Risk Sharing towards the European Fiscal Union

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Abstract

This research estimates a two-country Dynamic Stochastic General Equilibrium Model (DSGE) for the euro area Core and Periphery. The estimation is done with Bayesian techniques using eleven macroeconomic time series. The model implements an automatic fiscal transfer mechanism, able to deal with idiosyncratic shocks affecting the two economies. The mechanism is able to improve the aggregate welfare in the economy, by reducing consumption variability and increasing cross-country risk sharing. Simulating the model with estimated parameters, we reach the conclusion that an optimal fiscal sharing mechanism should absorb 70% of idiosyncratic shocks when agents are credit constrained. The risk sharing mechanism under analysis is able to deal with EMU cyclical heterogeneity and external imbalances. The implementation of a risk sharing system would lead to a greater fiscal coordination, marking a first step towards greater fiscal integration in the euro area.

Key Words: DSGE, RBC, Euro Area, Risk Sharing

Contents

Introduction

There are many reasons behind the ongoing crisis in the euro area but they are all attributable to the coexistence of one supranational entity and several nation-state economic policies. In this work we focus on fiscal coordination, trying to assess the feasibility and the optimal magnitude of an inter-state insurance system able to stabilize country's business cycles while dealing with asymmetric shocks. In doing so, we estimate a two country macroeconomic model for the euro area with bayesian technique.

Several studies have analyzed risk sharing mechanisms among residents of different regions and countries affected by idiosyncratic shocks. The main idea behind inter-state or inter-regional risk sharing is that when a country/region is affected by an idiosyncratic shock, the disturbance should be smoothed so that the final impact on consumptions is lower than the initial shock on the GDP. However, only 40% of shocks are smoothed in the EMU.

This is one of the most important weaknesses of the region; as stressed by many studies, the stability of a currency union depends on the ability to deal with asymmetric shocks generated outside or within the union. It is now clear that the EMU is not an Optimal Currency Area and this calls for "out of the market" adjustment mechanisms. There is a strong consensus both at institutional and academic levels, on the need for a supranational risk sharing mechanism in the euro area, able to deal with the stabilization of countries' business cycles. This is not a secondary issue, before the introduction of the common currency, great attention was dedicated to the study of exogenous asymmetric shocks, a potential threat for the forthcoming currency union. After more than 10 years since the introduction of the euro, exogenous shocks have been relatively rare while idiosyncratic shocks have been mostly generated within the EMU. One of the causes is the "one-fits-none" monetary policy. The European Central Bank is forced by its mandate to keep euro area inflation close to 2%, while different economies with inflationary differentials would need country specific monetary policies. This contradiction in the euro area design contributed, prior to the crisis, to internal imbalances, with demand booms in the peripheral countries that were not counterbalanced. At the same time, core economies were facing too high interest rates.

The transfer mechanism proposed in this work should contribute to narrow future imbalances, acting as a countercyclical system thus facilitating monetary and fiscal policies. The insurance mechanism should be automatic, collecting money in good times while transferring resources during economic downturns. The main goals of the study are to determine the impact that such a mechanism would have on the behavior of the most important macroeconomic variables and to quantify the amount of resources that an optimal fiscal transfer mechanism should have. In order to achieve these objectives we will estimate a two-country Dynamic Stochastic General Equilibrium Model (DSGE) with Bayesian techniques. The model includes a fiscal transfer mechanism between the two economies. Data used for the estimation refer to eleven center and peripheral European economies, aggregated to build two pseudo countries: Core and Periphery.

The study is organized as it follows. Section one introduces the issues under analysis and reports a review of the literature. Section two describes the theoretical model while section three describes the Bayesian estimation, the model simulations and the main results. Final results and policy implications are discussed in the end of section three.

1 Risk Sharing and Business Cycles in open economies

1.1 Inter-State Risk Sharing

As outlined in the pionering work of Mundell (1961) if an area with a common currency and monetary policy lacks some of the Optimal Currency Area criteria, it will not be able to deal with asymmetric shocks. The reason for this is straightforward. When fiscal policies are strictly bounded and the monetary authority responds only to aggregate economic dynamics, member countries have few policy instruments to deal with country specific downturns, even if they are temporary. As outlined by Melitz and Zumer (2002), most member countries of the OECD have automatic mechanisms to deal with adverse, region-specific, shocks. These works through countercyclical taxation or transfers from the central government budget. The EMU institutional framework, however, lacks such a counter cyclical mechanism: there are no central budget transfers, neither taxation mechanisms designed to deal with such issues. The EU has a central budget but is limited and not designed to deal with temporary idiosyncratic shocks. With these issues in mind, many researchers have tried to study and quantify the existing risk-sharing mechanism in place in existing federations[1], which allows to obtain homogeneous business cycles among regions of the same nation or among member states of a federation. The idea is to assess the existence and importance of such mechanism in other countries in order to evaluate the necessity of similar institution for the EMU. Most of these researches have focused on United States that is directly comparable with the EMU: a union of 50 states, with their specific economic structures, a single currency and central bank. In the following sections we are going to review the empirical economic literature on international risk sharing and international business cycles.

1.2 Risk Sharing in Existing Federations

One of the most influential studies on regional stabilization mechanisms was presented in 1991 by Sala-i-Martin and Sachs (SS). In their seminal paper they estimated the amount of income smoothed by central government in the US through variation of taxation and direct transfers to the local governments. The aim of the study was to estimate to what extent the Federal Government of the United State insures its member countries against regional shocks. The main finding of SS was that in the case of an asymmetric shock (defined as a misalignment of a region GDP compared

[1] We will largely refer to these studies in the following secions.

to the US average) almost 34% of the disturbance was absorbed via taxation, while 6% through direct transfers. Such a system contributed in shaping homogenous business cycles among US states, helping households to smooth consumption over time, avoiding sudden changes in their spending behaviors. This means that if adjustments have to be made, they do not entail devaluations, pressure on the fixed one-to-one parity or extraordinary recessions.

The implications of these findings are crucial for the EMU, as stressed by the authors: "Some economists may want to argue that this regional insurance scheme provided by the federal government is one of the key reasons why the system of fixed exchange rates within the United States has survived without major problems. And this is a lesson to be learnt by the proponents of a unified European currency: the creation of a unified currency without a federal insurance scheme, could very well lead the project to an eventual failure." Sala-i-Martin and Sachs, 1991, p.20.

Before going on with the literature review, is worth considering the different channels through which risk-sharing works. One of the most influential papers in the empirical literature on risk sharing was written by Adrubali Sorensen and Yosha (ASY) in 1996, just few years before the implementation of the euro as a single currency . ASY's research deals with the evaluation of risk sharing among states in the United States. They find a way to decompose the risk sharing in three different channels that we can simplify with the following categories:

1. Capital Market
2. Central Government
3. Credit Market

Capital market refers to the agents ability to share risk through a certain degree of portfolio diversification. Second, the federal government, through taxes and transfers, can contribute to smooth idiosyncratic shocks. Finally, if shocks are not smoothed through these first channels, agents can smooth their consumption through savings, namely lending and borrowing on the credit markets. This channel represents the ex-post ability to smooth consumption relative to income. According to ASY estimations for the USA, 39% of shocks are smoothed through the Capital Market, 13% via the Federal Government and 23% through Credit Market, leaving 25% of shocks to GDP not smoothed. Other studies tried to assess the level of risk sharing in the US. See Von Hagen (1992) , Fatàs (1998), Melitz and Zumer (2002).

1.3 Risk Sharing in the EMU

One of the most influential papers on risk sharing taking place in the EMU was written by Sorensen and Yosha (SY) in 1997. The empirical framework is the one proposed by Adrubali. Variance decomposition is used in order to measure the fraction of shocks to GDP that are smoothed via the three risk sharing channles. Aggregating the results, the following table based on the work of SY and ASY give us a first picture of the differences in inter-state risk sharing between EU [2] and US states in the same sample period: 1981-1990.

Table 1.1: Consumption Smoothing Europe, OECD, United States. 1981-1990

	EC8	USA
Capital Markets	8	48
Central Governement	7	14
Credit Market	3	19
Not Smoothed	82	19

Source: Sorensen Yosha (1997)

The biggest difference comes from the Capital Market channel that is able to absorb 48% of idiosyncratic shocks in the US while only 8% in the EC8 group. Transfers account only for the 7% among EC8, while US have a 14% of shocks absorbed. The understanding of these numbers is important: the role of the fiscal transfers is very low among EC8 countries while has a central role in the US where the 14% of shocks is absorbed by transfers. This reflects a system in which when an idiosyncratic downturn occurs, the region affected receive direct transfers from the central budget while automatic fiscal stabilizers allow for a reduction in taxation. The credit market channel has a very low impact in the EC8 mirroring the undeveloped international credit market present in the period 1981-1990. In the USA the role of credit market is important but (as expected) lower than the capital market. The bottom line of the table gives us the most important results for our discussion: 82% of idiosyncratic shocks in the period 1981-90 are left unsmoothed in the EC8 while for the USA the residual deviation account only for the 19%.

In a recent work, Oczan, Luttini and Yosha (2012) analyzes the cross country risk sharing dynamic in the crisis period. During severe economic downturns central banks and governments act as a lender of last resort, providing the needed insurance so that consumption does not fall as output. Their role is even more important if economic agents are credit constrained (as it happened during the crisis) as they cannot exploit the financial intermediaries to borrow money. However, if public finances are under pressure, the central Government cannot provide such an insurance role. Motivated by these considerations, OLY measured the role of capital and credit markets in providing risk sharing during the crisis, dividing the EMU countries in PIGS and non-PIGS.[3]These results are interesting and give us more details about the credit markets role in smoothing consumption during the crisis. A high value for the Credit Market channel means that government, households and corporate exploit the credit channel to smooth consumption over-time. As we can see from the table, the credit channel effectiveness was higher in Non-PIGS compared to PIGS countries in normal periods (2000-2007) preceding the Great Recession. In this period the fraction of shocks left unsmoothed was 65% for Non-Pigs and 81% for PIGS. After the beginning of the crisis, Non-Pigs countries were able to react and smooth consumption through savings (Credit Market). For PIGS a 26%

[2]EC8: Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, UK.
[3]PIGS: Italy, Portugal, Spain, Greece, Ireland.

of shocks were absorbed through Capital Market however pripheral countries were not able to smooth consumption through credit market. Moving to the last period (2010) the situation is even worse, with 66% of shocks unsmoothed for Non-PIGS and 96% of shocks unsmoothed for PIGS. Summarizing, the 2010 it is a year in which no national neither international smoothing was in place, leaving the consumption totally fluctuate with GDP. The main reason of this dynamic comes from the inefficient saving-consumption path that took place in Europe, in particular in the PIGS countries, and in the lack of automatic risk-sharing mechanisms at EMU level.

Table 1.2: Risk Sharing EMU PIGS Non-PIGS Cuntries

	Capital Market	Credit Market	Unsmoothed
GDP (2000-2007) Non-PIGS	-9,34	38,9	65,3
GDP (2000-2007) PIGS	11,2	6,83	81
GDP (2008-2009) Non-PIGS	4,58	52,8	46,4
GDP (2008-20079) PIGS	26,7	-7,03	83,8
GDP (2010) Non-PIGS	1,68	19,9	66,3
GDP (2010) PIGS	-7,88	-10,3	96,8

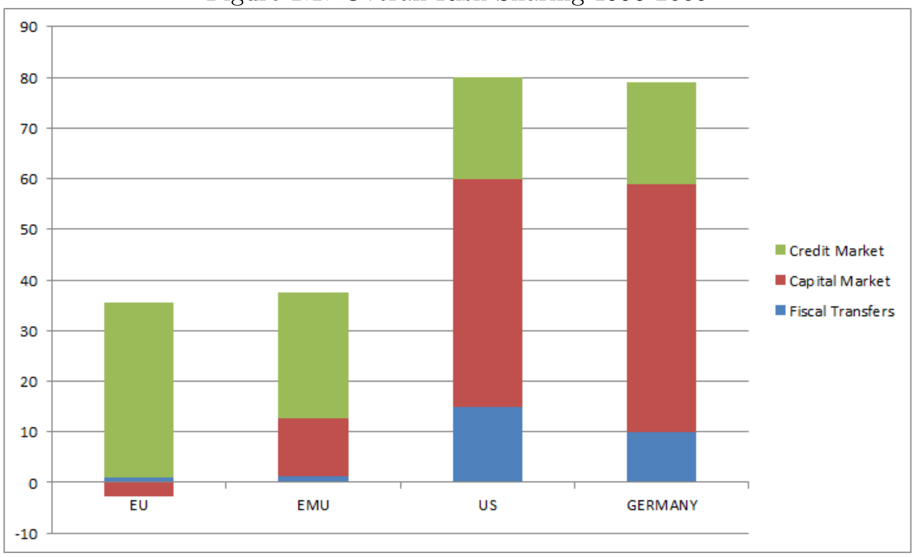
Source:Oczan, Luttini and Yosha 2012

The last and most updated paper on risk haring in the EMU was written by Furceri and Zdienicka (2013) for the working paper series published by the IMF. Their results are similar to the ones of OLY: the amount of shocks left unsmoothed during periods of recession is significantly larger than during normal times. These results are of central importance for the EMU. In the absence of capital and credit market smoothing of income and consumption (as registered during the last crisis) and with the lack of fiscal space associated with high debts and deficits, there are not enough stabilizers mechanisms in order to provide insurance against shocks. In this scenario a supranational fiscal risk sharing mechanism may provide greater international insurance through a stabilization fund. The reason is that, in period of recession, the amount of credit needed by citizens and government is much higher and they can easily find themselves credit constrained. This implies that the share of shock to GDP smoothed by the credit market is negatively correlated with the size of the shock. As a result, the amount of shocks to GDP smoothed during crisis is lower than the one smoothed during normal times.

