The London School of Economics and Political Sciences

Financial Intermediation, Economic Development and Business Cycles Fluctuations

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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Declaration of Joint Work

I certify that Chapter 3 of this thesis describes joint work with Pau Rabanal. The work presented in Chapter 3 was conceived together and it reflects input from both authors. Overall, my net contribution is 50%.

Abstract

Identifying the effects of the financial sector on economic growth and business cycles fluctuations has been one the main debates in economics during the last decades. While a lot of progress has been done, we are still far from fully understanding the channels linking the financial sector with the rest of the economy.

In the first chapter I focus on the relation between financial development and economic growth. I obtain a measure of the impact of financial development on output from a dynamic general equilibrium model with a productive financial sector. The model predicts that having access to a better financial technology reduces the cost of credit and increases the net return of investment, generating positive and sizeable effects on output. The benefits from a better financial technology are maximized when it is used to invest in ex-ante riskier, but more profitable, investment projects.

In the following two chapters I focus on the relation between the performance of the financial sector and business cycle fluctuations. First, I study the impact of credit standards policies. The model used is able to replicate the countercyclical pattern of credit standards documented by the literature. The increase in the probability of default during expansionary periods reduces the efficiency with which investment is transformed into capital. In addition, the increase in the default rate reduces the return of savings, which in turn reduces the labor supply. Second, I study the effects of the financial sector to the economy through the collateral channel for the case of Spain. I find that loosing monetary policy autonomy is of first order importance to cushion risk premium shocks, while this is not the case for housing demand shocks. In addition, labor market rigidities provide stronger amplification effects to all type of shocks than financial frictions do.

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"A banker is a fellow who lends you his umbrella when the sun is shining, but wants it back the minute it begins to rain." *Mark Twain*

Contents

Chapter 1

The Effects of Financial Technology and Credit Recovery Efficiency on Economic Growth

Ever since Goldsmith (1969) economists have been trying to establish how important financial development is in fostering economic growth. Proving a causal link has been difficult due to endogeneity problems. I take a step forward by identifying the effects of exogenous changes in financial development and credit recovery efficiency on output using a dynamic general equilibrium model with a productive financial sector. The calibration of the model at the steady state for a panel of countries allows me to identify the level of financial technology and the risk-return investment profile for each of them. Having access to a better financial technology reduces the cost of credit and increases the net return of investment, generating positive and sizable effects on output. The benefits from a better financial technology are maximized when it is used to invest in ex-ante riskier, but more profitable, investment projects.

1.1 Introduction

Ever since Goldsmith (1969) economists have been trying to establish how important financial development is in fostering economic growth. Now, there is a well established literature showing a positive relation between them. The seminal papers of King and Levine (1993a) and (1993b) were the first to document a positive association between different measures of financial development and economic growth. This raised a fundamental question: was the higher level of financial development the result of a higher level of economic development? Or did instead the former lead to the later?.

Proving a causal relationship has resisted decades of research. The main difficulty has been in identifying the growth of output that is caused by exogenous changes in financial development. Three different approaches have been taken to overcome this problem. One approach uses instrumental variables that are correlated with cross-country differences in financial development, but which are uncorrelated with economic growth beyond their link with financial development and other growth determinants (La Porta, Lopez-de-Silanes, Shleifer and Vishny (1998), Levine (1998) and Levine Loayza and Beck (2000)). A second approach relies on industry-level and firm-level data across a broad cross-section of countries (Rajan and Zingales (1998), Fisman and Love (2003) and Bena and Jurajda (2007)). They find that the effects of financial development are especially pronounced on those industries that rely more on external finance. Finally, there is a large literature analysing how changes in financial regulation have affected regional growth (Jayaratne and Strahan (1996), Guiso, Sapienza and Zingales (2002) and Bertrand, Schoar and Thesmar (2007)).[1]

The literature mentioned above makes the rejection of a causal effect of financial development on economic growth very difficult. However, we still lack a reliable quantitative measure of the contribution of financial development to output, and the transmission mechanisms through which it ends up enhancing economic growth

[1] See Levine (2005) for a more extended discussion of the theoretical and empirical literature.

are far from being understood. As Levine (2004, p. 86) says:

> *"To the extent that financial systems exert a first-order impact on economic growth, we need a fuller understanding of what determines financial development ... much more work is required to better understand the role of financial factors in the process of economic growth."*

The aim of this paper is to take a step forward in understanding the mechanics of financial development and to obtain a quantitative measure of the effects on output. To do so, I develop a general equilibrium model with two sectors: a sector that produces consumption goods and a productive financial sector. Firms on the former sector combine labor and capital to produce consumption goods. To increase the stock of capital, which depreciates over time, firms obtain funding from financial intermediaries and invest in risky investment opportunities. Financial intermediaries base the loan approval decision on an estimate of the probability of default of each investment project. The production structure of the financial sector is similar to that of Hauswald and Marquez (2003) and Ruckes (2004), in which the default rate depends on the resources that banks spend generating information about the quality of each investment project to be financed, the financial technology and, of course, the risk of the investment project. From a general equilibrium point of view, the conceptual modeling strategy of the financial sector is similar to Boyd and Prescott (1986), Greenwood and Jovanovic (1990), and Greenwood, Sanchez and Wang (2007): financial intermediaries affect economic growth to the extent that their performance modifies the efficiency with which the resources are allocated. By improving information on firms, financial intermediaries can accelerate economic growth.

Then, the model is calibrated at the steady state for a panel of countries. The modeling of the financial industry as a productive sector allows to calibrate the deep variables of the financial sector of each country. More precisely, the values of the risk return investment profile and the financial technology are chosen such that the cost of credit and the default rate are equal to the historical average value for each country.

To asses the goodness of the calibration of the model I first construct a cross country data set and study the relation of output with the credit to output ratio, the traditional measure of financial development, and different variables that can, potentially, uncover the mechanics of financial development: the default rate, the cost of credit and the credit recovery efficiency. Following Levine (1993), this is done using a cross-country panel data-set and comparing the cross-country time series averages. As expected, there is a positive and strong relationship between the credit to output ratio and output. The rest of the variables also exhibit a clear pattern: in richer countries credit is cheaper, the default rate is lower and the credit recovery efficiency is higher. The cross-correlations generated by the calibrated model turn out to be very similar to those obtained from the real data. They also provide interesting insights when analyzing the calibrated risk-return investment profile and the financial technology. Richer countries invest in more risky projects, but that deliver higher returns if they succeed. Richer countries are also associated with a better financial technology.

To understand the importance the model assigns to each factor for economic growth, I analyse how the calibrated output, consumption and investment change when the financial technology, the credit recovery efficiency and the risk-return investment profile are changed exogenously for each country. When the financial technology of all countries is exogenously changed for the value of the most financially developed country, the cross-country average increase of output is 0.7%, while consumption and investment increase 0.5% and 1.5% respectively. When, in addition to changing the financial technology, the risk-return is also exogenously changed to the values of the most financially developed country, the average increase of output, consumption and investment is 15%. Financial technology enhances economic growth significantly, but its maximum profitability is obtained when it is used to invest in riskier and more profitable projects. The effects of changing the credit recovery efficiency turn out to be insignificant since the increase of the net return it produces is substantially lower than the increase obtained from high risk-return projects when investing with a developed financial technology.

The analysis of the cross-country effects of the change in the financial sector fundamentals also allows us to track the transmission mechanism of financial development predicted by the model. On the one hand, a better financial technology reduces the cost of credit and the NPL rate. This, in turn, increases the net return of investment. On the other hand, an exogenous change in the risk-return investment profile only has positive effects on output if it is accompanied with a better financial technology. This is key to obtain the high return of investment projects with a moderate default rate.

The rest of the paper is organized as follows. The model is presented in section 1.2, and the calibration at the steady state in section 1.3. Section 1.4 discusses the goodness of the calibration of the model and the relation between the financial sector fundamentals and the rest of the economy. The contribution of financial development to economic growth and its transmission mechanisms are presented in section 1.5. The conclusions are presented in section 1.6.

1.2 The model

The model economy is composed by a measure one of identical and infinitely lived agents. Agents are endowed with one unit of time each period, which can be used to work and to enjoy leisure. There are two perfectly competitive sectors in which they can work: the final goods production (FGP) sector and the financial sector. The former produces consumption goods combining capital and labour. To increase the stock of capital, which depreciates over time, firms obtain funding from financial intermediaries and invest into risky investment projects. Financial intermediaries base the loan approval decision on an estimate of the probability of default of each investment project, and only approve those from which they expect positive returns.

1.2.1 Final Good Producers

There is a large number of perfectly competitive final good producers. Each final good producer j produces consumption goods using capital, k_j, and labour, $n_{j,c}$, according to a Cobb-Douglas production function

$$n_{j,c,t}^{\alpha} k_{j,t}^{1-\alpha}$$

A fraction δ of capital depreciates each period. However, firms have access to an infinite set of investment opportunities. Each investment opportunity requires 1 unit of the consumption good and only a fraction $p \in (0,1)$ of them deliver positive units of the capital good, $r_I > 0$. These new units of capital become productive the following period, and depreciate over time with the rest of capital at a rate δ. The remaining investment opportunities, a fraction $1-p$, fail to produce any capital good, and consume $1-\tau$ units of the initial investment, where $0 < \tau < 1$. All variables concerning the investment technology, p, r_I and τ, are exogenous to final good producers and they are known by all agents of the economy. What no agent knows is which investment opportunities are profitable, and which ones are not.

For each investment project that a FGP wishes to perform, $i_{j,t}$, it has to apply for funding to a financial intermediary. Financial intermediaries base the loan approval decision upon an estimate of the probability of default of the investment project. The loan application is approved with probability θ_t. An investment project that obtains funding succeeds with probability $q_t \geq p$, depending on the accuracy of the estimation of the probability of default. This is assumed to be non-observable, and hence, final good producers have to take it as given. If the investment project succeeds, final good producers pay the lending interest rate $r_{B,t}$. If the investment project turns out to be non-productive, they can only promise to pay back τ. It is assumed that they cannot pledge the stock of capital as collateral when applying for a loan. However, it is also assumed that financial intermediaries have access to the returns from investment projects since they supervise them closely from the moment they are initiated. Therefore, the transition equation of capital is:

$$k_{j,t} = (1-\delta)k_{j,t-1} + r_I q_t \theta_t i_{j,t} \tag{1.1}$$

Following Greenwood, Hercowitz, and Krusell (1997) and Fisher (2006), r_I captures the efficiency with which consumption goods are transformed into capital.

Note that while in a traditional RBC model investment is transformed one to one into capital, in the current set up the transition equation of capital has a crucial role since it connects both sectors. The ability of firms to accumulate capital depends on the tightness of lending policies, θ_t, and the accuracy of the estimation of the probability of default, q_t.

The firm's optimisation problem becomes:

$$\begin{aligned} V_{j,t}\left(k_{j,t}; a_t, r_{I,t}\right) &= \max_{(i_{j,t}, n_{j,c,t})} \left((a_t n_{j,c,t})^{\alpha} k_{j,t}^{1-\alpha} - w_{c,t} n_{j,c,t} - r_{k,t} \frac{k_{j,t}}{\hat{r}_t} \right) \\ &\quad + \beta V_{j,t+1}\left(k_{j,t+1}; a_{t+1}, r_{t+1}\right) \end{aligned}$$

$r_{K,t}$ is the rental rate of capital and $w_{c,t}$ the wage rate. The relative price of capital with respect to consumption goods, $\hat{r}_t$, is,

$$\hat{r}_t = \frac{q_t r_I}{\bar{r}_{B,t}} = \frac{q_t r_I}{q_{i,t} r_{B,t} + (1-q_{i,t})\tau}$$

the first order conditions resemble those obtained with a traditional RBC model,

$$r_{K,t} \frac{k_{j,t}}{\hat{r}_t} = (1-\alpha)\, y_{j,t} \tag{1.2}$$

$$w_{c,t} = \alpha \frac{y_{j,t}}{n_{j,c,t}} \tag{1.3}$$

namely that the marginal cost of both production factors, $w_{c,t}$ for labour and $r_{K,t}$ for capital, have to be equal to the marginal profits.

