*_t)] - \frac{1}{2}\bar{Y}_F^{1+\eta} \frac{(1+\eta\theta)\alpha\theta}{(1-\alpha)(1-\alpha\beta)} \pi_{F,t}^{*2} \Big\} \Bigg\} \end{aligned} \tag{1.38}$$

In matrix form, this amounts to:

$$W = \bar{U}_C \bar{C} E_0 \sum_{t=0}^{\infty} \beta^t [z'_x x_t + \frac{1}{2} x'_t Z_x x_t + x'_t Z_\epsilon \epsilon_t + \frac{1}{2}\epsilon'_t Z_{\epsilon\epsilon}\epsilon_t + \frac{1}{2} z_{\pi_H} \pi_{H,t}^2 + \frac{1}{2} z_{\pi_F} \pi_{F,t}^{*2}] \tag{1.39}$$

where

$$z_x = \begin{bmatrix} -\bar{Y}_H^{1+\eta} & \bar{C}^{1-\sigma} & -\bar{Y}_F^{1+\eta} & \bar{C}^{*1-\sigma} & 0 & 0 \end{bmatrix}$$

$$z_\epsilon = \begin{bmatrix} 0 & 0 & 0 & \chi\bar{G}^{1-\sigma} & \chi\bar{G}^{*1-\sigma} \end{bmatrix}$$

[35] In the completely symmetric case without home bias and with complete markets, the loss function that I obtain is the same as the one obtained by Benigno and Benigno (2006).

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$$Z_x = \begin{bmatrix} -\bar{Y}_H^{1+\eta}(1+\eta) & 0 & 0 & 0 & 0 & 0 \\ 0 & (1-\sigma)\bar{C}^{1-\sigma} & 0 & 0 & 0 & 0 \\ 0 & 0 & -\bar{Y}_F^{1+\eta}(1+\eta) & 0 & 0 & 0 \\ 0 & 0 & 0 & (1-\sigma)\bar{C}^{*1-\sigma} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$Z_\epsilon = \begin{bmatrix} \bar{Y}_H^{1+\eta}(1+\eta) & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & \bar{Y}_F^{1+\eta}(1+\eta) & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$Z_{\epsilon\epsilon} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \chi(1-\sigma)\bar{G}^{1-\sigma} & 0 \\ 0 & 0 & 0 & 0 & \chi(1-\sigma)\bar{G}^{*1-\sigma} \end{bmatrix}$$

$$z_{\pi_H} = -\bar{Y}_H^{1+\eta}\frac{(1+\eta\theta)\alpha\theta}{(1-\alpha)(1-\alpha\beta)}$$
$$z_{\pi_F} = -\bar{Y}_F^{1+\eta}\frac{(1+\eta\theta)\alpha\theta}{(1-\alpha)(1-\alpha\beta)}$$

Second-order Approximations to the Equilibrium Equations

The equilibrium equations of the model are the AD equations, the AS equations, a resource constraint, as well as the equation relating the real exchange rate to the terms of trade. All these equations can be expressed in terms of the variables figuring in the vectors x_t (output and consumption in each country, the terms of trade and the real exchange rate) and ϵ_t (the technology shocks, the current account and the levels of government spending). In this appendix, for simplicity, I focus on the case where prices are fully flexible.[36]

In the following I present the second-order approximations to the equilibrium equations, assuming that the monopolistic distortions are offset by appropriate taxation in the steady

[36]Introducing price stickiness is straightforward, see e.g. Benigno and Benigno (2006).

state. Note that I define deviations of the current account in terms of output, i.e. $\hat{CA}_t = \frac{CA_t - CA}{Y_H}$. All other variables are defined in terms of deviations from their own steady state. Note also that variables without a time subscript denote steady state variables.

AS equations. The aggregate supply (AS) equation derived from optimal price setting decisions under flexible prices is:

$$\frac{P_{H,t}}{P_t} = \frac{\theta}{(\theta-1)(1-\tau)} \frac{1}{A_t} \frac{W_t}{P_t} = \frac{1}{A_t} \frac{L_t^{\eta}}{C_t^{-\sigma}} = \frac{1}{A_t^{1+\eta}} \frac{Y_{H,t}^{\eta}}{C_t^{-\sigma}}$$

$$[a_H + (1-a_H)T_t^{1-\phi}]^{\frac{1}{1-\phi}} = \frac{1}{A_t^{1+\eta}} \frac{Y_{H,t}^{\eta}}{C_t^{-\sigma}}$$

Taking a second-order approximation of the equation above and discounting it forward yields:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [(\sigma \hat{C}_t + \eta \hat{Y}_{H,t} - (1+\eta)\hat{A}_t + (1-a_H)\hat{T}_t + \frac{1}{2} a_H (1-a_H)(1-\phi)\hat{T}_t^2] \qquad (1.40)$$

which can be rewritten as:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [a_x' x_t + a_\epsilon' \epsilon_t + \frac{1}{2} x_t' A_x x_t + x_t' A_\epsilon \epsilon_t + \frac{1}{2} \epsilon_t' A_{\epsilon\epsilon} \epsilon_t] \qquad (1.41)$$

where

$$a_x = \begin{bmatrix} \eta & \sigma & 0 & 0 & 1-a_H & 0 \end{bmatrix}$$

$$a_\epsilon = \begin{bmatrix} -(1+\eta) & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$A_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_H(1-a_H)(1-\phi) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$A_\epsilon = 0$$

$$A_{\epsilon\epsilon} = 0$$

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For the Foreign country, the optimal price setting equation is:

$$\begin{aligned}\frac{P_{F,t}}{P_t^*} &= \frac{1}{A_t^{*1+\eta}} \frac{Y_{F,t}^{\eta}}{C_t^{*-\sigma}} \\ [a_H + (1-a_H)T_t^{\phi-1}]^{\frac{1}{1-\phi}} &= \frac{1}{A_t^{*1+\eta}} \frac{Y_{F,t}^{\eta}}{C_t^{*-\sigma}}\end{aligned}$$

Approximating to second order and discounting forward yields:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [(\sigma \hat{C}_t^* + \eta \hat{Y}_{F,t} - (1+\eta)\hat{A}_t^* - (1-a_H)\hat{T}_t + \frac{1}{2} a_H (1-a_H)(1-\phi)\hat{T}_t^2] \tag{1.42}$$

which can be rewritten as:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [b_x' x_t + b_\epsilon' \epsilon_t + \frac{1}{2} x_t' B_x x_t + x_t' B_\epsilon \epsilon_t + \frac{1}{2} \epsilon_t' B_{\epsilon\epsilon} \epsilon_t] \tag{1.43}$$

where

$$b_x = \begin{bmatrix} 0 & 0 & \eta & \sigma & -(1-a_H) & 0 \end{bmatrix}$$

$$b_\epsilon = \begin{bmatrix} 0 & -(1+\eta) & 0 & 0 & 0 \end{bmatrix}$$

$$B_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_H(1-a_H)(1-\phi) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$B_\epsilon = 0$$

$$B_{\epsilon\epsilon} = 0$$

AD equations. The Home aggregate demand (AD) equation is:

$$\begin{aligned}Y_{H,t} &= a_H \left(\frac{P_{H,t}}{P_t}\right)^{-\phi} C_t + a_H^* \left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\phi} C_t^* + G_t \\ &= [a_H + (1-a_H)T_t^{1-\phi}]^{\frac{\phi}{1-\phi}} [a_H C_t + (1-a_H) Q_t^{\phi} C_t^*] + G_t\end{aligned}$$

The second-order approximation to aggregate Home demand is:

$$
\begin{aligned}
& s_c^{-1}\hat{Y}_{H,t} + (1-s_c^{-1})\hat{G}_t + \frac{1}{2}s_c^{-1}(1-s_c^{-1})[\hat{Y}_{H,t}^2 + \hat{G}_t^2 - 2\hat{Y}_{H,t}\hat{G}_t] \\
& = \phi(1-a_H)\hat{T}_t + a_H\hat{C}_t + (1-a_H)\hat{C}_t^* + \phi(1-a_H)\hat{Q}_t \\
& + \frac{1}{2}a_H(1-a_H)\{\phi(1-\phi)\hat{T}_t^2 + \hat{C}_t^2 + \hat{C}_t^{*2} + \phi^2\hat{Q}_t^2 - \hat{C}_t\hat{C}_t^* - \phi\hat{Q}_t(\hat{C}_t - \hat{C}_t^*)\}
\end{aligned} \tag{1.44}
$$

where $s_c = \frac{C}{Y_H}$.

Discounted forward, the AD equation can thus be written in the following way:

$$
0 = E_0 \sum_{t=0}^{\infty} \beta^t [c_x' x_t + c_\epsilon' \epsilon_t + \frac{1}{2}x_t' C_x x_t + x_t' C_\epsilon \epsilon_t + \frac{1}{2}\epsilon_t' C_{\epsilon\epsilon}\epsilon_t] \tag{1.45}
$$

with

$$
c_x' = \begin{bmatrix} -s_c^{-1} & a_H & 0 & 1-a_H & \phi(1-a_H) & \phi(1-a_H) \end{bmatrix}
$$

$$
c_\epsilon' = \begin{bmatrix} 0 & 0 & 0 & -(1-s_c^{-1}) & 0 \end{bmatrix}
$$

$$
C_x = \begin{bmatrix}
-s_c^{-1}(1-s_c^{-1}) & 0 & 0 & 0 & 0 & 0 \\
0 & a & 0 & -a & 0 & -\phi a \\
0 & 0 & 0 & 0 & 0 & 0 \\
0 & -a & 0 & a & 0 & \phi a \\
0 & 0 & 0 & 0 & \phi(1-\phi)a & 0 \\
0 & -\phi a & 0 & \phi a & 0 & \phi^2 a
\end{bmatrix}
$$

where $a \equiv a_H(1-a_H)$.

$$
C_\epsilon = \begin{bmatrix}
0 & 0 & 0 & s_c^{-1}(1-s_c^{-1}) & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

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$$C_{\epsilon\epsilon} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -s_c^{-1}(1-s_c^{-1}) & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Aggregate demand for the Foreign good amounts to:

$$\begin{aligned} Y_{F,t} &= (1-a_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\phi} C_t + a_H \left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\phi} C^*_t + G_t \\ &= [a_H + (1-a_H)T_t^{\phi-1}]^{\frac{\phi}{1-\phi}}[(1-a_H)Q_t^{-\phi}C_t + a_H C^*_t] + G_t \end{aligned}$$

Similar derivations as for the Home AD apply to the foreign AD, and Foreign demand can thus be expressed as:

$$\begin{aligned} & s_c^{-1}\hat{Y}_{F,t} + (1-s_c^{-1})\hat{G}^*_t + \frac{1}{2}s_c^{-1}(1-s_c^{-1})[\hat{Y}^2_{F,t} + \hat{G}^{*2}_t - 2\hat{Y}_{F,t}\hat{G}^*_t] \\ & = -\phi(1-a_H)\hat{T}_t + a_H\hat{C}^*_t + (1-a_H)\hat{C}_t - \phi(1-a_H)\hat{Q}_t \\ & + \frac{1}{2}a_H(1-a_H)\{\phi(1-\phi)\hat{T}^2_t + \hat{C}^2_t + \hat{C}^{*2}_t + \phi^2\hat{Q}^2_t - \hat{C}_t\hat{C}^*_t - \phi\hat{Q}_t(\hat{C}_t - \hat{C}^*_t)\} \end{aligned} \tag{1.46}$$

Discounted forward, the Foreign AD equation can thus be written in the following way:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [d'_x x_t + d'_\epsilon \epsilon_t + \frac{1}{2}x'_t D_x x_t + x'_t D_\epsilon \epsilon_t + \frac{1}{2}\epsilon'_t D_{\epsilon\epsilon}\epsilon_t] \tag{1.47}$$

with

$$d'_x = \begin{bmatrix} 0 & 1-a_H & -s_c^{-1} & a_H & -\phi(1-a_H) & -\phi(1-a_H) \end{bmatrix}$$

$$d'_\epsilon = \begin{bmatrix} 0 & 0 & 0 & 0 & -(1-s_c^{-1}) \end{bmatrix}$$

$$D_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & a & 0 & -a & 0 & -\phi a \\ 0 & 0 & -s_c^{-1}(1-s_c^{-1}) & 0 & 0 & 0 \\ 0 & -a & 0 & a & 0 & \phi a \\ 0 & 0 & 0 & 0 & \phi(1-\phi)a & 0 \\ 0 & -\phi a & 0 & \phi a & 0 & \phi^2 a \end{bmatrix}$$

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where $a \equiv a_H(1-a_H)$.

$$D_\epsilon = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & s_c^{-1}(1-s_c^{-1}) \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$D_{\epsilon\epsilon} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -s_c^{-1}(1-s_c^{-1}) \end{bmatrix}$$

Real Exchange Rate. The definition of the real exchange rate is:

$$Q_t \equiv \frac{P_t^*}{P_t} = \left[\frac{a_H T_t^{1-\phi} + (1-a_H)}{a_H + (1-a_H)T_t^{1-\phi}}\right]^{\frac{1}{1-\phi}}$$

This definition of the real exchange rate yields the following second-order expansion[37]:

$$\hat{Q}_t = (2a_H - 1)\hat{T}_t \tag{1.48}$$

which implies

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [h_x' x_t] \tag{1.49}$$

where

$$h_x' = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 2a_H - 1 & -1 \end{bmatrix}$$

Resource constraints.

[37]The equation is only exactly log-linear when the home bias is symmetric across countries

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Incomplete markets. When markets are incomplete it is necessary to keep track of the evolution of the current account.[38] One of the resource constraints is sufficient for this.[39] The Home resource constraint, describing the current account, is:

$$C_t + \frac{B_{H,t}}{P_t(1+i_t)\Phi(B_{H,t}/P_t)} = \frac{P_{H,t}}{P_t}(Y_{H,t} - G_t) + \frac{1}{\pi_t}\frac{B_{H,t-1}}{P_{t-1}} + [\frac{1}{\Phi(B_{F,t}/P_t^*)} - 1]\frac{B_{F,t}}{P_t^*(1+i_t)}Q_t$$
$$\Leftrightarrow \frac{P_{H,t}}{P_t}(Y_{H,t} - G_t) = C_t + \frac{B_{H,t}}{P_t(1+i_t)\Phi(B_{H,t}/P_t)} - \frac{1}{\pi_t}\frac{B_{H,t-1}}{P_{t-1}} - [\frac{1}{\Phi(B_{F,t}/P_t^*)} - 1]\frac{B_{F,t}}{P_t^*(1+i_t)}Q_t$$

Defining the current account as $CA_t \equiv \frac{B_{H,t}}{P_t(1+i_t)\Phi(B_{H,t}/P_t)} - \frac{1}{\pi_t}\frac{B_{H,t-1}}{P_{t-1}} - [\frac{1}{\Phi(B_{F,t}/P_t^*)} - 1]\frac{B_{F,t}}{P_t^*(1+i_t)}Q_t$, the resource constraint simplifies to:

$$\frac{P_{H,t}}{P_t}(Y_{H,t} - G_t) = C_t + CA_t \Rightarrow [a_H + (1-a_H)T_t^{1-\phi}]^{\frac{1}{\phi-1}}(Y_{H,t} - G_t) = C_t + CA_t$$

Taking a second-order approximation of the above specified resource constraint yields:

$$s_c^{-1}\hat{Y}_{H,t} - (s_c^{-1} - 1)\hat{G}_t + \frac{1}{2}s_c^{-1}(1 - s_c^{-1})\hat{Y}_{H,t}^2 + \frac{1}{2}s_c^{-1}(1 - s_c^{-1})\hat{G}_t^2 + s_c^{-1}(sc^{-1} - 1)\hat{Y}_{H,t}\hat{G}_t$$
$$= (1-a_H)\hat{T}_t + \hat{C}_t + s_c^{-1}\widehat{CA}_t + \frac{1}{2}a_H(1-a_H)(1-\phi)\hat{T}_t^2 - s_c^{-1}\hat{C}_t\widehat{CA}_t \tag{1.50}$$

where $\widehat{CA}_t = \frac{CA_t - CA}{Y_H}$.
Discounted forward, the above approximation can be written in matrix form as:

$$0 = E_0\sum_{t=0}^{\infty}\beta^t[f_x'x_t + f_\epsilon'\epsilon_t + \frac{1}{2}x_t'F_xx_t + x_t'F_\epsilon\epsilon_t + \frac{1}{2}\epsilon_t'F_{\epsilon\epsilon}\epsilon_t] \tag{1.51}$$

$$f_x' = \begin{bmatrix} -s_c^{-1} & 1 & 0 & 0 & 1-a_H & 0 \end{bmatrix}$$

[38]The current account constitutes an additional variable as compared to the complete markets case. The linear terms in this variable, in the loss function, cannot be replaced by quadratic terms. Fortunately, the current account does not enter linearly in the final loss function, and hence the fact that I cannot replace it does not result in additional linear terms in the loss function.

[39]Indeed, in combination with the AD-equations, the Domestic resource constraint implies that the Foreign resource constraint must hold. Hence, it is redundant.

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and

$$F_x = \begin{bmatrix} -s_c^{-1}(1-s_c^{-1}) & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_H(1-a_H)(1-\phi) & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$F_\epsilon = \begin{bmatrix} 0 & 0 & 0 & -s_c^{-1}(1-s_c^{-1}) & 0 \\ 0 & 0 & -s_c^{-1} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$f'_\epsilon = \begin{bmatrix} 0 & 0 & s_c^{-1} & s_c^{-1}-1 & 0 \end{bmatrix}$$

$$F_{\epsilon\epsilon} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -s_c^{-1}(1-s_c^{-1}) & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Complete markets. Under complete markets, the full risk sharing equation holds. The second-order approximation to the full risk sharing equation $\frac{C_t^{-\sigma}}{C_t^{*-\sigma}} = \frac{1}{Q_t}$ is

$$\sigma(\hat{C}_t - \hat{C}_t^*) = \hat{Q}_t \tag{1.52}$$

which, when discounted forward, amounts to:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [k'_x x_t] \tag{1.53}$$

with

$$k'_x = \begin{bmatrix} 0 & -\sigma & 0 & 0 & \sigma & 0 & 0 & 1 \end{bmatrix}$$

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Deriving the quadratic loss function

In the following, I explain the procedure which leads to the final quadratic loss function, or loss function, illustrating the objectives of the Ramsey policy maker.

As we have already seen, the welfare function can be expressed in the following way:

$$W = \bar{U}_C \bar{C} E_0 \sum_{t=0}^{\infty} \beta^t [z_x' x_t + \frac{1}{2} x_t' Z_x x_t + x_t' Z_\epsilon \epsilon_t + \frac{1}{2} z_{\pi_H} \pi_{H,t}^2 + \frac{1}{2} z_{\pi_F} \pi_{F,t}^{*2}] + t.i.p + o(||\epsilon||^3)$$

One can then derive ζ such that

$$\Lambda \zeta = z_x$$

where $\Lambda = [a_x \;\; b_x \;\; c_x \;\; d_x \;\; h_x \;\; f_x]$, i.e. Λ contains the first order terms appearing in the equilibrium equations.
It then follows that

$$z_x' x_t = \zeta' \Lambda' x_t = \zeta' \begin{bmatrix} a_x' x_t \\ b_x' x_t \\ c_x' x_t \\ d_x' x_t \\ h_x' x_t \\ f_x' x_t \end{bmatrix} = \begin{bmatrix} -\frac{1}{2} x_t' A_x x_t - x_t' A_\epsilon \epsilon_t - \frac{1}{2} \epsilon_t' A_{\epsilon\epsilon} \epsilon_t - a_\epsilon' \epsilon_t \\ -\frac{1}{2} x_t' B_x x_t - x_t' B_\epsilon \epsilon_t - \frac{1}{2} \epsilon_t' B_{\epsilon\epsilon} \epsilon_t - b_\epsilon' \epsilon_t \\ -\frac{1}{2} x_t' C_x x_t - x_t' C_\epsilon \epsilon_t - \frac{1}{2} \epsilon_t' C_{\epsilon\epsilon} \epsilon_t - c_\epsilon' \epsilon_t \\ -\frac{1}{2} x_t' D_x x_t - x_t' D_\epsilon \epsilon_t - \frac{1}{2} \epsilon_t' D_{\epsilon\epsilon} \epsilon_t - d_\epsilon' \epsilon_t \\ -\frac{1}{2} x_t' H_x x_t - x_t' H_\epsilon \epsilon_t - \frac{1}{2} \epsilon_t' H_{\epsilon\epsilon} \epsilon_t - h_\epsilon' \epsilon_t \\ -\frac{1}{2} x_t' F_x x_t - x_t' F_\epsilon \epsilon_t - \frac{1}{2} \epsilon_t' F_{\epsilon\epsilon} \epsilon_t - f_\epsilon' \epsilon_t \end{bmatrix} \quad (1.54)$$

Replacing $z_x' x_t$ by the above expression enables me to rewrite the welfare function in the following way:

$$\begin{aligned} W &= E_0 \sum_{t=0}^{\infty} \beta^t [\frac{1}{2} x_t' Z_x x_t + x_t' Z_\epsilon \epsilon_t + \frac{1}{2} z_{\pi_H} \pi_{H,t}^2 + \frac{1}{2} z_{\pi_F} \pi_{F,t}^{*2} \\ &\quad - \zeta_1 (\frac{1}{2} x_t' A_x x_t - x_t' A_\epsilon \epsilon_t - ...) - \zeta_2 (\frac{1}{2} x_t' B_x x_t - x_t' B_\epsilon \epsilon_t - ...) - ...] \\ &= E_0 \sum_{t=0}^{\infty} \beta^t [\frac{1}{2} x_t' (Z_x - \zeta_1 A_x - \zeta_2 B_x - ...) x_t + x_t' (Z_\epsilon - \zeta_1 A_\epsilon - \zeta_2 B_\epsilon - ...) \epsilon_t \\ &\quad + \frac{1}{2} \epsilon_t' (Z_{\epsilon\epsilon} - \zeta_1 A_{\epsilon\epsilon} - \zeta_2 B_{\epsilon\epsilon} - ...) \epsilon_t + (z_\epsilon' - \zeta_1 a_\epsilon' - \zeta_2 b_\epsilon' - ...) \epsilon_t \\ &\quad + \frac{1}{2} (z_{\pi_H} - \zeta_1 a_{\pi_H} - \zeta_2 b_{\pi_H} - ...) \pi_{H,t}^2 + \frac{1}{2} (z_{\pi_F} - \zeta_1 a_{\pi_F} - \zeta_2 b_{\pi_F} - ...) \pi_{F,t}^{*2}] \end{aligned} \quad (1.55)$$

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In a simpler form, this can be expressed as

$$W = E_0 \sum_{t=0}^{\infty} \beta^t [\frac{1}{2} x_t' Q_x x_t + x_t' Q_\epsilon \epsilon_t + \frac{1}{2} \epsilon_t' Q_{\epsilon\epsilon} \epsilon_t + q_\epsilon' \epsilon_t + \frac{1}{2} q_{\pi_H} \pi_{H,t}^2 + \frac{1}{2} q_{\pi_F} \pi_{F,t}^{*2}] + t.i.p + o(||\epsilon||^3) \tag{1.56}$$

where

$$\begin{aligned}
Q_x &= Z_x - \zeta_1 A_x - \zeta_2 B_x - ... \\
Q_\epsilon &= Z_\epsilon - \zeta_1 A_\epsilon - \zeta_2 B_\epsilon - ... \\
Q_{\epsilon\epsilon} &= Z_{\epsilon\epsilon} - \zeta_1 A_{\epsilon\epsilon} - \zeta_2 B_{\epsilon\epsilon} - ... \\
q_\epsilon &= z_\epsilon - \zeta_1 a_\epsilon - \zeta_2 b_\epsilon - ... \\
q_{\pi_H} &= z_{\pi_H} - \zeta_1 a_{\pi_H} - \zeta_2 b_{\pi_H} - ... \\
q_{\pi_F} &= z_{\pi_F} - \zeta_1 a_{\pi_F} - \zeta_2 b_{\pi_F} - ...
\end{aligned}$$

Simplification

The welfare expression figuring above can be transformed such as to make welfare a function of a smaller group of endogenous variables, e.g. a function of consumption and the terms of trade as in Benigno and Benigno (2006), or a function of world output and the terms of trade as in Corsetti, Dedola, and Leduc (2010b), by using the first-order approximations to the equilibrium equations.
Indeed rewriting the system of first order approximations to the equilibrium equations in the following way:

$$x_t = N_y y_t + N_\epsilon \epsilon_t \tag{1.57}$$

where y_t is the vector of variables we want to figure in the loss function, allows me to rewrite the loss function as:

$$W = E_0 \sum_{t=0}^{\infty} \beta^t [\frac{1}{2} y_t' \tilde{Q}_y y_t + y_t' \tilde{Q}_\epsilon \epsilon_t + \frac{1}{2} \epsilon_t' \tilde{Q}_{\epsilon\epsilon} \epsilon_t + \tilde{q}_\epsilon' \epsilon_t + \frac{1}{2} q_{\pi_H} \pi_{H,t}^2 + \frac{1}{2} q_{\pi_F} \pi_{F,t}^{*2}] + t.i.p + o(||\epsilon||^3) \tag{1.58}$$

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where

$$\begin{aligned}
\tilde{Q}_y &= N_y' Q_x N_y \\
\tilde{Q}_\epsilon &= N_y' Q_x N_\epsilon + N_y' Q_\epsilon \\
\tilde{Q}_{\epsilon\epsilon} &= N_\epsilon' Q_x N_\epsilon + 2N_\epsilon' Q_\epsilon + Q_{\epsilon\epsilon} \\
\tilde{q}_\epsilon &= q_\epsilon
\end{aligned}$$

In the following section I will use the approach described above in order to derive loss functions. I will focus on the case where government spending is wasteful: $\chi \to 0$. This case gives a clear picture of the objectives of the policy maker, and the relative weights put on these objectives, whatever the policy instruments available. However, it does not emphasize the role of government spending as the fiscal policy instrument, nor does it point out that the fiscal policy maker trades off the objectives in the derived loss function with the distortions arising from using his instruments. In the case of government spending entering the utility function, the policy maker would have to trade off reducing the different inefficiencies as illustrated by the derived quadratic loss function with avoiding deviations from the optimal spending composition.