The results presented suggest that risk sharing channels in the euro area are not able to provide a level of insurance against normal business cycle fluctuations comparable to the one in the United States. Moreover market-based risk sharing mechanisms are ineffective when they are most needed, namely during severe downturns of the economy. These results lead us to a clear conclusion. A deeper financial coordination is needed in the EMU; however, it is crucial to identify alternative risk sharing mechanisms that could insure countries against severe downturns, beyond the market channels. A possible solution is the implementation of a cyclical fiscal transfer mechanism able to enhance the Central Government risk sharing channel, insuring consumptions against shocks on GDP.

As we have seen, the empirical literature on risk sharing is fragmented and gives us different results on the different risk sharing channels. However, we can try to sum up the different results building a comprehensive picture of the risk sharing taking place in the EMU, EU,US. We include here also the German federation.

Figure 1.1: Overall Risk Sharing 1998-2005



Source: Hepp and Von Hagen (2012) for Germany; Sorensen and Yosha (1998) for US; Afonso and Furceri (2008) for EMU and UE

As Figure 1.1 clearly suggests, the overall risk sharing is higher in US and Germany compared to the EU and EMU. Shocks left unsmoothed are 60% in the EMU while are not higher than 20% in the other federations. The income smoothing obtained through capital market is much higher in the US compared to EMU, while the smoothing coming from the credit market in the EMU is comparable to other countries taken in consideration; this suggests that the road to financial integration in the EMU is still far to be achieved. The impact of fiscal transfers in smoothing shocks to GDP is negligible in the EMU, while range from 10% to 13% in US and Germany. We might than conclude that risk sharing mechanisms in the EMU are not working well, or at least, are working less compared with existing federations. In particular the impact of capital market and fiscal transfers in the US is much larger than EU. The lesson of Sala-i-Martin and Sachs (1991) for Europe, written 23 years ago, is still true and we believe that the different impact that the Great Recession had on US end EMU has one of his roots in the different institutional framework concerning cross country risk sharing.

2 A Two-Country Real Business Cycle, DSGE Model

So far we have seen a review of the main empirical studies on international risk sharing. The main conclusion is that European Union and in particular the countries that are part of the EMU, do not have any fiscal mechanism that allows consumer to smooth consumption during negative, country-specific downturns. Moreover the market-based smoothing channels (capital and credit markets) are less effective just when they are most necessary, namely during economic crisis such as the period after 2007. As suggested by the paper of Sala-i-Martin (1991) and the more recent paper of Furceri and Zdienicka (2013) we can argue that the EMU lacks a risk sharing mechanism, able to stabilize country specific shocks.

In this part of the paper we take in consideration a macroeconomic model that allows us to study the impact that a fiscal transfer mechanism would have on the main macroeconomic variables. The theoretical framework is the one suggested by Baxter and Crucini (1995) and further developed by Kim and Kim (2001). Our main contribution is a Bayesian estimation of the two-country model, using data from EMU "Core Countries" and "Peripheral Countries"[4]. A weighted aggregation of six main economic variables, based on country specific Real GDP, will allows us to estimate the model referring to two pseudo-countries: Core and Periphery. In order to have a proper estimation of the model, three structural shocks will be added to the baseline model. This section is divided in two parts, in the first we outline the two-country Real Business Cycle Model while in the second we will analyze the results of the baseline model as calibrated by Kim and Kim (2001).

2.1 The Model

The original model developed by Kim and Kim (2001) represents a World composed of two identical countries which have the same preferences and production technologies. We depart from this setup allowing for differences in the deep parameters. In the economy there is a single non-durable tradable good with the role of numeraire. The two countries are composed by a representative household, a representative firm and a government. Households establish the level of consumption, leisure, investment and bond holdings subject to a budget constraint. The Government is not explicitly modeled and it's role is represented by a lump-sum transfer-tax in the household's budget constraint. In order to better fit theoretical macroeconomic variables variability with the ones observed in real data, bond holding and investments are subject to adjustment costs. For the bond market, adjustment costs help to represent the credit market completeness, higher costs means a restricted possibility of using the credit channel to smooth consumption. The feature of the model on which we will focus is the fiscal transfer mechanism; the mechanims allows fiscal revenues to be shared among economies. The "sharing rule" will be shortly explained.

[4]Core Countries:Germany. France, Finland, Belgium, Netherlands, Austria. Peripheral countries: Italy, Greece, Spain, Portugal, Ireland

2.2 Households

Throughout this section we will describe the Home country economy. We should recall, however, that for each of the following equations, a foreign corresponding exists. In the cases in which foreign variables are explicitly described, these will be marked with an asterisk. In each period a representative household choose his level of consumption, leisure, investment and savings maximizing the following expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t, \ where \ U_t = \frac{\left[C_t^{\theta}(1-L_t)^{1-\theta}\right]^{1-\sigma}}{1-\sigma} \tag{2.1}$$

Ct is consumption, $L_t$are hours worked. The time endowment is normalized to one and households are able to choose the fraction of time devoted to work. In both countries households have the same discount factor while the utility function differs in the other parameters. The utility to which we refer is a constant relative risk aversion (CRRA) transformation of a Cobb-Douglas function of consumption and leisure. θ and $1-\theta$ represent, respectively, the consumption and leisure shares on personal utility. Wealth is the primary determinant of the level of consumption and leisure. Households are subject to the following budget constraint:

$$(1+\tau_{ct})C_t + I_t + B_t + \frac{\zeta}{2}(B_t)^2 = (1-\tau_{lt})w_t L_t + [(1-\tau_{kt})r_t + \tau_{kt}\delta]K_t + R_{t-1}B_{t-1} + T_t \tag{2.2}$$

On the left side of the constraint we have households expenses depending on consumption, investment, bond accumulated at time t and taxes on consumption τ_{ct}. As already mentioned, bond holding is subject to adjustment costs $\frac{\zeta}{2}(B_t)^2$. The degree of adjustment costs can be seen as a measure of the credit market incompleteness. On the right side of the equation we have households earning coming from wages, rented capital and bond purchased at time t-1, where $R_t$is the gross interest rate on bonds and $r_t$the rental rate. Earnings are reduced by labor and capital taxes while a depreciation allowance reimburse taxes paid on depreciated capital. Finally $T_t$is the lump-sum transfer (tax) that is equal to the government budget surplus (deficit). In this setup$B_t$are the international bonds and denote the net-quantity of purchased bonds irrespective of the issuing country. Interest rates process adjusts to clear the bond market. Households accumulate capital according to the following equation:

$$K_{t+1} = [\delta(I/\delta)^{1-\phi} + (1-\delta)K_t^{1-\phi}]^{\frac{1}{1-\phi}} \tag{2.3}$$

$\phi$are the adjustment costs that ranges from zero to one. When $\phi = 0$ there are no adjustment costs. Finally a No-Ponzi-Game condition is imposed on the households borrowing. From the households maximization problem we obtain the following First Order Conditions:

$C_t \Longrightarrow (1+t_{ct})\lambda_t C_t = \theta U_t(1-\sigma)$

$I_t \Longrightarrow \lambda_t = \mu_t \left[\delta(I/\delta)^{1-\phi} + (1-\delta)K_t^{1-\phi}\right]^{\frac{\phi}{1-\phi}} \left(\frac{I_t}{\delta}\right)^{-\phi}$

$K_{t+1} \Longrightarrow \mu_t = \beta E_t \left\{(1-\delta)\,\mu_{t+1}\left[\delta(I/\delta)^{1-\phi} + (1-\delta)K_t^{1-\phi}\right]^{\frac{\phi}{1-\phi}} (K_{t+1})^{-\phi} + \lambda_{t+1}(r_{t+1}(1-tk_{t+1}) + \delta tk_{t+1}\right\}$

$B_{t+1} \Longrightarrow \lambda_t(1+\zeta B_t) = \beta R_t E_t(\lambda_{t+1})$

2.3 Firms

The production function is a standard Cobb-Douglas with labor and capital.

$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha}$

Labor is not mobile across countries while capital is fully mobile, this means that domestic investments can be financed by foreign households. For this reason $K_t$is equal to the capital in place in the Core country but this do not mean that capital is owned by household living in the Core country. Firm's first order condition for profit maximization are the following:

$w_t = \alpha \frac{Y_t}{L_t}$

$r_t = (1-\alpha)\frac{Y_t}{K_t}$

2.4 Fiscal Transfers

As already outlined the two countries share fiscal revenues through a risk sharing mechanism. This system is an ex-ante agreement between the two countries in which they choose to share fiscal revenues following a certain rule. The idea is that during a country specific downturn the affected economy will receive a fiscal transfer from the other economy while the opposite is true. The main idea is to stabilize the business cycle of the two economies in order to make the two as close as possible. As largely outlined in the first section, this would be of crucial importance in Europe. The system developed by Kim and Kim (2001) is based on an ex-ante agreement in which two countries make arrangement to transfer part of their budget surplus (or deficit) to the other country. When such agreement is in place the Government budget constraint is the following:

$$\tau_{ct}C_t + \tau_{lt}w_t L_t + \tau_{kt}(r_t - \delta)K_t + \frac{\zeta}{2}(B_t)^2 = G_t + X_t \tag{2.4}$$

The left side of the equation shows Government earnings coming from taxes and from bond holding costs, assumed to be owned by government. The right side of the equation outlines Government spending (G_t) and budget surplus or deficit (X_t). Holding taxes and Government spending fixed, $X_t$is positive when Government earnings (left side of the equations) are higher than Government spending. The crucial point here are the transfers (T_t) that the Government gives to households in a lump-sum fashion. Given the sharing mechanism, these are function of domestic and foreign surplus and deficit as expressed by the following expression, describing the sharing mechanism:

$$T_t = (1-k)X_t + k\frac{X_t + X_t^*}{2} \tag{2.5}$$

$$T_t^* = (1-k)X_t^* + k\frac{X_t + X_t^*}{2} \tag{2.6}$$

When k=0 there are no fiscal transfers, when k=1 there is full risk sharing: all fiscal surplus (deficit) of the two countries is equally distributed. Following equations 2.5 and 2.6, we can see that transfers from one economy to the other are function of country-specific surplus and deficit. The degree by which income is shared is ruled by the parameter k. The following table shows a simulation for different values of k, in three different scenarios. In the first case both countries have a budget surplus, in the second they both face a deficit and in the third the Core country faces a surplus while the Periphery a deficit. In all the three cases, the Core economy has a better balance. X and $X*$are core and periphery surplus-deficit, $T, T*$ are gross transfer, k is the sharing parameter while $T_{net} = T - X$, showing transfers net of initial surplus-deficit. In the first case under analysis, both countries register a surplus; when k=1, surplus are equally shared among countries, with a negative net-transfer from the Core country and a positive net-transfer for the Periphery. The two extremes are the cases with no sharing and k=2; in the latter case, the surplus of the two countries simply shift from one economy to the other. In the second case, both countries have a deficit and the results are symmetrical to the first. The last case is the most interesting. When a country faces a surplus and the other a deficit, resources are shifted from the first to the second economy. In the case of k=1, income are perfectly shared among the two economies, with negative net transfer for the economy in surplus. As in the previous case, when k=2 the two countries fiscal position are inverted, with a negative fiscal transfer of 150 for the Core. In this case the Core fiscal surplus is not enough to finance the transfer and Core's agents will face a negative transfer (tax) in order to finance the fiscal mechanism. We should think at this mechanism as an insurance system in which the two economies agree to help each other in the case of needs. If shocks are random, in the long-run each of the two countries will benefit from the insurance agreement. Other information on the model can be found in the Appendix and in the article of Kim and Kim (2001).