1.2.2 The Financial Sector

The financial sector is populated by a large number of perfectly competitive financial intermediaries. Each financial intermediary i has to decide each period how many investment projects to analyse $i_{i,t}$, and the accuracy of the analysis it performs. As described before, investment projects can be of two types, $\pi \in (H, L)$. Type H investment projects are those that deliver $r_{I,t}$ units of the capital good, while type L projects produce zero units of the capital good, and destroy $1 - \tau$ units of the initial investment. Financial intermediaries, as the rest of the agents in the economy, cannot observe the true type of each project. However, by analysing them, they can obtain an imperfect signal about the project type, $\eta \epsilon (H, L)$. The precision of the signal, *i.e.* the probability that the signal is correct, is given by:

$$\phi_{i,t} = P(\eta = H \mid \pi = H) = 1 - 0.5 \exp\left(-\lambda_t \frac{n_{i,f,t}}{i_{i,t}}\right) \tag{1.4}$$

The precision of the signal depends on the amount of resources spent to produce information, $n_{i,f}$, per investment project analysed, $i_{i,t}$: for the same level of resources spent, the larger is the number of projects analysed, the lower is going to be the quality of the analysis and hence, the precision of the signal produced is going to be worse. Following the recently developed micro literature on banking (Hauswald and Marquez (2003), D'ella Riccia and Marquez (2006) , Ruckes (2004) and Amian (2006)), it is assumed that there are two key ingredients that determine the quality of the information produced: the risk analysis technology available, λ_t, which is assumed to be exogenous, and the soft information produced by local bankers, $n_{i,f,t}$[2]. Intuitively, if a financial intermediary has no one analysing the investment

[2] $n_{i,f,t}$ captures both the positive effect of spending more time in analysing each investment project, and the positive effect of having each financial intermediary closer to its customers, an important determinant of the quality of the information produced raised by Hauswald and Marquez

projects, $n_{i,f,t} = 0$, the signal produced will be totally uninformative , *i.e.* it will be independent of the true type of each project, $\phi_{i,t} = 0.5$. However, the greater the amount of labour resources spent in analysing them, or the more efficient is the risk analysis technology, the better is the precision of the signal produced. At the limit, if the technology available is infinitely precise, or the labour resources used are infinitely large, financial intermediaries will be able to distinguish type H and type L projects perfectly, *i.e.* $\phi_{i,t}$ will equal 1.

Given that only type H projects are profitable, financial intermediaries only accept to provide funding to those investment projects from which they obtain a positive assessment. However, as the information they produce is not perfect, they also end up providing funding to the non-profitable investment projects that are misclassified. The probability that an investment project is accepted is given by:

$$\begin{aligned} \theta_{i,t} &= P(\eta = H \mid \pi = H)P(\pi = H) + P(\eta = H \mid \pi = L)P(\pi = L) \qquad (1.5) \\ &= \phi_{i,t}p + (1 - \phi_{i,t})(1 - p) \end{aligned}$$

and it depends on both the quality of the information produced by the financial intermediary, $\phi_{i,t}$, and the percentage of type H and type L projects in the economy, p, which is assumed to be exogenous.

The final lending of each intermediary i is a fraction $\theta_{i,t}$ of all investment projects analysed, $i_{i,t}$:

$$l_{i,t} = \theta_{i,t} i_{i,t} \qquad (1.6)$$

and the expected probability of success is given by:

(2005) and Amian (2007).

$$
\begin{aligned}
q_{i,t} &= \frac{P(\eta = H \mid \pi = H)P(\pi = H)}{P(\eta = H \mid \pi = H)P(\pi = H) + P(\eta = H \mid \pi = L)P(\pi = L)} \\
&= \frac{\phi_{i,t}p}{\phi_{i,t}p + (1-\phi_{i,t})(1-p)}
\end{aligned}
\tag{1.7}
$$

i.e., the fraction of investment projects that were correctly assessed among all investment projects accepted.

Intermediaries decide how many investment projects to analyse and the amount of labour resources to use in each period, taking $r_{B,t}$, $r_{D,t}$, $w_{f,t}$, τ and p as given. Then, they obtain the returns from lending, which they use to pay back the deposits. Financial intermediaries' optimisation problem is:

$$
V_{i,t} = \max_{(i_{i,t}, n_{i,f,t})} \left(q_{i,t}r_{B,t} + (1-q_{i,t})\tau\right) l_{i,t} - w_{f,t}n_{i,f,t} - r_{D,t}d_{i,t} \tag{1.8}
$$

Further insights on the trade off that financial intermediaries face can be obtained using equations (1.5), (1.6), (1.7), and the fact that the amount of deposits raised, $d_{i,t}$, is equal to the amount of lending, $l_{i,t}$. The maximisation problem becomes:

$$
V_{i,t} =
$$

$$
\max_{(i_{i,t}, n_{i,f,t})} (p\phi_{i,t}(r_{B,t} - r_{D,t})i_{i,t} - (1-\phi_{i,t})(1-p)(r_{D,t} - \tau)i_{i,t} - w_{F,t}n_{i,F,t}) \tag{1.9}
$$

This shows that the profits of financial intermediaries depend on the income they obtain from the interest margin, $r_{B,t} - r_{D,t}$, of the projects that succeed, and the interest cost, $r_{D,t} - \tau r_{B,t}$, they suffer from those loans that were misclassified. The trade off faced by financial intermediaries consists on increasing their lending by augmenting the number of investment projects analysed, at the cost of a worse estimation of the probability of default, or to reduce the volume of lending, with the benefit of having a pool of loans of better quality. This trade off is reflected in the first order conditions:

$$(r_{B,t} - r_{D,t})i_{i,t}p_t\frac{\partial \phi_{i,t}}{\partial n_{i,f,t}} + (r_{d,t} - \tau)(1 - p_t)i_{i,t}\frac{\partial \phi_{i,t}}{\partial n_{i,f,t}} = w_{F,t} \tag{1.10}$$

$$(r_{B,t} - r_{D,t})p_t\phi_{i,t} = (r_{B,t} - r_{D,t})i_{i,t}p_t\frac{\partial \phi_{i,t}}{\partial i_{i,t}} + (r_{D,t} - \tau)(1 - p_t)\left((1 - \phi_{i,t}) + i_{i,t}\frac{\partial \phi_{i,t}}{\partial i_{i,t}}\right) \tag{1.11}$$

Equation (1.10), the first order condition with respect to $n_{i,f,t}$, shows that an increase of the labour force increases its profits to the extend that it improves the quality of the information in which they are based when deciding whether to accept or deny a borrowing application. A better precision of the signal allows them to increase the proportion of lending to profitable projects, and hence, to increase the amount of lending from which they obtain a benefit $(r_{B,t} - r_{D,t})$, and to reduce the amount of lending from which they loose $(\tau - r_{D,t})$. Equation (1.11), the first order condition with respect to $i_{i,t}$, shows that financial intermediaries maximise expected profits choosing the amount of investment projects to analyse that balances the increased expected income obtained through a higher volume of lending, left hand side of the equation, and the reduction of it due to the lower quality of the information produced, right hand side of the equation.

1.2.3 Preferences

The model economy is composed by a continuum of measure 1 of infinitely lived agents. To maximise the expected present discounted value of utility, agents decide how much to consume, how much to save and how much to work at every period. That is,

$$\max \sum_{t=0}^{\infty} \beta^t \ln c_t - \psi(n_{C,t} + n_{F,t})$$

s.t:

$$c_t + d_{t+1} + \frac{k_{t+1}}{\hat{r}_t} = w_{c,t}n_{c,t} + w_{f,t}n_{f,t} + r_{D,t}d_t + r_{K,t}\frac{k_t}{\hat{r}_t} \tag{1.12}$$

Where c_t is the consumption at period t, d_t is the amount of deposits (or savings), k_t is the capital rented to FGP and ψ is a parameter capturing the disutility of effort.

The first order condition with respect to savings, d_t,

$$1 = \beta E_t \left(\frac{c_t}{c_{t+1}} r_{D,t+1} \right) \tag{1.13}$$

delivers the standard Euler equation relating present and future consumption as a function of the return from savings. A similar Euler equation is obtained from the first order condition with respect to capital, k_t,

$$1 = \beta E_t \left(\frac{c_t}{c_{t+1}} \frac{\hat{r}_t}{\hat{r}_{t+1}} (1 - \delta) r_{K,t+1} \right) \tag{1.14}$$

It takes into account the relative price of investment with respect to consumption goods over time.

The supply of labour in each sector is given by,

$$w_{C,t} = w_{F,t} = \psi c_t \tag{1.15}$$

1.2.4 Market clearing conditions

The labour demand from both sectors equals the labour supplied by consumers:

$$N_{c,t}^{d} = N_{c,t}^{s}$$

$$N_{f,t}^{d} = N_{f,t}^{s}$$

And hence, the total number of hours worked in both sectors equals the total number of hours worked:

$$N_{c,t} + N_{f,t} = N_t$$

The supply of savings of consumers equals the demand of deposits from financial intermediaries:

$$D_t^s = D_t^d$$

The demand from loans from FGP equals the supply of lending by financial intermediaries:

$$L_t^s = I_t^d$$

And the aggregate level of consumption and savings equals the aggregate production of consumption goods in the economy:

$$C_t + D_t = Y_t$$

1.3 Calibration of the model at the steady state

As is customary in the literature, the objective is to use the minimum number of parameters of the model to match the data. To have a good characterisation of the financial sector of each country, the key variables of it, the lending rate, $r_{B,}$, the deposit rate, r_D, and the default rate, $1-q$, are calibrated for each country. The model is calibrated at a quarterly frequency.

1.3.1 Fixed parameters

The output to capital ratio, Y/K, is obtained from the Penn World tables (PWT). Briefly, Y is GDP in purchasing power parity (PPP) in 1996. The capital stock, K, is constructed with the perpetual inventory method from time series data on real investment (also from the PWT). The depreciation rate of capital , δ, is 0.01.

According to the model, the labor income in the FGP sector to output is

$$\alpha = \frac{w_c N_c}{Y}$$

This is different from the labor share usually estimated in the literature because it does not contain the labor income from the financial sector. To obtain an appropriate measure of the labor share, the standard labor share is rescaled by the share of labor in the non-financial industry,

$$\alpha = \alpha^* \frac{N_c}{N}$$

Estimates of the labour share in output, α^*, for each country are obtained from Caselli and Feyrer (2007), who expand the cross-country data initiated by Bernanke and Gurkaynak (2001) and Gollin (2002), and take into account the employee compensation in the corporate sector from the National Accounts, plus a number of adjustments to include the labor income of the self-employed and non-corporate employees. The share of labor in the non-financial sector is obtained from the International Labor Organisation.

The values of the amount of resources that financial intermediaries recover in case the investment project fails, τ, for each country are obtained from Djankov, Hart, McLiesh and Shleifer (2006), who estimate the average cents of a dollar that are recovered after a borrower defaults for a large panel of countries between 2002 and 2007.

1.3.2 Calibrated parameters

The following 6 parameters are calibrated: the discount factor, β, the return on investment, r_I, the fraction of type H projects, p, the return of capital, r_K, and the financial technology, λ. The first 3 parameters are chosen so that the model matches the following 3 moments: the average real interest rate of deposits, r_D, the average real interest rate of lending, r_B, and the average default rate of lending, $1-q$.