The transformation needed in order to achieve a loss function which is quadratic in output and terms of trade, such that $y_t = \begin{bmatrix} \hat{Y}_{H,t} & \hat{Y}_{F,t} & \hat{T}_t \end{bmatrix}$, is:

$$N_y = \begin{bmatrix} 1 & 0 & 0 \\ \frac{a_H}{2a_H-1} s_c^{-1} & -\frac{1-a_H}{2a_H-1} s_c^{-1} & -\frac{2a_H(1-a_H)\phi}{2a_H-1} \\ 0 & 1 & 0 \\ -\frac{1-a_H}{2a_H-1} s_c^{-1} & \frac{a_H}{2a_H-1} s_c^{-1} & \frac{2a_H(1-a_H)\phi}{2a_H-1} \\ 0 & 0 & 1 \\ 0 & 0 & 2a_H - 1 \end{bmatrix} \tag{1.59}$$

$$N_\epsilon = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{a_H}{2a_H-1}(1 - s_c^{-1}) & -\frac{1-a_H}{2a_H-1}(1 - s_c^{-1}) \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{1-a_H}{2a_H-1}(1 - s_c^{-1}) & \frac{a_H}{2a_H-1}(1 - s_c^{-1}) \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tag{1.60}$$

Furthermore, I use the definition

$$\begin{aligned}
Dgap_t \equiv& \sigma(\hat{C}_t - \hat{C}_t^*) - \hat{Q}_t \\
=& \frac{\sigma}{2a_H - 1} s_c^{-1}(\hat{Y}_{H,t} - \hat{Y}_{F,t}) - \frac{4\phi\sigma a_H(1-a_H) + (2a_H-1)^2}{2a_H - 1}\hat{T}_t \\
&+ \frac{\sigma}{2a_H - 1}(1 - s_c^{-1})(\hat{G}_t - \hat{G}_t^*)
\end{aligned}$$

to introduce the *Dgap* measure quadratically into the loss function.

Quadratic loss function

In this section figures the quadratic loss function in the case where prices are flexible and government spending is wasteful. This simplification clarifies how the benevolent policy maker's loss function is affected by the introduction of market incompleteness in a relatively simple context, and whatever the potential instruments of the policy maker might be.
Eliminating the terms which are linear in production, consumption, and the terms of trade as well as the exchange rate, as explained above, and using the transformation system figuring in the previous section, the quadratic loss function of the policy maker under complete markets can be expressed as:

$$\begin{aligned}
\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ &(\sigma + \eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] \\
&+ 2a_H(1-a_H)\frac{(\phi\sigma - 1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H-1)^2]\hat{T}_t^2 \\
&- 4a_H(1-a_H)(\phi\sigma - 1)\hat{T}_t(\hat{Y}_{H,t} - \hat{Y}_{F,t})\} + t.i.p. \qquad (1.61)
\end{aligned}$$

where $t.i.p.$ denotes terms independent of policy making, and

$$\begin{aligned}
\tilde{Y}_{H,t} \equiv& \frac{2(2a_H-1)^2(1+\eta)}{(2a_H-1)^2\eta + \sigma[1 - 2a_H(1-a_H)]}\hat{A}_t \\
\tilde{Y}_{F,t} \equiv& \frac{2(2a_H-1)^2(1+\eta)}{(2a_H-1)^2\eta + \sigma[1 - 2a_H(1-a_H)]}\hat{A}_t^*
\end{aligned}$$

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Under incomplete markets, in stead, the loss function is:

$$
\begin{aligned}
\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & (\sigma+\eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] \\
& + 2a_H(1-a_H)\frac{(\phi\sigma - 1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H - 1)^2]\hat{T}_t^2 \\
& - 4a_H(1-a_H)(\phi\sigma - 1)\hat{T}_t(\hat{Y}_{H,t} - \hat{Y}_{F,t}) + \frac{2a_H(1-a_H)}{\sigma} Dgap_t^2 \} + t.i.p. \qquad (1.62)
\end{aligned}
$$

The loss function is exactly similar to the one derived under the assumption of complete markets, except for the introduction of demand imbalances into the loss function.[40] As in Benigno and Benigno (2006), or Corsetti, Dedola, and Leduc (2010b), the quadratic loss function of the benevolent policy maker is increasing in output gaps and terms of trade movements. Moreover, the demand-gap enters in the loss function illustrating the distortions associated with deviations from full risk sharing across countries.

The relative coefficients attached to the terms of trade and output targets are identical across market structures. Only the additional demand gap target makes the rules different according to the international financial market structure. The coefficient in front of the demand gap, assigning the relative weight that this objective should be given relative to the other objectives, is dependent on the degree of home bias, as well as on the inter-temporal elasticities of labor and consumption, and on the trade elasticity.[41]. This confirms the findings in Corsetti et al (2011) that openness and elasticities play a key role in shaping the policy trade-offs in open economies with incomplete markets.

Specifically, the following Proposition holds:

Proposition 1.1 *In the case where the countries are symmetric, prices are flexible, and government spending is wasteful, the relative weight the Ramsey policy maker attaches to reducing international demand imbalances is decreasing in the trade elasticity:* $\frac{\partial \frac{\lambda_D}{\lambda_T}}{\partial \phi} < 0$ *for* $\phi > \frac{1 - \frac{1}{8a_H(1-a_H)}}{\sigma}$.

[40]Indeed, all the terms which are linear in bonds (the current account) and the interest rate cancel out, so that the final loss function is quadratic. The assumption of cooperation is crucial for this result. Note also that under complete markets and no home bias in consumption, the rule can be rewritten as in Benigno and Benigno (2006).

[41]Even though the trade elasticity does not figure in the coefficient on the D-gap, it enters the coefficient on the terms of trade and thus affects the relative weight assigned to either of those objectives

Note that ϕ needs to be very small for the proposition not to hold, under a wide range of plausible values for the coefficient of relative risk aversion and home bias in consumption.

Sticky prices and government spending. Introducing sticky prices renders the coefficients in front of inflation positive. Because inflation is distortionary under sticky prices, it enters the loss function of the Ramsey policy maker. However, the introduction of sticky prices does not affect the other relative coefficients in the loss function.
Similarly, the loss function of the policy maker would be affected by the presence of government spending in that deviations from the optimal spending composition (government spending gaps) would be present in the loss function. These show that it is optimal to avoid too large deviations from the optimal spending composition level. Indeed, the policy maker, when allowed to use government spending as fiscal policy instruments, would like to, simultaneously close output gaps (through efficient terms of trade movements), close the international demand imbalances when markets are incomplete, and close the government spending gaps.

The rules show which distortions are important for the policy maker. The exact way in which the trade-off differs between the different cases studied here depends on the parameters affecting the relative coefficients. When restricting the fiscal policy instruments to be government spending, allowing for $\chi \neq 0$, and introducing price stickiness, due to the many coefficients and the fact that they are affected simultaneously by the parameters, it is hard to compare those coefficients. The natural next step to analyse this more complex case is thus to engage in numerical analysis, as done in "Imbalances and Fiscal Policy in a Monetary Union."

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Chapter 2

Fiscal Policy Interactions and Imbalances in a Monetary Union

2.1 Introduction

Are there important economic consequences from conducting fiscal policy at the national level within a monetary union? This question was first addressed in the 1960s in the framework of the theory of optimal currency areas, then regained interest with the construction of the Economic and Monetary Union (EMU) in the 1990s. Recently, the eurozone crisis has put the question into the spotlight once again. This paper aims at assessing the effects of strategic fiscal policy interactions between countries taking part in a monetary union. Specifically, I investigate the consequences for imbalances and price misalignments across countries.
The investigation is based on a two-country DSGE model of a monetary union in which there are international financial frictions. Furthermore, firms are monopolistically competitive and set prices sluggishly. These features imply inefficiencies in the face of country-specific shocks, and ensure a potential stabilization role for fiscal policies. The inefficiencies arising in this monetary union framework can be illustrated by imbalances, price misalignments, and output misallocations. I show that the importance of these inefficiencies depend on the strategic interaction of fiscal policy makers.

The analysis carried out in this paper contributes to the strand of the New Open Economy Macroeconomic literature dealing with the consequences of strategic interactions between policy makers. This literature first focused on monetary policy interactions; Obstfeld

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and Rogoff (2002) as well as Corsetti and Pesenti (2001) are part of that earlier literature. Corsetti and Pesenti (2001) show that national policy makers face an incentive to attempt to manipulate the terms of trade in their favor - they face a terms of trade externality. This terms of trade externality implies that inward-looking monetary policies are welfare-deteriorating, due to increased inflation volatility - unless the benchmark case of no spillovers across countries figuring in Obstfeld and Rogoff (2002) is considered.
The strategic interaction of fiscal policy makers in open economies has been considered inter alia by Lombardo and Sutherland (2004), as well as by Benigno and De Paoli (2010). My analysis departs from theirs in that I consider a monetary union with international financial frictions which affect misalignments and imbalances across countries and shape the fiscal policies. Indeed, the presence of internationally incomplete markets imply deviations from perfect risk sharing which affect not only the transmission of shocks, but also the optimal behavior of fiscal policy makers. The incentive to engage in strategic fiscal policy making and the consequences thus also depend on international financial markets.
The inclusion of international financial frictions is motivated by the empirical evidence on relatively low risk sharing across countries, also within the EMU, indicating that there are international financial frictions which prevent international risk sharing from taking place, see e.g. Demyanyk, Ostergaard, and Sorensen (2008). Though the presence of international financial frictions and the resulting deviations from perfect risk sharing might have important consequences for welfare, optimal policy making and the transmission of shocks across countries, they have not been introduced into the literature on fiscal policy making in open economies.[1] I contribute to the literature by pointing out the potential importance of market incompleteness in a monetary union with independent fiscal policy makers.

I analyse strategic fiscal policy interactions in a two-country DSGE model of a monetary union with nominal rigidities and international financial frictions. I show that the fiscal policy makers in this framework face an incentive to switch the terms of trade in their favor. This incentive, the terms of trade externality, results in a Nash equilibrium where inflation differentials across countries and intra-union imbalances may be significantly larger than if the fiscal policy makers had cooperated. Indeed, the main results of the analysis is that strategic interactions between national fiscal policy makers can lead to excessive inflation differentials across countries as well as sub-optimally high current account imbalances within the monetary union. When this is the case, there are non-negligeable welfare losses associ-

[1] In the monetary policy literature, inter alia Corsetti, Dedola, and Leduc (2010) have emphasized the importance of international financial markets for optimal policy making.

ated with conducting national fiscal policies strategically.

These results seem important in the context of the current eurozone crisis. Indeed, they indicate that part of the excessive inflation differentials and current account imbalances observed between the core and the periphery of the zone could potentially be explained by the strategic conduct of fiscal policies. In the light of this analysis, it might be beneficial to re-consider the potential gains from fiscal policy cooperation within the EMU, since fiscal cooperation might lower imbalances arising in the face of country-specific shocks. Especially, if these imbalances have negative effects not considered here, e.g. through their effects on risk in the banking sector, fiscal cooperation could imply even larger benefits than those found here.

The next section highlights the main features of the framework used for the investigation of strategic interactions between fiscal policy makers in a monetary union. The subsequent section derives analytical characterizations of optimal fiscal policy making under cooperation and non-cooperation. In Section 4 figures a numerical analysis emphasizing the effects of fiscal policy interactions on price misalignments, international imbalances, and welfare. Section 5 then concludes the paper.

2.2 Model

The model used for this analysis is similar to the two-country DSGE model of a monetary union presented in Chapter 1. Only the settings of monetary and fiscal policies differ. Hence, I only point out the main features of the model in this section, and refer the reader to Chapter 1 for further details.

The monetary union considered is composed of two countries, country H (Home) and country F (Foreign).

Monopolistically competitive firms in each of the countries produce differentiated goods using a technology which is linear in labor. They can be hit by country-specific technology shocks. Moreover, these firms are subject to staggered price setting a la Calvo (1983). The differentiated goods are assembled into a final good by competitive final good producers. This final good is traded across countries.

Households, who own the national firms, get utility from private consumption and from government spending, and disutility from working.[2] Whereas goods are traded across countries,

[2]The discount factor is endogenous in that preferences are specified a la Uzawa, see Appendix.

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labor is not mobile across borders. Households which buy the final goods might have a bias for domestically produced goods. Moreover, the elasticity of substitution between domestic and Foreign goods might depart from unity. In particular, I will assume, in the benchmark case, that the internationally traded goods are complements in utility, meaning that the marginal utility of consumption of the Foreign good is positively related to the marginal utility of consumption of the Home good.[3]
Financial markets are perfect within each country, but there are frictions at the international level. Specifically, markets are incomplete in that only nominal bonds are traded across countries. Furthermore, the yield on those bonds is positively correlated to the amount of external debt.

The model might exhibit inefficiencies in the face of country-specific shocks because of distortions arising due to monopolistic competition, staggered price setting, and internationally incomplete markets. When these inefficiencies arise, policy makers face an incentive to reduce them by using the instruments available. Doing so, policy makers might face a trade-off between reducing the different inefficiencies.

As in Chapter 1, the monetary policy instrument is the common interest rate and the fiscal policy instruments are national government spending levels. These are financed by lump-sum taxation of national households (no fiscal transfers are allowed across countries) such that the focus is on the spending side of fiscal policy. Government spending is directed towards domestically produced goods only. This implies that an increase in government spending shifts demand towards the domestically produced goods. Through such a shift in demand government spending is capable of affecting relative prices, output, and consumption. Fiscal policy can thus potentially reduce some of the inefficiencies arising in the face of shocks. However, there is a cost to using government spending to stabilize the economies. Because government spending enters the utility function of households the first-best allocation implies a particular spending composition, relating government spending to private spending and prices. That is, any deviations from the optimal spending composition level in order to stabilize the economies introduces another inefficiency. Hence, the fiscal policy maker has to trade-off the welfare gains of reducing inefficiencies arising due to monopolistic power, staggered price setting, and internationally incomplete markets with the implied welfare loss associated with deviating from the optimal spending composition.

[3]See discussion in Section 4.1.

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The policy set-up differs from Chapter 1 in that the common monetary policy instrument, the nominal interest rate, is set according to a simple Taylor-type rule. Indeed, I assume that the nominal interest rate i is set according to the rule

$$\log i_t = \phi_\pi[n \log \pi_{H,t} + (1-n)\log \pi_{F,t}] \tag{2.1}$$

where π_H and π_F denote respectively Home and Foreign producer price inflation, and n and $1-n$ are the respective sizes of the countries. ϕ_π is a policy parameter determining the interest sensitivity to union-wide inflation. Since monetary policy cannot accommodate country-specific shocks, the precise form of the Taylor rule is not crucial for the results. Among other things, it would not change the results much if I would allow the Taylor rule to incorporate a response to output as well.

The equilibrium can thus be characterized by equations (1.5)-(1.7) and (1.9)-(1.18) figuring in Chapter 1, and the interest rate rule (2.1), given last period prices, external debt, and fiscal policies. The determination of fiscal policies, the paths for government spending, depends on the strategic interaction of national fiscal policy makers. I consider two different set-ups for fiscal policy making: one in which the fiscal policy makers cooperate in that they set government spending such as to maximize union-wide welfare; and another in which each fiscal authority decides on its own government spending level, taking monetary policy and the other country's fiscal policy as given. The latter results in a Nash equilibrium.[4]

2.3 Cooperative and non-cooperative policies

In the following, I illustrate the policy problem facing respectively the cooperative and the non-cooperative policy makers by their quadratic loss functions. Indeed, I derive the cooperative and the non-cooperative loss functions under incomplete markets by approximating the relevant welfare function; the resulting quadratic loss function is correct up to second-order. The details of the derivation figure in the Technical Appendix to Chapter 2. For simplicity I will here focus on the case where $\chi \to 0$, implying that government spending is wasteful. This simplification will allow me to point out the objectives of the policy maker, whatever the available instruments. In other words, inefficiencies arising due to the nature of policy instruments will not appear in the loss function; in the framework described previously this implies that deviations from the optimal spending composition will not explicitly appear in

[4]The computation of the Nash policies is explained in Section 4.

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the loss function. I also restrict the results to the case of perfectly flexible prices, for clarity and without consequences for the main findings. First, the cooperative and non-cooperative loss functions under complete markets will be compared. Then, I will introduce international financial frictions and point out how these affect the objectives of the policy makers according to their strategic behaviour.

2.3.1 Complete markets

Under complete markets, the cooperative loss function illustrating the objectives, or targets, of the cooperative policy maker can be written as:

$$\begin{aligned}\mathcal{L}^C = E_0 \sum_{t=0}^{\infty} \{ & (\sigma+\eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] \\ & + 2a_H(1-a_H)\frac{(\phi\sigma - 1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H - 1)^2]\hat{T}_t^2 \\ & - 4a_H(1-a_H)(\phi\sigma-1)\hat{T}_t(\hat{Y}_{H,t} - \hat{Y}_{F,t})\} + t.i.p. + O(||\xi||)^3 \end{aligned} \quad (2.2)$$

where $t.i.p.$ denotes terms independent of policy making, $O(||\xi||)^3$ denote terms of order 3 or higher, such as exogenous shocks, and a variable with a tilde denotes the efficient deviation of that variable from steady state. The loss function can alternatively be expressed in the following way:

$$\begin{aligned}\mathcal{L}^C = E_0 \sum_{t=0}^{\infty} \{ & [\frac{a_H(1-a_H)}{\sigma^2}[4a_H(1-a_H)\eta(\phi\sigma-1)^2 + \phi\sigma(\sigma+2\eta) - 2\sigma - 3\eta] + \frac{\sigma+\eta}{2\sigma^2}](\hat{T}_t - \tilde{T}_t)^2 \\ & + (\sigma+\eta)(\hat{C}_t - \tilde{C}_t)^2 - \frac{(2a_H-1)(\eta+\sigma)}{2\sigma}\hat{T}_t\hat{C}_t\} + t.i.p. + O(||\xi||)^3 \end{aligned} \quad (2.3)$$

These loss functions show that the policy maker aims at minimising deviations from the efficient level of consumption (or, equivalently output gaps) as well as deviations from the efficient relative prices (terms of trade). Moreover, (2.3) shows that a negative correlation between the terms of trade and Home consumption is welfare deteriorating (increases the loss). This is so because if a deterioration of the terms of trade (corresponding to an increase in the measure) is accompanied by a fall in Home consumption, purchasing power of Home households is reduced through two channels: Not only is consumption reduced, but Foreign goods are also more expensive. Such a correlation would imply welfare-deteriorating variance of purchasing power. The relative weights put on the different objectives, or targets, are illustrated by the coefficients in front of the different targets. They depend on the structural

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parameters of the model.
The non-cooperative loss function of the Home policy maker, in stead, can be written as:

$$\begin{aligned}\mathcal{L}^{NC} = E_0 \sum_{t=0}^{\infty} \{ &\frac{(1-a_H)}{\sigma^2}[(2a_H-1)^2(1+(1-a_H)\eta) - 2\phi\sigma a_H(2a_H-1)(1+2(1-a_H)\eta) \\ &+ a_H\phi\sigma^2(1+4(1-a_H)a_H\eta\phi)](\hat{T}_t - \tilde{T}_t)^2 + (\sigma+\eta)(\hat{C}_t - \tilde{C}_t)^2 \\ &+ \frac{(1-a_H)(1+\eta)(1+2a_H(\phi\sigma-1))}{\sigma}\hat{T}_t\hat{C}_t\} + t.i.p. + O(||\xi||)^3 \end{aligned} \tag{2.4}$$

When home bias in consumption is present, then the weights differ across the two strategies. Notably, the weight put on avoiding deviations of the terms of trade from its efficient level relative to avoiding a domestic consumption gap, or equivalently, output gap is lower when no cooperation takes place. This is stated in Proposition 2.1.

Proposition 2.1 *Under complete markets, flexible prices, and wasteful government spending, the relative weight attached to the terms of trade objective relative to the output gap objective in the quadratic approximation to the Ramsey policy maker's loss function is higher under cooperation than in the case where the policy makers are inward-looking, for* $\frac{1}{2} < a_H < 1$ *and* $\sigma > 1$.

Under complete markets and flexible prices, the efficient allocation ensuring zero output gaps (or consumption gap) and a zero terms of trade gap can be obtained under cooperation. At this efficient allocation, both countries' welfare is maximized, and the Nash policy maker will thus not have an incentive to deviate from the cooperative allocation. Hence, the difference in weights associated with the different objectives would not be observed. However, the loss function does illustrate the terms of trade externality facing Nash policy makers which implies a lower weight attached to reducing international price inefficiencies rather than reducing domestic output gaps. As a result, in the face of distortions such as staggered price setting or market incompleteness, larger price variations would arise under inward-looking policy making.

2.3.2 Incomplete markets

Under internationally incomplete markets, the loss function of the cooperative policy maker can be expressed as in Chapter 1:

$$
\begin{aligned}
\mathcal{L}^C = E_0 \sum_{t=0}^{\infty} \{ & 2a_H(1-a_H)\frac{(\phi\sigma-1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H-1)^2](\hat{T}_t - \tilde{T}_t)^2 \\
& + (\sigma+\eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] + \frac{2a_H(1-a_H)}{\sigma}\widehat{Dgap}_t^2 \\
& - 4a_H(1-a_H)(\phi\sigma-1)(\hat{T}_t - \tilde{T}_t)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) - (\hat{Y}_{F,t} - \tilde{Y}_{F,t})]\} + t.i.p. + O(||\xi||)^3
\end{aligned}
\tag{2.5}
$$

The loss function is exactly similar to the one derived under the assumption of complete markets, (2.2), except for the introduction of demand imbalances into the loss function. The non-cooperative loss function of the Home policy maker can be written in a similar way.

$$
\begin{aligned}
\mathcal{L}^{NC} = E_0 \sum_{t=0}^{\infty} \{ & \lambda_T^{NC}(\hat{T}_t - \tilde{T}_t)^2 + \lambda_{Y,H}^{NC}(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + \lambda_{Y,F}^{NC}(\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2 + \lambda_D^{NC}\widehat{Dgap}_t^2 \\
& + \lambda_{TY,H}^{NC}(\hat{T}_t - \tilde{T}_t)(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) + \lambda_{TY,F}^{NC}(\hat{T}_t - \tilde{T}_t)(\hat{Y}_{F,t} - \tilde{Y}_{F,t}) + \lambda_{CA}^{NC}\widehat{CA}_t\} \\
& + t.i.p. + O(||\xi||)^3
\end{aligned}
\tag{2.6}
$$

Because the coefficients are rather complex, they are not stated here, but can be obtained from the author. The loss function under non-cooperation departs from the cooperative loss function in several ways: not only deviations of the current account matter, but the sign of the deviations does too for $a_H > 1/2$. Furthermore, denoting the coefficient for variable i in the cooperative loss function λ_i^C, we can, by comparing the coefficients of the above stated loss functions, deduct the following:

Proposition 2.2 *The relative importance of reducing international demand imbalances, as illustrated by the Dgap, as opposed to reducing the national output gap is higher under cooperative policy making than under non-cooperative policy-making:* $\frac{\lambda_D^C}{\lambda_{Y,H}^C} > \frac{\lambda_D^{NC}}{\lambda_{Y,H}^{NC}}$ *for any* $\phi \notin [\phi^l; \phi^h]$ *where* $\phi^l = f^l(a_H, \eta, \sigma)$ *and* $\phi^h = f^h(a_H, \eta, \sigma)$.