Table 2.1: Transfer Mechanism Simulation

X	X^*	T	T^*	k	T_{net}	$T*_{net}$
100	50	100	50	0	0	0
100	50	75	75	1	-25,00	25,00
100	50	62,50	87,50	1,5	-37,50	37,50
100	50	50	100	2	-50	50
100	50	37,5	112,5	2,5	-62,5	62,5
-50	-100	-50	-100	0	0	0
-50	-100	-75	-75	1	-25	25
-50	-100	-87,5	-62,5	1,5	-37,5	37,5
-50	-100	-100	-50	2	-50	50
-50	-100	-112,5	-37,5	2,5	-62,5	62,5
100	-50	100	-50	0	0	0
100	-50	25	25	1	-75	75
100	-50	-12,5	62,5	1,5	-112,5	112,5
100	-50	-50	100	2	-150	150
100	-50	-87,5	137,5	2,5	-187,5	187,5

2.5 Structural Shocks

In order to obtain a proper estimation we need to slightly modify the model in order to have shocks related to the observable variables. We depart from the Kim and Kim (2001) original model in two ways. First we modify the original utility function, adding two preference shocks. An inter-temporal shock affecting the marginal utility of consumption and leisure $\chi_t$and an intra-temporal shock affecting the disutility of laborη_t. The modified utility function is the following:

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t,\ where\ U_t = \chi \frac{\left[C_t^{\theta}(1-\eta L_t)^{1-\theta}\right]^{1-\sigma}}{1-\sigma}$$

The second modification to the model is an "investment shock" affecting the marginal productivity of investments. We follow Justiniano, Primiceri and Tambalotti (2009) assuming that this shock might arise from technological factors specific to the production investment goods or from disturbances to the process by which these investment good are turned into productive capital. As in the cited research, we do not take an explicit position on the ultimate source of the disturbances. The modified equation for capital accumulation is the following:

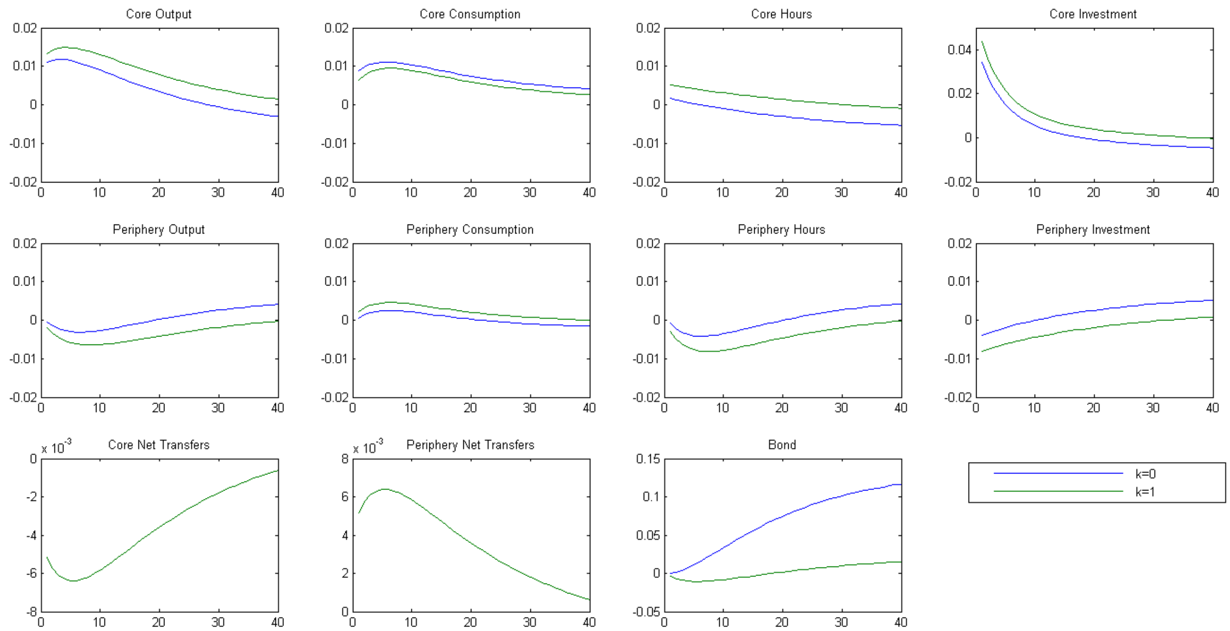
$$K_{t+1} = [\gamma_t \delta (I/\delta)^{1-\phi} + (1-\delta) K_t^{1-\phi}]^{\frac{1}{1-\phi}}$$

2.6 Calibrated Model

In this subsection we will analyze Impulse Response Functions (IRFs) for the two-country symmetric model, calibrated as in Kim and Kim(2012). The IRFs show the dynamic response to one-percent shock on productivity in the

Core Country. The simulation is done in the two cases of unrestricted and restricted borrowing. Bond holding costs represent the credit constraint faced by households. We start with the case of low bond holding costs: unrestricted borrowing. We simulate the model in the two cases of no risk sharing $k = 0$ and full risk sharing $k = 1$. Figure2.1 shows IRFs following a one percent shock in the case of unrestricted borrowing (low bond holding costs). From this moment, we will refer to the home country as the Core and to the foreign country as the Periphery.

Figure 2.1: IRFs 1% Productivity Shock in the Core - Unresticted Borrowing



After a positive productivity shock in the Core country, agents produce and consume more exploiting the persistent but temporary shock. Capital is fully mobile across countries and is shifted from the Periphery toward the more productive country. Home investments increase by 4%, dampened by the investment adjustment costs. Agents in the Core face an increase in output and consumption and smooth their spending accumulating bond over time. Peripheral agents are able to slightly increase their consumption by increasing their stock of debt over time. They know that shocks are random and temporary; thus they found optimal to increase their stock of debt in view of future positive shocks in their economy.

In the case of full risk sharing ($k = 1$) Core's agents produce more and consume less, sharing part of their revenue to Periphery through the risk sharing mechanism. In the case of a country specific positive shock to productivity (as showed in Figure 2.1) the country positively affected shares part of its income with the other economy, knowing that in a reversal situation, the opposite will be true. As we can see from the above graphs on transfers, Core country agents face a negative transfer while, symmetrically, Periphery receives a positive inflow of income. It is clear from the IRF on bond that the fiscal transfer mechanism substitutes the credit channel.

Figure 2.2: IRFs 1% Productivity Shock in the Core - Restricted Borrowing

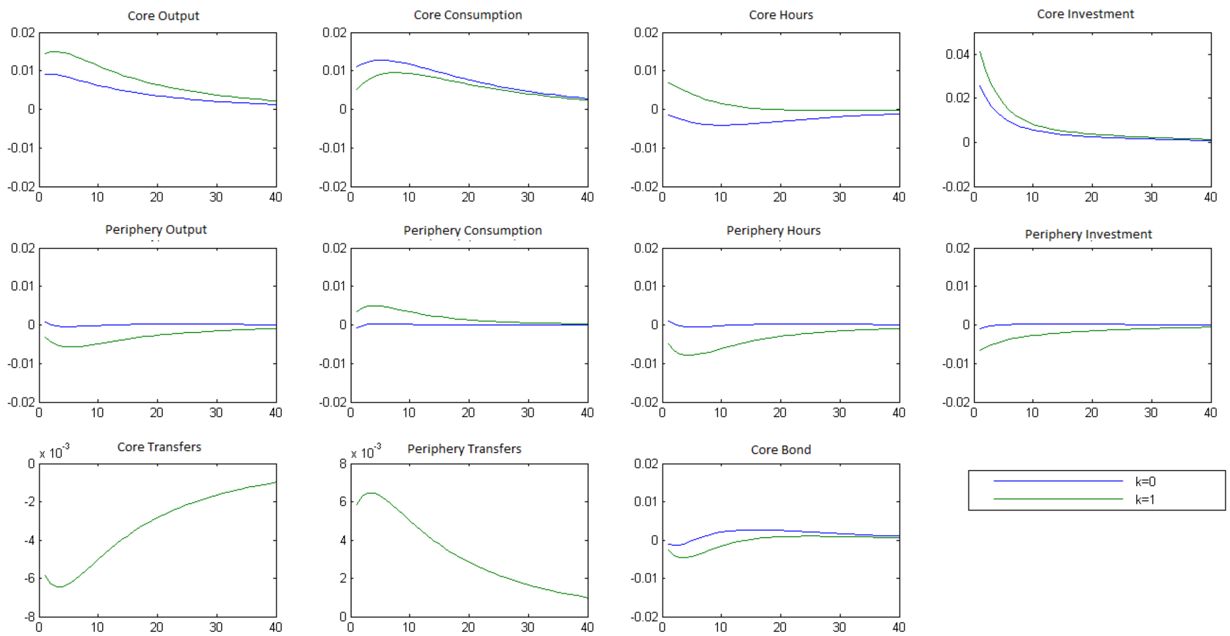


Figure 2.2 shows the IRFs for the case of high bond holding costs, meaning that agents in the economy are credit constrained. As expected, the bond channel is not exploited and agents are not able to use the credit channel to smooth their consumptions. Core dynamics for output, consumption and investment are qualitatively similar to the previous case. However, we note that in this case output responds less and consumption responds more to the productivity shock, while labor is reduced on impact. The reason is that agents are not able to exploit the consumption smoothing channel and tend to consume more in the present. Moreover, hours worked are reduced because of the augmented productivity. In the case of zero fiscal transfers (k=0) IRFs for Periphery do not react to the positive productivity shock in the Core. The reason is that in this baseline model we assume zero correlation among productivity shocks and no spillover effects. The only variable that reacts is investment, that on impact are shifted to the more productive country.

If we move to the case of positive fiscal sharing (k=1), IRFs for the Core country move to a pattern similar to the one of unrestricted borrowing. When the sharing system is in place, Core agents optimally decide to work and produce more, while consumption is lower. The increase in domestic income is shared to Periphery through fiscal transfers, and this allows an increase of consumption for Peripheral households. Hours worked, output and investment decrease in the Periphery. The reason is that with fiscal transfers in place, it is optimal to produce more in the country affected by the productivity shock and share income with the other country, that will thus enjoy increased consumption.

2.7 Welfare Implications

Kim and Kim (2012) developed an accurate study on the welfare implications of a fiscal transfer mechanism . In order to achieve this result, they evaluate how welfare changes following a one time change in k. It is clear from the results in the following table that, when bond holding costs are high (credit is constrained) , the transfer mechanism is welfare improving. When bond holding costs are equal to 0.1 a sharing parameter set to 1 allows welfare gains equal to 0.16%. When bond holding costs are low and the credit market is well functioning, consumption smoothing in the economy is already optimal and the sharing mechanism lead agents to sub-optimal consumption/saving decisions. Consumption smoothing is already in place and the sharing mechanism push agents to an inefficient pattern. With the calibrated parametrization a welfare maximum is obtained with a value of k between 2 and 2.4.

Table 2.2: Conditional Welfare Gains

	Bond holding costs (ζ)				
Degree of revenue sharing (κ)	0.0001	0.001	0.01	0.1	0.5
0	0	0	0	0	0
0.5	*(-0.049)*	*(0.050)*	*(0.035)*	*(0.030)*	*(0.029)*
1	*(-0.219)*	*(0.114)*	*(0.075)*	*(0.062)*	*(0.060)*
1.5	*(-0.740)*	*(0.194)*	*(0.116)*	*(0.095)*	*(0.091)*
2	*(-2.378)*	*(0.274)*	*(0.154)*	*(0.123)*	*(0.119)*
2.4	*(-6.410)*	*(0.224)*	*(0.163)*	*(0.137)*	*(0.134)*

Source: Kim and Kim 2012

3 Model Estimation and Simulations

3.1 Bayesian Estimation Results

In this section we are going to show the results coming from the Bayesian estimation of the two-country model. The goal is to fit the model developed by Kim and Kim (2001) to actual time series. The series taken in consideration for the two "pseudo-countries" are real GDP per capita, investment on GDP, wages, hours worked, public surplus-deficit, and long term interest rates for the period 1999 - 2013. We take in consideration a weighted average of eleven countries divided in two groups: Core and Periphery. For each of these variables we take in consideration two time series: one for the Core and one for the Periphery, with the exception of interest rates that refers to an average of 10 years govern bonds real interest rates for the whole group. More information on the estimation setup and in particular on data, measurement equations, calibrated parameters, prior distributions and diagnostics can be found in the Appendix. Here we report the results of our estimation, namely the parameters that we will use to fit the macroeconomic model to actual time series.