The calibration of the endogenous parameters proceeds as follows. The discount factor is chosen such that the deposit interest rate is equal to the average real deposit interest rate for the last ten years at a quarterly frequency.

$$r_D = \frac{1}{\beta}$$

The deposit interest rate for each country is obtained from the IMF International Financial Statistics database and is deflated using the CPI. The value for the return of capital is obtained combining the two Euler equations,(1.13) and (1.14),

$$r_K = r_D - (1-\delta)$$

The lending rate is determined using the first order condition of the FGP optimisation problem with respect to capital,

$$\bar{r}_B = \frac{q r_I (1-\alpha) \frac{Y}{K}}{r_K}$$

The value of the fraction of type L investment projects accepted, $1-q$, is equal to the average non-performing loans rate of each country. The data is obtained from the IMF Financial Soundness Indicators database, which is the result of an effort to compile comparable indicators of NPL. In order to use the most comparable set of countries, only those reporting the NPL rate at a domestically controlled, cross-border and cross-sector consolidation basis are considered. This limits the data set to 19 countries. Then, the value chosen for the return of investment, r_I, is such that the value of the lending rate is equal to the average real reference rate for commercial loans (the prime rate) for the last 2 decades.

The value chosen for the fraction of type H investment projects in the economy, p, is such that the fraction of type L investment projects accepted, $1-q$, is equal to the average NPL rate described above. To obtain q as a function of p some algebra is needed. First, the definition of ϕ, equation (1.4), is rewritten as,

$$\lambda \frac{N_f}{I} = \log \frac{0.5}{1-\phi} \tag{1.16}$$

Then, the financial technology parameter, λ, the labor in the financial sector to investment ratio, $\frac{N_f}{I}$, and the accuracy of the information produced by loan officers, ϕ, are substituted for functions of q and p. The labor in the financial sector to investment ratio is obtained using the definition of lending, equation (1.6), and the first order condition *w.r.t.* I, equation (1.11),

$$\frac{I}{N_f} = \frac{\lambda(1-\phi)p}{\theta} \frac{IM + IC}{NIM} \tag{1.17}$$

where, IM, is the potential interest margin,

$$IM = p(r_B - r_D)$$

IC is the potential interest cost,

$$IC = (1-p)(r_D - \tau)$$

and NIM is the net interest margin,

$$NIM = qr_B + (1-q)\tau - r_D$$

The accuracy of the information produced by loan officers, ϕ, is obtained rewriting the definition of the default rate, equation (1.7), as,

$$\phi = \frac{q(1-p)}{q(1-p)+(1-q)p} \tag{1.18}$$

and the function for the financial technology parameter is obtained from the first order condition with respect to n_f,

$$\lambda = \frac{w^f}{(1-\phi)p(IM+IC)} \tag{1.19}$$

To evaluate how different financial sectors affect economic development, we also obtain the main aggregates of the economy from the calibrated model. Total credit is obtained using equation (1.17) and the level of hours worked in the financial sector, N_f. This, in turn, requires first to get the relative labour force combining equations (1.17) and (1.1),

$$\begin{aligned} \frac{N_f}{N_c} &= \frac{N_f}{L}\frac{L}{K}\frac{K}{N_c} \qquad (1.20) \\ &= \frac{w}{NIM}\frac{rq}{\delta}\left(\frac{K}{Y}\right)^{\frac{1}{\alpha}} \end{aligned}$$

and then, to normalise the total amount of hours worked, N, to 0.3. N_f is,

$$N_f = \frac{N}{1 + \frac{N_c}{N_f}}$$

We obtain the values of K and Y using the transition equation of capital, equation (1.1), and the production function of output,

$$K = \frac{r_I q L}{\delta}$$

$$Y = N_c^{\alpha} K^{1-\alpha}$$

The level of consumption is obtained using the aggregate budget constrain:

$$C = Y - D$$

1.4 Analysis of the model at the steady state

In this section, first I document the relation between financial sector variables and economic development using a cross-country data set. Then, I analyze the cross-country correlations of the variables obtained from the calibration of the model at the steady state. The goodness of the calibration of the model is assessed by comparing the cross-correlations generated by the model with those obtained from the data. Next, I analyze the relation of the calibrated deep financial sector variables, the financial technology parameter and the risk-return profile, with the rest of the variables of the financial sector, and the main aggregates of the economy.

1.4.1 Benchmark cross-country correlations

One of the indicators of financial development that has been more widely used is the credit to output ratio. The seminal contribution of King and Levine (1993) documents its positive relationship with output using a panel of more than 70 countries. More precisely, they analyze the relation between cross-country averages of the credit to output ratio and output growth. This section follows a similar approach and documents the relation of the credit to output ratio, and other financial sector specific variables with output and investment. These variables are the cost of credit, the return from savings, the default rate and the credit recovery efficiency. The relation between output and the output to capital ratio is also documented. As argued in Corrado, Hulten and Sichel (2006) and Greenwood, Sanchez and Wang (2007), capital deepening could be the result of a more efficient financial intermediation, which, by reducing its costs, increases the relative importance of the capital stock on the economy.

Data for output per worker and the output to capital ratio is obtained from the Penn World tables. The credit to output ratio is obtained from the World Bank Financial Development Indicators, and the lending and deposit rates are obtained from the IMF International Financial Statistics. To compare the relation between different financial systems and the economy at the steady state, 10 year averages of the data are taken. The estimates of the credit recovery efficiency are obtained from Djankov, Hart, McLiesh and Shleifer (2006), who estimate the average cents of a dollar that are recovered after a borrower defaults for a large panel of countries between 2002 and 2007. The NPL rate is obtained from the IMF Financial Soundness Indicators. Comparable data across countries is only available for the last 5 years and for 19 countries.

The cross-country correlations are reported in Table (1.1), and Figures (1.1) and (1.2) present detailed cross-country scatter plots. As it has been widely documented by the literature, there is a positive and strong correlation between output per worker and the credit to output ratio. This is reassuring since we are dealing with a limited data set. Interesting insights are also obtained from the other financial sector variables. The real lending and deposit rates are lower in more developed countries. The credit recovery efficiency is also highly correlated with economic development, being higher in richer countries. Finally, the NPL rate is lower in richer countries.

Apart from output, the financial sector variables are also correlated with investment and the credit to output ratio. The latter appears to be specially related to the cost of credit and the non-performing loans rate: a lower cost of credit and a lower level of the default rate are associated with higher levels of the credit to output ratio. The output to capital ratio also appears to be strongly and negatively correlated with output.

The cross-correlations documented in this section will be later used as a benchmark to asses the ability of the model to replicate the data.

1.4.2 Cross-country correlations generated by the model

The cross-country correlations of the calibrated variables from the model are compared with those obtained from the data in Table (1.1), and Figures (1.3) to (1.5) provide detailed cross-country scatter plots. The relation of output with respect to the level of credit as well as the credit to output ratio is qualitatively the same as the one documented in the previous section. It is worth noting that the cross-country correlation is also quantitatively very similar, indicating a strong and positive relation between output and credit, as it has been widely documented by the literature. The output to capital ratio is also strongly negatively correlated with output and credit.

The model also succeeds in replicating the relation between financial sector specific variables and aggregate variables: the credit recovery efficiency is positively and strongly related with output and credit, the NPL rate is negatively related with output and credit, and both, lending and deposits, are cheaper in richer countries.

Regarding the calibrated deep financial variables, the results reported in Table (1.2) show that the financial technology is strongly negatively correlated with the NPL rate. It is also negatively related to the cost of credit. A better financial technology is present in those countries with a more efficient credit recovery rate, and it is strongly and positively related with the main economic aggregates, namely credit and output.

The risk return investment profile also varies substantially across countries: those investing into riskier, but also more profitable projects have a higher level of credit, a higher credit to output ratio and higher level of output. Interestingly, even if they invest into ex-ante riskier projects, their NPL ratio is lower. This may be the reason why, even if ex-ante those projects are riskier, they end up being growth enhancing. Given that the financial technology is negatively related to the NPL rate, and it is positively related with those countries investing into riskier and more profitable projects, it is a good candidate to explain how a riskier investment profile can end up being growth enhancing.

The evidence presented so far does not help to identify if the financial sector is an engine for economic growth or, on the contrary, if its development is just the result of higher economic activity, even if the insights obtained from the calibrated financial technology parameter and the risk-return investment profile of each country make the later reasoning more difficult to defend. A measure of the importance of financial technology to perform riskier investment strategies, and their role in fostering economic growth should help answering the question. These are the issues tackled in the next section.

1.5 The effects of financial development

This section tries to disentangle the relation between the financial sector fundamentals and economic aggregates documented in the previous section. To do so, it analyzes the response of the economy to an exogenous change of the financial sector fundamentals: the financial technology, λ, and the credit recovery efficiency, τ. The interaction of these changes with a change in the risk-return investment profile is also studied. This allows ascertaining if the model attributes part of the output differential between countries to differences in the financial sector fundamentals.

Furthermore, analyzing the impact that these exogenous changes have at the different stages of financial development provides some information about the channel through which financial development contributes to economic growth.

Re-calibrating the model

In order to analyze how changes in financial technology, the credit recovery efficiency and the risk-return investment profile affect economic growth, p, r, τ and λ are treated as exogenous parameters, and r_B, r_D, q and Y/K are endogenously determined.

The calibration of the endogenous parameters proceeds as follows: to obtain the new default rate, $1-q$, we fix p using equation (1.5). We also have to rewrite equation (1.4) as,

$$\frac{N_F}{I} = \frac{1}{\lambda} \log \left(\frac{1}{2(1-\phi)} \right) \tag{1.21}$$

the first order condition from the financial intermediaries problem with respect to I, equation(1.11), as,

$$r_B = \frac{\left(\lambda(1-\phi)(1-2p) + \frac{L}{N_F}\right) r_D + \left(\lambda(1-\phi)(1-p) - \frac{L}{N_F} q\right) \tau}{(1-q)\frac{L}{N_F} - \lambda(1-\phi)p} \tag{1.22}$$

the first order condition of FGP with respect to capital, equation (1.2), as,

$$\frac{Y}{K} = \frac{r_K}{\hat{r}(1-\alpha)} \tag{1.23}$$

and the first order condition of FGP with respect to labor,

$$w = \alpha \left(\frac{K}{Y} \right)^{\frac{1-\alpha}{\alpha}} \tag{1.24}$$

Finally, rewriting the first order condition with respect to N_F,equation (1.10), as,

$$1 - \phi = \frac{w}{\lambda\left(p(r_B - r_D) + (1-p)(r_D - \tau)\right)} \tag{1.25}$$

The value of ϕ is obtained after replacing equations (1.7), (1.21), (1.22), (1.23) and (1.24) in equation (1.25). The new value of the default rate, $1-q$, is obtained using equation (1.7). Then, the new lending rate is obtained using equations (1.21) and (1.22), and the new output to capital ratio from equation (1.23). The values for the total output, credit and consumption are obtained as before.

Exogenous changes in financial development

To study the effect that financial sector fundamentals may have on economic growth the value of the financial technology and the credit recovery efficiency of each country are exogenously changed for the values calibrated for Finland, who has the most developed financial sector. The same is done for the risk-return investment profile.

The first two columns of Table (1.3) present the average cross-country effect of the change in financial technology and the credit recovery. A better financial technology reduces the default rate substantially. It also has a negative impact on the cost of credit and a positive impact on the economic aggregates. The results from changing the credit recovery efficiency go in the opposite direction. Even if a higher financial recovery efficiency reduces the cost of credit, the resultant increase in the return leads financial intermediaries to increase the volume of credit without increasing the accuracy of the information produced accordingly. The result is a significant increase of the default rate that ends up hurting consumption and output.

The effects of having a more risky and more profitable investment profile are presented in columns (3) to (6). If the financial technology and the recovery efficiency are kept fix, investing into riskier projects has highly damaging effects for the economy. The cost of credit and the default rate soar, while the levels of consumption, credit and output are depleted. Things change a lot when the value of the financial technology is also changed. A better financial technology allows investing in riskier projects with a lower default rate and a lower cost of credit. By extracting the maximum benefit from the high yielding projects, all aggregates rise substantially. The interaction between financial technology and the risk-return investment profile appears to be crucial to enhance economic growth. As it could be expected from the results obtained in column (2), a better credit recovery efficiency does not add much to it.