Given the fact that the relative weights put on the different objectives according to the strategic interaction of the policy makers is a function of the structural parameters of the model, I engage in a numerical investigation in the next section. In the numerical benchmark

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chosen in the next section of this chapter, $\phi^l = 0.37$ and $\phi^h = 0.40$ such that $\frac{\lambda_D^C}{\lambda_{Y,H}^C} > \frac{\lambda_D^{NC}}{\lambda_{Y,H}^{NC}}$ holds for all $\phi \notin [0.37; 0.40]$.[5]

The approximated loss functions illustrate how policy objectives differ according to the strategic interaction of policy makers. The extent to which the objectives differ is a function of the structural parameters of the model. By engaging in a numerical analysis, we shall see how the cooperative equilibrium differs from the non-cooperative equilibrium.

2.4 A numerical investigation of fiscal policy interactions

2.4.1 Solution method and Parameterization

The recursive solution to the model described in Section 2 consists in policy functions describing the response of variables to shocks and initial conditions, given the specified form of the rules for monetary and fiscal policies. Given that no closed-form solution to the model exists, I approximate the solution around a specified steady state, for given policy strategies. Indeed, by using the method of undetermined coefficients (perturbation methods), based on the knowledge of the derivatives of the equilibrium equations at the steady state, the model is solved by approximating the solution around the symmetric zero-inflation steady state in which monopolistic distortions are eliminated through appropriate subsidies.[6] Given the solution, I can compute the optimal parameters of the fiscal rules depending on the strategic behaviour of fiscal policy makers, thus specifying the constrained optimal fiscal policies. This computation is discussed in further details later.

Concretely, the definition of the equilibria under cooperation and non-cooperation are the following:

The cooperative equilibrium is the allocation which maximizes union-wide welfare with respect to the fiscal policy instruments subject to the equilibrium equations (1.5)-(1.7),(1.9)-(1.18), and the interest rate rule (2.1).

The non-cooperative equilibrium is the Nash equilibrium which ensures that each country maximizes its own welfare with respect to the national fiscal policy instrument given the other country's policies. At the Nash equilibrium none of the national policy makers have

[5]Hence, for the benchmark of $\phi = 0.5$, $\frac{\lambda_D^C}{\lambda_{Y,H}^C} > \frac{\lambda_D^{NC}}{\lambda_{Y,H}^{NC}}$ holds.

[6]I used Dynare to solve the model by second-order approximation given monetary and fiscal policies. I then used those solutions to compute the constrained Ramsey optimal policies. I also used code developed by Schmitt-Grohe and Uribe (2004) to check that results are identical across the two packages.

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an incentive to deviate from their chosen policy.

The parameter values used throughout this section figure in the Table 1. Most of them are quite standard in the business cycle literature, and realistic for the EMU.[7]
The populations of each of the countries are assumed to be identical. The discount factor is set such that the steady state annual real interest rate is 4 percent. The Frisch elasticity of labor is set equal to 0.5. The inverse of the intertemporal elasticity of substitution, the risk aversion coefficient, is set to 1.5 in the benchmark calibration following Smets and Wouters (2003). χ is equal to 1/5 such that in steady state private consumption is three times larger than government consumption.
The degree of home bias is set to 0.8, implying that the steady state import ratio is 20 percent. The elasticity of substitution between goods produced within a country is set equal to 7.66 such as to ensure a mark-up of 15 percent. On average prices are sticky for a year: $\alpha = 0.75$. This value is in line with the GMM-estimates found by both Gali, Gertler, and Lopez-Salido (2001) and the Bayesian DSGE estimations carried out by Smets and Wouters (2003).
The international trade elasticity is a particularly important determinant of the equilibrium dynamics of the model presented in Section 2, and thus of the trade-off faced by fiscal policy makers. My benchmark parameterization figures a relatively low trade elasticity of 0.5, corresponding to the estimates found in the international macroeconomic literature, see e.g. Hooper, Johnson, and Marquez (2000) or Corsetti, Dedola, and Leduc (2008). The low trade elasticity is crucial in ensuring complementarity of the internationally traded goods, a realistic feature for advanced, relatively specialised countries such as the countries within the EMU.
The sensitivity of the bond yield to debt, δ, is set such as to roughly mimic the observed yield differences across the EMU before the debt crisis: the benchmark value of δ is such that for every ten percentage points increase in debt,[8] the annual interest increases by 0.5 percentage points.
Monetary policy is characterized by a Taylor-type rule, with a coefficient of 1.5 on population-weighted union-wide inflation.

[7]The parameter values used are within the range of estimates found by Smets and Wouters (2003) by engaging in Bayesian estimation of a DSGE model of the euro area, or follow Benigno (2004) who calibrates his model to the EMU. See also Gali and Monacelli (2008).

[8]this corresponds approximately to a similar increase in debt-to-steady state gdp.

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Table 2.1: Parameter values in benchmark case

Population in country H	n	0.5
Discount factor	β	$1.04^{-1/4}$
Inverse of the elasticity of labor supply	η	2
Risk aversion coefficient	σ	1.5
Degree of home bias	a_H	0.8
Price stickiness coefficient	α	0.75
Weight on government expenditures	χ	1/5
Intratemporal elasticity of substitution	θ	7.66
Trade elasticity	ϕ	0.5
Yield sensitivity to debt	δ	0.05
Taylor-rule coefficient on inflation	ϕ_π	1.5

The following process is assumed for the technology shocks:

$$\begin{bmatrix} \log A_t \\ \log A_t^* \end{bmatrix} = \begin{bmatrix} 0.95 & 0 \\ 0 & 0.95 \end{bmatrix} \begin{bmatrix} \log A_{t-1} \\ \log A_{t-1}^* \end{bmatrix} + \begin{bmatrix} v_t \\ v_t^* \end{bmatrix} \tag{2.7}$$

where v_t and v_t^* are white noise processes with standard deviations 0.01.

In the following, the parameter values listed above are used in order to investigate the effects of strategic behaviour of fiscal policy makers. The constrained optimal fiscal responses to a country-specific shock are computed, and the consequences of having independent fiscal policies rather than cooperative fiscal policies are put forward.

2.4.2 Constrained optimal fiscal policy

Fiscal rules. I restrict cooperative and non-cooperative fiscal policies to follow fiscal rules. In particular, I specify government spending to follow rules which ensure that government spending levels satisfy the optimal spending composition, unless shocks hit the economies. Moreover, I only consider rules which are easily implementable. Specifically, this analysis focuses on two types of rules: rules which allow government spending to deviate from the optimal spending composition in the presence of deviations of output from steady state; and rules which imply a response of government spending to national inflation. Fiscal policy makers have to abide to the specified functional form of the rule imposed on them, but they can choose the policy parameters of the rule.
The specific forms of the fiscal rules to which I restrict my analysis are thus:

- rules in deviations from steady state output:

$$\log G_t = \log G_t^{OSC} + \alpha_Y \log(\frac{Y_{H,t}}{\bar{Y}_H})$$
$$\log G_t^* = \log G_t^{*OSC} + \alpha_Y^* \log(\frac{Y_{F,t}}{\bar{Y}_F}) \quad (2.8)$$

- or rules in inflation:

$$\log G_t = \log G_t^{OSC} + \alpha_\pi \log(\frac{\pi_{H,t}}{\bar{\pi}_H})$$
$$\log G_t^* = \log G_t^{*OSC} + \alpha_\pi^* \log(\frac{\pi_{F,t}}{\bar{\pi}_F}) \quad (2.9)$$

I compute the optimal policy parameters of the imposed rules, the resulting rules being defined as constrained optimal policies. In this computation, I restrict the analysis to parameter values which ensure the existence of a unique equilibrium.
I consider two scenarios for strategic interaction of fiscal policy makers: One in which there is a unique fiscal policy maker who chooses the parameters of the rules $\{\alpha_Y^C, \alpha_Y^{*C}\}$ or $\{\alpha_\pi^C, \alpha_\pi^{*C}\}$, such as to maximize union-wide welfare, corresponding to the cooperative case; The other in which there are independent fiscal policy makers who may act strategically such as to maximize their own agents' welfare. The resulting $\{\alpha_Y^{NC}, \alpha_Y^{*NC}\}$ or $\{\alpha_\pi^{NC}, \alpha_\pi^{*NC}\}$ will differ from the ones obtained under cooperation if the national fiscal policy makers fail to internalize the result of their choice on the other policy maker's choice of parameters. The extent to which fiscal policies differ between these two scenarios, the consequences, and the welfare implications constitute the object of the analysis carried out in the following.

Cooperative and non-cooperative fiscal policies. Policy makers are assumed to be constraint by the functional form of the policy rule they must abide to. However, they have a choice on the feedback coefficient. They choose this coefficient before shocks are realised, and they are assumed to be able to commit to the implied rule. The cooperative fiscal policy maker chooses the policy parameters such as to maximize union-wide welfare. On the contrary, the strategically competitive fiscal policy makers maximize national welfare, given the other country's fiscal policy. The computation procedure for this case consists in the following steps:

1. An initial guess for the policy parameters is chosen, for example the cooperative policy parameters.

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2. Home country fiscal authority chooses the policy parameter which, given the initial guess for the Foreign policy parameter and the specification of monetary policy, yields the highest welfare for his agents.

3. Given the optimal Home parameter, the Foreign fiscal policy maker optimizes his agents' welfare by choosing a parameter to his rule.

4. This procedure continues until the policy makers arrive to a point in which they have chosen the same parameter values. At this point, they have no incentive to deviate from the chosen policy parameter.

The resulting optimal policy parameter values, in the benchmark case, figure here: The

Table 2.2: Optimal policy parameters under complementarity

$\phi = 0.5$	Cooperation	Non-cooperation	Welfare loss from non-cooperation
$\alpha_Y = \alpha_Y^*$	2.66	0.74	0.20
$\alpha_\pi = \alpha_\pi^*$	-54.27	-11.89	0.06

The welfare loss is computed in percent of steady state consumption.

rules show that the cooperative policies respond more aggressively to changes in output or inflation than the non-cooperative fiscal policies do. This has relatively large welfare consequences: around 0.20 percent of consumption every quarter under output rules, and 0.06 percent under rules in inflation. It is interesting to notice that the welfare losses are 3 times larger when government spending reacts to deviations from steady state output rather than inflation.

The lack of response under non-cooperation can be explained by the "terms of trade externality" facing policy makers in open economies. This externality has been put forward for the conduct of monetary policy by authors such as Obstfeld and Rogoff (2002) and Corsetti and Pesenti (2001), and for the conduct of fiscal policy by Benigno and De Paoli (2010).[9]

[9]The latter authors consider the desirability of distortionary taxation in a small open economy, i.e. in the presence of the terms of trade externality. This paper departs from the analysis of Benigno and De Paoli

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The terms of trade externality is inherent to open economies, and results from the incentive which national policy makers might face to tilt the terms of trade in their favour. By doing so, policy makers attempt to increase national welfare by allowing their households to consume more without higher labor effort. In the framework presented here, by varying government spending, the fiscal policy makers can exploit the terms of trade externality. To understand the trade-off faced by the policy makers, and the effects of the terms of trade externality, it is useful to consider the constrained optimal response to a country-specific shock.

Consider first the cooperative response. The optimal policy parameters under cooperation implies a rise in domestic government spending in the face of a positive Home technology shock which raises output above its steady state level and reduces inflation. This ensures that the fall in Home prices induced by the technology shock is dampened. Given the domination of the income effect over the substitution effect under complementarity of the goods, this fiscal policy increases Home output further. As a result, the Home current account deficit, originating in the technology shock which temporarily reduces Home income through its negative effect on the price of the Home good, is reduced. That is, the cooperative fiscal policy consists in reducing the distortionary international demand imbalances while raising the output gaps. This is very much in line with the results of the unconstrained Ramsey policy analysed in Chapter 1: optimal cooperative fiscal policy reduces international imbalances at the expense of larger output gaps.

Consider now the non-cooperative response obtained in a Nash equilibrium. When the national fiscal authorities do not cooperate, the optimal policy parameters differ from the cooperative parameters. Indeed, the national fiscal authorities do not internalize the outcome of their policy on the other country's policy. Hence, they face an incentive to deviate from the cooperative solution. By deviating slightly from the cooperative solution, policy makers can affect the terms of trade such as to reduce production and thus disutility from labor effort without an equivalent decrease in the utility of consumption (in the aftermath of a positive technology shock). This can be achieved by reducing government spending in the Home country, thereby reducing relative prices and thus, through the income effect, reducing demand and labor effort. These deviations from the cooperative fiscal policy arise because the national fiscal policy makers do not internalize the effect of their policy on foreign policy and thereby on the equilibrium levels of inflation, output, and demand imbalances. As a result the Nash equilibrium illustrates the well-known terms of trade externality: the national

(2010) in several aspects: I do not assume that perfect risk sharing takes place; I consider a two-country model with strategic interactions between policy makers rather than a small open economy; the fiscal policy instrument is government spending rather than taxation.

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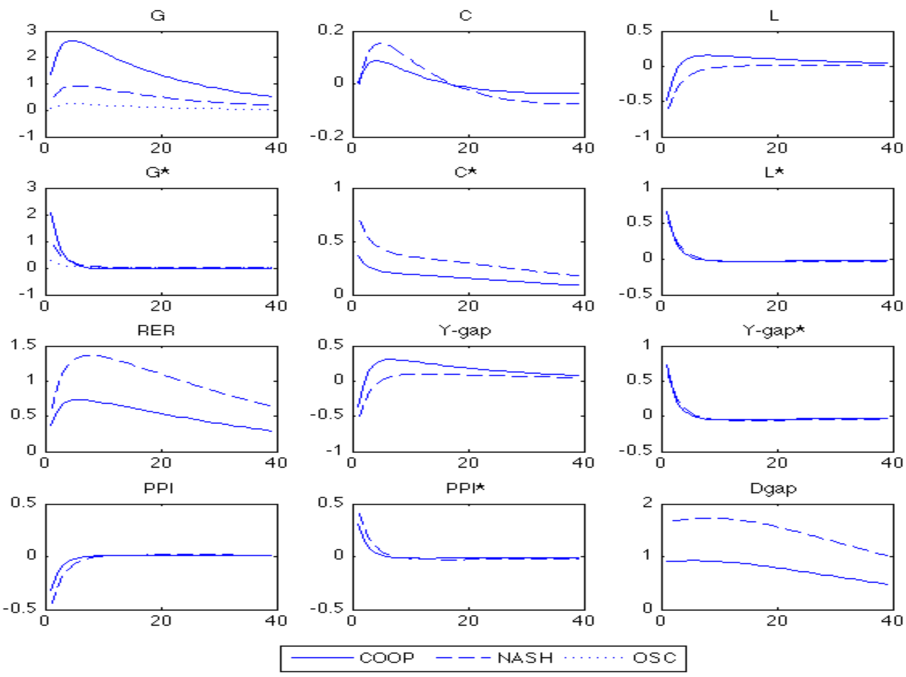
fiscal policy maker attempts to increase the purchasing power of its agents without taking into account the effect on the other country's welfare and thus on its policy response, an effect transmitted through changes in the terms of trade.

The difference between the cooperative fiscal response to a Home productivity shock, and the Nash equilibrium response is illustrated below. In Figure 2.1 the optimal response under the rule (2.8) is illustrated, whereas the optimal response under the rule (2.9) figures in Figure 2.2. Though the rules differ in their quantitative optimal fiscal response to a country-specific shock, their qualitative response is similar. The Nash policies result in lower output gaps than those resulting under cooperation, but these are obtained at the expense of higher inflation as well as higher demand imbalances.

Figure 2.1: Impulse responses following a Home technology shock (output rule)



This figure depicts the impulse response functions following a positive one standard deviation shock to Home productivity. Percentage deviations from the steady state are on the y-axes. On the x-axes figure the time periods (quarters) after the shock. The impulse responses are depicted for the case where the constrained optimal fiscal policy is cooperative (the solid line), and the case where each of the fiscal policy makers engage in non-cooperative fiscal policy making leading to a Nash equilibrium (the dashed line). The dotted line represents the government spending level satisfying the optimal spending composition under cooperative fiscal policies.

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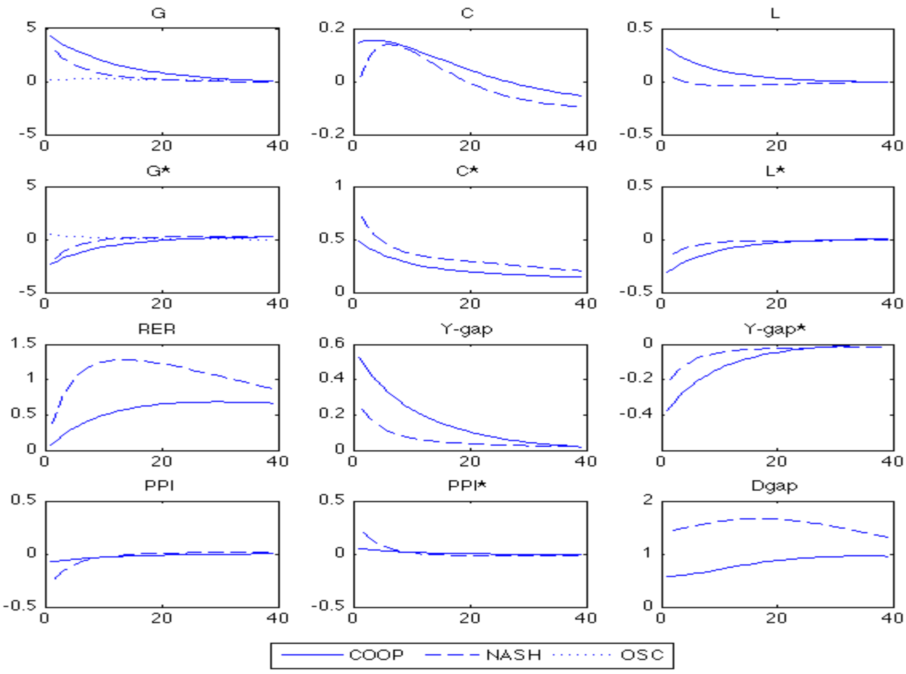
Figure 2.2: Impulse responses following a Home technology shock (inflation rule)



See footnote for Figure 2.1.

The terms of trade externality present under strategically competitive fiscal policy making has important consequences, both for welfare and for the volatility of variables such as inflation and current account imbalances. These implications are spelled out in the next subsection.

2.4.3 The consequences of non-cooperation

The strategic interaction of fiscal policy makers in open economies implies optimal policies which differ substantially from the optimal cooperative policies, as illustrated in Figure 2.1 and in Figure 2.2. This implies different equilibrium dynamics, and has consequences for union-wide welfare. Here, I discuss the effects of the strategic behaviour of fiscal policy makers on the volatility of certain variables such as output, inflation and imbalances. Indeed, in the context of the current eurozone crisis, many economists have emphasized the crucial role played by current account imbalances and inflation differentials between the Northern countries and the Southern countries in the eurozone. This subsection suggests that fiscal

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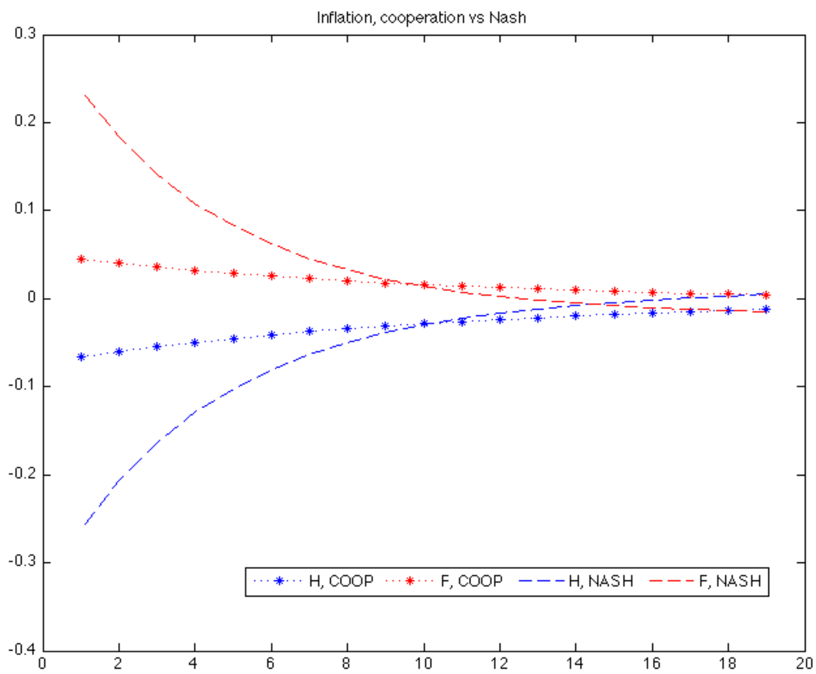
policy cooperation within a monetary union can contribute to lower the imbalances and price misalignments across countries.[10]

Inflation differentials. In the benchmark case, strategically competitive policy making results in excessive inflation differentials across countries when a country-specific shock hits. A technology shock to country H of one standard deviation results in an immediate producer price deflation of 0.25 percent in H, and a similar rise of producer prices in country F. This is almost five times as high an inflation differential as the one which would prevail under fiscal cooperation, see Figure 2.3.

Figure 2.3: Inflation following Home technology shock



Home producer price inflation dynamics following a positive one standard deviation shock to Home productivity, under constrained optimal fiscal policies following rule (2.9). The solid line depicts the outcome under cooperative fiscal policies, whereas the dashed line illustrates the outcome in the Nash equilibrium.

This inflation differential is distortionary due to staggered price setting, and is therefore

[10]The analysis carried out here is constrained by the fiscal rule being of the form (2.9), i.e. dependent on inflation. This is not of importance for the qualitative results, but nevertheless for the quantitative results.

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costly in terms of welfare. It is an inefficiency which could be partly eliminated through co-operation in fiscal policy. Moreover, not only does this excessive inflation differential arising under Nash fiscal policy making imply direct welfare costs in terms of inflation. It could also capture or result in other inefficiencies which are not captured in this model. For example, it could affect productivity if there are frictions in the labor market.

The excessive inflation differential arising because of non-cooperative fiscal policies in a monetary union is quite robust to most parameters, conditional on the trade elasticity being relatively low as in the benchmark case. Figure 2.9 shows that the higher the degree of home bias, the larger the inflation differential. However, even when the countries are completely open and households exhibit no home bias in consumption preferences, does the initial inflation differential between the Nash equilibrium and the cooperative equilibrium persist. Similarly, the excessive inflation resulting from Nash fiscal policy making persists for different risk aversion degrees as well. This is illustrated in Figure 2.10.

Concerning the sensitivity of the results to the degree of price stickiness, we can notice that the higher the stickiness, the less do prices in general vary. However, at the same time, the more sticky are prices, the higher is the inflation differential between the cooperative case and the non-cooperative case, see Figure 2.11.