Table 3.1: Estimated parameters - Posterior Distributions

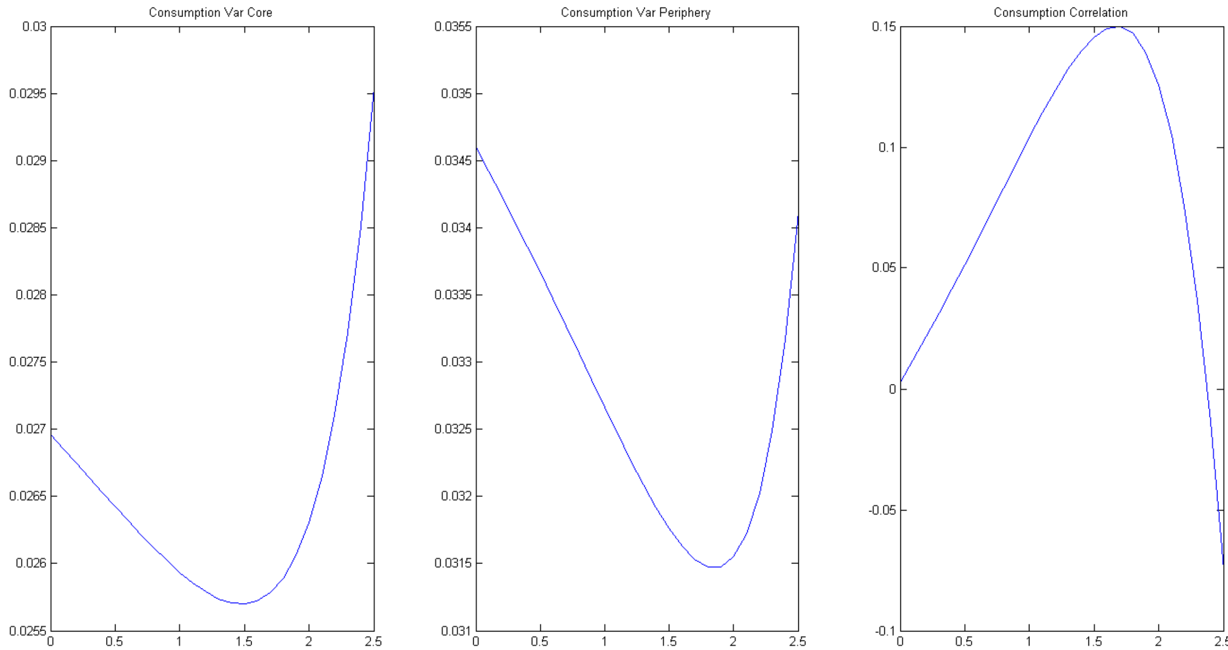
	mode	std	10%	mean	90%
σ	2.1845	0.3817	1.5948	2.2151	2.8406
σ^*	2.6546	0.3529	2.0693	2.6613	3.2092
θ	0.2534	0.2534	0.1726	0.2598	0.3474
θ^*	0.3687	0.3687	0.2798	0.3708	0.4601
ψ	0.4798	0.4798	0.3925	0.4850	0.5737
ψ^*	0.3083	0.3083	0.2459	0.3178	0.3937
ρ^a	0.9578	0.0155	0.9290	0.9544	0.9798
ρ^{a*}	0.9048	0.0351	0.8334	0.8937	0.9562
ρ^η	0.9094	0.0255	0.8645	0.9066	0.9483
$\rho^{\eta*}$	0.9463	0.0164	0.9166	0.9436	0.9702
ρ^g	0.9337	0.0181	0.9003	0.9309	0.9613
ρ^{g*}	0.9521	0.0166	0.9177	0.9465	0.9767
ε^a	0.0038	0.0004	0.0033	0.004	0.0047
ε^{a*}	0.0040	0.0004	0.0034	0.0041	0.0047
ε^η	0.0054	0.0007	0.0044	0.0056	0.0067
$\varepsilon^{\eta*}$	0.0080	0.0009	0.0067	0.0083	0.0098
ε^χ	0.0372	0.0048	0.0297	0.0383	0.0461
$\varepsilon^{\chi*}$	0.0649	0.0072	0.0547	0.0671	0.0791
ε^g	0.0088	0.0009	0.0074	0.0090	0.0106
ε^{g*}	0.0077	0.0008	0.0066	0.0079	0.0093
ε^γ	0.0038	0.0011	0.0025	0.0043	0.0061
$\varepsilon^{\gamma*}$	0.0040	0.0009	0.0026	0.0042	0.0057
ε^{me}	0.0048	0.0005	0.0040	0.0049	0.0058

3.2 Model Simulations

We are now able to simulate our baseline model with the estimated parameters. Throughout this section we take in consideration the scenario in which credit market is restricted. As previously mentioned, this is the scenario in which the transfer mechanism allows welfare improvements in the economy. The model is parameterized using the posterior means of the structural parameters obtained through the Bayesian estimation. Having replicated the paper of Kim and Kim (2013) we found that the welfare maximum identified by the authors corresponds (with a certain degree of error) to the point in which consumption variability is minimized. Moreover, we know that higher the cross country correlation of consumption, higher the degree of risk sharing in the economy. We can then use minimization of consumption variability and improvement in correlation of consumptions to establish the optimal level of sharing in the economy. Table 3.1 shows consumption variability and correlation, generated by the estimated model. The variables have on the horizontal axis different degrees for the sharing parameter k.

The introduction of the risk sharing mechanism allows a reduction in the consumption variability in both countries and an increase in the cross country correlation of consumptions. The maximum cross country risk sharing is achieved for values of k close to 1,5 in the Core country and 1.8 in the Periphery. Maximum risk sharing (consumpti+on correlation) is achieved for a level of k equal to 1.7. Taking an average of the first two results and combining it with the correlation, we can conclude that an optimal fiscal transfer mechanism should have a share parameter equal to 1.7 under this parameterization. This is the value that allows a minimization of the consumption variability in the two countries and a maximization of the cross country correlation of consumptions. As mentioned above, we can say that this value maximizes the welfare in the economy. When a negative idiosyncratic shock hits one of the two economies, the sharing mechanism is able to transfer resources towards the affected one. If a negative country specific shock hits the Periphery, resources are shifted from the Core to the affected country, with an increase in the Periphery and a decrease in the Core's consumption. An increase in consumption, right after an economic downturn, helps the economic recovery and households' consumption smoothing, our main target. If, by contrary, a positive idiosyncratic shock hits an economy, the transfer mechanism transfers resources from the affected economy to the other. As in the previous case, this transfer allows a greater correlation in the consumption cycles among households of different countries.

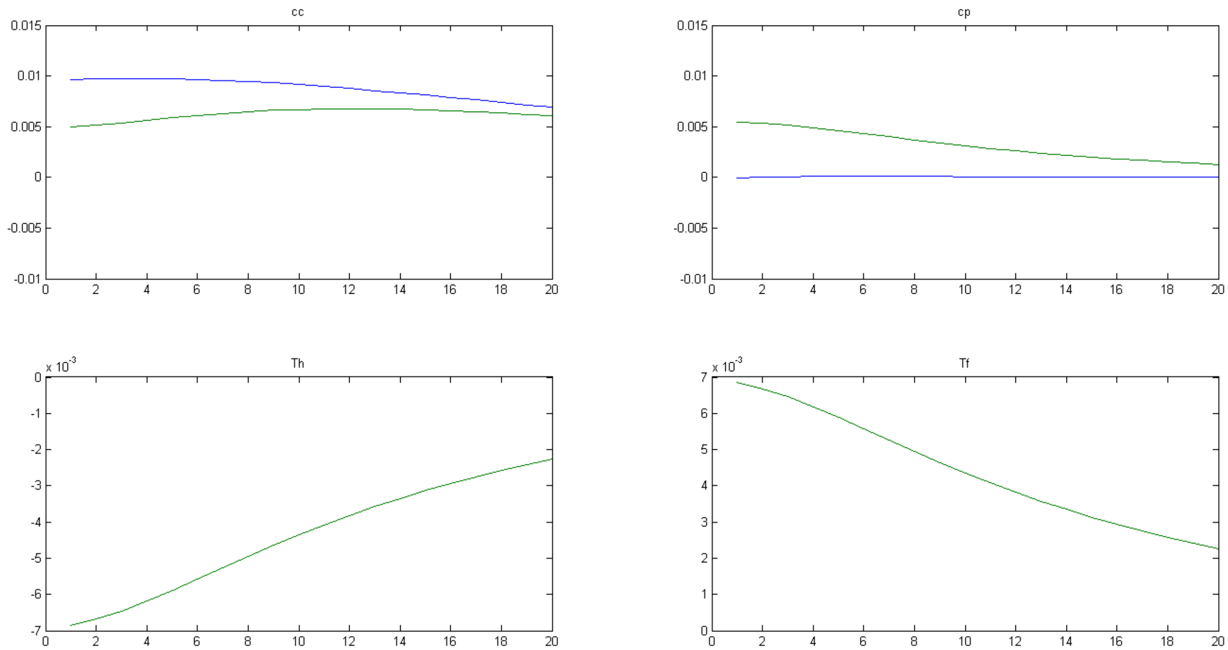
Figure 3.1: Consumption Variability and Correlation - Productivity, Preferences and Investment Shocks



In order to better understand the dynamic effects behind the transfer mechanism and to quantify the resources that have to be transferred in the case of an idiosyncratic shock, we draw impulse responses functions for a positive productive shock in the Core country. The IRFs dynamic is similar to the one previously analyzed. In this case, however, the model is parameterized with the estimated values. Figure 3.2 shows IRFs for consumption and transfers, the variables to which we are most interested. The simulated shock is a one time, one percent shock in the productivity of the Core country. Here we focus only on consumptions and transfers, since we are interested in quantifying the net fiscal transfers triggered by a one percent productivity shock in the core countries, given the optimal share parameter k=1.7 previously identified. As we can see from Figure 2.6 a one percent productivity shock in the Core triggers a fiscal transfer to the Periphery equal to 0.7% of GDP. The same is true for a negative productivity shock that would trigger a transfer equal to 0.7% of GDP towards the Core. We recall here, that this is the amount that minimizes the consumption variability and maximizes the cross country correlation of consumption dynamics. We can than conclude our analysis on the optimal fiscal transfer degree saying that, given the model structure and parameterization, the optimal amount of resources shifted from one economy to the other in the case of an idiosyncratic shock on output should be equal to 70% of the disturbances. This means that a one percent positive productivity shock should trigger a negative transfer from the affected country equal to 0,7% of its GDP. By contrary, a one percent negative productivity shock would entail a transfer to the affected economy equal to

0,7% of its GDP.

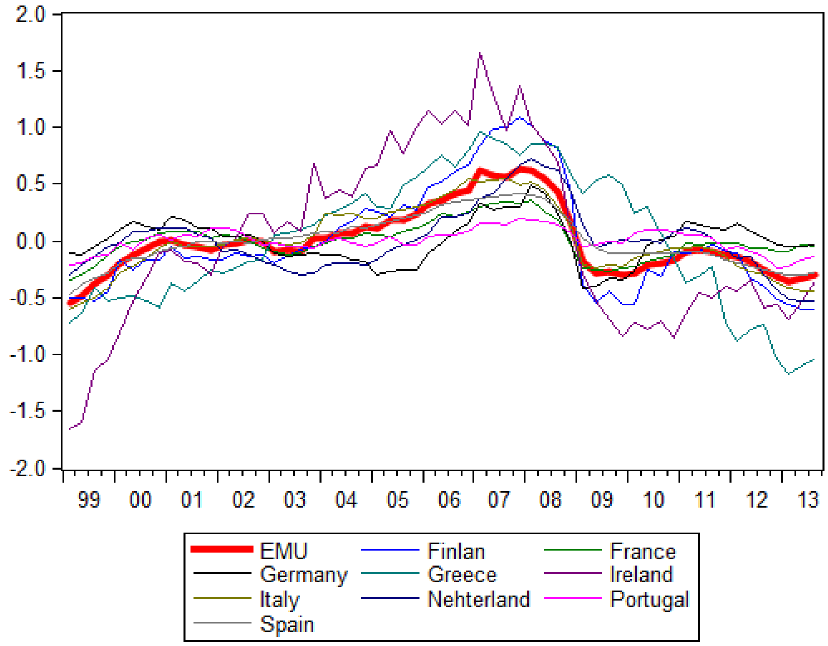
Figure 3.2: Estimated Model - IRFs Consumption and Transfers



3.3 Fiscal Transfer Mechanism

Given the results of our estimation we found that a one percent country specific shock should trigger an optimal transfer equal to 0.7% of Real GDP. In this study we will not go in the details of the creation of such a mechanism, however we will try to determine the resources needed to reproduce the optimal fiscal transfers mechanism outlined in the previous section. To do this we simulate a mechanism that, as in the theoretical model, collects money when a country is affected by a positive shock while transfers money in the opposite case. Such a system it is sustainable only if, in the long run, positive and negative shocks compensate each other's. We assume here that the fund has the capabilities to re-invest the collected money in low risk securities and to borrow on the market. Figure 3.3 show the Real GDP per capita cycles for the countries we have analyzed in the estimation, obtained regressing the time series with respect to a linear trend.

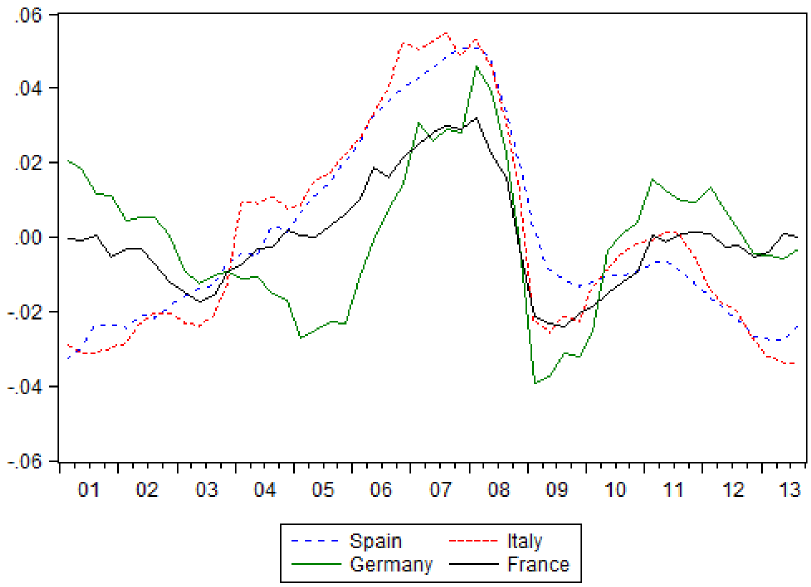
Figure 3.3: EMU and National GDP Cycles



Source:Eurostat and Author's Calculations

It is clear that a European specific component exists in the GDP dynamics. EMU countries, however, have important differences in their GDP cycles, with a significant dispersion with respect to the EMU aggregate. The goal of the fiscal transfer mechanism is to diminish the difference among national business cycles, acting as a countercyclical automatic stabilizer. Figure 3.4 shows the GDP cycle for a sub-group of countries: Italy, Spain, Germany and France. Variables are percentage deviations from a linear trend. The main intuition coming from the graph is that peripheral countries were performing better than core countries before the crisis while the opposite is true after 2009. A countercyclical fiscal transfer mechanism would have reduced this divergence, limiting the credit boom in peripheral countries before the crisis and helping them in the recovery after it. This is a clear example of the countercyclical effects that such a mechanism would have if implemented, with the important result of limiting internal imbalances among euro area countries.