The transmission channel of financial development

This section exploits the cross-section variation of changing the financial technology, the credit recovery efficiency and the risk-return investment profile of countries to better understand the transmission channel of financial development produced by the model. The results are presented in Table (1.4). The first raw shows that poorer countries are those experiencing higher increases of the financial technology, and that the higher is the change in the financial technology, the higher is the increase of output, credit and consumption. A similar reasoning applies for the risk-return investment profile: poorer countries are those investing into safer and less profitable projects, and are those that benefit more from changing the investment profile.

To see how the change in financial technology and the risk-return investment profile ends up affecting the aggregate variables, first it is analyzed how the financial variables change. Then it's analyzed how these changes are related with the changes of the aggregate variables. As shown in the right hand side of Table (1.4), greater improvements of the financial technology are related to greater drops in the cost of credit and the default rate, and to greater increases in the net return of investment. The return of investment also has a direct impact on the net return of it, as well as on the cost of credit. Finally, the countries that experience greater increases in the risk profile of their investment are those who see greater drops on the default rate.

In turn, the changes of the financial variables are also related to changes of the main aggregates. The results are presented in the last 3 rows of Table (1.4). The net return of investment and the cost of credit are strongly related to the aggregate ones. On the one hand, greater changes in the net return of investment are strongly positively related to greater changes in output, consumption and credit. On the other hand, the greater is the reduction of the cost of credit, the greater is the increase in output, consumption and credit. The default rate does not have a direct impact on the aggregate variables, and it only operates through improving the net return of investment and reducing the cost of credit.

Finally, there are signs that capital deepening occurs as a result of financial development, at least in part.

1.6 Conclusions

The recent empirical literature studying the impact that the financial sector has on economic growth concludes that it is significant and positive. However, we still lack a measure of the size of that impact. This paper takes a step forward on this direction by analyzing the effect of exogenous changes in the financial technology on output. To do so, I construct a dynamic general equilibrium model with two sectors: a sector that produces consumption goods an invests into capital goods, and a financial sector that provides funds and credit risk assessment to final good producers to invest in capital goods.

The model is calibrated for a panel of countries. The goodness of the calibration is assessed by comparing the cross-country correlations generated by the model with those obtained from a cross-country data set. The model turns out to replicate them fairly well. The calibration of the model at the steady state also allows us to obtain calibrated values of the financial technology and the risk return investment profile for each country. A better financial technology is associated with lower levels of the non-performing loans rate and cheaper credit. As expected, richer countries are those with a better financial technology. It is also found that richer countries perform ex-ante riskier, but more profitable, investments.

The importance of financial development for economic growth is studied from the effects of exogenous changes in the financial technology, exogenous changes in the credit recovery efficiency and their interaction with changes in the risk-return investment profile. It is found that the benefits from a better financial technology are maximized when it is used to invest into riskier, but more profitable, investment projects. The average cross-country increase of output is 15%.

Analysing the cross-section effects of the exogenous changes in the financial technology, the financial recovery efficiency and the risk-return investment profile allows us to track the transmission mechanism of financial development generated by the model. On the one hand, higher increases of the financial technology are associated with higher drops of the cost of credit, higher drops of the rates of non-performing loans and higher increases of the returns from investment. On the other hand, ex-ante riskier, but more profitable, investment profiles are associated with higher levels of the net-return of investment, provided that a country has access to a developed financial technology. Cheaper access to credit and higher net returns of investment are, in turn, strongly and positively associated to economic development.

1.A Appendix

1.A.1 Tables

Cross-country correlations: actuals vs. model predictions

	Output		Investment		Credit to Output	
	actuals	calibrated	actuals	calibrated	actuals	calibrated
Output			0.53	0.92	0.70	0.67
			(0.04)	(0.00)	(0.00)	(0.01)
Output to capital ratio	-0.74	-0.89	-0.69	-0.69	-0.33	-0.35
	(0.00)	(0.00)	(0.00)	(0.00)	(0.23)	(0.21)
Lending rate	-0.50	-0.40	-0.36	-0.36	-0.46	-0.24
	(0.06)	(0.14)	(0.19)	(0.19)	(0.09)	(0.40)
Deposit rate	-0.41	-0.43	-0.44	-0.44	-0.23	-0.36
	(0.12)	(0.11)	(0.10)	(0.10)	(0.41)	(0.19)
Non-performing loans rate	-0.40	-0.36	-0.38	-0.38	-0.47	-0.34
	(0.14)	(0.19)	(0.16)	(0.16)	(0.08)	(0.22)
Credit recovery efficiency	0.58	0.51	0.56	0.56	0.26	0.54
	(0.02)	(0.05)	(0.03)	(0.03)	(0.34)	(0.04)

Table 1.1: Stylised facts and predictions from the model. The p-values of the pairwise correlations are in parenthesis

Cross-country correlations of the non-observable variables calibrated

	Financial technology	Ex-ante risk of investment	Net return of investment
Output	0.57	0.55	0.64
	(0.03)	(0.04)	(0.01)
Investment	0.62	0.62	0.32
	(0.01)	(0.01)	(0.24)
Credit to Output	0.54	0.56	-0.09
	(0.04)	(0.03)	(0.74)
Lending rate	-0.35	-0.21	-0.40
	(0.20)	(0.45)	(0.14)
Deposit rate	-0.39	-0.34	-0.40
	(0.15)	(0.21)	(0.14)
Non-performing loans rate	-0.68	-0.57	-0.14
	(0.00)	(0.03)	(0.61)
Credit Recovery Efficiency	0.61	0.56	0.31
	(0.02)	(0.03)	(0.26)

Table 1.2: The p-values of the pairwise correlations are in parenthesis

Average (%) effects of changes in,						
Financial Technology	v	-	-	v	-	v
Recovery Efficiency	-	v	-	-	v	v
Risk-Return inv. Profile	-	-	v	v	v	v
lending rate	-0.80	-0.17	296.09	-0.40	266.09	-0.41
default rate	-92.23	73.50	7509.69	-76.91	8702.29	-71.88
consumption	0.51	-0.13	-32.88	15.30	-33.51	15.30
investment	1.15	0.26	-63.88	15.47	-61.36	15.48
output to capital ratio	-1.01	0.35	227.50	-21.95	240.46	-21.94
output	0.70	-0.02	-41.86	15.36	-41.59	15.36

Table 1.3: "v" indicates which exogenous shock is active.

	Aggregate Variables					Financial Variables		
	Y_0	ΔY	ΔI	ΔC	ΔYK	$\Delta(qr_I)$	Δr_B	$\Delta(1-q)$
Direct effects								
Change in financial tech.	-0.5421*	0.3403	0.3328	0.3463	-0.3196	0.4133	-0.6480*	-0.8153*
Change of return of inv.	-0.6680*	0.9661*	0.9585*	0.9681*	-0.9769*	0.9998*	-0.4033	-0.0332
Change of risk	-0.2200	-0.1879	-0.2151	-0.1771	0.0753	-0.0977	0.3219	-0.4877*
Indirect effects								
Change of net ret. of inv.	-0.6721*	0.9661*	0.9585*	0.9681*	-0.9748*			
Change of lending rate	0.2768	-0.4911*	-0.5087*	-0.4846*	0.2835			
Change of default rate	0.353	-0.0166	-0.0142	-0.0208	-0.0735			

Table 1.4: The transmission channel of financial developement

1.A.2 Figures

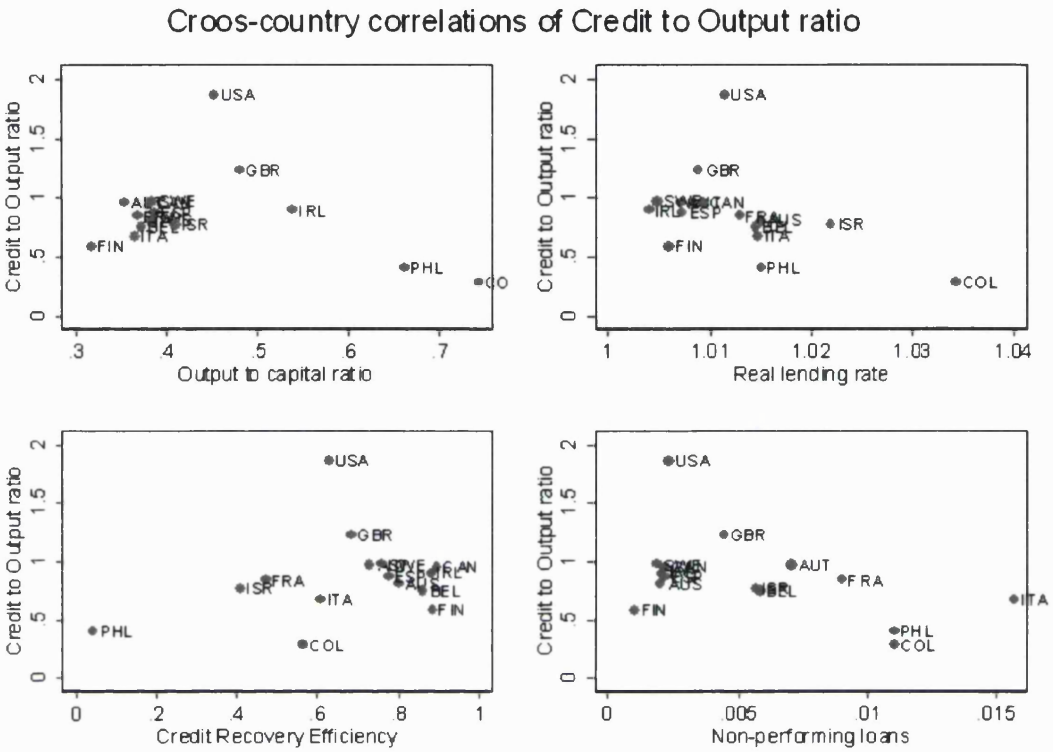

Figure 1.1: Stylised facts: cross-country scatter plots.

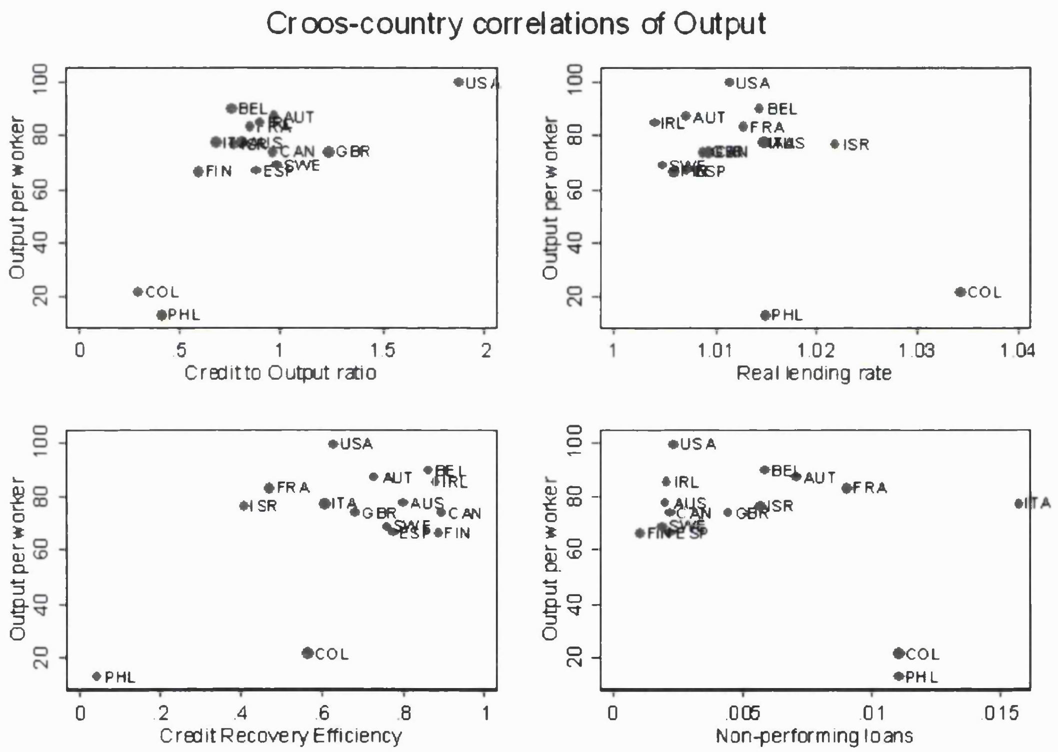

Figure 1.2: Stylised facts: cross-country scatter plots.