Current account imbalances. The strategic interaction of fiscal policies not only shapes inflation differentials across countries but also affects the volatility of current account imbalances significantly. Indeed, following a country-specific productivity shock, the current account imbalances are more pronounced and volatile when the fiscal policy makers act strategically such as to maximize their own country's welfare. This is apparent in Figure 2.4.

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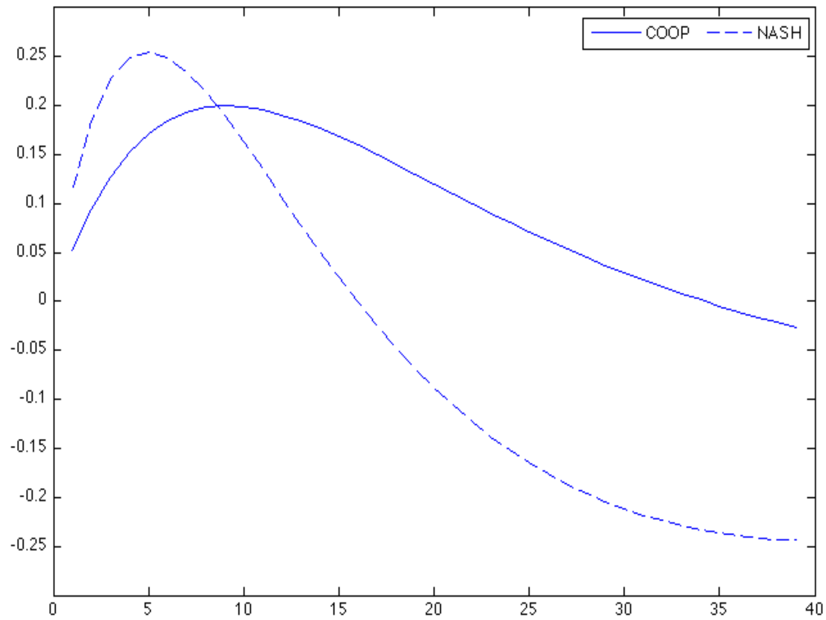
Figure 2.4: Current account following Home technology shock



This figure depicts the deviations of the current account from its steady state value in percent of steady state output. The solid line depicts the outcome under cooperative fiscal policies, whereas the dashed line illustrates the outcome in the Nash equilibrium.

This results from the terms of trade externality which implies larger inflation differentials and thus larger income differentials under non-cooperation when the internationally traded goods are complements. Hence, in line with the sensitivity of inflation differentials, is the volatility of current account imbalances increasing in the degree of home bias, and also remains excessive even when there is no home bias in consumption present. Moreover, the presence of excessive imbalances is robust to the coefficient of relative risk aversion, and increasing in the degree of price stickiness. It is interesting to note that the structure of fiscal policies can lead to large excessive current account imbalances within the monetary union. Indeed, Figure 2.4 shows that the current account imbalances not only are twice as large as under fiscal cooperation - they are also much more volatile. Given the importance attributed to the role of current account imbalances in the current eurozone crisis, it is interesting to note this point. Indeed, if current account imbalances affect risk in a way not modelled here, e.g. through the banking sector, these excessive imbalances might have other consequences than those appearing in this model. This analysis indicates that if this is so,

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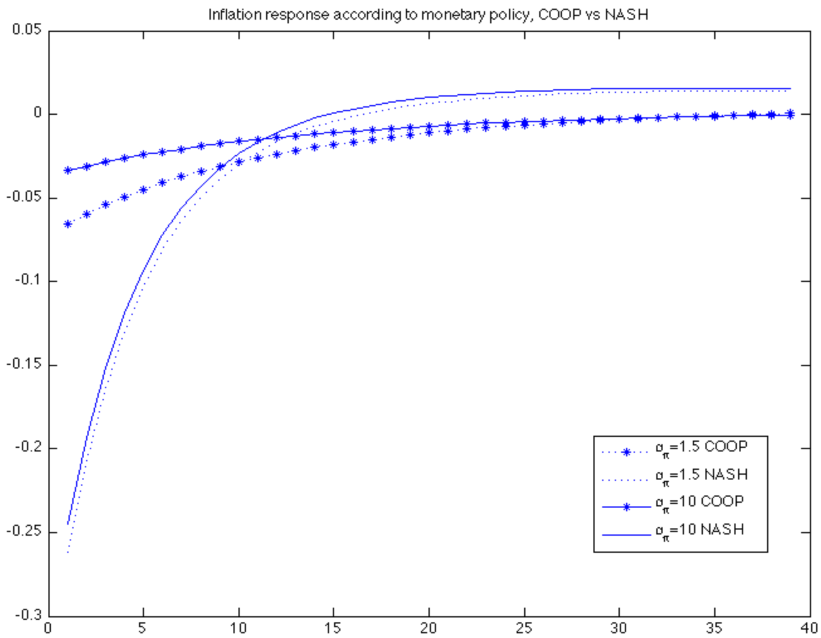
then fiscal cooperation could proof particularly beneficial.

The role of monetary policy. Can monetary policy play a role in affecting the strategic behaviour of policy makers and the resulting imbalances and misalignments?
Figure 2.5 shows that the aggressiveness of monetary policy does not have much influence on the volatility or level of inflation arising in the face of country-specific shocks when fiscal policies are set in a strategically competitive way. Only under cooperation does the aggressiveness of monetary policy play a significant role in reducing price volatility.

Figure 2.5: Inflation dynamics following Home technology shock



This figure depicts the inflation differential (Home-Foreign inflation) in percentage points following a positive one standard deviation shock to Home output. The solid lines depict the dynamics under cooperative fiscal policies, whereas the dashed lines illustrates the dynamics in the Nash equilibrium.

The effect of monetary policy on the current account imbalances is also dampened by strategic competition of fiscal policy makers. The more hard-nosed is the common central bank, the lower is the volatility of imbalances under fiscal cooperation. However, when the fiscal authorities do not cooperate, then the effect of monetary policy on the volatility is quasi inexistent, see Figure 2.6.

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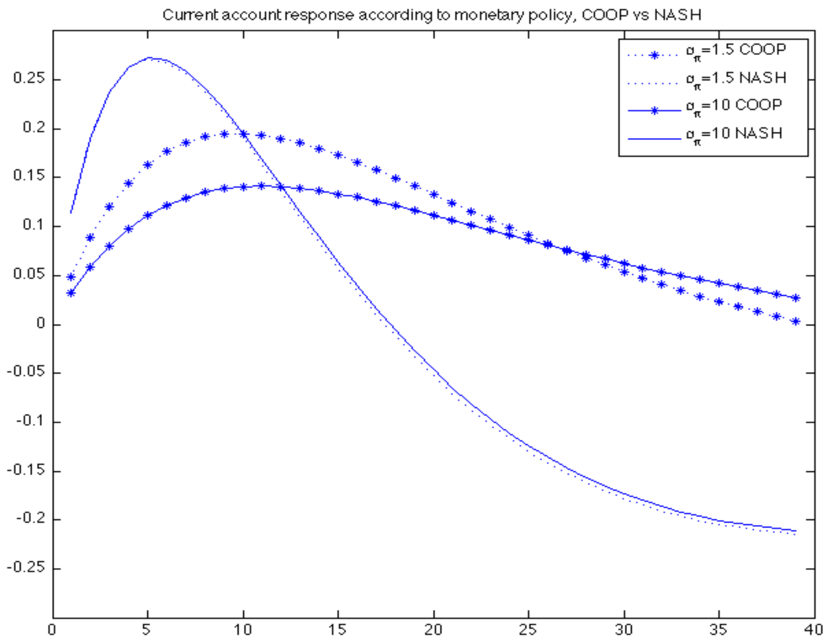
Figure 2.6: Current account dynamics following Home technology shock



In other words: the power of the common central bank in reducing cross-country imbalances and inflation differentials is hampered by the strategic behaviour of fiscal policy makers!

Sensitivity to the trade elasticity. While the results are rather robust to different parameter values, there is one exception: the trade elasticity. The importance of this parameter is evident in that it governs the interaction between the two countries, and thus the incentive to deviate from the cooperative solution. It thus plays a crucial role in determining the inflation differentials arising due to strategically competitive fiscal policy making. When the internationally traded goods are complements, then strategic competition in fiscal policy implies excessive inflation differentials. Figure 2.12 illustrate that around the benchmark value of 0.5 for the trade elasticity, the inflation differentials resulting from country-specific shocks are largest. Though they become less important as we depart from that value, they remain present as long as the goods are complements. As a result, when the internationally traded goods are complements, then the current account imbalances are always excessive

when fiscal policies are set strategically, see Figures 2.13 and 2.14[11]. Similarly to the inflation differentials, they are largest around values close to 0.5.
However, when the trade elasticity is so large that the internationally traded goods are substitutes, then the terms of trade externality becomes insignificant for fiscal policy making. As a result, the non-cooperative and the cooperative constrained optimal fiscal policies are almost identical, as shown in Table 2.3 for a value of the trade elasticity of 4.

Table 2.3: Optimal policy parameters under substitutability

$\phi = 4$	Cooperation	Non-cooperation	Welfare loss from non-cooperation
$\alpha_Y = \alpha_Y^*$	0.07	0.05	9×10^{-6}
$\alpha_\pi = \alpha_\pi^*$	-4.82	-5.80	2×10^{-5}

The welfare loss is computed in percent of steady state consumption.

Welfare effects of non-cooperation in a monetary union. The previous paragraphs have shown that when fiscal authorities in a monetary union engage in strategic policy making, then excessive inflation differentials and sub-optimally high imbalances across countries may arise. These inefficiencies have welfare implications which have already been pointed out in Table 2.2. The welfare losses associated with non-cooperative fiscal policies are higher the more hard-nosed is the central banker, that is the higher is the Taylor coefficient. This is illustrated in Figure 2.7.

[11]Note that for $\phi \geq 0.67$ the goods are substitutes.

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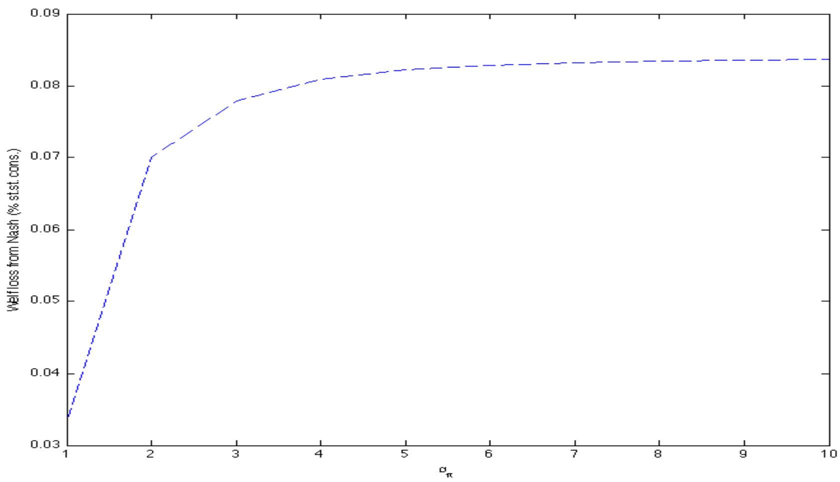
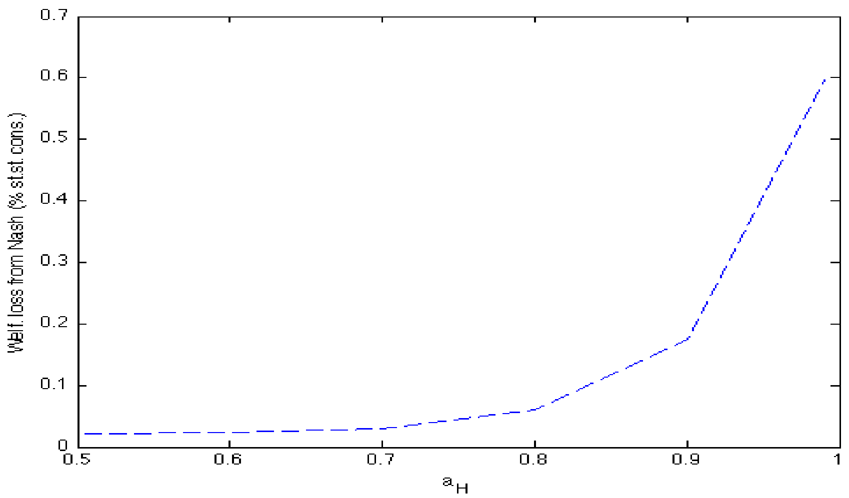
Figure 2.7: Welfare loss according to monetary policy



The welfare loss from non-cooperative fiscal policies is illustrated in percent of steady state consumption, as a function of the parameter α_π figuring in the Taylor rule of the monetary authority.

Moreover, we can note that the welfare loss associated with non-cooperative fiscal policy making is increasing in the degree of home bias in consumption, as Figure 2.8 shows.

Figure 2.8: Welfare sensitivity to home bias



The welfare loss from non-cooperative fiscal policies is illustrated in percent of steady state consumption, as a function of the degree of home bias in consumption, a_H.

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This section has provided a numerical analysis of the implications of strategic fiscal policy interactions within a monetary union. I have shown that the consequences can be non-negligeable for rather realistic values of the trade elasticity: current account imbalances and inflation differentials are excessively large under non-cooperation of the fiscal authorities. This implies that there are relatively important welfare gains from engaging in fiscal policy cooperation within the monetary union framework analysed.

2.5 Conclusion

This paper sheds light on the potential implications of strategic fiscal policy interactions in a monetary union with international financial frictions. I have shown that the objective of policy makers differs according to whether they aim at maximizing union-wide welfare or national welfare. More specifically, I have pointed out that, for most parameter combinations, is the relative importance of international demand imbalances lower under non-cooperation than when the fiscal authorities cooperate. I have also shown, by engaging in numerical analysis, that strategic fiscal policy making results in a Nash equilibrium which exhibits excessive inflation differentials across countries as well as sub-optimally high volatility of the current account. These characteristics of the Nash equilibrium implies that there might be important welfare gains associated with fiscal policy cooperation in a monetary union.

By pointing out the importance of fiscal policy cooperation within a monetary union, this paper underlines the fact that the best outcome for the monetary union as a whole cannot be achieved by conducting strategically competitive fiscal policies. This, of course, raises questions concerning the optimal conduct of fiscal policies within monetary unions such as the EMU, and more specifically, it points out the welfare improvements which might arise from fiscal policy cooperation.

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Appendix

Figure 2.9: Inflation following home technology shock

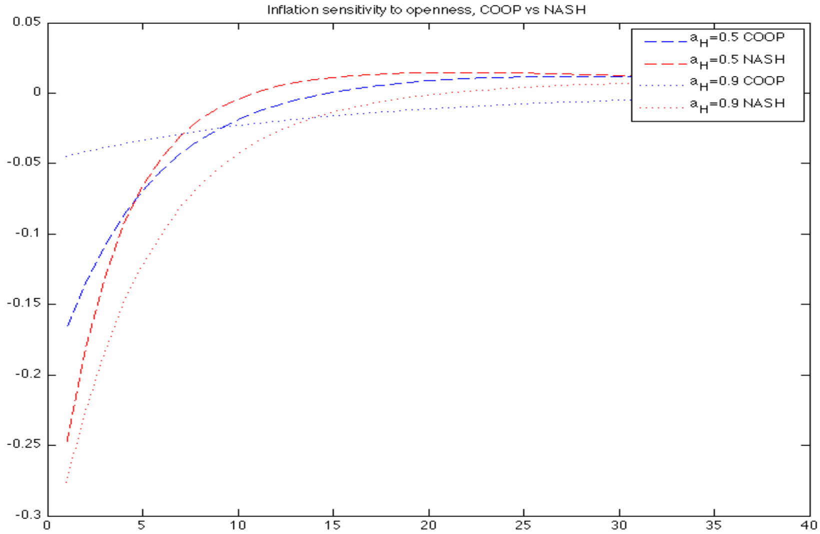

Figure 2.10: Inflation following home technology shock

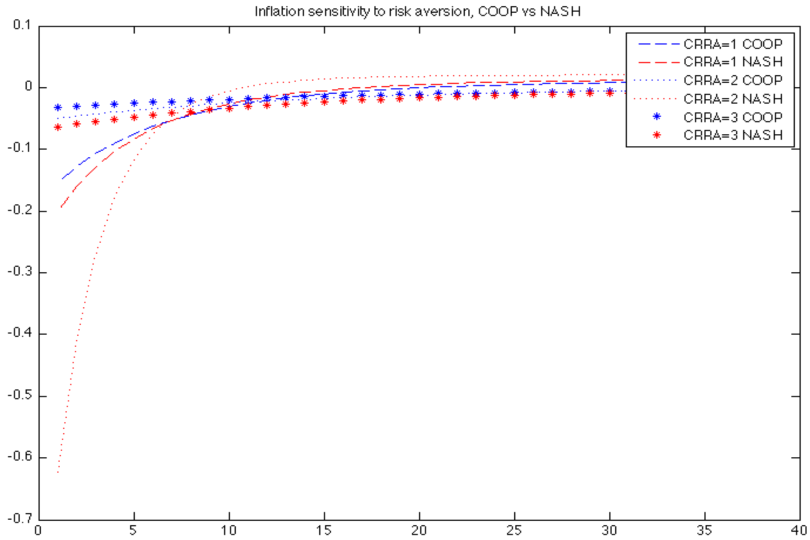

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Figure 2.11: Inflation following home technology shock

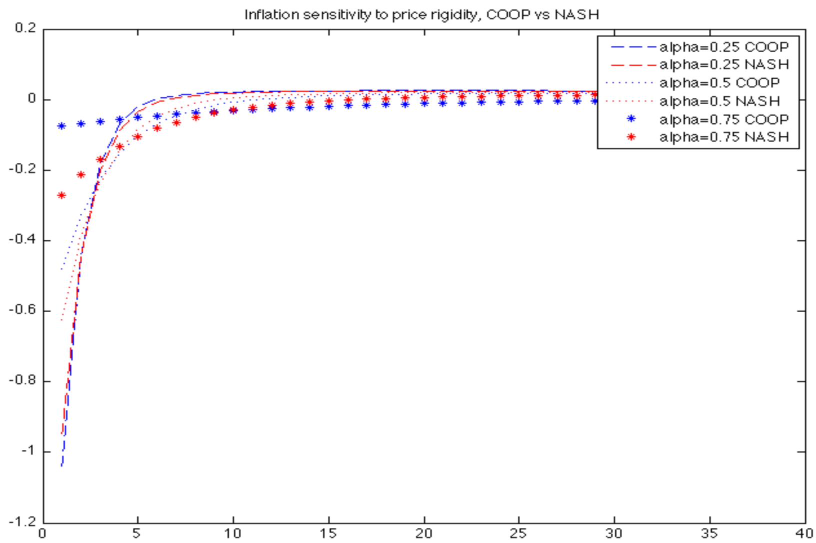

Figure 2.12: Inflation following home technology shock

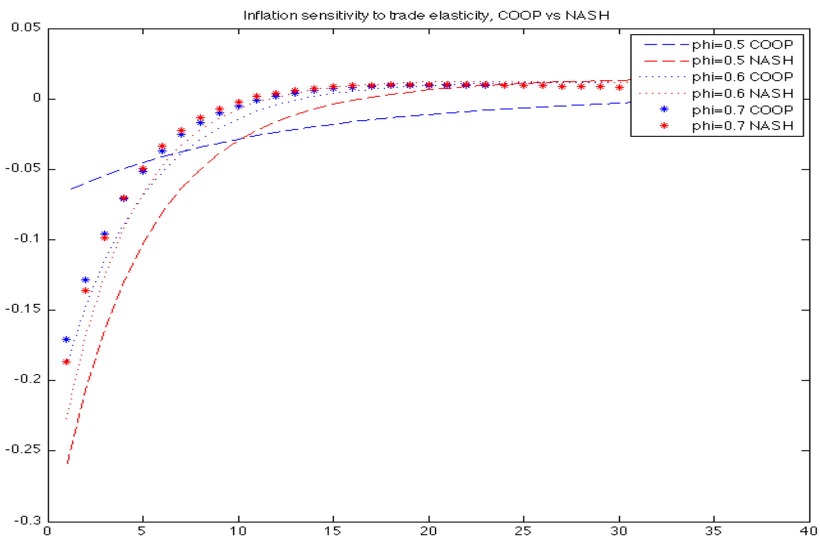

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Figure 2.13: Current account following home technology shock

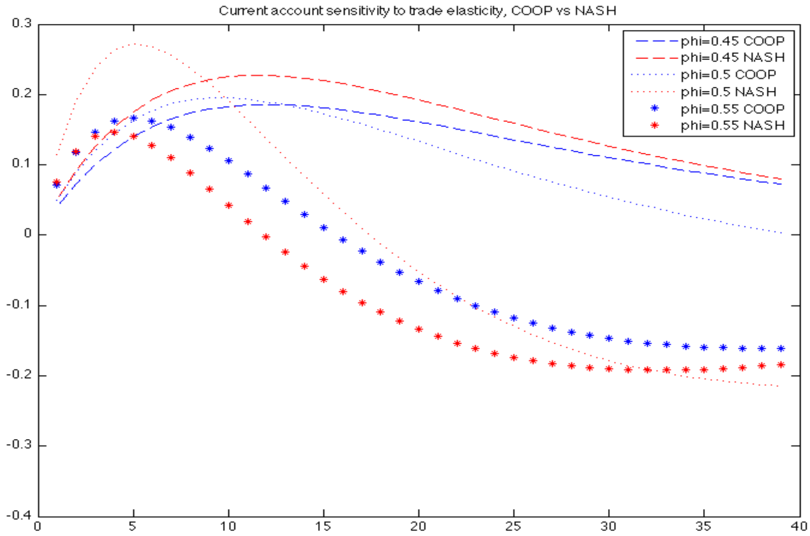
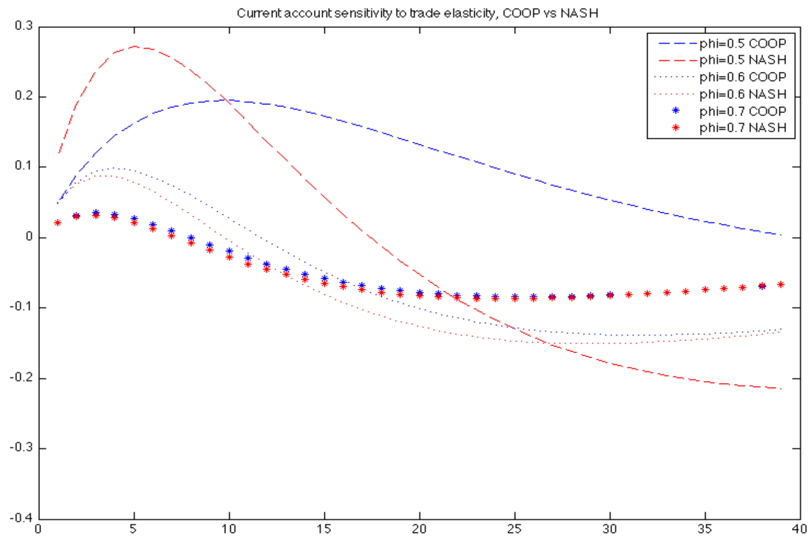


Figure 2.14: Current account following home technology shock



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2.6 Technical appendix to Chapter 2

Cooperative and Non-cooperative Loss functions under Complete and Incomplete Markets

Introduction

In the following, I explain how to derive the quadratic loss function from the world welfare function when fiscal and monetary policy is specified as in Chapter 2. I derive the cooperative and the non-cooperative loss functions under incomplete markets by approximating the world welfare function; the resulting loss function is correct up to second-order. The methodology follows Benigno and Benigno (2006), or Ferrero (2009), and the steps to derive the loss function are as in the Technical appendix to Chapter 1.

In this appendix, I will focus on the simple case in which government spending does not enter the utility function of households, i.e. it is wasteful. This case serves as to illustrate the main points in a simple context: the quadratic approximation to the loss function and the coefficients are analytically more approachable when we keep it simple. Allowing government spending to yield utility to households is straightforward and does not change the main results outlined here.