Figure 3.4: Cycle, Percentage Deviation from Linear Trend



A counter-cyclical fiscal sharing mechanism should deal with uncorrelated shocks affecting the European economies, collecting money in good times and transferring resources during economic downturns. Here we simulate a modified version of the transfer mechanism outlined in section 1.6, to quantify the resources needed in order to build a mechanism able to stabilize European countries business cycles. The transfer mechanism is based on an ex-ante agreement among European countries in which they agree to transfer each year a fixed amount of national GDP to an insurance fund. The sharing mechanism will automatically transfer resources to countries affected by negative downturns and will collect money from the others. The stabilization budget is composed by the sum of fixed proportion of national GDP:

$Stabilization\, Budget_t = \sum_i \tau GDP^i_{t-1}$

where τ is the contribution rate. The Stabilization Budget collects and transfer money with the following rules :

$$T_{i,t} = -\tau \times GDP^i_{t-1} \qquad if \qquad \varepsilon^i_t \geq 0 \tag{3.1}$$

$$T_{it=} k \times \epsilon^i_t \times GDP^i_{t-1} \qquad if \qquad \varepsilon^i_t < 0 \tag{3.2}$$

When shocks (ε^i_t) on GDP are positive country i pays a fixed proportion (τ) of its GDP to the fund while a negative shock triggers a transfer equal to $k \times \epsilon^i_t \times GDP^i_{t-1}$: a percentage of the shock affecting the economy. We use the result found in the theoretical model estimation and we set $k = 0,7$. This means that a negative shock equal to 1% would trigger a transfer to the affected economy equal to 0,70% of its GDP. This system should be able to stabilize the business cycle, creating a buffer in good times that is exploited during downturns. The amount of transfers could decrease according to the fund available resources.

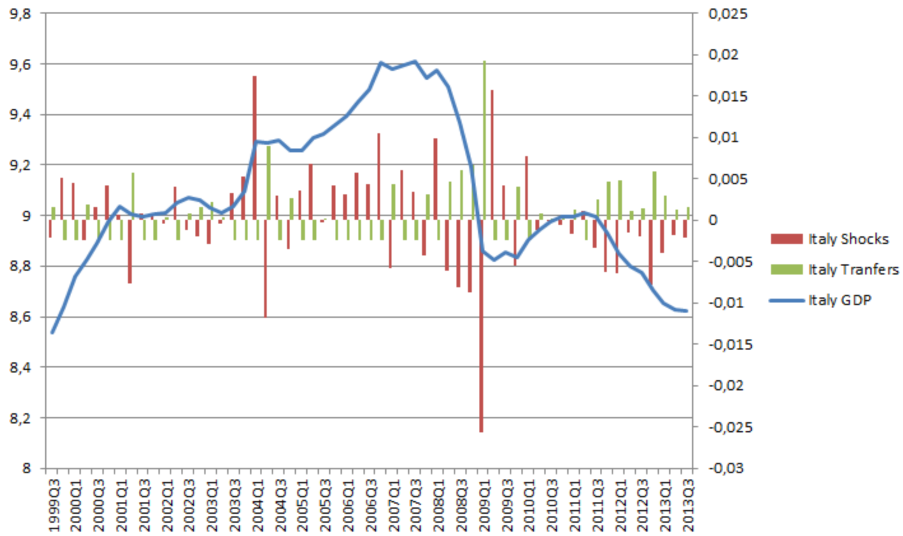
A critical point in the setup of such mechanism is the way in which we derive uncorrelated shocks. As already mentioned, we are interested in dealing with shocks that are uncorrelated so as to avoid permanent transfers towards economies affected by long recession. In order to derive uncorrelated shocks we estimate the following simple regression:

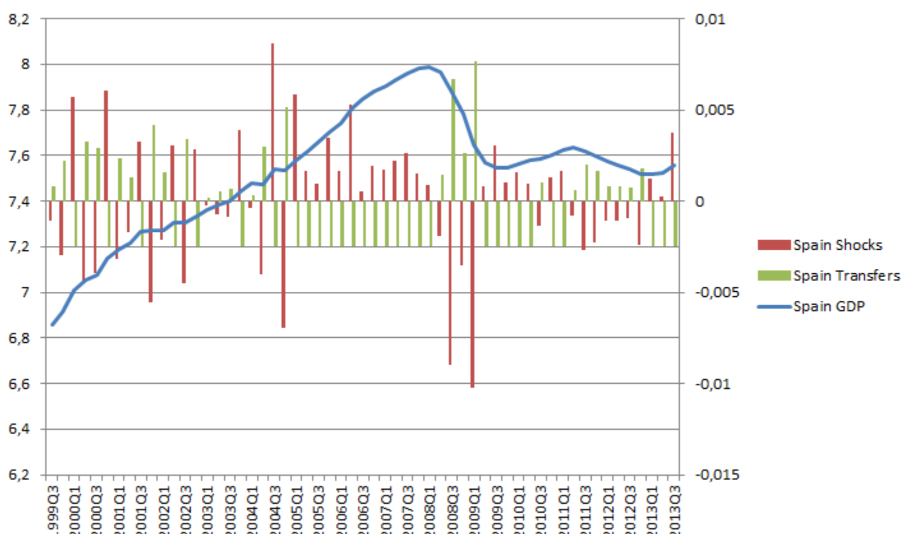
$$log(GDP) = \alpha_i + \sum_{j=1}^{2} \beta_j log(GDP)_{i,t-j} + \epsilon_{i,t}$$

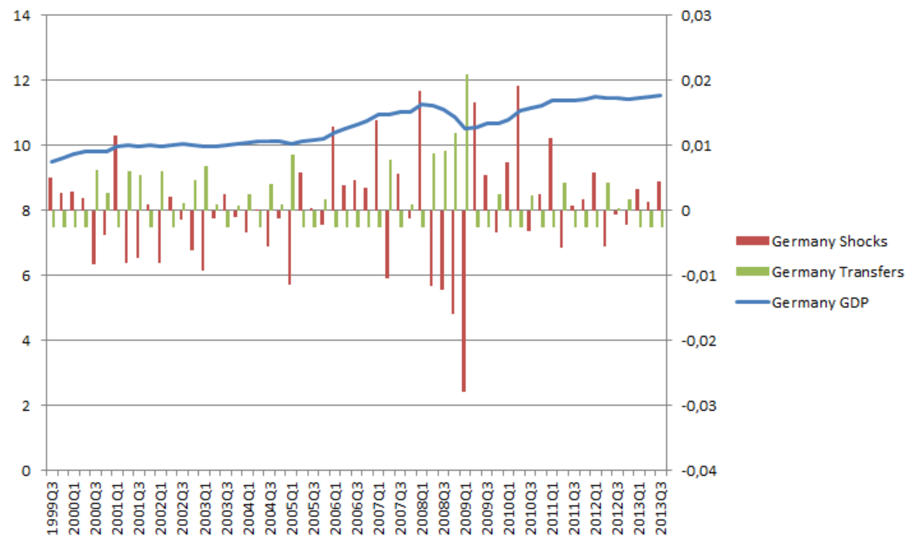
We are now able to simulate the fund behavior for the period 1999-2013, assuming the participation to the risk sharing mechanism of the eleven countries taken in consideration in the previous analysis[5]. First of all we calculate the uncorrelated shocks; knowing that 70% of the negative shocks should be absorbed by the fund, the amount of resources that the fund would have needed in order to setup the fiscal sharing mechanism are close to 1,3% of GDP per year for each country. This means that for the period 1999-2013 a fixed contribution equal to 1,3% of GDP would have insured the economies taken in consideration against negative shocks. Figure 3.5 shows the impact that such a mechanism would have produced on the EMU economies. We take in consideration Italy, Spain, Germany and France as they are the most representative economies of our Core and Periphery groups. The green bars represent contribution to the fund (when negative) and transfer received (when positive) while the red bars are the uncorrelated shocks affecting the economies. When an economy faces a negative shock, it receives a contribution from the fund. The system would have transferred resources from peripheral to the Core countries in the years before the crisis while would have distributed resources to the Peripheral countries in the last years, as shown by the graphs. As expected, the system would have limited demand booms before the insurgence of the crisis, restricting the cyclical divergences among euro area countries. It is important to underline the randomness by which the system transfers resources from an economy to another, without entailing permanent transfers towards certain economies. This is achieved by taking in consideration only uncorrelated shock, so as to avoid the financing of long lasting recessions.

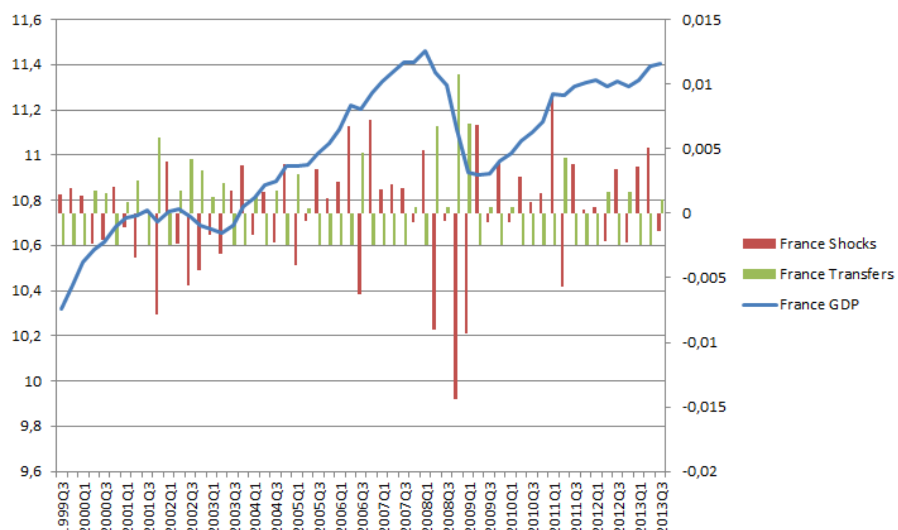
[5] Germany, France, Finland, Belgium, Netherlands, Austria,Italy, Greece, Spain, Portugal, Ireland

Figure 3.5: GDP - Uncorrelated Shocks - Transfers





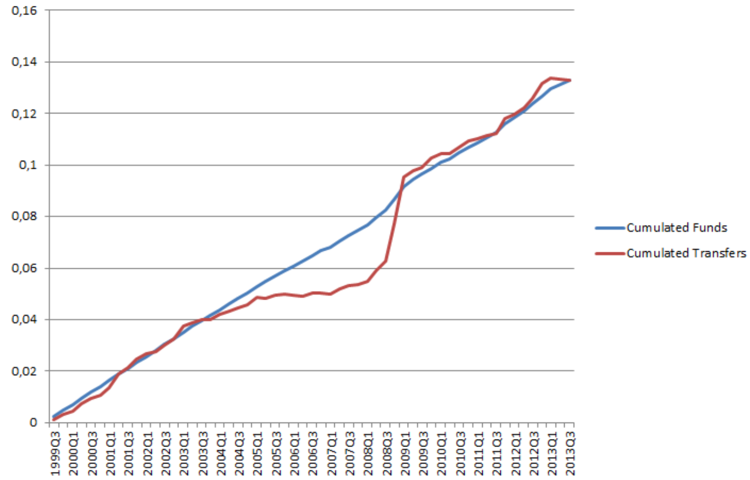




Source: Eurostat and Author's calculations

Figure 3.6 is based on the fund simulations for the eleven countries. It shows the cumulated funds collected and cumulated transfers that the fund would have produced in the period 1999:2013. A 1,3% GDP fixed contributions would have guaranteed a stream of transfers able to absorb 70% of country specific shocks. This is in line with the study of Furceri and Zdianicka (2012) that calculate a 1,9% of fixed resources needed in order to finance a similar mechanism for the period 1979-2010.

Figure 3.6: Cumulated Contributions and Transfers



Conclusions

There are three main channels by which agents of an economy are able to smooth their income and consumption: capital markets, credit markets, fiscal transfers. In the first section we have outlined several empirical studies on risk sharing, which are taking place in existing federations. While results are fragmented, they all lead to the same conclusion: the share of idiosyncratic shocks smoothed in the euro area is too low compared to other federations. For this reason, in line with several scholars' contributions, we propose the institution of a cyclical fiscal transfer mechanism: an inter-state insurance fund able to deal with cyclical divergences in the euro area. The system should be able to shrink the cyclical heterogeneity in the EMU, thus facilitating the role of the ECB and national governments.

To study the impact of such a mechanism we have performed a Bayesian estimation of a two-country, Real Business Cycle, DSGE model, in which economies agree to share part of their income through a fiscal transfer mechanism. The estimation was carried out using data from eleven euro area economies, aggregated in two groups: Core and Periphery, weighting for the relative size of each economy in the relative group. The estimation results highlighted the structural differences among Core and Peripheral euro area countries.

A fiscal transfer mechanism is able to reduce consumption variability and increase cross-country risk sharing in a world represented by two countries, rational agents, flexible prices and free movements of capital.