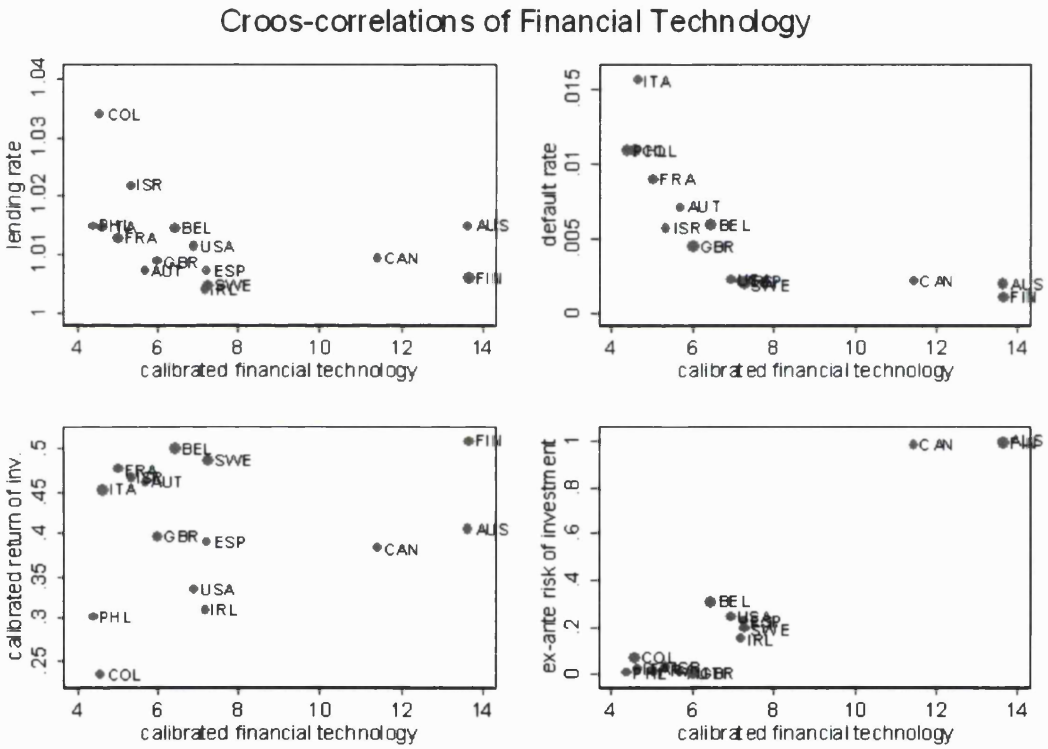

Figure 1.3: Stylised facts: cross-country scatter plots from the calibrated model.

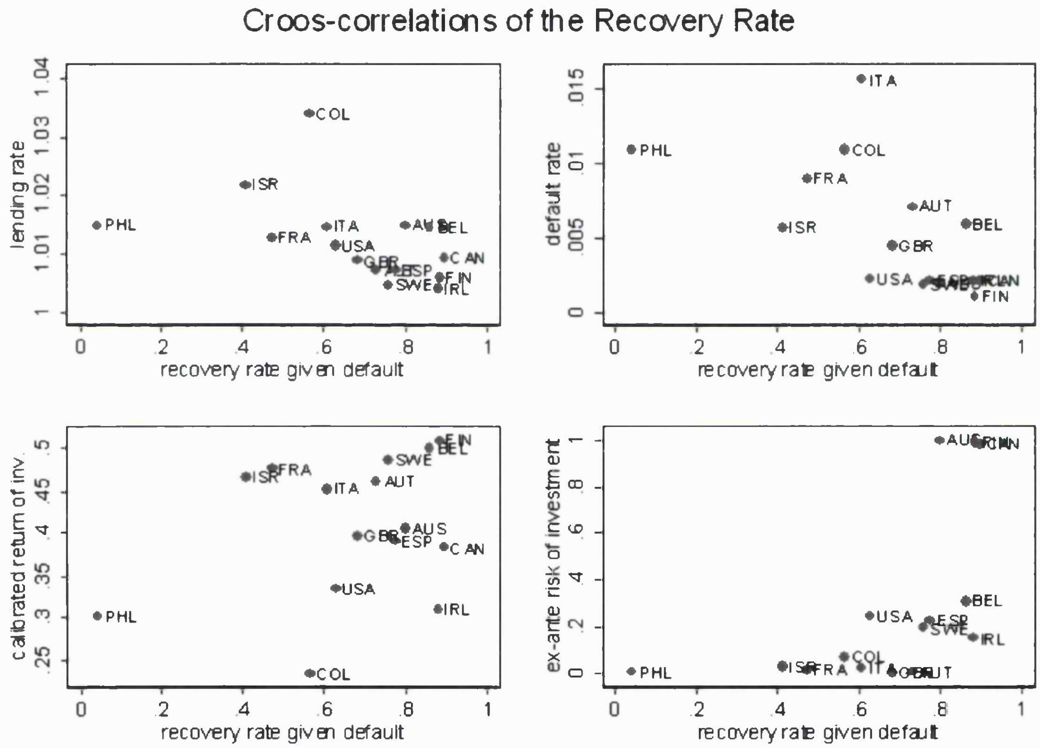

Figure 1.4: Stylised facts: cross-country scatter plots from the calibrated model.

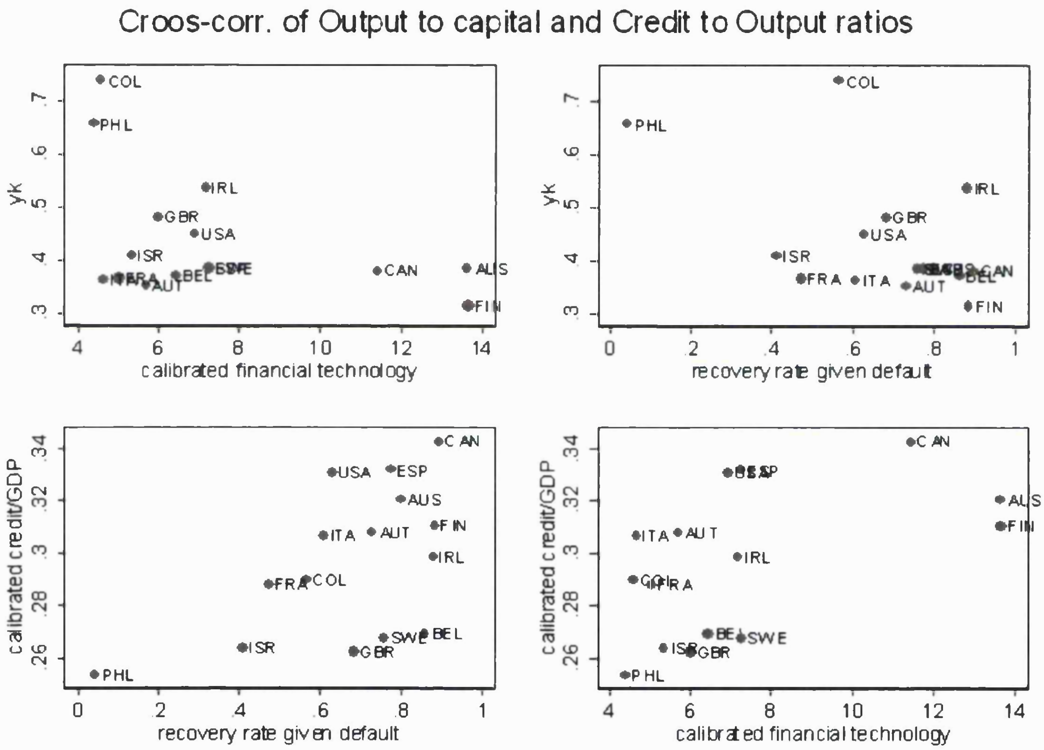

Figure 1.5: Stylised facts: cross-country scatter plots from the calibrated model.

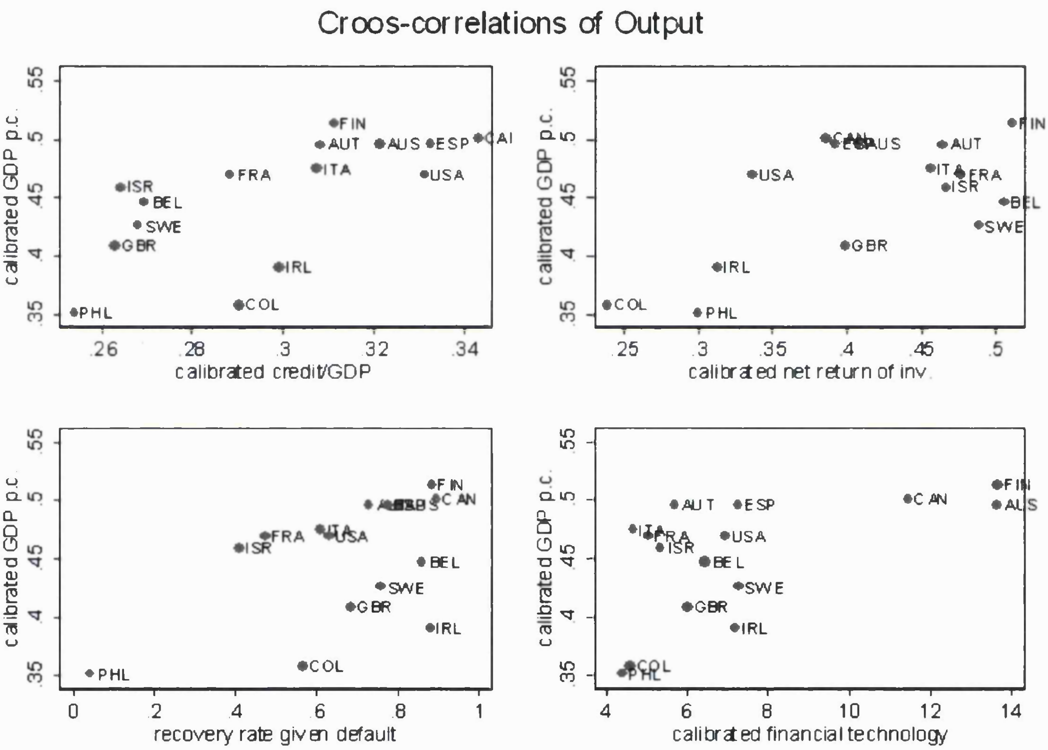

Figure 1.6: Stylised facts: cross-country scatter plots from the calibrated model.

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Chapter 2

Credit Standards Cycles

The loose credit standard policies that loan officers took during the 2000s' credit boom are at the root of the 2007/08 global financial turmoil (Bernanke (2007) and Dell'Ariccia, Igan and Laeven (2008)). To study the impact of such policies on the economy as well as the mechanisms behind them, this paper presents a Real Business Cycle model with two sectors, a standard production sector and a productive financial sector. The former obtains funding from the latter to invest in risky investment opportunities. The latter bases the loan approval decisions on estimates of the probability of default of each investment project. The model is calibrated for the US and is able to replicate the counter-cyclical pattern of credit standards documented by the literature. The increase in the probability of default during expansionary periods reduces the efficiency with which investment is transformed into capital. In addition, the increase in the default rate reduces the return of savings, which in turn reduces the labor supply. The effect of counter-cyclical credit standards is especially important for investment specific shocks.