Deriving the loss function

Analysing the case where government spending is wasteful is a first step towards understanding the more complex analytical results derived for the case in which government spending yields utility to households. The simpler case in which government spending is entirely wasteful is particularly useful because it makes the results more easy to analyse, and figure here for that simple purpose. The case analysed here thus corresponds to the special case where $\chi = 0$ implying that steady state government spending is zero.

I will also take this occasion to clarify the transformations and approximations undertaken in the derivations of the quadratic loss functions. Note that, in this appendix, for simplicity, I focus on the case where prices are fully flexible, and the two countries are symmetric.[12]

I will start by analysing the complete markets case, such as to compare the difference in trade-offs faced by the national non-cooperative and the international cooperative policy makers, by investigating their respective loss functions.

[12] Introducing price stickiness is straightforward, see e.g. Benigno and Benigno (2006).

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Complete markets

In this case of complete markets and wasteful government spending, the following vectors of variables will be used::

$$x_t' = \begin{bmatrix} \hat{Y}_{H,t} & \hat{C}_t & \hat{Y}^*_{F,t} & \hat{C}^*_t & \hat{T}_t & \hat{Q}_t \end{bmatrix}$$

$$\epsilon_t' = \begin{bmatrix} \hat{A}_t & \hat{A}^*_t \end{bmatrix}$$

Second-order Approximation to the Welfare function. The second order approximation to the cooperative welfare function is

$$W = E_0 \sum_{t=0}^{\infty} \beta^t \{\{U_C \bar{C}[\hat{C}_t + \frac{1}{2}(1-\sigma)\hat{C}_t^2] - \bar{Y}_H^{1+\eta}\hat{Y}_{H,t}[1 + \frac{1}{2}(1+\eta)\hat{Y}_{H,t} - (1+\eta)\hat{A}_t)]\}+$$
$$\{U_C^* \bar{C}^*[\hat{C}_t^* + \frac{1}{2}(1-\sigma)\hat{C}_t^{*2}] - \bar{Y}_F^{1+\eta}\hat{Y}_{F,t}[1 + \frac{1}{2}(1+\eta)\hat{Y}_{F,t} - (1+\eta)\hat{A}_t^*)]\}\} \tag{2.10}$$

In matrix form, this amounts to:

$$W = \bar{U}_C \bar{C} E_0 \sum_{t=0}^{\infty} \beta^t [z_x' x_t + \frac{1}{2} x_t' Z_x x_t + x_t' Z_\epsilon \epsilon_t + \epsilon_t' Z_{\epsilon\epsilon} \epsilon_t] \tag{2.11}$$

where

$$z_x = \begin{bmatrix} -\bar{Y}_H^{1+\eta} & \bar{C}^{1-\sigma} & -\bar{Y}_F^{1+\eta} & \bar{C}^{*1-\sigma} & 0 & 0 \end{bmatrix}$$

$$Z_x = \begin{bmatrix} -\bar{Y}_H^{1+\eta}(1+\eta) & 0 & 0 & 0 & 0 & 0 \\ 0 & (1-\sigma)\bar{C}^{1-\sigma} & 0 & 0 & 0 & 0 \\ 0 & 0 & -\bar{Y}_F^{1+\eta}(1+\eta) & 0 & 0 & 0 \\ 0 & 0 & 0 & (1-\sigma)\bar{C}^{*1-\sigma} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

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$$Z_\epsilon = \begin{bmatrix} \bar{Y}_H^{1+\eta}(1+\eta) & 0 \\ 0 & 0 \\ 0 & Y_F^{1+\eta}(1+\eta) \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$$

The second order approximation to the non-cooperative welfare function of the Home policy maker, instead, is:[13]

$$W = E_0 \sum_{t=0}^{\infty} \beta^t \{U_C \bar{C}[\hat{C}_t + \frac{1}{2}(1-\sigma)\hat{C}_t^2] - \bar{Y}_H^{1+\eta}\hat{Y}_{H,t}[1 + \frac{1}{2}(1+\eta)\hat{Y}_{H,t} - (1+\eta)\hat{A}_t)]\} \quad (2.12)$$

In matrix form, this amounts to:

$$W = \bar{U}_C \bar{C} E_0 \sum_{t=0}^{\infty} \beta^t [z_x' x_t + \frac{1}{2} x_t' Z_x x_t + x_t' Z_\epsilon \epsilon_t] \quad (2.13)$$

where

$$z_x = \begin{bmatrix} -\bar{Y}_H^{1+\eta} & \bar{C}^{1-\sigma} & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$Z_x = \begin{bmatrix} -\bar{Y}_H^{1+\eta}(1+\eta) & 0 & 0 & 0 & 0 & 0 \\ 0 & (1-\sigma)\bar{C}^{1-\sigma} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$Z_\epsilon = \begin{bmatrix} \bar{Y}_H^{1+\eta}(1+\eta) & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$$

The equilibrium equations of the model in this simple set-up are the AD equations, the AS equations, a resource constraint, as well as the equation relating the real exchange rate to

[13]The national loss function for country F is symmetric.

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the terms of trade. The equilibrium equations can be expressed in terms of the variables figuring in the vectors x_t (output and consumption in each country, the terms of trade, and the real exchange rate) and ϵ_t (the exogenous technology). In the following I present the second-order approximations to the equilibrium equations.

Second-order approximations to the AS equations. I assume that the monopolistic distortions are offset by appropriate taxation in the steady state. The aggregate supply (AS) equation derived from optimal price setting decisions under flexible prices is:

$$\frac{P_{H,t}}{P_t} = \frac{\theta}{(\theta-1)(1-\tau)}\frac{1}{A_t}\frac{W_t}{P_t} = \frac{1}{A_t}\frac{L_t^\eta}{C_t^{-\sigma}} = \frac{1}{A_t^{1+\eta}}\frac{Y_{H,t}^\eta}{C_t^{-\sigma}}$$

$$\Leftrightarrow [a_H + (1-a_H)T_t^{1-\phi}]^{\frac{1}{\phi-1}} = \frac{1}{A_t^{1+\eta}}\frac{Y_{H,t}^\eta}{C_t^{-\sigma}}$$

In order to derive the second-order approximation to this equation, we first take logs:

$$\frac{1}{\phi-1}\log[a_H + (1-a_H)T_t^{1-\phi}] = -(1+\eta)\log A_t + \eta \log Y_{H,t} + \sigma \log C_t$$

The log-approximation (of first order) is:

$$-(1-a_H)[a_H + (1-a_H)T^{1-\phi}]^{-1}T^{-\phi}(T_t - T) = -(1+\eta)A^{-1}(A_t - A) + \eta Y_H^{-1}(Y_{H,t} - Y_H) + \sigma C^{-1}(C_t - C)$$

$$\Leftrightarrow -(1-a_H)\hat{T}_t = -(1+\eta)\hat{A}_t + \eta\hat{Y}_{H,t} + \sigma\hat{C}_t$$

The second-order approximation then is:

$$-(1-a_H)(\hat{T}_t + \frac{1}{2}\hat{T}_t^2) + \frac{1}{2}(1-a_H)^2(1-\phi)\hat{T}_t^2 + \frac{1}{2}\phi(1-a_H)\hat{T}_t^2 = -(1+\eta)\hat{A}_t + \eta\hat{Y}_{H,t} + \sigma\hat{C}_t$$

$$\Leftrightarrow -(1-a_H)\hat{T}_t - \frac{1}{2}a_H(1-a_H)(1-\phi)\hat{T}_t^2 = -(1+\eta)\hat{A}_t + \eta\hat{Y}_{H,t} + \sigma\hat{C}_t$$

Discounting this second-order approximation forward yields:

$$0 = E_0\sum_{t=0}^{\infty}\beta^t[(\sigma\hat{C}_t + \eta\hat{Y}_{H,t} - (1+\eta)\hat{A}_t + (1-a_H)\hat{T}_t + \frac{1}{2}a_H(1-a_H)(1-\phi)\hat{T}_t^2] \tag{2.14}$$

which can be rewritten as:

$$0 = E_0\sum_{t=0}^{\infty}\beta^t[a_x'x_t + a_\epsilon'\epsilon_t + \frac{1}{2}x_t'A_x x_t + x_t'A_\epsilon\epsilon_t + \frac{1}{2}\epsilon_t'A_{\epsilon\epsilon}\epsilon_t] \tag{2.15}$$

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where

$$a_x = \begin{bmatrix} \eta & \sigma & 0 & 0 & 0 & 0 & 1-a_H & 0 & 0 \end{bmatrix}$$

$$a_\epsilon = \begin{bmatrix} -(1+\eta) & 0 & 0 \end{bmatrix}$$

$$A_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & a_H(1-a_H)(1-\phi) & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$A_\epsilon = 0$$

$$A_{\epsilon\epsilon} = 0$$

For the Foreign country, the optimal price setting equation is:

$$\frac{P_{F,t}}{P_t^*} = \frac{1}{A_t^{*1+\eta}} \frac{Y_{F,t}^\eta}{C_t^{*-\sigma}}$$

$$\Leftrightarrow [a_H + (1-a_H)T_t^{\phi-1}]^{\frac{1}{\phi-1}} = \frac{1}{A_t^{*1+\eta}} \frac{Y_{F,t}^\eta}{C_t^{*-\sigma}}$$

Approximating to second order and discounting forward, in a similar fashion as above, yields:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [(\sigma \hat{C}_t^* + \eta \hat{Y}_{F,t} - (1+\eta)\hat{A}_t^* - (1-a_H)\hat{T}_t + \frac{1}{2} a_H(1-a_H)(1-\phi)\hat{T}_t^2] \tag{2.16}$$

which can be rewritten as:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [b_x' x_t + b_\epsilon' \epsilon_t + \frac{1}{2} x_t' B_x x_t + x_t' B_\epsilon \epsilon_t + \frac{1}{2} \epsilon_t' B_{\epsilon\epsilon} \epsilon_t] \tag{2.17}$$

where

$$b_x = \begin{bmatrix} 0 & 0 & 0 & \eta & \sigma & 0 & -(1-a_H) & 0 & 0 \end{bmatrix}$$

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$$b_\epsilon = \begin{bmatrix} 0 & -(1+\eta) & 0 \end{bmatrix}$$

$$B_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & a_H(1-a_H)(1-\phi) & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$B_\epsilon = 0$$
$$B_{\epsilon\epsilon} = 0$$

Second-order approximations to the AD equations. The Home aggregate demand (AD) equation is:

$$\begin{aligned} Y_{H,t} &= a_H \left(\frac{P_{H,t}}{P_t}\right)^{-\phi} C_t + a_H^* \left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\phi} C_t^* \\ &= [a_H + (1-a_H)T_t^{1-\phi}]^{\frac{\phi}{1-\phi}} [a_H C_t + (1-a_H)Q_t^\phi C_t^*] \end{aligned}$$

Taking logs, we get:

$$\log Y_{H,t} = \frac{\phi}{1-\phi} \log[a_H + (1-a_H)T_t^{1-\phi}] + \log[a_H C_t + (1-a_H)Q_t^\phi C_t^*]$$

The log-approximation of this equation then is:

$$\begin{aligned} \hat{Y}_{H,t} =& \phi(1-a_H)[a_H + (1-a_H)T^{1-\phi}]^{-1} T^{-\phi}(T_t - T) \\ &+ [a_H C + (1-a_H)Q^\phi C^*]^{-1} [a_H(C_t - C) + (1-a_H)(C_t^* - C^*) + \phi(1-a_H)C^*(Q_t - Q)] \\ \Leftrightarrow \hat{Y}_{H,t} =& \phi(1-a_H)\hat{T}_t + a_H \hat{C}_t + (1-a_H)\hat{C}_t^* + \phi(1-a_H)\hat{Q}_t \end{aligned}$$

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The second-order approximation to aggregate Home demand is then:

$$
\begin{aligned}
\hat{Y}_{H,t} =& \phi(1-a_H)(\hat{T}_t + \frac{1}{2}\hat{T}_t^2) + \frac{1}{2}[-\phi^2(1-a_H) - (1-a_H)^2\phi(1-\phi)]\hat{T}_t^2 \\
&+ a_H(\hat{C}_t + \frac{1}{2}\hat{C}_t^2) + (1-a_H)(\hat{C}_t^* + \frac{1}{2}\hat{C}_t^{*2}) + \phi(1-a_H)(\hat{Q}_t + \frac{1}{2}\hat{Q}_t^2) \\
&- \frac{1}{2}[a_H C + (1-a_H)Q^\phi C^*]^{-2}[a_H(C_t - C) + (1-a_H)Q^\phi(C_t^* - C^*) + \phi(1-a_H)C^* Q^{\phi-1}(Q_t - Q)]^2 \\
&+ \frac{1}{2}[a_H C + (1-a_H)Q^\phi C^*]^{-1}[2\phi(1-a_H)(C_t^* - C^*)(Q_t - Q) + \phi(\phi-1)(1-a_H)(Q_t - Q)^2] \\
\Leftrightarrow \hat{Y}_{H,t} =& a_H\hat{C}_t + (1-a_H)\hat{C}_t^* + \phi(1-a_H)\hat{T}_t + \phi(1-a_H)\hat{Q}_t + \\
&\frac{1}{2}(1-a_H)\phi[1-\phi-(1-a_H)(1-\phi)]\hat{T}_t^2 + a_H\frac{1}{2}\hat{C}_t^2 + (1-a_H)\frac{1}{2}\hat{C}_t^{*2} + \phi(1-a_H)\frac{1}{2}\hat{Q}_t^2 \\
&- \frac{1}{2}[a_H^2\hat{C}_t^2 + (1-a_H)^2\hat{C}_t^{*2} + \phi^2(1-a_H)^2\hat{Q}_t^2 + 2a_H(1-a_H)\hat{C}_t\hat{C}_t^* + 2(1-a_H)^2\phi\hat{Q}_t\hat{C}_t^* \\
&+ 2a_H(1-a_H)\phi\hat{Q}_t\hat{C}_t] + \phi(1-a_H)\hat{Q}_t\hat{C}_t^* + \frac{1}{2}\phi(\phi-1)(1-a_H)\hat{Q}_t^2 \\
\Leftrightarrow \hat{Y}_{H,t} =& a_H\hat{C}_t + (1-a_H)\hat{C}_t^* + \phi(1-a_H)\hat{T}_t + \phi(1-a_H)\hat{Q}_t \\
&+ \frac{1}{2}a_H(1-a_H)\{\phi(1-\phi)\hat{T}_t^2 + \hat{C}_t^2 + \hat{C}_t^{*2} + \phi^2\hat{Q}_t^2 - 2\hat{C}_t\hat{C}_t^* - 2\phi\hat{Q}_t(\hat{C}_t - \hat{C}_t^*)\} \qquad (2.18)
\end{aligned}
$$

The AD equation can thus, when discounted forward, be written in the following way:

$$
0 = E_0 \sum_{t=0}^{\infty} \beta^t [c_x' x_t + c_\epsilon' \epsilon_t + \frac{1}{2} x_t' C_x x_t + x_t' C_\epsilon \epsilon_t + \frac{1}{2}\epsilon_t' C_{\epsilon\epsilon}\epsilon_t] \qquad (2.19)
$$

with

$$
c_x' = \begin{bmatrix} -1 & a_H & 0 & 1-a_H & \phi(1-a_H) & \phi(1-a_H) \end{bmatrix}
$$

$$
C_x = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & \\
0 & a & 0 & -a & 0 & -\phi a & \\
0 & 0 & 0 & 0 & 0 & 0 & \\
0 & -a & 0 & a & 0 & 0 & \phi a \\
0 & 0 & 0 & 0 & \phi(1-\phi)a & 0 & \\
0 & -\phi a & 0 & \phi a & 0 & \phi^2 a & 0
\end{bmatrix}
$$

$$
\begin{aligned}
c_\epsilon &= 0 \\
C_\epsilon &= 0 \\
C_{\epsilon\epsilon} &= 0
\end{aligned}
$$

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where $a \equiv a_H(1-a_H)$. Aggregate demand for the Foreign good amounts to:

$$\begin{aligned} Y_{F,t} &= (1-a_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\phi} C_t + a_H \left(\frac{P_{F,t}}{P_t^*}\right)^{-\phi} C_t^* + G_t \\ &= [a_H + (1-a_H)T_t^{\phi-1}]^{\frac{\phi}{1-\phi}}[(1-a_H)Q_t^{-\phi}C_t + a_H C_t^*] \end{aligned}$$

Similar derivations as for the Home AD apply to the Foreign AD, and Foreign demand can thus be expressed as:

$$\begin{aligned} \hat{Y}_{F,t} =& (1-a_H)\hat{C}_t + a_H\hat{C}_t^* - \phi(1-a_H)\hat{T}_t - \phi(1-a_H)\hat{Q}_t \\ &+ \frac{1}{2}a_H(1-a_H)\{\phi(1-\phi)\hat{T}_t^2 + \hat{C}_t^2 + \hat{C}_t^{*2} + \phi^2\hat{Q}_t^2 - 2\hat{C}_t\hat{C}_t^* - 2\phi\hat{Q}_t(\hat{C}_t - \hat{C}_t^*)\} \end{aligned} \quad (2.20)$$

Discounting the Foreign AD equation forward thus yields:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [d_x' x_t + d_\epsilon' \epsilon_t + \frac{1}{2}x_t' D_x x_t + x_t' D_\epsilon \epsilon_t + \frac{1}{2}\epsilon_t' D_{\epsilon\epsilon}\epsilon_t] \quad (2.21)$$

with

$$d_x' = \begin{bmatrix} 0 & 1-a_H & -1 & a_H & -\phi(1-a_H) & -\phi(1-a_H) & 0 \end{bmatrix}$$

$$D_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & a & 0 & -a & 0 & -\phi a \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -a & 0 & a & 0 & \phi a \\ 0 & 0 & 0 & 0 & \phi(1-\phi)a & 0 \\ 0 & -\phi a & 0 & \phi a & 0 & \phi^2 a \end{bmatrix}$$

$$\begin{aligned} d_\epsilon &= 0 \\ D_\epsilon &= 0 \\ D_{\epsilon\epsilon} &= 0 \end{aligned}$$

Real Exchange Rate. The definition of the real exchange rate is:

$$Q_t \equiv \frac{P_t^*}{P_t} = \left[\frac{a_H T_t^{1-\phi} + (1-a_H)}{a_H + (1-a_H)T_t^{1-\phi}}\right]^{\frac{1}{1-\phi}}$$

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This definition of the real exchange rate yields the following second-order expansion[14]:

$$\hat{Q}_t = (2a_H - 1)\hat{T}_t \tag{2.22}$$

which implies

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [h'_x x_t] \tag{2.23}$$

where

$$h'_x = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 2a_H - 1 & -1 & 0 \end{bmatrix}$$

Resource constraint. Under complete markets, the full risk sharing equation holds. The second-order approximation to the full risk sharing equation $\frac{C_t^{-\sigma}}{C_t^{*-\sigma}} = \frac{1}{Q_t}$ is

$$\sigma(\hat{C}_t - \hat{C}_t^*) = \hat{Q}_t \tag{2.24}$$

which, when discounted forward, amounts to:

$$0 = E_0 \sum_{t=0}^{\infty} \beta^t [k'_x x_t] \tag{2.25}$$

with

$$k'_x = \begin{bmatrix} 0 & -\sigma & 0 & 0 & \sigma & 0 & 0 & 1 \end{bmatrix}$$

Loss functions

Complete markets

This section, as already noted, allows for a simpler analytical exercise than the more complex case with government spending yielding utility to households. We first consider the case where markets are complete.[15]

Under complete markets, the loss function can be shown to be quadratic in either consumption and the terms of trade, or in output and the terms of trade. The first option relates closely to the results found by Benigno and Benigno (2006), whereas the second option is the chosen one in Corsetti, Dedola, and Leduc (2010). In the following I consider the loss functions expressed as in Benigno and Benigno (2006), as well as in the case where both

[14] The equation is only exactly log-linear when the home bias is symmetric across countries

[15] This section also allows to compare the results with those found in Benigno and Benigno (2006), and Corsetti, Dedola, and Leduc (2010).

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home and foreign output enter the loss function along with the terms of trade (the Corsetti, Dedola, and Leduc (2010) case). Whereas the first allow for neat analytics, the second will serve as a benchmark case for future reference.

The loss function can be expressed as being quadratic in domestic consumption and the terms of trade, by using the AD-equations, the RER definition and the full risk sharing equation. Indeed, the system which leads to such a loss function is:

$$x_t = N_y y_t + N_\epsilon \epsilon_t$$

where

$$y_t' = \begin{bmatrix} \hat{C}_t & \hat{T}_t \end{bmatrix}$$

$$N_y = \begin{bmatrix} 1 & 2\phi a_H(1-a_H) - \frac{(1-a_H)(2a_H-1)}{\sigma} \\ 1 & 0 \\ 1 & -2\phi a_H(1-a_H) - \frac{a_H(2a_H-1)}{\sigma} \\ 1 & -\frac{(2a_H-1)}{\sigma} \\ 0 & 1 \\ 0 & 2a_H - 1 \end{bmatrix}, \; N_\epsilon = 0$$

Transforming the quadratic loss function, $\mathcal{L} \equiv -W$, into a system dependent on consumption and the terms of trade yields the following cooperative loss function:

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ [\frac{a_H(1-a_H)}{\sigma^2}[4a_H(1-a_H)\eta(\phi\sigma-1)^2 + \phi\sigma(\sigma+2\eta) - 2\sigma - 3\eta] + \frac{\sigma+\eta}{2\sigma^2}](\hat{T}_t - \tilde{T}_t)^2$$
$$+ (\sigma+\eta)(\hat{C}_t - \tilde{C}_t)^2 - \frac{(2a_H-1)(\eta+\sigma)}{2\sigma}\hat{T}_t\hat{C}_t\} + t.i.p. \quad (2.26)$$

where $t.i.p.$ denotes terms that are independent of policy, such as exogenous shocks. The expression reduces under no home bias in consumption to:

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ (\sigma+\eta)(\hat{C}_t - \tilde{C}_t)^2 + \frac{1}{4}\phi(1+\phi\eta)(\hat{T}_t - \tilde{T}_t)^2 \} + t.i.p. \quad (2.27)$$

Note that these coefficients are identical to the ones found by Benigno and Benigno (2006) under the assumption of no home bias.

In the case of inward-looking policy making the loss function is:

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ \frac{(1-a_H)}{\sigma^2} [(2a_H - 1)^2 (1 + (1-a_H)\eta) - 2\phi\sigma a_H (2a_H - 1)(1 + 2(1-a_H)\eta)$$
$$+ a_H \phi \sigma^2 (1 + 4(1-a_H) a_H \eta \phi)](\hat{T}_t - \tilde{T}_t)^2 + (\sigma + \eta)(\hat{C}_t - \tilde{C}_t)^2$$
$$+ \frac{(1-a_H)(1+\eta)(1 + 2a_H(\phi\sigma - 1))}{\sigma} \hat{T}_t \hat{C}_t \} + t.i.p. \tag{2.28}$$

With no home bias in consumption this reduces to:

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ (\sigma + \eta)(\hat{C}_t - \tilde{C}_t)^2 + \frac{1}{4}\phi(1 + \phi\eta)(\hat{T}_t - \tilde{T}_t)^2 + \frac{1}{2}(1+\eta)\phi \hat{T}_t \hat{C}_t \} + t.i.p. \tag{2.29}$$

Under no home bias in consumption the only difference between the cooperative and the non-cooperative loss function pertains to the presence of the correlation between consumption and the terms of trade which matters for the Nash policy maker, but not for the cooperative policy maker. The relative weights on consumption and the terms of trade remain identical across the two strategic set-ups.
However, when home bias in consumption is present, then the weights differ across the two strategies. Notably, the relative weight put on avoiding deviations of the terms of trade from its efficient level is lower when no cooperation takes place. This is stated in Proposition 1.