Having simulated the model using estimated parameters obtained through the Bayesian estimation, we came to the conclusion that an optimal risk sharing mechanism should smooth 70% of GDP idiosyncratic shocks, when agents are credit constrained. This means that a one percent negative shock should trigger a positive transfer to the affected economy equal to the 0.7% of its Gross Domestic Product. According to our simulations, the needed resources for the implementation of such a mechanism are close to 1,3% of euro area countries GDP per year. This result is in line with other empirical studies.

Concluding, a fiscal transfer mechanism, financed through a relatively small amount of resources, would lead to automatic countercyclical adjustments in the euro area, thus improving the economic integration among member states. The institution of a cyclical fiscal transfer mechanism is only one of the several reforms needed within the euro area. However, we think it's one of the most achievable goals in the short run, given the relatively small resources needed and the broad consensus that this proposal is having in the European institutional environment.

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A Appendix

Equilibrium

Labor market equilibrium is achieved using the same notation (L_t) for labor demand and supply while domestic equilibrium is achieved following households and firms optimization. Government behavior is implicitly considered having inserted it's budget constraint in the household's. Taking in consideration the transfer mechanism, the budget constraint becomes:

$$Y_t + R_{t-1}B_{t-1} = C_t + I_t + G_t + B_t + k\frac{X_t - X_t^*}{2} \tag{A.1}$$

Bond market-clearing is needed in order to reach the world equilibrium. The condition establish that bonds are always in zero-net supply given the changes on bonds interest rate.

$$B_t + B_t^* = 0 \tag{A.2}$$

By the Walras law, equilibrium condition for bond market lead to the goods market equilibrium:

$$(Y_t - C_t - I_t - G_t) + (Y_t^* - C*_t - I_t^* - G_t^*) = 0 \tag{A.3}$$

Shocks dynamics and steady state relations are discussed in the appendix.

Shocks

Productivity in the two countries follows a vector Markov process:

$$\begin{bmatrix} log(A_t) \\ log(A_t^*) \end{bmatrix} = \begin{bmatrix} \rho^a & v_a \\ v_a & \rho_a \end{bmatrix} \begin{bmatrix} log(A_{t-1}) \\ log(A_{t-1}^*) \end{bmatrix} + \begin{bmatrix} \epsilon A_t \\ \epsilon^* A_t \end{bmatrix} \tag{A.4}$$

where $E(\epsilon A_t) = E(\epsilon A_t^*) = 0$ and $E(\epsilon^2 A_t) = \sigma^2_{\epsilon A}, E(\epsilon *^2_{A_t}) = \sigma^2_{\epsilon^*_A}$ and $\rho(\epsilon A_t . \epsilon^* A_t) = \psi_A$for all t. $\rho A$is the persistence of productivity and $v A$ represents the spillover effects, namely the degree of transmission of productivity from one country to an other with one period lag. A non zero $\Psi_A$means that innovations are contemporaneously correlated across countries. Tax rates on consumption, capital and labor follow a stationary stochastic autoregressive process of order one.

$$\tau_{ct} = \rho_c \tau_c, t - 1 + (1 - \rho_c)\bar{\tau}_c + \epsilon_{ct} \tag{A.5}$$

$$\tau_{lt} = \rho_l \tau_l, t-1 + (1-\rho_l)\bar{\tau}_l + \epsilon_{lt} \tag{A.6}$$

$$\tau_{kt} = \rho_k \tau_k, t-1 + (1-\rho_k)\bar{\tau}_k + \epsilon_{kt} \tag{A.7}$$

in the above stochastic processes $\bar{\tau}$is the steady- state tax rate and $\epsilon_t$follows a normal distribution with mean 0 and variance σ_ϵ^2. As for the other equations, there are foreign analogues for tax processes. The Government does not issue any debt and his budget is balanced by rebating it's surplus in a lump-sum transfer and it's deficit in a lump-sum tax that directly affect the households budget constraint.

Data

We aggregate data for different European countries in two main groups representing Core and Peripheral EMU countries. We define Core countries as those EMU member states that were less affected by the sovereign debt crisis, measured as the sharp increase in public bonds interest rates. The Core group is composed by Belgium, Germany, Austria, France, Netherlands and France. The Periphery group, instead, is composed by Portugal, Spain, Greece, Italy and Ireland. The aggregation is made taking in consideration the relative size (in term of GDP) of each country in the group. The observations are quarterly data for the period 1999:1 - 2013:4. We collect real data for GDP per Capita, Investments, Wages, Employment, Fiscal Surplus/Deficit and Long Term interest rates.

Observable Variables and Measurement Equations

The series taken in consideration for the two countries are real GDP per capita, investment on GDP, wages, hours worked, public surplus-deficit, and long term interest rates. To each of these variable correspond two time series: one for the Core and one for the Periphery, with the exception of interest rates that refers to an average of 10 years govern bonds real interest rates for the whole group. Unfortunately, no data are available on hours worked and we use employment as a substitute. This is common in the literature (i.e. Smets and Wouters, 2003). Summarizing we have a total of 11 time series: log differences of output, investment and wages: Δy^{obs},$\triangle y^{obs*}$,$\triangle i^{obs}$,$\triangle i^{obs}$, $\triangle w^{obs}$, $\triangle w^{obs*}$ and observations for surplus, hours worked and interest rates: $s^{obs}, s^{obs*}, l^{obs}, l^{obs*}, rb^{obs}$. Variables signed by asterisks refer to Periphery.

Given the linearized solution of our model, we need stationary time series. For this reason series on GDP, wages and investment are log-differentiated and the sample mean removed using proper measurement equations. Moreover, following Tancioni and Beqiraj (2014) in order respect the assumption of a balanced growth pact, we build measurement equations that remove positive-negative excess trend with respect to the steady state output growth rate μ. In order to obtain hours' cycles from the employment time series we use a one sided HP filter. Data on surplus-deficit are percentage on GDP; we assume a stationary dynamic around a balanced budget for fiscal finances, thus no data trasformation is needed. Annualized quarterly data on interest rates are treated using the following transformation, in order to obtain stationary and scaled quarterly data. Assuming a sample mean equal to the variable steady state, we obtain a stationary cycle that do not needs further measurement transformations.

$$rb_t^{obs} = log(1 + \frac{rb_t^{data}}{400}) - mean(log(1 + \frac{rb_t^{data}}{400})) \tag{A.8}$$

Given the observed variables and relative transformations, we set the following measurement equations:

$$\begin{bmatrix} \Delta y^{obs} \\ \triangle i^{obs} \\ \triangle w^{obs} \\ l^{obs} \\ s^{obs} \\ rb^{obs} \end{bmatrix} = \begin{bmatrix} \tilde{y}_t - \tilde{y}_{t.1} + log\mu \\ \tilde{i} - \tilde{i}_{t-1} + log\mu + log\mu_{iy} \\ \tilde{w} - \tilde{w}_{t-q} + log\mu + log\mu_{wy} \\ \tilde{l} \\ \tilde{s} \\ \tilde{r} + \varepsilon^{me} \end{bmatrix} \tag{A.9}$$

With the exception of interest rates, measurement equations refer to Core and Periphery variables for a total of 11 measurement equations. $log\mu_{wy}$and $log\mu_{iy}$are excess trend of the observed variable with respect to real per capita output growth rate. We estimate the model using 10 structural shock while a measurement error ε^{me} is added to the interest rate measurement equation to avoid the singularity issue.

Calibrated Parameters

For different reasons, some of the structural parameters are calibrated. One of this is the model construction, given the symmetric framework under analysis we are not able to obtain good simulations if we do not keep a certain degree of similarity between the two economies under analysis. Another motivation behind the calibration is that we can derive certain values from the time series analysis, while other are not identified. The discount factor is calibrated using the data in the time series and the steady state relation for interest rates. The discount factor and the labor share is set following Smets and Wouters (2003). The autoregressive parameter related to intertemporal shocks (ρ^{χ}) added in section 2.9, result to be not identified and we choosed to calibrate it at the standard value of 0.75. The following table summarizes the calibrated parameter values. With a quarterly gross interest rate equal to 1.01 the discount factor is set to 0.99. Depreciation δ and labor shareα are set following Smets and Wouter (2003).

Table A.1: Calibrated Parameters

Parameter	Value
β	0.99
δ	0.02
α	0.70
ρ^{χ}	0.75

Core and Periphery have symmetric calibrated parameters $\beta = \beta^*$,$\delta = \delta^*$, $\alpha = \alpha^*$,$\rho^{\chi} = \rho^{\chi*}$ values refer to quarterly data.

Prior distributions

As already mentioned, priors distribution are set basing our decision on out-of-the-sample information. For elasticity, persistence and standard error priors setup we follow Smets and Wouters 2003, 2007. Elasticity is defined on the positive domain, however with a mean equal to 2 the Normal distribution it is in line with the estimation and in our case performs better than other options. A standard Beta distribution is set for all the autoregressive parameters with mean 0.5 and variance 0.15, while an Inverse Gamma with mean 0.01 and variance 2 is used for standard errors. We decided to set relatively narrow distributions for the parameters of market activities share θ and investment adjustment costs ψ to be in line with the relevant literature, suggesting a time devoted to leisure equal to 2/3 and adjustment costs close to 0.3. The foolowing table summarizes priors distributions setting:

Table A.2: Priors Distributions

		Domain	Distribution	Mean	Variance
σ	CRRA	$\mathbb{R}+$	Normal	2	0.4
σ^*					
θ	Market Activities Share	[0,1]	Beta	0.3	0.05
θ^*					
ψ	Investment Adj. Costs	[0,1]	Normal	0.2	0.1
ψ^*					
ρ^a	TFP	[0,1]	Beta	0.5	0.15
ρ^{a*}					
ρ^η	Intratemporal Shock	[0,1]	Beta	0.5	0.15
$\rho^{\eta*}$					
ρ^g	Government	[0,1]	Beta	0.5	0.15
ρ^{g*}					
ε^a	TFP	$\mathbb{R}+$	Inv.Gamma	0.010	2
ε^{a*}					
ε^η	Intratemporal Shock	$\mathbb{R}+$	Inv.Gamma	0.010	2
ε^η					
ε^χ	Intertemporal Shock	$\mathbb{R}+$	Inv.Gamma	0.010	2
$\varepsilon^{\chi*}$					
ε^g	Government	$\mathbb{R}+$	Inv.Gamma	0.010	2
ε^{g*}					
ε^γ	Investment Shock	$\mathbb{R}+$	Inv.Gamma	0.010	2
$\varepsilon^{\gamma*}$					
ε^{me}	Measurement Error	$\mathbb{R}+$	Inv.Gamma	0.010	2

Steady State Relations

$B = 0$

$R\beta = 1$

$\frac{I}{K} = \delta$

$\frac{K}{Y} = \frac{\beta(1-\alpha)(1-\tau_k)}{1-\beta(1-\delta(1-\tau_k))}$

$r = (1-\alpha)\left(\frac{K}{Y}\right)^{-1}$

$\frac{C}{Y} = 1 - \frac{I}{Y} - \frac{G}{Y}$

$\frac{X}{Y} = \tau_c \frac{C}{Y} + \alpha\tau_l + (1-\alpha)\tau_k - \delta\tau_k \frac{K}{Y} - \frac{G}{Y}$

$\frac{L}{1-L} = \frac{\alpha\theta}{1-\theta}\left(\frac{C}{Y}\right)^{-1} \frac{1-\tau_l}{1+\tau_c}$

- Moreover

$\frac{G}{Y} = 0.375$

$\frac{G^*}{Y^*} = 0.375$

- Variables signed by asterisks refer to Periphery.