2.1 Introduction

The loose credit standard policies that loan officers took during the 2000s' US credit boom were determinant for the deterioration of banks' balance sheets and, ultimately, for the 2007/08 global financial turmoil. This has been highlighted by the chairman of the Federal Reserve Ben S. Bernanke,

> *"The practices of some mortgage originators have also contributed to the problems in the subprime sector. ...some lenders evidently loosened underwriting standards. ...The accuracy of much of the information on which the underwriting was based is also open to question. As the problems in the subprime mortgage market have become manifest, we have seen some signs of self-correction in the market. Investors are scrutinizing subprime loans more carefully and, in turn, lenders have tightened underwriting standards."*
>
> Ben S. Bernanke, 43rd Annual Conference on Bank Structure and Competition, Chicago. May 17, 2007.

Dell'Ariccia, Igan and Laeven (2008) provide formal evidence for this phenomenon by identifying a decrease in the lending standards which is not explained by an improvement in the underlying economic fundamentals. To do so, they study the relationship between the recent boom and current delinquencies in the US subprime mortgage market using a data set that combines 50 million individual loan applications, local and national data.

Counter-cyclical credit standard policies have also been identified during other economic cycles. Jimenez and Saurina (2006) use Spanish individual loan data between 1980 and 2000 and show that loans made during periods of high credit growth have a higher probability of default. Asea and Bloomberg (1998) use aggregate data for the US and show that the probability that a loan is collateralised increases during contractions and decreases during expansions, and Lown and Morgan (2006) use the US Loan Officer Survey and find that tighter lending standards are related with periods of low economic and credit growth. Berger and Udell (2004) show that banks find it harder to recruit experienced and qualified loan officers to keep up with the rapid pace of loan applications, leading to a deterioration in loan processing and risk assessment procedures.

There are several mechanisms that incite loan officers to perform counter-cyclical credit standards policies. Ruckes (2004) argues that when the fraction of good loan applicants is high enough the incentives to generate (costly) information about their probability of default decrease since a lower fraction of them will be screened out. D'ella Riccia and Marquez (2006) argue that the incentives to generate information about borrowers are low when large number of new applicants reduce the adverse selection problem that arises from informational asymmetries among lenders. These episodes, which are assumed to characterise expansionary periods, lead to a reduction in lending standards. Rajan (1994) argues that rational bank managers with short horizons set credit policies which influence, and are influenced by other banks and demand side conditions. This leads to a theory of low frequency business cycles driven by bank credit policies.

The aim of the present paper is to study the impact of credit standards policies to the economy as well as the mechanisms behind them. To abstract from the effect that other variables have on the evolution of credit over the business cycle, this paper develops a dynamic general equilibrium model with financial intermediaries that choose at each period the optimal credit standards. The effects of credit standards are studied from the impulse response functions and the moments of the simulated linear model.

The theoretical approach consists on integrating a productive banking sector into a standard Real Business Cycle model. Both sectors, the standard final goods production (FGP) sector and the financial sector, are perfectly competitive. The FGP sector combines labor and capital to produce consumption goods. To increase the stock of capital, which depreciates over time, firms obtain funding from financial intermediaries and invest into risky investment opportunities. Financial intermediaries base the loan approval decision on an estimate of the probability of default of each investment project. The production structure of the financial sector is similar to that of Hauswald and Marquez (2003) and Ruckes (2006), in which the default rate depends on the resources that banks spend generating information about the quality of each investment project to be financed. Hence, in the context of the model, financial intermediaries relax the credit standards when the loan approval decisions rely on less informed credit assessments. And vice versa, they tighten them when they are certain that the investment project will succeed.

The model is calibrated at the steady state using US quarterly data to match the main economic aggregates as well as financial sector variables: the default rate, and the lending and deposit real interest rates.

The behavior of credit standards over the business cycle is studied from the impulse response functions to a technology shock and an investment specific shock, as well as the correlations of the simulated linear model. According to the literature, these are the most important shocks (Greenwood, Hercowitz and Krusell (1997), Fisher (2006), Justiniano and Primiceri (2008), and Justiniano, Primiceri and Tambalotti (2008)), at least for output, investment, hours and capital, which are the variables we are interested in. Financial intermediaries respond to both shocks by increasing their lending, as is customary in the literature. In addition, the quality of the information in which loan approvals is based deteriorates. Therefore, we observe that after positive technology shocks and investment specific shocks the default rate increases. The correlation of the simulated model with investment specific shocks confirms that the probability of default of loans made during expansions is higher, while the cross-correlation obtained when simulating the model with technology shocks is also positive but much lower.

To better grasp the role played by financial intermediaries, we take advantage of the fact that the standard Real Business Cycle model is a particular case of the model with financial intermediaries. More precisely, the existence of a financial sector depends on the degree of development of the financial technology. As the financial technology becomes more accurate, the amount of resources spent by financial intermediaries in generating information about loan applications decrease. At the limit, the model becomes a standard real business cycle model with only one sector. Therefore, the comparison between both models facilitates the understanding of the channel through which the decisions of loan officers modify the effects of technology shocks and investment shocks, as well as their economic impact. In this regard, the paper finds that the two economies behave quite similarly when they are hit with a technology shock, but this is not the case for an investment shock because of the strong and persistent impact it has on the return of capital. This incites loan officers to expand the lending supply even if it comes at the cost of a higher default rate, which can be compensated with an increase of the interest margin. The effects of lending policies on output, which are sizeable in comparison to the one sector model, operate through two channels. On the one hand, the increase in the default rate reduces the efficiency with which investment is transformed into capital. Hence, for the same increase of investment the capital accumulation is lower. On the other hand, the increase in the default rate reduces the return of savings. This reduces the wealth effect generated by the shock, which in turn reduces the increase of the labor supply. Thus, two main conclusions can be extracted from comparing the general model with financial intermediaries and the one sector RBC model. First, lending policies are far from being constant over the business cycle, neither quantitatively nor qualitatively. This feature could not be captured with a one sector RBC model because it treats the financial sector as a clearing sector between savers and investors. Second, capturing the response of the financial sector policies to technology and investment shocks is important to the extent that their actions have important consequences to the performance of the rest of the economy.

The present paper is related to the literature that studies the effects of credit availability on business cycle fluctuations. This literature argues that the Modigliani-

Miller theorem does not apply in the financial sector due to the presence of a moral hazard conflict between borrowers and lenders. This conflict might be present between entrepreneurs and banks (Repullo and Suarez (1996) and Stein (2000)), between households and banks (Iacoviello and Neri (2006) and Aoki (2004)), between depositors and banks (Bernanke and Gertler (1999), Kiyotaki and Moore (1997), Kashyap and Stein (2000) and Bolton and Freixas (2006)), or between both depositors and banks, and banks and borrowers (Holmstrom and Tirole (1996)). In either case, the moral hazard problem between borrowers and lenders tights the amount of credit that each agent can obtain to the collateral it can pledge. Therefore, the evolution of credit over the business cycle not only responds to the traditional supply and demand forces, but also to changes in collateral values. The mechanism presented in this paper abstracts from the collateral channel and it is not based on a departure from the Modigliani-Miller theorem: all agents have perfect access to credit as long as the expected net present value of investment is positive. Instead, it relies on how banks manage the quality and the size of their loan portfolio. This channel was not active in the previous literature since the quality of the loan portfolio was kept fix. Both channels should be seen as complementary.

The present paper is also connected to the literature that considers the financial sector as a productive industry rather than a passive sector that just clears the savings from depositors and the demand of funds from investors, and remains passive over the business cycle. Boyd and Prescott (1986) were the first to model financial intermediaries as productive coalitions that generate information about borrowers in a static general equilibrium set up. A more recent strand of the literature has followed a partial equilibrium approach to analyse the effects of competition on the incentives to produce information about borrowers (von Thaden (1998) and Hauswald and Marquez (2003) and (2006)). There is as well a recent empirical literature studying the role of the soft information produced by loan officers for the competition structure of the financial industry in general, and the loan pricing and loan approval decisions in particular (Degryse and Ongena (2005), Amian (2007)

Jimenez, Peydró, Ongena and Saurina (2007)).

The rest of the paper is organised as follows. Section 2.2 describes the model and section 2.3 discusses the stationary version of it. The calibration of the model is presented in section 2.4, and the results are discussed in section 2.5. Section 2.6 discusses the robustness checks. The concluding remarks are presented in section 2.7.

2.2 The model

The model economy is composed by a measure one of identical and infinitely lived agents. Each period they are endowed with one unit of time, which can be used to work and to enjoy leisure. There are two perfectly competitive sectors in which they can work: the final goods production (FGP) sector and the financial sector. The former produces consumption goods combining capital and labour. To increase the stock of capital, which depreciates over time, firms obtain funding from financial intermediaries and invest into risky investment projects. Financial intermediaries base the loan approval decision on an estimate of the probability of default of each investment project, and only approve those from which they expect positive returns.

2.2.1 Final Good Producers

There is a large number of perfectly competitive final good producers. Each final good producer j produces consumption goods using capital, k_j, and labour, $n_{j,c}$, according to a Cobb-Douglas production function

$$\left(a_t n_{j,c,t}\right)^{\alpha} k_{j,t}^{1-\alpha}$$

where a_t is a unit root economy wide technology shock with drift. In logs,

$$\log a_t = \log a_{t-1} + \psi_a + \epsilon_{a,t}$$

where ψ_a is the growth rate of the economy and $\epsilon_{a,t}$ is $i.i.d.N(0, \sigma_a^2)$.

A fraction δ of capital depreciates at each period. However, firms have access to an infinite set of investment opportunities. Each investment opportunity requires 1 unit of the consumption good and only a fraction $p \in (0,1)$ of them deliver positive units of the capital good, $r_{I,t} > 0$. This new units of capital become productive the following period, and depreciate over time with the rest of capital at a rate δ. The remaining investment opportunities, a fraction $1-p$, fail to produce any capital good, and consume $1-\tau$ units of the initial investment, where $0 < \tau < 1$. All variables concerning the investment technology, p, $r_{I,t}$ and τ, are exogenous to final good producers and they are known by all agents of the economy. What no agent knows is which investment opportunities are profitable, and which ones are not.

For each investment project that a FGP wishes to perform, $i_{j,t}$, it has to apply for funding to a financial intermediary. Financial intermediaries base the loan approval decision upon an estimate of the probability of default of the investment project. The loan application is approved with probability θ_t. An investment project that obtains funding succeeds with probability $q_t \geq p$, depending on the accuracy of the estimation of the probability of default. This is assumed to be non-observable, and hence, final good producers have to take it as given. If the investment project succeeds, final good producers pay the lending interest rate $r_{B,t}$. If the investment project turns out to be non-productive, they can only promise to pay back τ. It is assumed that they cannot pledge the stock of capital as collateral when applying for a loan. However, it is also assumed that financial intermediaries have access to the returns from investment projects since they supervise them closely from the moment they are initiated. Therefore, the transition equation of capital is:

$$k_{j,t} = (1-\delta)k_{j,t-1} + r_{I,t}q_t\theta_t i_{j,t} \tag{2.1}$$

Following Greenwood, Hercowitz, and Krusell (1997) and Fisher (2006), $r_{I,t}$ can be interpreted as an investment specific technology shock affecting the efficiency with which consumption goods are transformed into capital. It is assumed that it follows an exogenous AR(1) process

$$\log r_{I,t} = \psi_I \log r_{I,t-1} + \epsilon_{r,t}$$

where $\epsilon_{r,t}$ is $i.i.d.N(0, \sigma_r^2)$.