The quadratic approximation to the loss function can also be written in terms of output gaps and deviations from the efficient terms of trade, such that

$$y_t' = \begin{bmatrix} \hat{Y}_{H,t} & \hat{Y}_{F,t} & \hat{T}_t \end{bmatrix}$$

The transformation matrix needed for this can be derived by using the first-order approximations to the AD equations and the relation between the real exchange rate and the terms of trade.

$$N_y = \begin{bmatrix} 1 & 0 & 0 \\ \frac{a_H}{2a_H - 1} & -\frac{1-a_H}{2a_H-1} & -\frac{2a_H(1-a_H)\phi}{2a_H-1} \\ 0 & 1 & 0 \\ -\frac{1-a_H}{2a_H-1} & \frac{a_H}{2a_H-1} & \frac{2a_H(1-a_H)\phi}{2a_H-1} \\ 0 & 0 & 1 \\ 0 & 0 & 2a_H - 1 \end{bmatrix}, \; N_\epsilon = 0$$

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Using this transformation process, and the fact that perfect risk sharing holds under complete markets, the loss function of the cooperative policy maker becomes:

$$\begin{aligned}\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & 2a_H(1-a_H)\frac{(\phi\sigma-1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H-1)^2](\hat{T}_t - \tilde{T}_t)^2 \\ & + (\sigma+\eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] \\ & - 4a_H(1-a_H)(\phi\sigma-1)(\hat{T}_t - \tilde{T}_t[(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) - (\hat{Y}_{F,t} - \tilde{Y}_{F,t})]\} + t.i.p. \end{aligned} \quad (2.30)$$

Under no home bias in consumption this reduces to:

$$\begin{aligned}\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & \frac{\phi(\phi\sigma-1)}{2}(\hat{T}_t - \tilde{T}_t)^2 + (\sigma+\eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] \\ & - (\phi\sigma-1)(\hat{T}_t - \tilde{T}_t)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) - (\hat{Y}_{F,t} - \tilde{Y}_{F,t})]\} + t.i.p. \end{aligned} \quad (2.31)$$

The non-cooperative loss function of the Home policy maker in stead becomes:

$$\begin{aligned}\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & 2a_H(1-a_H)\frac{(\phi\sigma-1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H-1)^2](2a_H-1)\kappa(\hat{T}_t - \tilde{T}_t)^2 \\ & + (\sigma+\eta)(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 - (1-a_H)(\sigma-1)\kappa(\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2 \\ & + 2a_H(1-a_H)[\phi - 1 - 2a_H(\phi\sigma-1)]\kappa(\hat{T}_t - \tilde{T}_t)(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) \\ & + 2a_H(1-a_H)[2\phi\sigma - \phi - 1 - 2a_H(\phi\sigma-1)]\kappa(\hat{T}_t - \tilde{T}_t)(\hat{Y}_{F,t} - \tilde{Y}_{F,t})\} + t.i.p. \end{aligned} \quad (2.32)$$

where $\kappa \equiv \frac{\eta+\sigma}{a_H(1+2\eta+\sigma)-1-\eta}$.
If there is no home bias in consumption preferences, the loss function reduces to the following loss function:

$$\begin{aligned}\mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & (\sigma+\eta)(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 - (\sigma+\eta)(\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2 \\ & - \phi(\sigma+\eta)(\hat{T}_t - \tilde{T}_t)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})]\} + t.i.p. \end{aligned} \quad (2.33)$$

Note that, for future reference, I have not rewritten the quadratic loss function as a function of solely Home output gap and terms of trade, even though this is feasible given that under complete markets, Foreign output is a function of Home output and the terms of trade. In stead, I have noted the loss function which is quadratic in Home output, Foreign output and the terms of trade in order to allow for comparison with the case of incomplete markets, where Foreign output is not a function of Home output and the terms of trade, but also

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depends on the current account dynamics. Replacing terms in Foreign output would result in a rule similar to the quadratic loss function in Home consumption and terms of trade. From that rule, or from the similar rule in consumption and terms of trade appearing above, the following proposition results. Indeed, by comparing the coefficients of the rules under cooperative and non-cooperative policies, we can deduct Proposition 1.

Proposition 1. *Under complete markets, flexible prices, and wasteful government spending, the relative weight attached to the terms of trade objective relative to the output gap objective in the quadratic approximation to the Ramsey policy maker's loss function is higher under cooperation than in the case where the policy makers are inward-looking, for* $\frac{1}{2} < a_H < 1$ *and* $\sigma > 1$.

Under complete markets and flexible prices, the efficient allocation ensuring zero output gaps (or consumption gap) and a zero terms of trade gap can be obtained under cooperation. At this efficient allocation, both countries' welfare is maximized, and the Nash policy maker will thus not have an incentive to deviate from the cooperative allocation. Hence, the difference in weights associated with the different objectives would not be observed. However, the loss function does illustrate the terms of trade externality facing Nash policy makers which implies a lower weight attached to reducing international price inefficiencies rather than reducing domestic output gaps. As a result, in the face of distortions such as staggered price setting or market incompleteness, larger price variations would arise under inward-looking policy making.

Sticky prices. Doing the same exercice as above, but with sticky prices yields the same results as those reported above, except for the coefficients in front of inflation not being zero. That is, the only difference pertains to the fact that inflation is distortionary under sticky prices and thus enters the loss function of the Ramsey policy maker. In other words: the introduction of sticky prices does not affect the other coefficients in the loss function.

Incomplete markets

In the following, I allow for market incompleteness, as specified in Chapter 2. Therefore, the current account will enter the vectors of variables:

$$x_t' = \begin{bmatrix} \hat{Y}_{H,t} & \hat{C}_t & \hat{G}_t & \hat{Y}_{F,t}^* & \hat{C}_t^* & \hat{G}_t^* & \hat{T}_t & \hat{Q}_t \end{bmatrix}$$

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$$\epsilon_t' = \begin{bmatrix} \hat{A}_t & \hat{A}_t^* & \hat{CA}_t \end{bmatrix}$$

Moreover, the perfect risk sharing equation will be replaced by the definition of the current account:

$$\begin{aligned} p_{H,t} Y_{H,t} &= C_t + CA_t \\ [a_H + (1-a_H)T_t^{1-\phi}]^{\frac{1}{\phi-1}} Y_{H,t} &= C_t + CA_t \end{aligned} \tag{2.34}$$

Taking logs of this equation yields

$$\frac{1}{\phi-1}\log[a_H + (1-a_H)T_t^{1-\phi}] + \log Y_{H,t} = \log(C_t + CA_t) \tag{2.35}$$

The first order approximation then is:

$$\begin{aligned} -(1-a_H)[a_H + (1-a_H)T_t^{1-\phi}]^{-1}T^{-\phi}(T_t - T) + Y_H^{-1}(Y_{H,t} - Y_H) &= (C+CA)^{-1}[(C_t - C) + (CA_t - CA)] \\ \Leftrightarrow -(1-a_H)\hat{T}_t + \hat{Y}_{H,t} &= \hat{C}_t + \frac{C}{Y}\widehat{CA}_t \end{aligned} \tag{2.36}$$

where $\widehat{CA}_t \equiv \frac{CA_t - CA}{Y}$.
Taking a second-order approximation yields:

$$-(1-a_H)\hat{T}_t + \hat{Y}_{H,t} + \frac{1}{2}(1-a_H)[(1-a_H)(1-\phi) - 1]\hat{T}_t^2 = \hat{C}_t + \frac{C}{Y}\widehat{CA}_t - \frac{C}{Y}\hat{C}_t\widehat{CA}_t \tag{2.37}$$

Using the transformation process described previously as well as the definition of the $Dgap$, the loss function of the cooperative policy maker can be expressed as:

$$\begin{aligned} \mathcal{L} = E_0 \sum_{t=0}^{\infty} \{ & 2a_H(1-a_H)\frac{(\phi\sigma - 1)}{\sigma}[4a_H(1-a_H)\phi\sigma + (2a_H - 1)^2](\hat{T}_t - \tilde{T}_t)^2 \\ & + (\sigma + \eta)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + (\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2] + \frac{2a_H(1-a_H)}{\sigma}\widehat{Dgap}_t^2 \\ & - 4a_H(1-a_H)(\phi\sigma - 1)(\hat{T}_t - \tilde{T}_t)[(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) - (\hat{Y}_{F,t} - \tilde{Y}_{F,t})] \} \end{aligned} \tag{2.38}$$

The loss function is exactly similar to the one derived under the assumption of complete markets, except for the introduction of demand imbalances into the loss function.

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The non-cooperative loss function of the Home policy maker can be written in a similar way.

$$-E_0 \sum_{t=0}^{\infty} \{\lambda_T(\hat{T}_t - \tilde{T}_t)^2 + \lambda_{Y,H}(\hat{Y}_{H,t} - \tilde{Y}_{H,t})^2 + \lambda_{Y,F}(\hat{Y}_{F,t} - \tilde{Y}_{F,t})^2 + \lambda_D \widehat{Dgap}_t^2 + \lambda_{TY,H}(\hat{T}_t - \tilde{T}_t)(\hat{Y}_{H,t} - \tilde{Y}_{H,t}) + \lambda_{TY,F}(\hat{T}_t - \tilde{T}_t)(\hat{Y}_{F,t} - \tilde{Y}_{F,t}) + \lambda_{CA}\widehat{CA}_t\} \quad (2.39)$$

Because the coefficients are rather complex, they are not stated here, but can be obtained from the author. The loss function under non-cooperation departs from the cooperative loss function in several ways: the current account deficit matters in absolute terms for $a_H > 1/2$! Moreover, the following proposition holds:

Proposition 2. For any $\phi > \bar{\phi}$, where $\bar{\phi} = f(a_H, \eta, \sigma)$, the coefficient in front of the current account in the Nash policy maker's loss function is positive: $\lambda_{CA} > 0$. This implies that it might be welfare-improving for the non-cooperative policy maker to have current account deficits. This is not the case under cooperative policy making.

In the numerical example chosen in this paper, $\bar{\phi} = 0.37$ implying that for $\phi = 0.5$ it holds that it might be welfare-improving to engage in current account deficits. This is only the case when policy making is non-cooperative.

Furthermore, we can, by comparing the coefficients of the above stated loss functions, deduct the following:

Proposition 3. The relative importance of reducing international demand imbalances, as illustrated by the *Dgap*, as opposed to reducing the national output gap is higher under cooperative policy making than under non-cooperative policy-making: $\frac{\lambda_D^C}{\lambda_{Y,H}^C} > \frac{\lambda_D^{NC}}{\lambda_{Y,H}^{NC}}$ for any $\phi \notin [\phi^l; \phi^h]$ where $\phi^l = f^l(a_H, \eta, \sigma)$ and $\phi^h = f^h(a_H, \eta, \sigma)$.

In the numerical example chosen in this paper, the above proposition holds for all $\phi \notin [0.37; 0.40]$ implying that for $\phi = 0.5$, $\frac{\lambda_D^C}{\lambda_{Y,H}^C} > \frac{\lambda_D^{NC}}{\lambda_{Y,H}^{NC}}$ holds.

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Chapter 3

Risk Sharing in the EMU

3.1 Introduction

Financial integration has accelerated in the last couple of decades. This acceleration in financial integration which is observed at the global level, is also observed across the countries taking part in the EMU. Specifically, the introduction of the common currency in the euro area, by eliminating exchange rate risk, seems to have led to higher cross-country financial integration. This has been pointed out for example by Allen and Song (2005) who, by examining data on merger and acquisitions, find that "EMU played a significant role in financial integration within Europe" and more so within the EMU itself. Jappelli and Pagano (2008) consider both price-based and quantity-based measures of financial integration[1] and find that financial integration seems to have been more important in the euro area than in other regions in the time period following the elimination of exchange rate risk. Similarly, Lane (2006) finds that in 2004 common membership of the euro area doubled the level of pairwise cross-border bond holdings. Also Lane and Milesi-Ferretti (2005) find that sharing the common currency increases cross-border equity holdings by 67 percent.
Though the realisation of the European Economic and Monetary Union (EMU) has enhanced financial integration within the euro area, it remains unclear whether improvements in the degree of consumption risk sharing across countries has resulted. In this paper, I attempt to assess the degree of risk sharing taking place within the EMU, and its evolution since the introduction of the common currency.

[1]Price-based measures of financial integration rely on the extent to which the law of one price holds (for example considering interest rate differentials), whereas quantity-based measures relate to the accessibility of external finance and can inter alia be approximated by the amount of cross-border flows of credit. Different measures of financial integration are discussed in Benetrix and Walti (2008).

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The degree and evolution of risk sharing within the EMU is interesting for several reasons. First, it measures the presence of inefficiencies arising due to incomplete markets. This is interesting per se because it quantifies the welfare effects of the presence of international financial market imperfections. Second, the evolution of the degree of risk sharing evaluates the extent to which financial integration translates into welfare gains. One of the benefits from the introduction of the common currency in the EMU was believed to stem from financial integration.[2] However, if financial integration does not improve risk sharing, the effects on welfare are contained. Third, the degree of risk sharing across countries has important implications within a monetary union, both for the transmission of shocks and policies, as well as for the optimal conduct of fiscal policies as shown in Chapter 1. A measure of the degree and the evolution of risk sharing in the EMU is thus crucial in order to understand the transmission of shocks and policies as well as potential changes in their transmission mechanism.

Consumption risk sharing across countries results from household optimization in open economies, when markets are complete. Indeed, under complete markets, agents will insure themselves against any idiosyncratic shocks, and the growth of marginal utilities of consumption will thus be equalized across countries. Formally, the full risk sharing condition relating two countries' consumption can be written as:

$$\frac{U_{c,t+1}}{U_{c,t}}\frac{P_t}{P_{t+1}} = \frac{U^*_{c,t+1}}{U^*_{c,t}}\frac{s_t P^*_t}{s_{t+1}P^*_{t+1}} \tag{3.1}$$

where $U_{c,t}$ and $U^*_{c,t}$ denote the per capita marginal utilities of consumption at time t in each of the countries respectively, P_t and P^*_t denote the consumer prices at time t in those countries, and s_t is the bilateral nominal exchange rate at time t.[3] Using the definition of the real exchange rate, $Q_t \equiv \frac{s_t P^*_t}{P_t}$, the risk sharing equation can be written as:

$$\frac{U_{c,t+1}}{U_{c,t}} = \frac{U^*_{c,t+1}}{U^*_{c,t}}\frac{Q_t}{Q_{t+1}} \tag{3.2}$$

Since Backus and Smith (1993) pointed out the consumption - real exchange rate anomaly

[2]Notably the Theory of Optimal Currency Areas put forward the benefits a common currency could bring in terms of asset market integration ensuring improved risk sharing across member countries thus endogenously contributing to fulfil the criteria for an optimal currency area.

[3]Note that the full risk sharing condition holds in the social planner solution.

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implying the failure of consumption risk sharing across countries, a vast empirical literature has tested the validity of international consumption risk sharing. Obstfeld (1994), Kollmann (1995), Ravn (2001) as well as Asdrubali, Sorensen, and Yosha (1996) and Crucini (1999) are part of this line of research. Though these empirical studies use different methods to test for risk sharing, they widely reject full risk sharing across countries. Because mainstream international macroeconomic models have difficulties replicating this stylized fact, the failure of risk sharing across countries remains one of the major puzzles in international macroeconomics.[4]

The approach taken by Backus and Smith (1993), as well as by inter alia Kollmann (1995) and Ravn (2001), consists in testing the relation between relative consumption and the real exchange rate. Backus and Smith (1993) show that consumption differentials are not positively correlated with the real exchange rate, thereby indicating that consumption risk sharing fails. Their test relies on the moments of relative consumption and real exchange rates for 8 OECD countries between 1971-1990. It builds on the fact that under complete markets, if the mean and the variance of relative consumption between two countries are relatively high, so are the mean and the variance of the real exchange rate. They find no evidence for this assertion implied by full risk sharing.

Using a similar approach, Kollmann (1995) tests the implications of full risk sharing both for the short term and in the long term. In the long term, full risk sharing implies that relative consumption between two countries and their bilateral real exchange rate are co-integrated. The co-integration tests used either reject the hypothesis of co-integration, or are incapable of rejecting the hypothesis of no co-integration between the time series, for a majority of countries, periods and datasets. In the short term, the complete markets hypothesis implies that consumption growth in one country should be predictable given consumption growth in another country and the change in their bilateral real exchange rate. However, regressing consumption growth in one country on consumption growth in another country and their bilateral real exchange rate results in poor fits (the R^2s are close to zero). The results thus reject full risk sharing strongly, both at higher and lower frequencies. The results are not altered decisively by the introduction of hours worked in the regression, such as to account for non-separabilities between consumption and hours in the utility of agents.

Ravn (2001) addresses the issue of non-separabilities in the utility function, including government spending and habits, when running regressions of the change in the bilateral real exchange rate on consumption growth differentials. He finds that changes in the exchange

[4]Some of these international macreoconomic puzzles are for example enumerated and examined in Obstfeld and Rogoff (2001).

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rate has no explanatory power on relative consumption growth rates: the hypothesis of integrated financial markets is also rejected in the presence of non-separabilities.

Whereas the aforementioned papers test the validity of full risk sharing across countries using data on a limited number of OECD countries, Asdrubali, Sorensen, and Yosha (1996), instead, contribute to the development of a measure of the degree of risk sharing.[5] They use it to measure the degree of risk sharing across states in the US. Their measure of risk sharing relies on the assumption that consumers optimally aim at consuming a fixed proportion of aggregate (US) output every period. Hence, the degree to which consumption within each state deviates from this principle measures the smoothing capacity indicating the degree of risk sharing. The authors find that 75 percent of output differences across states were smoothed in the period 1963-1990. They decompose this number, and find that 39 percent of output differences are smoothed through capital markets, 23 percent through credit markets, and 13 percent through federal government.
Crucini (1999) develops a slightly different measure of the degree of risk sharing: the variance of regional consumption which is due to variance in aggregate (permanent) consumption. Using this measure, the author finds that more risk sharing takes places across states within the US and within Canada than across countries.
The approach developed by Asdrubali, Sorensen, and Yosha (1996) has been applied to the EMU by Demyanyk, Ostergaard, and Sorensen (2008). They find that consumption risk sharing has not increased during the period 1995-2006.
The above-mentioned empirical literature measures the degree of risk sharing without taking appropriately into account the role played by prices. The incoherence between the measures for risk sharing described above and the measure inherent to most open-economy macroeconomic models has been pointed out by Viani (2011). She develops a welfare-based measure of the degree of risk sharing which can be derived from macro-models of open economies and takes into account the role of international price changes. Her results for bilateral risk sharing between the US and other OECD countries are in line with the previous literature: risk sharing has not improved, in general. Only when allowing for time-varying risk aversion, does it appear that risk sharing has improved over time for a few specific couple of countries.

In the following, I attempt to quantify the deviations from risk sharing within the EMU, and study the evolution of risk sharing associated with the introduction of the euro.

[5]This measure of risk sharing was first developed by Mace (1991) and Cochrane (1991) to test the assumption of risk sharing using microeconomic data. Following, Obstfeld (1994) applied this method to macroeconomic data.

I will use two methods which have been developed previously, as described above. The first one measures the consumption smoothing capacity, whereas the second instead quantifies the inefficiencies arising due to imperfect risk sharing. The former method has been developed by Asdrubali, Sorensen, and Yosha (1996) to quantify risk sharing among US states, whereas the latter method was developed by Viani (2011) and used for quantifying risk sharing between the US and other OECD countries. We shall see the advantages and short-comings of these two methods. I will apply them to the EMU, and explain why differences in the resulting measures of risk sharing and their evolution may arise.

3.2 Consumption-Smoothing Capacity as a Measure of Risk Sharing

3.2.1 Literature

The first tests of perfect risk sharing across households were developed by Mace (1991) and Cochrane (1991). These tests were following applied to macroeconomic data by inter alia Obstfeld (1994) and Townsend (1994). Mace (1991) built her empirical analysis on the hypothesis that under complete markets individual consumption responds to aggregate risk (instrumented by aggregate consumption) but not to individual risk (such as individual income or employment status)[6]. Building on a similar argument, Cochrane (1991) tests an implication of full risk sharing, namely that exogenous individual shocks do not affect consumption. The evidence on full risk sharing in the US at the microeconomic level is mixed: Mace (1991) finds that consumption risk sharing takes place for a large range of consumption goods, but not completely for all goods. Cochrane (1991) finds that risk sharing takes place for some exogenous occurences such as spells of unemployment following involuntary job loss but not for others such as long illness and longer periods of unemployment following involuntary job loss.

Obstfeld (1994) extends the approach taken by Mace (1991) and Cochrane (1991) to macroeconomic data.[7] By regressing consumption growth on world consumption growth and idiosyncratic variables such as country-specific output, investment and government consumption, he finds results which are consistent with increasing financial integration in the post-war

[6]The empirical estimation thus requires that income and employment status are uncorrelated with shifts in consumption preferences, implying that income and employment status have to be assumed exogenous to the households. As pointed out by Cochrane (1991) this assumption is questionable.

[7]The extension to the macroeconomic level was simultaneously taken by Townsend (1994) who used it to measure risk insurance within high-risk villages in India.

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period in the G-7 countries: domestic and world consumption growth have become more correlated. However, whether this is indeed due to higher financial integration, or the result of for example higher correlation between home output and world output, or due to unobserved preference shifts across countries, remains an open question. Asdrubali, Sorensen, and Yosha (1996) develop the approach further, their aim being to quantifying the degree of risk sharing taking place across US states and the associated channels of risk sharing.
Building on this line of research, Demyanyk, Ostergaard, and Sorensen (2008) use the method developed by Asdrubali, Sorensen, and Yosha (1996) to investigate whether risk sharing has increased among EU-countries (and also among EMU-countries) since the introduction of the common currency. They identify risk sharing as increased consumption - or income - smoothing. Perfect consumption smoothing can be achieved by trade in assets across countries. Consider the case where the Home country has a temporarily high output growth. If the return on assets held by domestic agents is highly correlated with other countries' output growth levels and the amount to be paid on liabilities to Foreign agents are high, then Home consumption will be smoothed, and risk sharing achieved. In other words, risk sharing requires that the amount paid to Foreigners in good times is high, and the amount received from Foreigners in bad times is high. Risk sharing thus implies consumption patterns over time be imperfectly correlated with output patterns. Hence, the correlation between consumption and income differentials can be considered as a proxy for the degree of risk sharing taking place. Based on this reasoning, Asdrubali, Sorensen, and Yosha (1996) develop a measure of the degree of risk sharing. Their measure is used by Demyanyk, Ostergaard, and Sorensen (2008) who point out that a first indication of the degree of risk sharing across EMU countries is the correlation between national output growth and national consumption growth. Hence, they identify increases in risk sharing as lower correlation between output and consumption growth differentials. As a result, perfect consumption risk sharing within the EMU ensues when consumption growth is identical across the EMU-countries.[8]
Their measure of risk sharing is built on the correlation between consumption and output within EMU-countries, taking away aggregate uninsurable risk which is proxied by aggregate fluctuations in the EMU:

$$Corr(\Delta \log C_t^i - \Delta \log C_t^{EMU}, \Delta \log Y_t^i - \Delta \log Y_t^{EMU})$$

[8]Note that their measure of consumption is composed by private consumption and government consumption.

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More precisely, they run regressions of the type

$$\Delta \log C_t^i - \Delta \log C_t^{EMU} = \alpha + \beta_t(\Delta \log Y_t^i - \Delta \log Y_t^{EMU}) + \epsilon_t^i \tag{3.3}$$

where the coefficient β_t measures the degree of risk sharing in period t. That is, using a panel of countries, the coefficient of risk sharing can be computed for every period and the evolution determined.[9] Their analysis indicates that the level of risk sharing is far from perfect. Furthermore, consumption risk sharing for the EMU-countries seems to have declined: the level of risk sharing decreases from more than 30 percent of GDP differences not being reflected in consumption differences to only a little more than 10 percent.[10]

This method does not measure the bilateral risk sharing between two countries, or two regions, but the general level of risk sharing achieved through asset diversification in all countries and regions. That is, when the authors find that risk sharing has increased for EMU countries this is not necessarily the result of higher risk sharing among EMU countries. And indeed, they find that the increased level of risk sharing within EMU countries is achieved by sharing risk with non-EMU countries. In other words, it seems that France or Italy have not benefited from joining the EMU due to increased risk sharing with e.g. Germany. In this paper, I am interested in investigating bilateral risk sharing across pairs of EMU-countries, and not of one EMU-country as compared to the rest of EMU. Hence, I apply the above method to account for bilateral risk sharing, instead, in the following.