Linarized Equations

- The complete set of 24 linearized equations is the following:

$$0 = \hat{U}_t - \hat{\chi}_t \theta(1-\sigma)\hat{C}_t + (1-\theta)(1-\sigma)\frac{L}{1-L}\hat{L}_t + (1-\theta)(1-\sigma)\frac{L}{1-L}\hat{\eta}_t$$

$$0 = \hat{Y}_t - \hat{A}_t - \alpha\hat{L}_t - (1-\alpha)\hat{K}_t$$

$$0 = \hat{\lambda}_t + \hat{C}_t + \frac{1}{1+\tau_c}\hat{\tau_{ct}} - \hat{U}_t$$

$$0 = \hat{\lambda}_t + \hat{w}_t - \frac{L}{1-L_t}\hat{L}_t - -\frac{L}{1-L_t}\hat{\eta}_t - \frac{1}{1-\tau_l}\hat{\tau_{lt}} - \hat{U}_t - \hat{\eta}_t$$

$$0 = \hat{K}_{t+1} - \frac{\delta}{1-\phi}\hat{\gamma}_t - (1-\delta)\hat{K}_t - \delta\hat{I}_t$$

$$0 = \hat{\lambda}_{t+1} - \hat{\lambda}_t - (\zeta Y)\hat{B}_t + \hat{R}_t$$

$$0 = \hat{G}_t + \hat{X}_t - \tau_c\frac{C}{Y}\hat{C}_t - (\alpha\tau_l + (1-\alpha)\tau_k)\hat{Y}_t + \tau_k\delta\frac{K}{Y}\hat{K}_t - \frac{C}{Y}\hat{C}_t - \alpha\tau_{lt} - (r-\delta)\frac{K}{Y}\hat{\tau}_{kt}$$

$$0 = \hat{Y}_t - \frac{C}{Y}\hat{C}_t - \frac{I}{Y}\hat{I}_t - \hat{G}_t - \hat{B}_t + R\hat{B}_{t-1} - \frac{k}{2}\left[\hat{X}_t - \left(\frac{Y^*}{Y}\right)\hat{X}_t\right]$$

$$0 = \hat{Y}_t - \hat{w}_t - \hat{L}_t$$

$$0 = \hat{Y}_t - \hat{r}_t - \hat{K}_t$$

$$0 = \hat{\lambda}_t - \hat{\gamma}_t - \hat{\mu}_t + \phi(1-\delta)(\hat{I}_t - \hat{K}_t) - \frac{\delta\phi}{1-\phi}\hat{\gamma}_t$$

$$0 = \hat{\mu}_t - \beta\phi(1-\delta)(\hat{I}_{t+1} - \hat{K}_{t+1}) - \hat{\lambda}_{t+1} - \left[1-\beta\left(1-\delta\left(1-\tau_{kt}\right)\right)\right]\hat{r}_{t+1} + \beta(r-\delta)\hat{\tau}_{k,t+1} - \beta(1-\delta)\hat{\gamma}_{t+1}$$

- For Peripheral countries, all equations are the same except for using B for $B^*$and th world resource constraint:

$$0 = \left[\hat{Y}_t - \frac{C}{Y}\hat{C}_t - \frac{I}{Y} - \hat{G}_t\right] + \frac{Y^*}{Y}\left[\hat{Y}_t^* - \frac{C^*}{Y*}\hat{C}_t^* - \frac{I^*}{Y^*}\hat{I}_t^* - \hat{G}_t^*\right]$$

- Defining:

$$\hat{\tau}_t = \tau_t - \tau$$

$$\hat{X}_t = \frac{X_t - X}{Y}$$

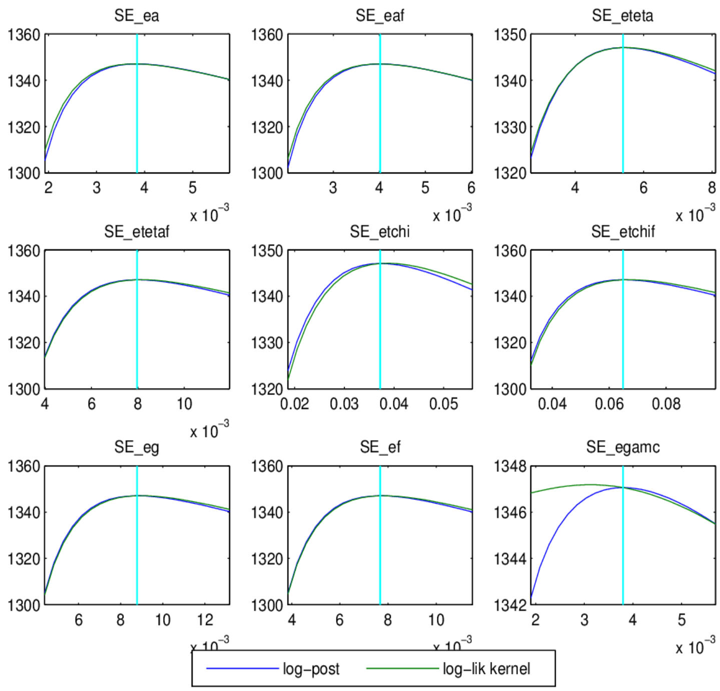
$$G_t = \frac{G_t - G}{Y}$$

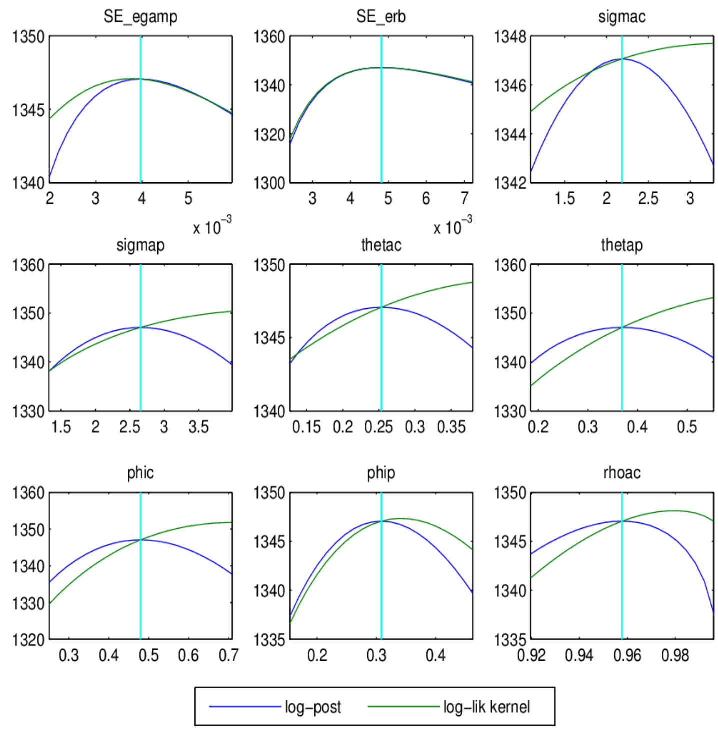
$$\hat{B}_t = \frac{B_t}{Y}$$

- Variables signed by asterisks refer to Periphery

Bayesian Estimations Diagnostic

Figure A.1: Bayesian Estimation, Mode Graphical Diagnostic

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SE_erb
sigmac
sigmap
thetac
thetap
phic
phip
rhoac
log−post
log−lik kernel

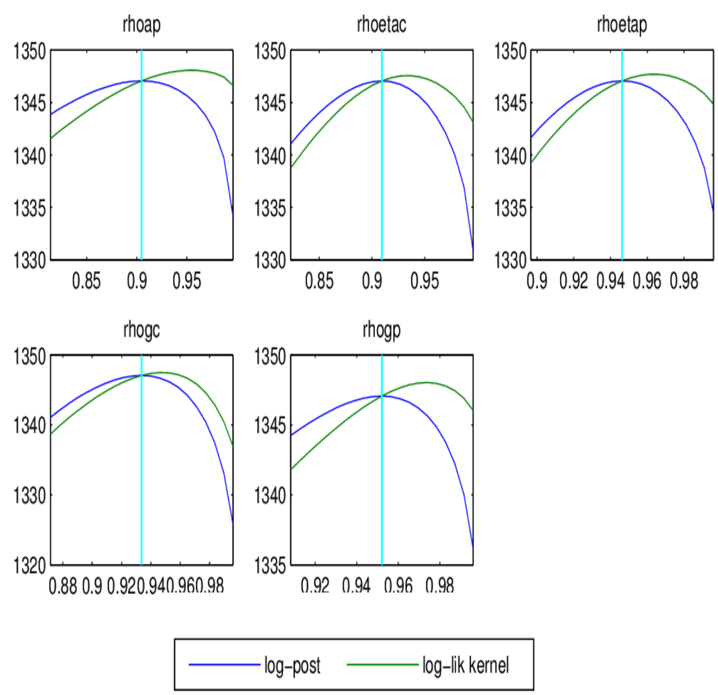
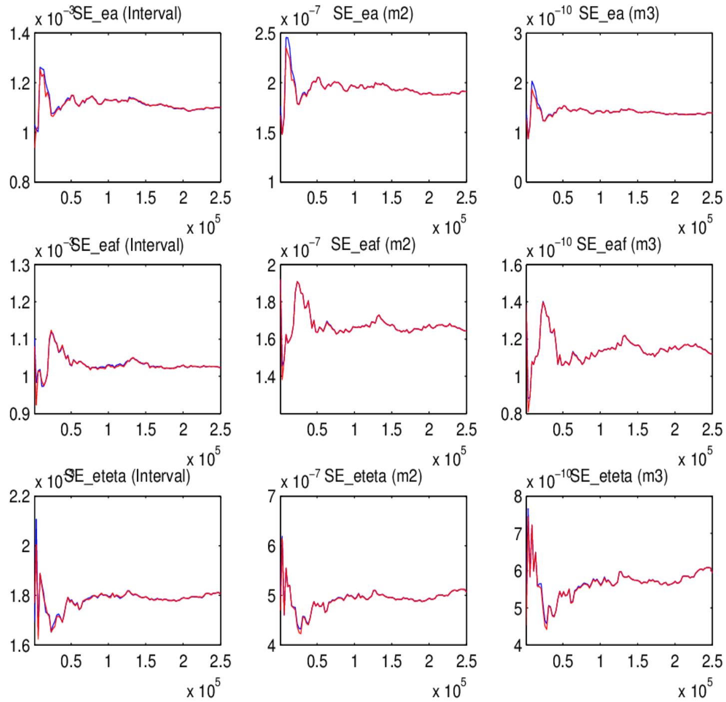
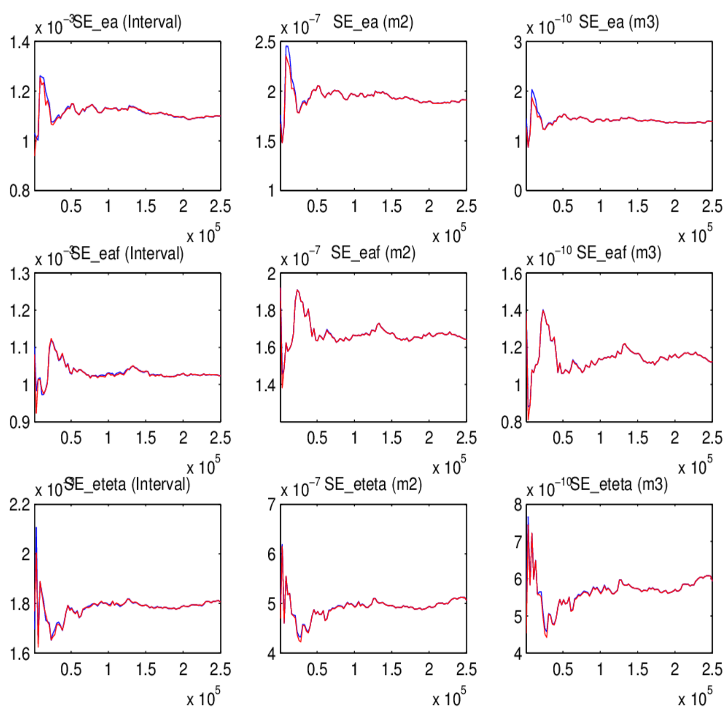
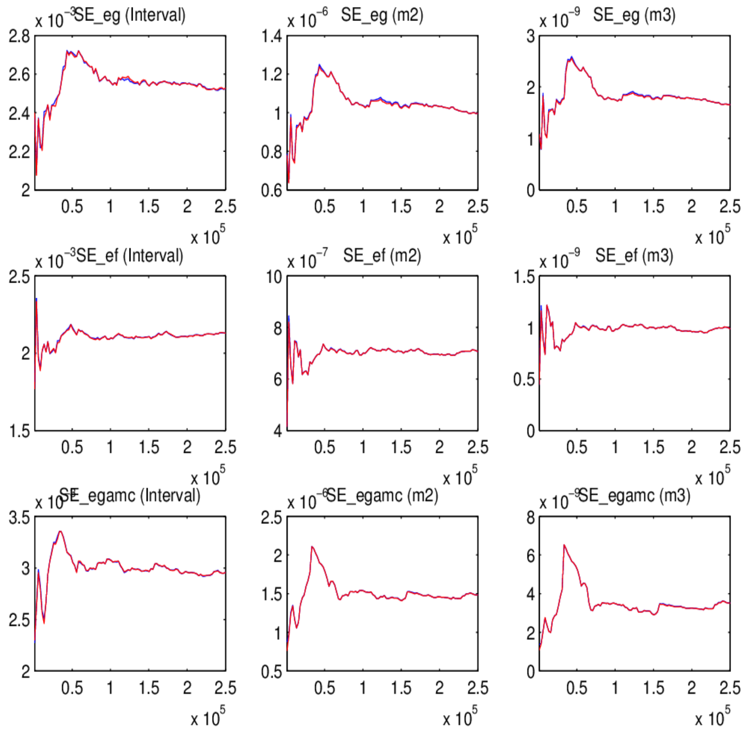