Note that while in a traditional RBC model investment is transformed one to one into capital, in the current set up the transition equation of capital has a crucial role since it connects both sectors. The ability of firms to accumulate capital depends on the tightness of lending policies, θ_t, and the accuracy of the estimation of the probability of default, q_t.

Firm's optimisation problem becomes:

$$\begin{aligned} V_{j,t}\left(k_{j,t}; a_t, r_{I,t}\right) &= \max_{(i_{j,t}, n_{j,c,t})} \left((a_t n_{j,c,t})^\alpha k_{j,t}^{1-\alpha} - w_{c,t} n_{j,c,t} - r_{k,t}\frac{k_{j,t}}{\hat{r}_t} \right) \\ &\quad + \beta V_{j,t+1}\left(k_{j,t+1}; a_{t+1}, r_{t+1}\right) \end{aligned}$$

$r_{K,t}$ is the rental rate of capital and $w_{c,t}$ the wage rate. The relative price of capital with respect to consumption goods, $\hat{r}_t$, is,

$$\hat{r}_t = \frac{q_t r_I}{\bar{r}_{B,t}} = \frac{q_t r_I}{q_{i,t} r_{B,t} + (1 - q_{i,t})\tau}$$

the first order conditions resemble those obtained with a traditional RBC model,

$$r_{K,t}\frac{k_{j,t}}{\hat{r}_t} = (1-\alpha)\, y_{j,t} \tag{2.2}$$

$$w_{c,t} = \alpha \frac{y_{j,t}}{n_{j,c,t}} \tag{2.3}$$

namely that the marginal cost of both production factors, $w_{c,t}$ for labour and $r_{K,t}$ for capital, have to be equal to the marginal profits.

2.2.2 The Financial Sector

The financial sector is populated by a large number of perfectly competitive financial intermediaries. Each financial intermediary i has to decide each period how many investment projects to analyse $i_{i,t}$, and the accuracy of the analysis it performs. As described before, investment projects can be of two types, $\pi \epsilon (H, L)$. Type H investment projects are those that deliver $r_{I,t}$ units of the capital good, while type L projects produce zero units of the capital good, and destroy $1 - \tau$ units of the initial investment. Financial intermediaries, as the rest of the agents in the economy, cannot observe the true type of each project. However, by analysing them, they can obtain an imperfect signal about the project type, $\eta \in (H, L)$. The precision of the signal, *i.e.* the probability that the signal is correct, is given by:

$$\phi_{i,t} = P(\eta = H \mid \pi = H) = 1 - 0.5 \exp\left(-\lambda_t \frac{n_{i,f,t}}{i_{i,t}}\right) \tag{2.4}$$

The precision of the signal depends on the amount of resources spent to produce information, $n_{i,f}$, per investment project analysed, $i_{i,t}$: for the same level of resources spent, the larger is the number of projects analysed, the lower is going to be the quality of the analysis and hence, the precision of the signal produced is going to be worse. Following the recently developed micro literature on banking (Hauswald and Marquez (2003), D'ella Riccia and Marquez (2006) , Ruckes (2004) and Amian (2006)), it is assumed that there are two key ingredients that determine the quality of the information produced: the risk analysis technology available, λ_t, which is assumed to be exogenous, and the soft information produced by local bankers, $n_{i,f,t}$[1]. Intuitively, if a financial intermediary has no one analysing the investment

[1] $n_{i,f,t}$ captures both the positive effect of spending more time in analysing each investment project, and the positive effect of having each financial intermediary closer to its customers, an important determinant of the quality of the information produced raised by Hauswald and Marquez

projects, $n_{i,f,t} = 0$, the signal produced will be totally uninformative , *i.e.* it will be independent of the true type of each project, $\phi_{i,t} = 0.5$. However, the greater the amount of labour resources spent in analysing them, or the more efficient the risk analysis technology is, the better the precision of the signal produced. At the limit, if the technology available is infinitely precise, or the labour resources used are infinitely large, financial intermediaries will be able to distinguish type H and type L projects perfectly, *i.e.* $\phi_{i,t}$ will equal 1.

It is assumed that the financial technology grows according to the following exogenous process,

$$\log \lambda_t = \log \lambda_{t-1} + \psi_\lambda + \epsilon_{\lambda,t}$$

where the growth rate is given by ψ_λ and $\epsilon_{\lambda,t}$ is $i.i.d.N(0, \sigma_\lambda^2)$.

Given that only type H projects are profitable, financial intermediaries only accept to provide funding to those investment projects from which they obtain a positive assessment. However, as the information they produce is not perfect, they also end up providing funding to the non-profitable investment projects that are misclassified. The probability that an investment project is accepted is given by:

$$\begin{aligned} \theta_{i,t} &= P(\eta = H \mid \pi = H)P(\pi = H) + P(\eta = H \mid \pi = L)P(\pi = L) \qquad (2.5) \\ &= \phi_{i,t}p + (1 - \phi_{i,t})(1 - p) \end{aligned}$$

and it depends on both the quality of the information produced by the financial intermediary, $\phi_{i,t}$, and the percentage of type H and type L projects in the economy p, which is assumed to be exogenous.

The final lending of each intermediary i is a fraction $\theta_{i,t}$ of all investment projects analysed, $i_{i,t}$:

(2005) and Amian (2007).

$$l_{i,t} = \theta_{i,t} i_{i,t} \tag{2.6}$$

and the expected probability of success is given by:

$$\begin{aligned} q_{i,t} &= \frac{P(\eta = H \mid \pi = H)P(\pi = H)}{P(\eta = H \mid \pi = H)P(\pi = H) + P(\eta = H \mid \pi = L)P(\pi = L)} \\ &= \frac{\phi_{i,t} p}{\phi_{i,t} p + (1 - \phi_{i,t})(1 - p)} \end{aligned} \tag{2.7}$$

i.e., the fraction of investment projects that were correctly assessed among all investment projects accepted.

Intermediaries decide how many investment projects to analyse and the amount of labour resources to use in each period, taking $r_{B,t}$, $r_{D,t}$, $w_{f,t}$, τ and p as given. Then, they obtain the returns from lending, which they use to pay back the deposits. Financial intermediaries' optimisation problem is:

$$V_{i,t} = \max_{(i_{i,t}, n_{i,f,t})} \left(q_{i,t} r_{B,t} + (1 - q_{i,t})\tau\right) l_{i,t} - w_{f,t} n_{i,f,t} - r_{D,t} d_{i,t} \tag{2.8}$$

Further insights on the trade off that financial intermediaries face can be obtained using equations (2.5), (2.6), (2.7), and the fact that the amount of deposits raised, $d_{i,t}$, is equal to the amount of lending, $l_{i,t}$. The maximisation problem becomes:

$$V_{i,t} =$$

$$\max_{(i_{i,t}, n_{i,f,t})} (p\phi_{i,t}(r_{B,t} - r_{D,t}) i_{i,t} - (1 - \phi_{i,t})(1 - p)(r_{D,t} - \tau) i_{i,t} - w_{f,t} n_{i,f,t}) \tag{2.9}$$

This shows that the current value of financial intermediaries depends on the income they obtain from the interest margin, $r_{B,t} - r_{D,t}$, of the projects that succeed, and the interest cost, $r_{D,t} - \tau r_{B,t}$, they suffer from those loans that were misclassified. The trade off faced by financial intermediaries consists on increasing their lending by augmenting the number of investment projects analysed, at the cost of a worse estimation of the probability of default, or to reduce the volume of lending, with the benefit of having a pool of loans of better quality. This trade off is reflected in the first order conditions:

$$(r_{B,t} - r_{D,t}) i_{i,t} p_t \frac{\partial \phi_{i,t}}{\partial n_{i,f,t}} + (r_{d,t} - \tau)(1 - p_t) i_{i,t} \frac{\partial \phi_{i,t}}{\partial n_{i,f,t}} = w_{f,t} \tag{2.10}$$

$$(r_{B,t} - r_{D,t}) p_t \phi_{i,t} = (r_{B,t} - r_{D,t}) i_{i,t} p_t \frac{\partial \phi_{i,t}}{\partial i_{i,t}} + (r_{D,t} - \tau)(1 - p_t) \left((1 - \phi_{i,t}) + i_{i,t} \frac{\partial \phi_{i,t}}{\partial i_{i,t}} \right) \tag{2.11}$$

Equation (2.10), the first order condition with respect to $n_{i,f,t}$, shows that an increase of the labour force increases its profits to the extent that it improves the quality of the information in which they are based when deciding whether to accept or deny a borrowing application. A better precision of the signal allows them to increase the proportion of lending to profitable projects, and hence, to increase the amount of lending from which they obtain a benefit $(r_{B,t} - r_{D,t})$, and to reduce the amount of lending from which they loose it $(\tau - r_{D,t})$. Equation (2.11), the first order condition with respect to $i_{i,t}$, shows that financial intermediaries maximise expected profits choosing the amount of investment projects to analyse that balances the increased expected income obtained through a higher volume of lending (left hand side of the equation), and the reduction of it due to the lower quality of the information produced (right hand side of the equation).

2.2.3 Preferences

The model economy is composed by a continuum of measure 1 of infinitely lived agents. To maximise the expected present discounted value of utility, agents decide how much to consume, how much to save and how much to work at every period. That is,

$$\max \sum_{t=0}^{\infty} \beta^t \left(\ln c_t - \frac{(n_t)^{1+\varphi}}{1+\varphi} \right)$$

s.t:

$$c_t + d_{t+1} + \frac{k_{t+1}}{\hat{r}_t} = w_{c,t} n_{c,t} + w_{f,t} n_{f,t} + r_{D,t} d_t + (1 - \delta + r_{K,t}) \frac{k_t}{\hat{r}_t} \tag{2.12}$$

Where c_t is the consumption at period t, d_t are the savings they lend to financial intermediaries and $r_{D,t}$ their return. k_t is the capital rented to FGP at the rental rate $r_{K,t}$, φ is the inverse of the labour supply elasticity (the Frisch elasticity) and n is the labour supply index. Horvath (2000) and Iacoviello and Neri (2006) have documented the existence of imperfect substitutability of labor across sectors and the importance to capture them when analyzing business cycle fluctuations. Then, the labor supply index is defined as follows,

$$n_t = \left[\varkappa^{-\iota} \left(n_{c,t} \right)^{1+\iota} + (1 - \varkappa)^{-\iota} \left(n_{f,t} \right)^{1+\iota} \right]^{\frac{1}{1+\iota}}, \text{ where } \iota > 0 \tag{2.13}$$

where $\varkappa$ is the weight each sector has in the utility function and the parameter ι measures the degree of labour market rigidities in reallocating the labour force instantaneously across sectors. If $\iota = 0$, labor can be reallocated freely. The degree of imperfect substitutability of labour across sectors increases with ι.

The first order condition with respect to savings, d_t,

$$1 = \beta E_t \left(\frac{c_t}{c_{t+1}} r_{D,t+1} \right) \tag{2.14}$$

delivers the standard Euler equation relating present and future consumption as a function of the return from savings. A similar Euler equation is obtained from the first order condition with respect to capital, k_t,

$$1 = \beta E_t \left(\frac{c_t}{c_{t+1}} (1 - \delta + r_{K,t+1}) \frac{\hat{r}_t}{\hat{r}_{t+1}} \right) \tag{2.15}$$

Finally, the first order conditions that determine the optimal amount of effort to exert in each sector are,

$$n_t^{\varphi-\iota} \varkappa^{-\iota} \left(n_t^c\right)^{\iota} = \frac{w_{c,t}}{c_t} \tag{2.16}$$

$$n_t^{\varphi-\iota} (1-\varkappa)^{-\iota} \left(n_t^f\right)^{\iota} = \frac{w_{f,t}}{c_t} \tag{2.17}$$

2.2.4 Market Clearing conditions

The labour demand from both sectors equals the labour supplied by consumers:

$$N_{c,t}^d = N_{c,t}^s$$

$$N_{f,t}^d = N_{f,t}^s$$

And hence, the total number of hours worked in both sectors equals the total number of hours worked:

$$N_{c,t} + N_{f,t} = N_t$$

The supply of savings of consumers equals the demand of deposits from financial intermediaries:

$$D_t^s = D_t^d$$

The demand of loans from FGP equals the supply of lending by financial intermediaries:

$$L_t^s = I_t^d$$

And the aggregate level of consumption and savings equal the aggregate production of consumption good in the economy:

$$C_t + D_t = Y_t = N_{c,t}^{\alpha} K_t^{1-\alpha}$$

2.2.5 A particular case: the one sector Real Business Cycle model

As mentioned in the introduction, the standard real business cycle model is a particular case of the model developed in the present paper. Understanding the link between both of them makes clear the nature of the financial sector and the role it plays over the business cycle.