Afterwards, we shall discuss the implications of casting the risk sharing problem in the social planner setting: the approach taken by Townsend (1994) as well as by Mace (1991) and Cochrane (1991) is not a test of financial integration as noted by Townsend, but a test of how far the allocation of consumption is from the Pareto optimal allocation.

3.2.2 Consumption smoothing capacity in the EMU

Consumption risk sharing ensures a high degree of consumption smoothing in the face of country-specific shocks. Accordingly, relative consumption growth differences between two countries should vary relatively less than their relative output growth. The figure below, depicting consumption and output growth differences between Germany and France does not indicate that this is generally the case within the EMU: consumption growth differences do not seem to vary less than output growth differences. Furthermore, there is no clear

[9]Note, however, that the number of EMU countries is relatively small, probably making the results relatively little robust. Confidence intervals are not reported in their analysis.

[10]See Figure 1 in Demyanyk, Ostergaard, and Sorensen (2008). It is not stated whether the decline is statistically significant.

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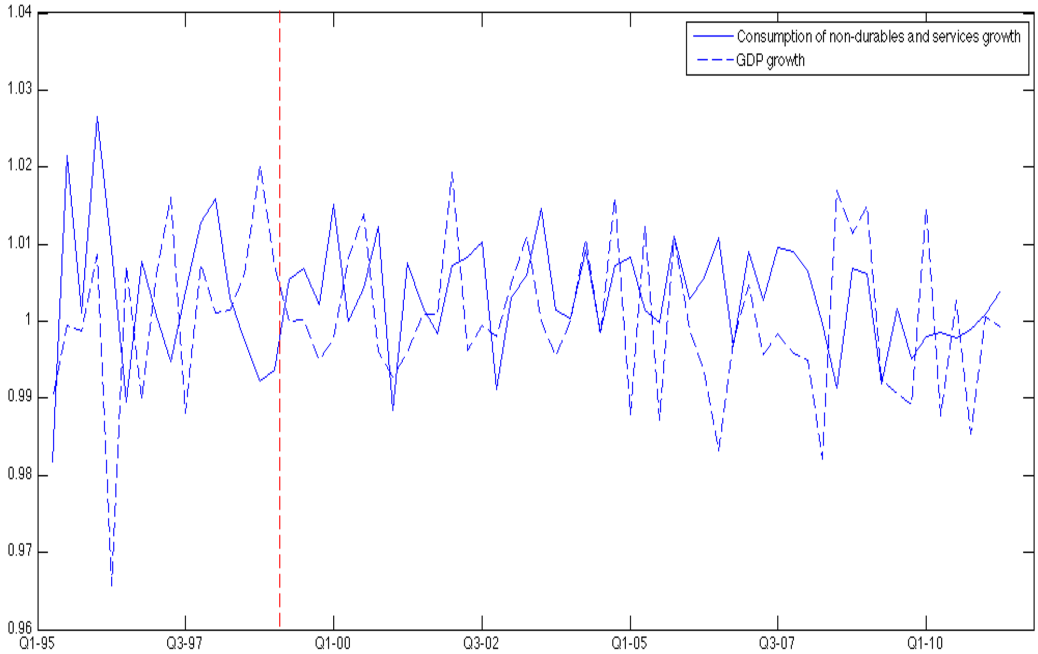
tendency towards a lower relative volatility of consumption growth differences as opposed to output growth differences. The same conclusion holds for other countries such as Italy or the Netherlands which are depicted in Figure 3.6 in the Appendix.

Figure 3.1: Consumption and output growth in France relative to Germany



Both GDP and consumption of non-durables and services are per capita variables deflated by the relevant country-specific consumer price index. Values above 1 illustrate positive growth of French variables relative to German variables, whereas values lower than 1 illustrate negative relative growth. The vertical dashed line illustrates the time of the introduction of the euro.

As already pointed out the correlation between consumption and output growth differentials across countries has been used as an indicator of the degree of risk sharing taking place, inter alia by Obstfeld (1994) or Demyanyk, Ostergaard, and Sorensen (2008). Building on this approach, I set up an indicator of bilateral risk sharing: the correlation between country-specific output changes and country-specific consumption changes, relative to common changes. This takes into account that one country cannot insure another country against shocks which affect both countries simultaneously. Under full consumption smoothing capacity this correlation is zero; under no consumption smoothing it is equal to unity, i.e the

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correlation is perfect.[11]
In order to get an indication of the degree of bilateral risk sharing within the EMU, I engage in an exercise similar to the one carried out in Demyanyk, Ostergaard, and Sorensen (2008).[12] I focus on measuring the degree of bilateral risk sharing between Germany and the other EMU-countries, but the main results hold for other reference countries too.[13] For each period, I compute the capacity of consumption smoothing between Germany and the other EMU-countries by running the following regression quarter-by-quarter:

$$\Delta \log C_t^i - \Delta \log(C_t^{DE} + C_t^i) = \alpha + \beta_t(\Delta \log Y_t^i - \Delta \log(Y_t^{DE} + Y_t^i)) + \epsilon_{i,t} \qquad (3.4)$$

That is, I regress the observations of output growth differentials (and a constant) on the observations of consumption growth differentials in order to get the co-movement between those two variables. I use data only on the EMU countries which participated in the single currency already from its introduction in January 1999.[14] The resulting $\hat{\beta}_t$ then indicates the amount of cross-border consumption smoothing taking place in period t, by summarising the co-movement of the different countries' gdp with consumption. Figure 3.2 depicts the results, smoothed over time, for $1 - \hat{\beta}_t$ indicating the amount of cross-border consumption smoothing taking place, full smoothing capacity then being characterized by a value of unity (100 percent).
If monetary unification has led to increased cross-border consumption smoothing within the EMU, this should be obvious from the plot of the co-movement of output differentials with consumption differentials over time: there should be an upward trend in the measure. Following Demyanyk, Ostergaard, and Sorensen (2008), I plot the smoothed time series and interpret it as a measure of the cross-border consumption smoothing capacity taking place. Similarly to those authors, I find no conclusive evidence that the degree of bilateral consumption smoothing has increased in the period 1996-2006 (their data period). Figure 3.2 indeed indicates that no large increase in the consumption smoothing capacity has taken

[11]If prices are constant, a zero correlation would correspond to perfect risk sharing. See the discussion in Section 2.3.

[12]This exercise departs from Demyanyk, Ostergaard, and Sorensen (2008) in several ways: I investigate bilateral consumption smoothing rather than multilateral; I use quarterly data (rather than annual) on household consumption (I do not include government consumption as well), and my data period is longer than the one considered by Demyanyk, Ostergaard, and Sorensen (2008).

[13]The consequences of having chosen Germany as the country of reference has no effect on the evolution of risk sharing implied by the measure considered. The level of bilateral risk sharing with Germany is for example a little higher than the bilateral risk sharing with France or Italy.

[14]These countries are Germany, France, Italy, Netherlands, Finland, Luxembourg, Austria, Italy, Spain, and Portugal.

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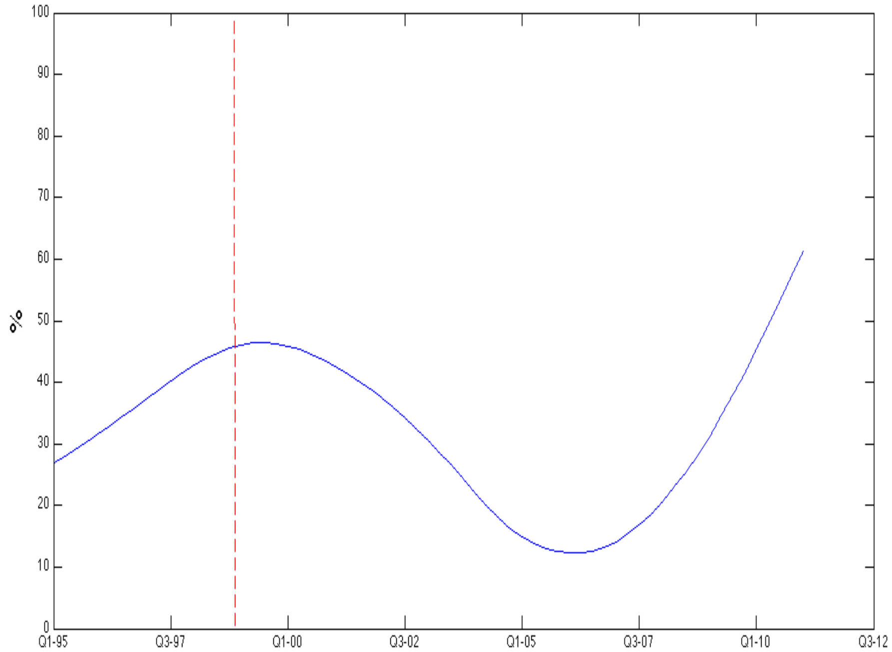
place since the introduction of the euro.
Furthermore, the degree of risk sharing is relatively small with an average of 33 percent over the period 1995-2011, especially if compared to the degree of risk sharing (obtained through capital and credit markets) within the US, which Asdrubali, Sorensen, and Yosha (1996) estimate to be 62 percent for the period 1963-1990[15].

Figure 3.2: Bilateral consumption smoothing $(1-\hat{\beta})$ between EMU-countries and Germany



The trend of $(1-\hat{\beta}_t)100\%$ (hp-filtered) is depicted by the solid line. The dashed line illustrates the date of introduction of the euro.

On the contrary to what would be expected from the introduction of the common currency, the average bilateral consumption smoothing was on average 42 percent over the period 1995-1999, but only 28 percent over the period 2000-2011. However, the point estimates are not very precise because of the few observations (countries) available every period:

[15]The authors use annual data which implies lower estimates than at the quarterly level, since short-term shocks are more easily insured against. When comparing to quarterly estimates, these estimates are thus to be considered as a lower bound.

the confidence intervals do not allow for concluding that one period was more favourable for cross-country consumption smoothing than the other.
In order to get more precise estimates for the different periods, I pull the data into two periods: before the introduction of the euro and after. The results figure in the table below:[16]
The results of this first exercise indicate that risk sharing is far from perfect within the

Table 3.1: **Consumption smoothing capacity EMU-Germany**

	1995-1999 pre-EMU	2000-2011 EMU
point estimate	18.41	42.30
95 percent confidence interval	[-28.07; 64.89]	[13.75;70.84]

The point estimates are $(1-\hat{\beta}_t)$ obtained by running the regression
$\Delta \log C_t^i - \Delta \log(C_t^{DE} + C_t^i) = \alpha^i + \beta_t(\Delta \log Y_t^i - \Delta \log(Y_t^{DE} + Y_t^i)) + \epsilon_{i,t}$
for $t = 1995q1 - 1999q4$ and $t = 2000q1 - 2011q2$.

EMU. Consumption smoothing of output differentials is considerably lower than within the US, and there is no clear trend towards higher cross-border smoothing. The introduction of the common currency has not improved consumption smoothing between countries. Interestingly, perfect consumption smoothing can be rejected at all points, but the results from the pulled regression indicates that risk sharing does take place - at least after the introduction of the euro. The fact that we can reject that no bilateral consumption smoothing takes place only after the euro is primarily a result of the extent of data available being larger in that period than before the EMU was put in place. Hence, there is no clear indication that an improvement in bilateral consumption smoothing has resulted from the monetary unification and the enhanced financial integration.

3.2.3 A critical assessment of consumption smoothing capacity as a measure of risk sharing

Evaluating the degree of risk sharing across countries by investigating the degree of consumption smoothing gives an indication of the amount of risk sharing. However, it is an imperfect measure of risk sharing for several reasons. First, there are several empirical issues

[16]Note that I allow for country-specific coefficients such as to focus on short term risk sharing.

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related to estimating the measure reported above. Secondly, consumption smoothing is not perfectly correlated with the measure of risk sharing most open-economy macroeconomic models rely on. This has been pointed out by Viani (2011), and can easily be understood by considering a simple two-country model.

Empirical issues related to measuring consumption smoothing capacity

The measure β indicates the correlation between output and consumption growth differentials. One main problem with measuring the degree of consumption smoothing capacity obtained through international financial markets with this measure pertains to the fact that not only output shocks might affect households' consumption patterns. Indeed, changes in the measure could be the result of shifts in preferences in one of the countries. Indeed, if France's households experience a shift in preferences they might change their consumption patterns even though there have been no changes in output. Such a shift would translate into the measure of consumption smoothing capacity. For example, if the preference shock increases relative consumption and an exogenous increase in relative output happens simultaneously, then the measure would indicate a lower degree of consumption smoothing, even though the French households are not experiencing a lower capacity but just a lower will to smooth.
Similarly, an increase in access to domestic financial markets - e.g. due to low interest rates and more risk-taking by domestic banks, or simply the development of the domestic banking sector - might show an increase in consumption smoothing capacity due uniquely to domestic determinants and not associated with international risk sharing. Indeed, this measure cannot properly separate changes in domestic consumption smoothing capacity from changes in international consumption smoothing capacity.
Hence, the assumption that potential preference shocks and other variables be uncorrelated to consumption growth is crucial. Indeed, if country-specific preference shocks affecting the utility of consumers, or the ability to access credit on the domestic market, are correlated with consumption, then the estimate is biased. The assumption that preference shocks (and other variables) be uncorrelated with consumption differentials is therefore a crucial assumption. Other crucial assumptions on which this measure relies is symmetric preferences across countries.

Furthermore, in order for the consumption smoothing capacity to be related to risk sharing, the functional form of the utility function and the international price mechanisms are crucial. These issues are discussed below, and illustrated by a simple two-country model.

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Consumption smoothing capacity and risk sharing

A simple two-country model of a monetary union. Consider a world composed of two symmetric countries, denoted Home and Foreign. The Home and Foreign countries are endowed with output $Y_{H,t}$ and $Y_{F,t}$ respectively every period. Consumption within each country is a CES index of Home and Foreign goods:

$$C_t = [a_H^{\frac{1}{\phi}} C_{H,t}^{\frac{\phi-1}{\phi}} + (1-a_H)^{\frac{1}{\phi}} C_{F,t}^{\frac{\phi-1}{\phi}}]^{\frac{\phi}{\phi-1}} \tag{3.5}$$

$$C_t^* = [a_H^{\frac{1}{\phi}} C_{H,t}^{*\frac{\phi-1}{\phi}} + (1-a_H)^{\frac{1}{\phi}} C_{F,t}^{*\frac{\phi-1}{\phi}}]^{\frac{\phi}{\phi-1}} \tag{3.6}$$

where $a_H > \frac{1}{2}$ implies a home bias in consumption, and $\phi > 0$ is the trade elasticity. C_H and C_F denote the consumption of the good produced in country H and F respectively, and their prices are denoted P_H and P_F respectively. The consumer price in country H is P, whereas it is P^* in country F.
Goods market clearing implies

$$Y_{H,t} = C_{H,t} + C_{H,t}^* \tag{3.7}$$

$$Y_{F,t} = C_{F,t} + C_{F,t}^* \tag{3.8}$$

Consumption demands for each good are:

$$C_{H,t} = a_H(\frac{P_{H,t}}{P_t})^{-\phi} C_t = a_H[a_H + (1-a_H)T_t^{1-\phi}]^{\frac{\phi}{1-\phi}} C_t \tag{3.9}$$

$$C_{H,t}^* = (1-a_H)(\frac{P_{H,t}}{P_t^*})^{-\phi} C_t^* = (1-a_H)[(1-a_H) + a_H T_t^{1-\phi}]^{\frac{\phi}{1-\phi}} C_t^* \tag{3.10}$$

$$C_{F,t} = (1-a_H)(\frac{P_{F,t}}{P_t})^{-\phi} C_t = (1-a_H)[(1-a_H) + a_H T_t^{\phi-1}]^{\frac{\phi}{1-\phi}} C_t \tag{3.11}$$

$$C_{F,t}^* = a_H(\frac{P_{F,t}}{P_t^*})^{-\phi} C_t^* = a_H[a_H + (1-a_H)T_t^{\phi-1}]^{\frac{\phi}{1-\phi}} C_t^* \tag{3.12}$$

where $T_t \equiv \frac{s_t P_{F,t}^*}{P_{H,t}}$ is the terms of trade. Inserting the above demands into the market clearing conditions, we get:

$$Y_{H,t} = a_H[a_H + (1-a_H)T_t^{1-\phi}]^{\frac{\phi}{1-\phi}} C_t + (1-a_H)[(1-a_H) + a_H T_t^{1-\phi}]^{\frac{\phi}{1-\phi}} C_t^* \tag{3.13}$$

$$Y_{F,t} = (1-a_H)[(1-a_H) + a_H T_t^{\phi-1}]^{\frac{\phi}{1-\phi}} C_t + a_H[a_H + (1-a_H)T_t^{\phi-1}]^{\frac{\phi}{1-\phi}} C_t^* \tag{3.14}$$

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Taking log-linear approximations of the above equations, under complete markets, we get:

$$\hat{C}_t - \hat{C}_t^* = \frac{2a_H - 1}{2\phi\sigma}(\hat{Y}_{H,t} - \hat{Y}_{F,t}) \tag{3.15}$$

This implies that under complete markets

$$\Delta \log C_{t+1} - \Delta \log C_{t+1}^* = \frac{2a_H - 1}{2\phi\sigma}(\Delta \log Y_{H,t+1} - \Delta \log Y_{F,t+1}) \tag{3.16}$$

Hence, unless $a_H = \frac{1}{2}$, this model does not imply the estimated coefficient in front of relative output growth (β in equation (4)) be zero under full risk sharing!

The role of relative price changes. The main failure of the correlation measure is that it is not correctly taking into account the effect of price changes for the transmission mechanism of shocks between countries and for the risk sharing measure. Viani (2011) evaluates the measure developed by Asdrubali, Sorensen, and Yosha (1996) through model simulations and points out shortcomings of the consumption smoothing capacity in accounting for the degree of risk sharing:

First of all, the fact that relative price changes can improve or deteriorate risk sharing across countries directly is not properly integrated into the consumption smoothing measure: As illustrated in the simple model above, the real exchange rate is a determinant of the risk sharing relation (3.2). Only under purchasing power parity (PPP implying $a_H = \frac{1}{2}$) is the smoothing measure a correct measure of consumption risk sharing. However, it is a well-known fact that PPP does not hold empirically.

A second failure of the consumption smoothing measure relates to the negative relation between the degree of risk sharing and the correlation between consumption and output growth on which the measure relies. Since the measure relies on the correlation between output and consumption being lower the higher the degree of risk sharing, it relies on relative output being positively correlated with relative wealth. However, this need not be the case because relative price movements might trigger large negative wealth effects following output increases. Indeed, consider the effects of an increase in output in one country. The increase in supply of that country's goods will tend to decrease the price. If the negative wealth effect of that fall in prices is high, and the increase in demand through substitution is small, then wealth in the country which experiences the increase in output will fall. Consequently, output increases while consumption falls. Hence, risk sharing would consist in ensuring a

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lesser fall in consumption of the country having experienced an increase in output. Risk sharing thus implies that income should be directed towards the relatively output-intensive. In this case, the more negative is the correlation between consumption and output growth, the lower is risk sharing. In other words: deviations from full risk sharing might imply a negative correlation rather than a perfect correlation between relative output and consumption growth. Hence, to conclude that the higher the correlation between consumption and output growth, the lower is the degree of risk sharing, as the consumption smoothing measure implies, could prove very wrong.

The above-mentioned short-comings indicate that a measure based on the consumption risk sharing equation (3.2) is more appropriate to evaluate the degree of risk sharing across countries. In the following I consider such a measure, also suggested by Viani (2011). This measure relates closely to welfare losses associated with imperfect risk sharing.

3.3 The Demand gap: a Welfare-Related Measure of Risk sharing

3.3.1 Literature

Viani (2011) proposes a measure of risk sharing across countries which - on the contrary to the methods previously used in the literature - takes correctly into account how price changes affect risk sharing. Her measure of risk sharing is closely related to international macroeconomic models such as the one presented previously. Indeed, the wedge between the stochastic discount factors of the two countries considered, denoted *Dgap* in Chapter 1, is used to measure bilateral risk sharing.[17] This measure illustrates the welfare losses which are associated with deviations from full risk sharing. Viani (2011) explains how changes in this measure can be due to changes in either the degree of risk sharing or the amount of risk to be shared. The contribution of each of these causes to changes in the measure can be disentangled by regressing the *Dgap* on the risk factors (such as output).
The measure of cross-border insurance figuring in Viani (2011) corresponds to:

$$Dgap_t = \log m_t - \log m_t^* \tag{3.17}$$

[17]This measure corresponds exactly to the demand imbalances (*Dgap*) considered in Chapter 1.

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such that $Dgap_t$ measures the difference between the SDFs at time t, denoted respectively m_t and m_t^*. Note that this measure is contingent on the shocks which hit the economies, and it is thus not a clear measure of the degree of insurance across countries but a measure of welfare losses associated with the degree of risk sharing AND the variance of shocks.

Viani (2011) assumes the presence of a representative agent, CRRA utility, and that the data do not reject the equalization of expected SDFs, in which case the unconditional mean of the gap is zero. As a result, the variance of the gap is a direct measure of deviations from full risk sharing.

In order to disentangle the causes of changes in the $Dgap$ in the case where TFP shocks constitute the only macroeconomic risk, Viani (2011) runs

$$Dgap_t = \alpha + \beta_H \Delta \log Y_{H,t} + \beta_F \Delta \log Y_{F,t} + \epsilon_t \tag{3.18}$$

The coefficients β_H and β_F indicate how much a 1 percent change in output affects the $Dgap$, thus illustrating the degree of insurance associated with output risk (TFP shocks). The higher the coefficients, the lower is the degree of risk insured. Full risk sharing would imply a zero coefficient.[18]

Viani (2011) estimates (3.18) for different time periods in order to disentangle the causes of changes in the $Dgap$ over time.

Method. Computing the $Dgap$ requires an estimation of the relative risk aversion coefficient, which might vary over time. Viani (2011) estimates this parameter by using the assumption of equality of expected SDFs across countries (amounting to equality of mean SDFs over time). Indeed, assuming a constant RRA coefficient, and using

$$\beta^i E_t\{(\frac{C^i_{t+1}}{C^i_t})^{-\sigma}\frac{P^i_{t+1}}{P^i_t}\} = \beta^j E_t\{(\frac{C^j_{t+1}}{C^j_t})^{-\sigma}\frac{P^j_{t+1}}{P^j_t}\frac{s^{i,j}_{t+1}}{s^{i,j}_t}\} \tag{3.19}$$

she can estimate the relative discount factor $\frac{\beta^i}{\beta^j}$ and the RRA coefficient. She then tests that the resulting (3.19) is not rejected by the data.

Using the estimates found, the $Dgap$, can be computed:

$$Dgap^{i,j}_t = \log m^i_t - \log m^j_t = \Delta \log Q^{i,j}_t - \sigma(\Delta \log C^i_t - \Delta \log C^j_t) + \log \beta^i - \log \beta^j \tag{3.20}$$

[18]In a later subsection I discuss the empirical issues related with running this regression.

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The variance of the *Dgap* constitutes a measure of contingent risk sharing: the higher the variance, the lower is risk sharing contingent on shocks (risk). Given the *Dgap* estimates, Viani attempts to disentangle the degree of insurance to TFP shocks by regressing the *Dgap* on output in the home and in the foreign country, as in equation (3.18). The output measures can be deflated by either PPI (gdp deflator) or CPI, depending on the result one is looking for; the degree of insurance uniquely from financial markets (CPI), or the degree of insurance from financial markets and price movements (PPI/ gdp deflator).

Results. Viani's results indicate a fall in inefficiencies related to incomplete risk sharing between the US and a number of OECD countries between 1970-2008. However, she finds that this fall is mainly due to decreases in the variance of macroeconomic shocks such as nominal exchange rate fluctuations and output volatility - and not much to a real improvement in insurance across these countries.