rhoap
rhoetac
rhoetap
rhogc
rhogp
log−post
log−lik kernel

Figure A.2: Bayesian Estimation - Convergence Diagnostic



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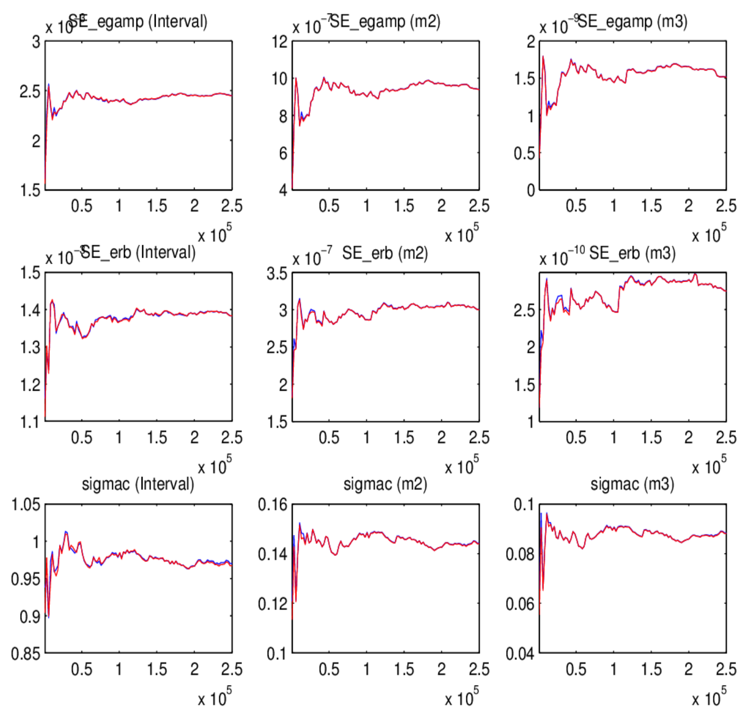
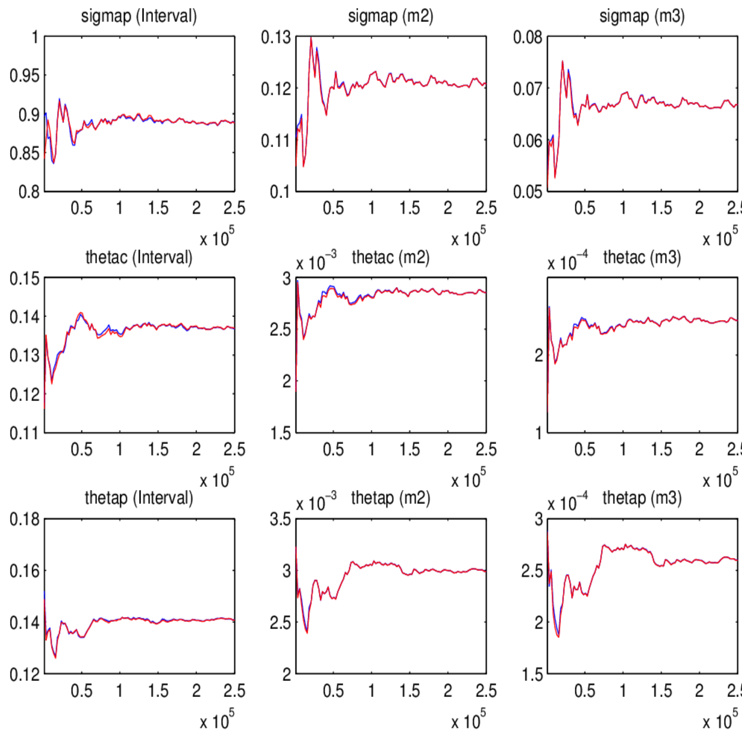
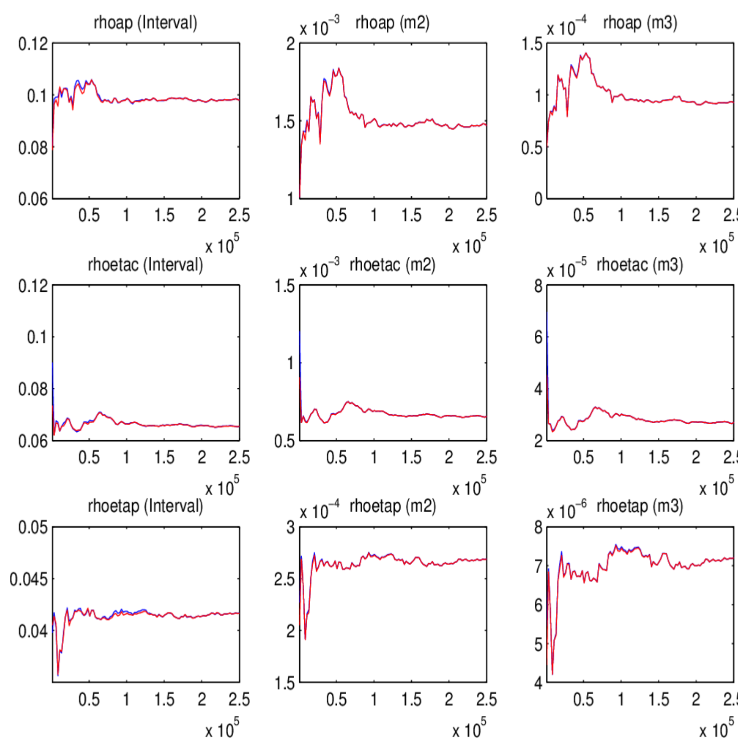
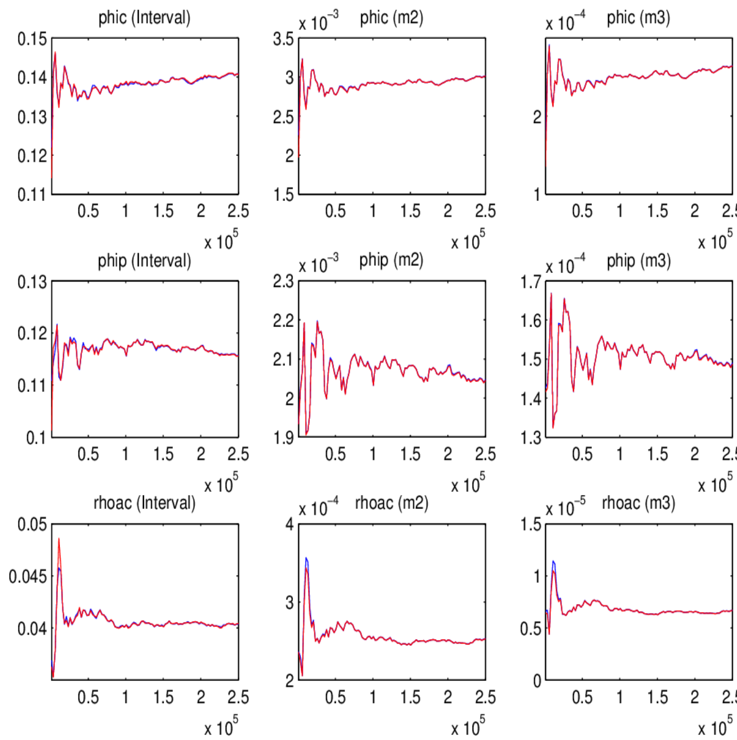
SE_eg (m2)
SE_eg (m3)
SE_ef (Interval)
SE_ef (m2)
SE_ef (m3)
SE_egamc (Interval)
SE_egamc (m2)
SE_egamc (m3)


SE_egamp (Interval)
SE_egamp (m2)
SE_egamp (m3)
SE_erb (Interval)
SE_erb (m2)
SE_erb (m3)
sigmac (Interval)
sigmac (m2)
sigmac (m3)


sigmap (Interval)
sigmap (m2)
sigmap (m3)
thetac (Interval)
x 10^−3 thetac (m2)
x 10^−4 thetac (m3)
thetap (Interval)
x 10^−3 thetap (m2)
x 10^−4 thetap (m3)
x 10^5


rhoap (Interval)
x 10^−3 rhoap (m2)
x 10^−4 rhoap (m3)
rhoetac (Interval)
x 10^−3 rhoetac (m2)
x 10^−5 rhoetac (m3)
rhoetap (Interval)
x 10^−4 rhoetap (m2)
x 10^−6 rhoetap (m3)
x 10^5


phic (Interval)
phic (m2)
phic (m3)
phip (Interval)
phip (m2)
phip (m3)
rhoac (Interval)
rhoac (m2)
rhoac (m3)
x 10^5
x 10^-3
x 10^-4
x 10^-5

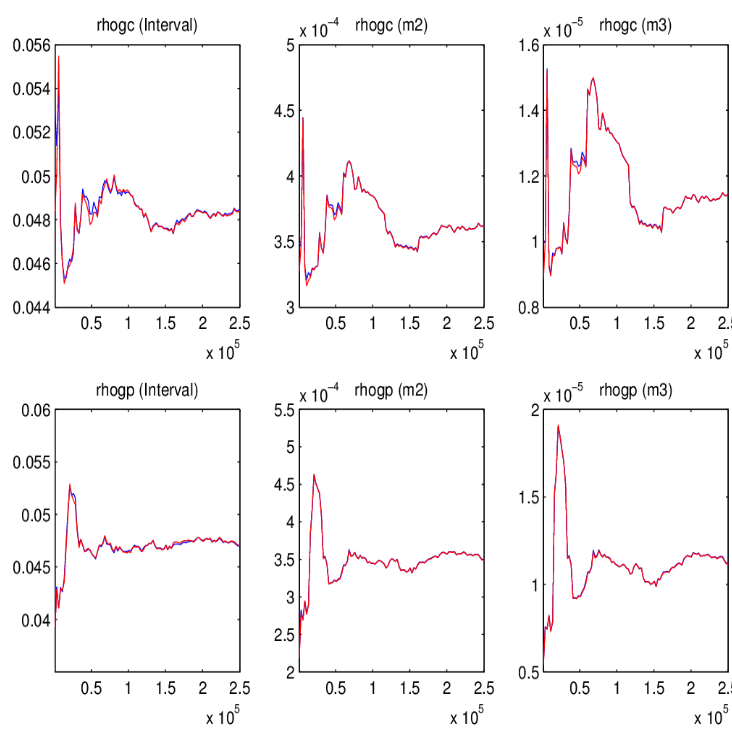
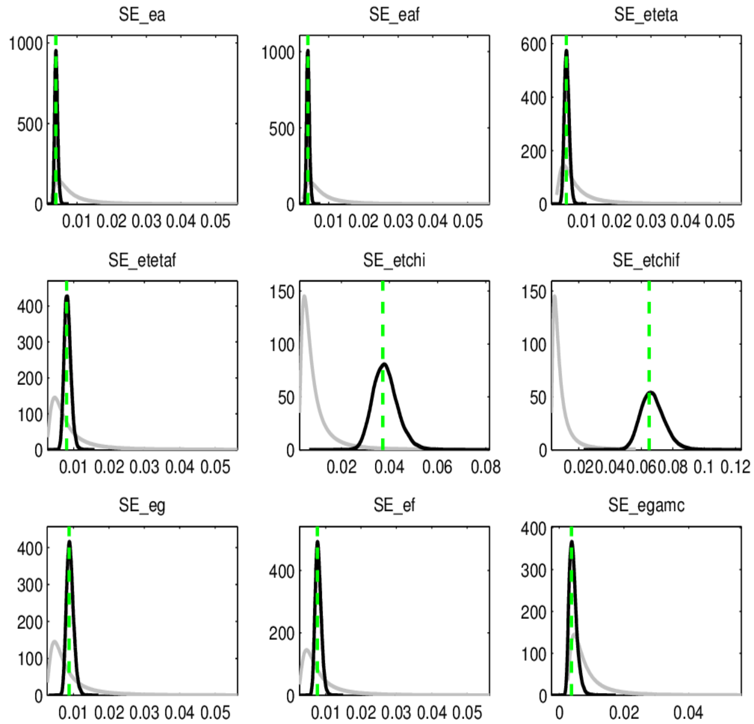
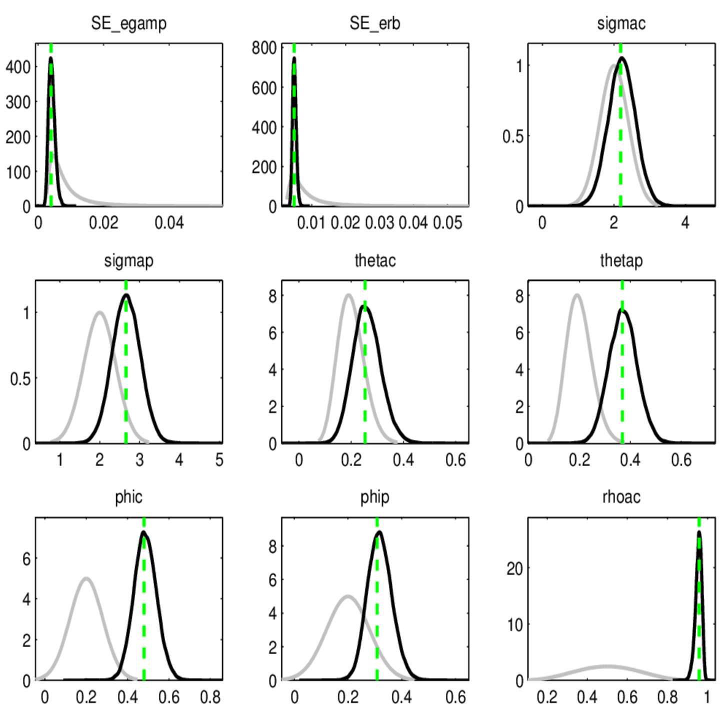

rhogc (Interval)
rhogc (m2)
rhogc (m3)
rhogp (Interval)
rhogp (m2)
rhogp (m3)
x 10^5
x 10^-4
x 10^-5

Figure A.3: Bayesian Estimation, Priors and Posteriors





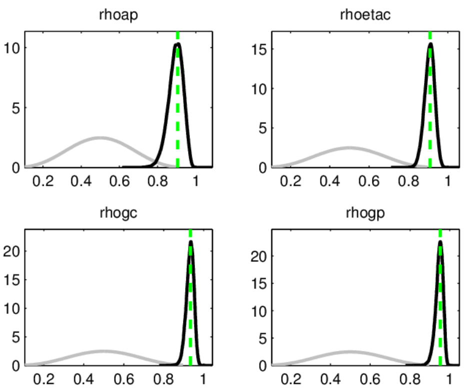


Figure A.4: Bayesian Estimation, Identification Analysis