3.3.2 The demand gap in the EMU

I compute the size and the evolution of the Demand gap in the EMU, and engage in similar exercises as Viani (2011) in order to disentangle how large an impact the changes in cross-country insurance has had on this measure.
Assuming that discount factors are identical across countries, and that utility of the representative household is a CRRA function, the demand gap is described by the wedge between the SDFs:

$$gap_t^{i,j} = \log m_t^i - \log m_t^j = \Delta \log Q_t^{i,j} - \sigma(\Delta \log C_t^i - \Delta \log C_t^j) + \log \beta^i - \log \beta^j \qquad (3.21)$$

Noting that the wedge can be characterized by: $m_t^i = \eta m_t^j$, we have that $Dgap_t^{i,j} = \log m_t^i - \log m_t^j = \log(\frac{\eta m_t^j}{m_t^j}) = \log \eta - \log 1$. The *Dgap* thus measures the deviations of the wedge between country i and j SDFs from the wedge under complete markets. In the following, I will, as in the previous section, focus on computing bilateral risk sharing of EMU countries with Germany.

For the computation of the bilateral demand gaps, I assume that countries are symmetric (their discount factors and CRRA coefficients are identical). Furthermore, I assume that the coefficient of relative risk aversion for all EMU countries is 1.5. The demand gap is computed using data from OECD on consumption of non-durable and services, and data from

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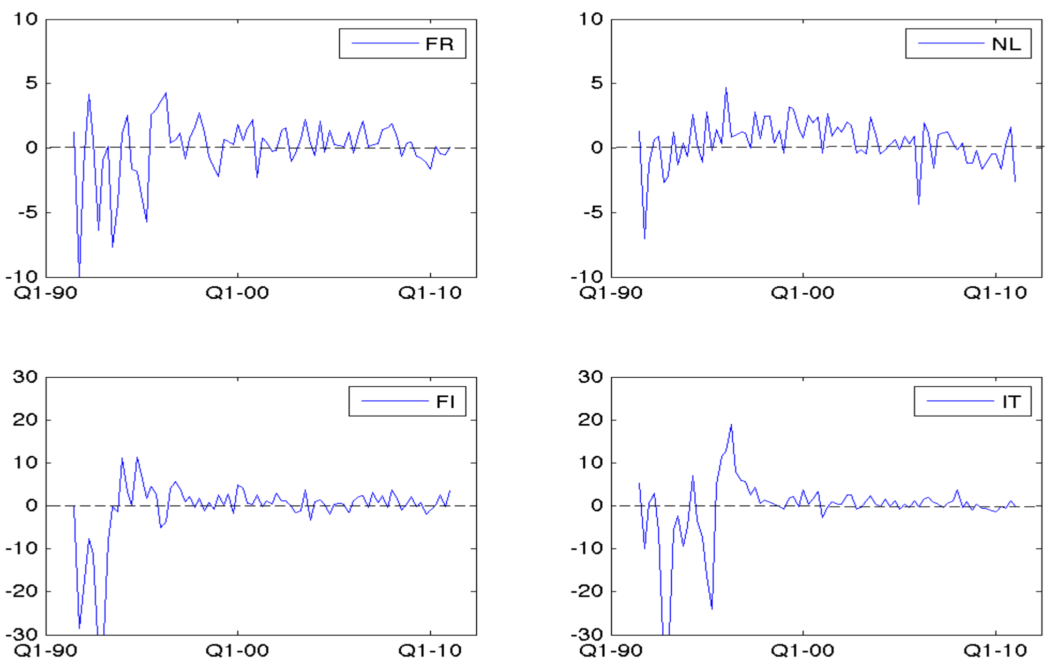
Eurostat on consumer prices and nominal exchange rates. The EMU-countries for which this data is available on a quarterly basis from 1991 - 2010 are Germany, France, Italy, Netherlands and Finland. I compute the bilateral demand gaps between those countries and Germany, a measure of the welfare losses associated with deviations from full risk sharing. Figure 3.3 depicts the bilateral *Dgap* of selected countries with respect to Germany. The figure indicates that the expected growth in real marginal utility of consumption is equalized across countries: on average the demand gap is very close to zero. This means that the variance or standard deviation of the demand gap is a correct measure of the welfare losses of incomplete markets. Furthermore, it shows that whereas some countries, such as Finland and Italy, have seen a clear reduction in the variance of the demand gap since the beginning of the 1990's, other countries such as the Netherlands have not experienced clear improvements in this measure.

Figure 3.3: Bilateral Dgap of selected EMU countries relative to Germany, 1991-2011



Percentage deviations from full bilateral risk sharing between Germany and respectively France (FR), Netherlands (NL), Finland (FI), and Italy (IT).

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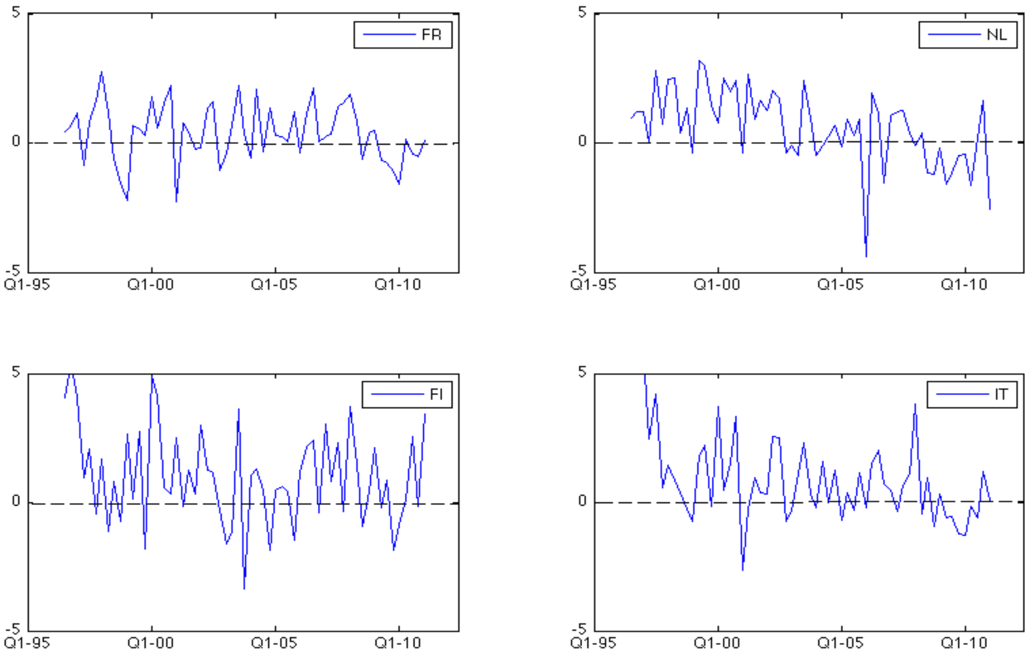
During the period considered, the standard deviation of the Dgap has been much lower for France and Netherlands, respectively 0.0239 and 0.0174, than for Italy and Finland, respectively 0.0739 and 0.0758. However, the numbers for Italy and Finland could be dependent on the situation within these countries in the beginning of the 1990s: Finland was hit by a banking crisis in the years 1991-1993 and Italy was hit by the ERM crisis in 1992. And, indeed, when we look at the evolution of the demand gap from 1996 onwards, the fall in welfare losses due to incomplete markets and country-specific shocks is much less evident, see Figure 3.4.

Figure 3.4: Bilateral Dgap of selected EMU countries relative to Germany, 1996-2011



Percentage deviations from full bilateral risk sharing between Germany and respectively France (FR), Netherlands (NL), Finland (FI), and Italy (IT).

The evolution of the demand gap over time can shed light on whether the introduction of the common currency has led to a fall in the welfare losses associated with incomplete markets. This is interesting both because it clarifies whether the increase in financial integra-

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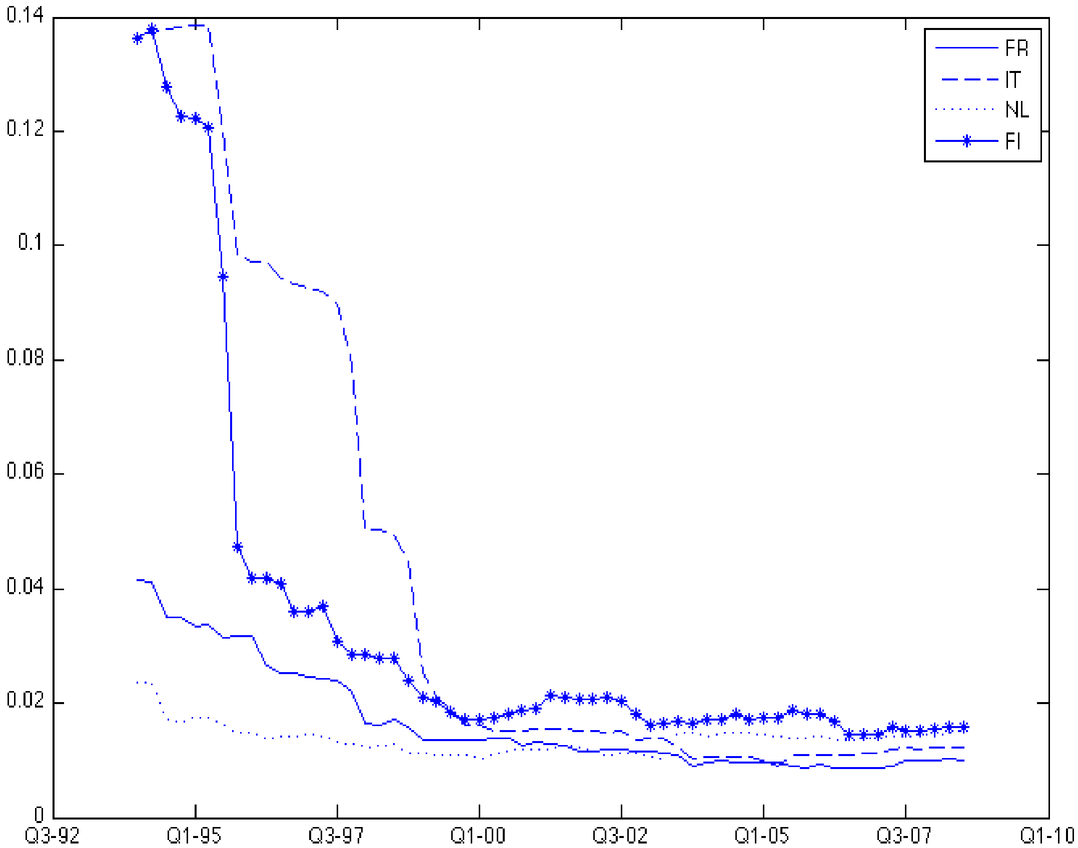
tion has actually had beneficial welfare effects, but also because it has potentially important implications for policy making, as pointed out in Chapters 1 and 2. I follow Viani (2011) in using the standard deviation of the demand gap as the relevant measure. The evolution of the standard deviation of the bilateral demand gap with Germany, the welfare-related measure, is depicted below.

Figure 3.5: Standard deviation of bilateral Dgap of selected EMU countries relative to Germany



"FR" refers to partner country France, "IT" refers to Italy, "NL" refers to Netherlands, and "FI" refers to Finland. The standard deviation is measured over a window of 5 years at each point in time.

Whereas the standard deviation of the bilateral demand gap has fallen since the begin-

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ning of the 1990s for Italy, Finland, and France, the tendency is less clear for the Netherlands.

3.3.3 Risk sharing and the demand gap

The observed fall in the welfare losses associated with incomplete markets during the last 20 years, measured by the variance of the demand gap, can be due to either an improvement in risk sharing across countries or a fall in the amount of macroeconomic risk to be shared. It is thus interesting to disentangle the part of the fall in the demand gap which is due to a fall in country-specific macroeconomic risk from the part due to an improvement in risk sharing. Theoretically, a fall in macroeconomic risk to be shared would result from the introduction of the common currency since it reduces exchange rate risk. Furthermore, it is commonly thought that the introduction of the common currency would lead to higher business cycle synchronisation across EMU-countries. Hence, according to these conjectures, the fall in the welfare losses associated with deviations from perfect risk sharing could be due in large part to the fall in macroeconomic risk to be shared among EMU-members. In the following, I attempt to estimate how large a part of the fall in the welfare loss associated with deviations from full risk sharing is a consequence of lower macroeconomic insurable risk relative to the part which results from improved risk sharing of specific types of risk across EMU-countries.

Measuring improvements in risk sharing. Deviations from full risk sharing arise in the face of country-specific shocks. Changes in the variance of the demand gap between two periods can be due to either a change in the amount of risk to be shared, or a change in the degree of risk sharing. In a model with only country-specific output shocks and uncorrelated nominal exchange rate shocks, these two effects can be disentangled by running the following regression for each of the periods:

$$Dgap_t = \beta_H \Delta \log Y_{H,t} + \beta_F \Delta \log Y_{F,t} + \beta_S \log \Delta s_t + \epsilon_t \tag{3.22}$$

By comparing the coefficients, β_H, β_F, and β_S across the periods it is then possible, according to Viani (2011), to infer whether the change in the welfare losses associated with deviations from perfect risk sharing is due to a change in those coefficients, that is the degree of respectively Home and Foreign output risk which is not shared - or whether it is due to different amounts of risk across periods. Hence, I consider the insurance against output risk, and, before the introduction of the common currency, to nominal exchange rate risk. Using the regression results for the period 1991-1999, I construct a counter-factual scenario for the second period, such as to extract the standard deviation of the *Dgap* under the assumption of the same degree of insurance against shocks (same coefficients β_H and β_F) given the macro variables of the second period. I can then compute the fraction of the change in the standard deviation of the *Dgap* which is due uniquely to changes in macroeconomic risk, and the fraction which is due to changes in the degree of risk insurance across countries. I find that changes in the coefficients, that is the degree of risk shared across countries only contributes relatively little to the fall in the *Dgap* observed during these periods. In particular, only between 0 and 17 percent (depending on the countries) of the reduction in the *Dgap* can be attributed to an improvement in risk sharing. Moreover, the countries which have experienced the highest welfare improvements in terms of fall in the volatility of the *Dgap*, such as Italy and Finland, are also the countries for whom the fraction of this improvement which is indeed due to improved insurance against output and nominal exchange rate shocks is the lowest, see Table 3.2.

Table 3.2: **Estimated fraction of the decrease in Dgap explained by change in risk**

Partner country	output risk only	output and nominal exchange rate risk
France	12.01	16.91
Netherlands	-116.02	10.84
Italy	-3.99	-0.39
Finland	8.94	6.93

The numbers are in percent: 16.91 percent of the fall in the standard deviation of the *Dgap* between France and Germany cannot be explained by macro volatility and must thus be the result of improved risk sharing. For Italy all of the fall (or more) can be explained by changes in macro volatility between the two periods. Note that for the Netherlands, the volatility of the *Dgap* in the period 2000-2011 would have been considerably smaller had the same risk sharing of output changes taken place before and after the introduction of the euro - if only output shocks affected the country. But when allowing exchange rate shocks to play a role, this is no longer the case.

Overall, these results indicate that the welfare improvements experienced in countries such as Italy and Finland result from higher business cycle synchronisation rather than higher risk sharing. These results are very much in line with the results obtained by investigating the consumption smoothing capacity. However, as with the previous method, the method developed by Viani (2011) rely on assumptions which can easily be put into question. In the following subsection, I attempt to address one particular issue.

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3.3.4 A critical assessment of the demand gap volatility as a measure of risk sharing

I have already pointed out that this measure of risk sharing, relies on assumptions such as CRRA utility and symmetry across countries. Furthermore, I assumed in my calculations that the coefficient of relative risk aversion is 1.5. Sensitivity analysis with respect to this parameterization figures in the appendix. It shows that though the estimates are of course different, the main results are robust to different coefficients of relative risk aversion.
However, the main empirical issues of the exercise carried out concern the regression determining the importance of changes in risk insurance for changes in the welfare measure of market incompleteness, the volatility of the *Dgap*. Indeed, endogeneity issues arise because all the explanatory variables could very well be correlated. Consider for example the effect of a shock to world output. Such a shock would affect output growth in both countries and thus bias the estimates. Similarly, the error terms associated with shocks to output and shocks to the nominal exchange rate might be highly correlated and thus bias the estimates. One way to attempt to control for common output shocks is to run the regression below in stead:

$$Dgap_t = \beta_H(\Delta \log Y_{H,t} - \Delta \log Y_{EMU,t}) + \beta_F(\Delta \log Y_{F,t} - \Delta \log Y_{EMU,t}) + \beta_S \log \Delta s_t + \epsilon_t \tag{3.23}$$

This should eliminate shocks which drive common EMU output to affect the estimates, but it does not resolve the endogeneity issue associated with nominal exchange rate movements. Consider another scenario which would result in biased estimates: a monetary policy shock to the interest rate. Such a shock would be expected to affect not only the nominal exchange rate but also, through its effect on consumption and thus labor supply, output. The shock affecting simultaneously the nominal exchange rate and output would bias the estimates.
This short-coming of the method developed by Viani (2011) is to keep in mind when considering the results reported previously.

3.4 Conclusion

This chapter had the ambition of quantifying the degree of risk sharing across EMU-countries and the evolution of risk sharing associated with the introduction of the common currency. For that purpose I use two different methods. The first method measures the capacity of consumption smoothing obtained through bilateral interactions, and indicates that no ma-

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jor changes in risk sharing translated into consumption smoothing capacity appear to have taken place since the introduction of the euro. However, this measure is not perfectly correlated to international risk sharing - unless very strict requirements are met, inter alia that PPP holds. The second measure which I use to measure risk sharing across EMU-countries relates to the inefficiencies arising due to incomplete risk sharing. I attempt to disentangle the fraction of changes in this measure which is due to changes in risk sharing from those which are due to changes in macroeconomic risk. The results are similar to those found for the first measure: though there has been a fall in welfare losses due to incomplete markets, there is no clear evidence of improved risk sharing across countries.

These results, though only indicative, are of importance in that they may contribute to the discussion of the benefits of joining currency unions, and more particularly the EMU. Indeed, the theory on Optimal Currency Areas, initiated by Mundell (1961), points out that one of the benefits arising from forming currency areas pertains to the enhanced ability to share macroeconomic risk across the area. This paper indicates that the predicted enhanced risk sharing has not, at least for now, taken place in the EMU.

Understanding how much risk sharing takes place across the EMU is also crucial for policy making as pointed out in Chapter 1 of this thesis. It is thus a topic which definitely deserves future attention.

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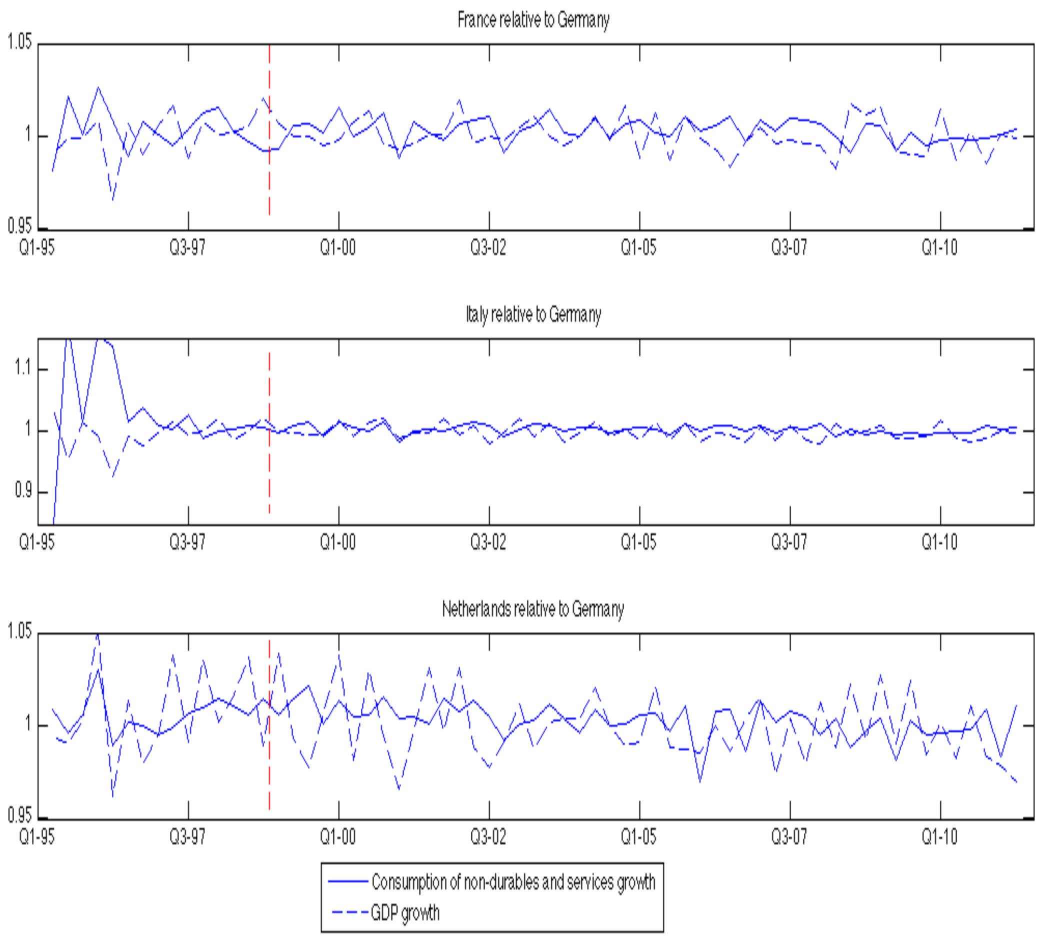
Appendix A. Figures

Figure 3.6: Consumption and output growth in France, Italy, and Netherlands relative to Germany



Appendix B. Tables

Table 3.3: **Standard deviation of bilateral *Dgap* with Germany**

Partner country	**1991 - 2011**	**1991 - 1999**	**2000 - 2011**
$\sigma = 1$			
France	1.87	2.69	0.77
Netherlands	1.24	1.49	1.02
Italy	6.35	9.59	0.95
Finland	6.41	9.50	1.21
$\sigma = 1.5$			
France	2.39	3.39	1.06
Netherlands	1.74	2.09	1.44
Italy	7.39	11.12	1.34
Finland	7.58	11.14	1.77
$\sigma = 4$			
France	5.35	7.50	2.61
Netherlands	4.41	5.21	3.69
Italy	13.33	19.93	3.40
Finland	14.16	20.31	5.03

Standard deviation in percentage deviations from full risk sharing.

Table 3.4: **Estimated fraction of the decrease in Dgap explained by change in risk, with $\sigma = 1$**

Partner country	output risk only	output and nominal exchange rate risk
France	13.04	12.08
Netherlands	-128.46	9.85
Italy	-2.92	-0.24
Finland	11.84	5.75

Table 3.5: **Estimated fraction of the decrease in Dgap explained by change in risk, with $\sigma = 4$**

Partner country	output risk only	output and nominal exchange rate risk
France	7.54	24.55
Netherlands	-110.71	11.91
Italy	-7.00	-0.83
Finland	-2.17	8.36

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Table 3.6: **Estimated coefficients of** $Dgap_t = \beta_H \Delta \log Y_{H,t} + \beta_F \Delta \log Y_{DE,t} + \beta_S \log(\frac{s_t}{s_{t-1}}) + \epsilon_t$.

Partner country	**1991 - 2011**			**1991 - 1999**			**2000 - 2011**		
	$\hat{\beta}_H$	$\hat{\beta}_F$	$\hat{\beta}_S$	$\hat{\beta}_H$	$\hat{\beta}_F$	$\hat{\beta}_S$	$\hat{\beta}_H$	$\hat{\beta}_F$	$\hat{\beta}_S$
France	1.45	-1.50	—	1.49	-1.76	—	1.05	-0.57	—
	1.18	-1.28	1.20	1.15	-1.49	1.07	1.05	-0.57	0
Netherlands	0.59	-0.75	—	0.60	-0.85	—	0.59	-0.42	—
	0.58	-0.72	-1.53	0.58	-0.84	-0.51	0.59	-0.42	0
Italy	0.21	-0.63	—	0.07	-0.99	—	0.82	-0.45	—
	0.03	-0.47	0.36	-0.13	-0.80	0.40	0.82	-0.45	0
Finland	1.54	-1.67	—	1.59	-1.87	—	0.62	0.02	—
	1.11	-1.14	1.10	1.20	-1.44	0.89	0.62	0.02	0

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