The existence of a financial sector depends on the financial technology. For intermediate levels of it, it is worth having some labor resources spent on creating information about investment projects. However, when the financial technology is infinitely precise, the contribution of labor resources tends to zero. This is illustrated in the first order conditions of financial intermediaries, (2.10) and (2.11), which can be re-written as,

$$w_{f,t} = (1-\phi_t)\lambda \left(p(r_{B,t} - r_{D,t}) + (1-p)(r_{D,t} - \tau)\right) \tag{2.18}$$

$$\left(q_t r_{B,t} + (1-q_t)\tau - r_{d,t}\right) l_t = w_{f,t} n_{f,t} \tag{2.19}$$

Equation (2.18), the first order condition with respect to n_f, shows that as the financial technology tends to infinity, $\lambda \to \infty$, financial intermediaries can distinguish perfectly between type H and type L investment projects, $\phi \to 1$, and hence the value added of labor resources tends to zero, $w_{f,t} \to 0$. Equation (2.19) implies that the savings rate and the deposit rate will be the same in this case, $r_{B,t} = r_{D,t}$.

Therefore, the consumers budget constraint collapses to,

$$c_t + d_{t+1} + \frac{k_{t+1}}{\hat{r}_t} = w_{c,t}n_{c,t} + r_{D,t}d_t + (1 - \delta + r_{K,t})\frac{k_t}{\hat{r}_t}$$

The maximisation problem of final goods producers remains unchanged, but their possibilities to accumulate capital are much higher since the default rate is zero, $q_t = 1$.

2.3 The stationary model

The model is assumed to exhibit long run growth so that the moments obtained from the simulated linear model can be compared with those obtained from the real data. Before calibrating the model at the steady state, the variables have to be detrended to obtain a stationary economy.

From the definition of output,

$$Y_t = (a_t n_{c,t})^\alpha k_t^{1-\alpha}$$

and the fact that the number of hours worked is stationary, the growth rate of output is equal to,

$$g_Y = (g_a)^\alpha (g_k)^{1-\alpha}$$

Where g_x is the growth rate of variable x. The transition equation of capital, equation (2.1), establishes that the growth rate of capital and the growth rate of investment must be the same, $g_k = g_D$. And from the feasibility constraint it can be concluded that output, consumption and savings grow at the same rate:

$$g_{Y,t} = g_{C,t}\frac{C_{t-1}}{Y_{t-1}} + g_{D,t}\frac{D_{t-1}}{Y_{t-1}}$$

Therefore, output, as well as the rest of the non-stationary variables, must grow at the same rate of technology, $g_Y = g_a$.

For the model to be stationary, the technology in the FGP sector and the financial technology must grow at the same rate, $g_a = g_\lambda$.

2.4 Calibration of the model at the steady state

As is customary in the literature, the objective is to use the minimum number of parameters of the model to match the data. To have a proper characterisation of the financial sector of the US economy, the model captures the key variables of it: the lending rate, $r_{B,}$, the deposit rate, r_D, and the default rate, $1-q$. These are the main parameters calibrated. The values of the rest of the parameters are standard in the literature. To capture the dynamics of the economy over the business cycle the model is calibrated at a quarterly frequency.

2.4.1 Fixed parameters

The values of the fixed parameters are presented in Table (2.1). The output to capital ratio, Y/K, is obtained from the Penn World tables (PWT). The depreciation rate of capital , δ, is 0.01.

According to the model, the labor income in the FGP sector to GDP is

$$\alpha = \frac{w_c N_c}{Y}$$

This is different from the labor share usually estimated in the literature because it does not contain the labor income from the financial sector. To obtain an appropriate measure of the labor share, the standard labor share is rescaled by the share of labor in the non-financial industry,

$$\alpha = \alpha^* \frac{N_c}{N}$$

Estimates of the labour share in GDP, α^*, are obtained from Caselli (2007). The share of labor in the non-financial sector is obtained from the International Labor Organisation.

The values of the parameters of the technology process and the investment shock are standard in the literature (Justiniano and Primiceri (2008), Del Negro, Schorfheide, Smets and Wouters (2007) and Justiniano, Primiceri and Tambalotti (2008)).

Following Elizalde and Repullo (2007), the value for the amount of resources that financial intermediaries recover in case the investment project fails, τ, is equal to 0.45[2]. This is the value specified in the IRB foundation approach of Basel II for senior claims on corporates, sovereigns and banks not secured by recognized collateral.

The value chosen for the weights of labor supply in each sector in the labor index, $\varkappa$, is such that the fraction of labor in the financial sector is equal to 10%, the average value for the last 15 years. Finally, following standard practice in the literature, the Frisch elasticity is equal to 1.

2.4.2 Calibrated parameters

The following 6 parameters are calibrated: the discount factor, β, the return on investment, r_I, the fraction of type H projects, p, the return of capital, r_K, and the financial technology, λ. The first 3 parameters are chosen so that the model matches

[2]This value is very close to the estimated average loss given default by Djankov, Hart, McLiesh, and Shleifer (2006) for the US.

the following 3 moments: the average real interest rate of deposits, r_D, the average real interest rate of lending, r_B, and the average default rate of lending, $1-q$.

The calibration of the endogenous parameters proceeds as follows. The discount factor is chosen such that the deposit interest rate is equal to the average real deposit interest rate for the last ten years at a quarterly frequency.

$$r_D = \frac{g_a}{\beta}$$

The deposit interest rate is obtained from the IMF International Financial Statistics database and is deflated using the CPI. The value for the return of capital is obtained combining the two Euler equations,(2.14) and (2.15),

$$r_K = r_D - (1-\delta)$$

The lending rate is determined using the first order condition of the FGP optimisation problem with respect to capital,

$$\bar{r}_B = \frac{q r_I (1-\alpha) g_a \frac{Y}{K}}{r_K}$$

The value of the fraction of type L investment projects accepted, $1-q$, is equal to the average net charge off rate of C&I loans of the last 2 decades, which is 0.15%. Then, the value chosen for the return of investment, r_I, is such that the value of the lending rate is equal to the average real reference rate for commercial loans (the prime rate) for the last 2 decades.

The value chosen for the fraction of type H investment projects in the economy, p, is such that the fraction of type L investment projects accepted, $1-q$, is equal to the average charge off rate described above. To obtain q as a function of p some algebra is needed. First, the definition of ϕ, equation (2.4), is rewritten as,

$$\lambda \frac{N_f}{I} = \log \frac{0.5}{1-\phi} \tag{2.20}$$

Then, the financial technology parameter, λ, the labor in the financial sector to investment ratio, $\frac{N_f}{I}$, and the accuracy of the information produced by loan afficers, ϕ, are substituted for functions of q and p. The labor in the financial sector to investment ratio is obtained using the definition of lending, equation (2.6), and the first order condition $w.r.t.$ I, equation (2.11),

$$\frac{I}{N_f} = \frac{\lambda(1-\phi)p}{\theta} \frac{IM + IC}{NIM} \tag{2.21}$$

where, IM, is the potential interest margin,

$$IM = p(r_B - r_D)$$

IC is the potential interest cost,

$$IC = (1-p)(r_D - \tau)$$

and NIM is the net interest margin,

$$NIM = qr_B + (1-q)\tau - r_D$$

The accuracy of the information produced by loan officers, ϕ, is obtained rewriting the definition of the default rate, equation (2.7), as,

$$\phi = \frac{q(1-p)}{q(1-p) + (1-q)p} \tag{2.22}$$

and the function for the financial technology parameter is obtained from the first order condition with respect to n_f,

$$\lambda = \frac{w^f}{(1-\phi)p(IM + IC)} \tag{2.23}$$

2.4.3 Calibration of the one sector Real Business Cycle model

The calibration of the one sector model provides a benchmark where the IR functions of the general model can be compared. This facilitates the understanding of the effect of financial intermediaries credit policies. Therefore, the values of the fundamental parameters of the one sector economy are equal to those of the general model, except for the financial technology. These parameters are summarised in table (2.3), and include the depreciation rate, δ, the return of investment projects, r_I, the parameters of the technology shock and the investment specific shock, and the output to capital ratio. The two endogenous parameters are the return of capital and the return from savings. The first is obtained from the first order condition from FGP,

$$r_K(r_K + 1 - \delta) = r_I(1-\alpha)g_a\frac{Y}{K}$$

The return from savings is obtained combining the two Euler equations from the consumers problem, as in the general model,

$$r_D = r_K + 1 - \delta$$

2.5 Results

In this section, the main features of the model are discussed by analysing the effects of a technology shock and an investment specific shock. There is a vast literature studying which are the main shocks driving business cycles fluctuations. The debate is mainly centered on the relative importance between technology shocks and investment specific shocks (see King and Rebelo (1999), Gali and Rabanal (2005)

Christiano, Eichenbaum, and Vigfusson (2004) and Fisher (2006)), even if recent evidence suggests that investment specific shocks may have had a more prominent role during the last two decades (Justiniano, Primiceri and Tambalotti (2008)). Be as it may, these two shocks explain most of the business cycle variation of the main aggregate variables, especially output, investment, hours and capital, which are the focus of this paper.

The impulse response functions of the main variables are presented first to understand the mechanics of the model. The ability of the model to replicate the pattern of the credit standards over the business cycle is checked by analyzing the cross correlations of the simulated model. Finally, an assessment of the impact of credit standards policies in terms of economic volatility is studied from the standard deviations of the simulated model. The model's dynamics are obtained by taking a log-linear approximation around the steady state.

2.5.1 Impulse Response functions

Figure (2.1) reports the impulse responses to the investment specific shock. To better understand their effects upon economic performance, the impulse response functions of the general model with two sectors are plotted together with the impulse response functions of the one sector model. In both models, output, hours and investment rise persistently following a positive impulse, as is customary in the literature. The response of investment is quite similar between the two economies, but the speed at which they accumulate capital is different, as well as the quantitative response of output. This is due to the rise in the default rate. With the increase in the return of investment, the optimal policy of financial intermediaries is to increase their lending even if it comes at the cost of funding a greater amount of bad investment projects. This is compensated by the increase in the interest margin. The increase in the default rate reduces significantly the speed at which the economy accumulates capital.

It is important to note that the fact that the default rate is positive in the general model at the steady state reduces its efficiency to transform investment into capital. This increases the optimal investment to capital ratio with respect to the one sector model. However, in net terms, both economies accumulate capital at the same speed in the steady state. Therefore, the difference in the accumulation of capital is only due to the lower response of investment and the higher default rate.

The increase in the default rate affects output through another channel: the lower efficiency of investment reduces the return from capital, and hence, the return from savings. This reduces the wealth effect that agents experience from the positive shock, and they reduce the labor supply, which reduces output even further.

The impulse responses of a neutral technology shock are presented in Figure (2.2). As expected output and capital increase following a positive impulse. The shock produces an important wealth effect to the agents, and this reduces substantially the response of hours and investment, which now move very mildly after the shock. The technology shock does not have such a positive and persistent effect on the return of capital. Then, financial intermediaries cannot expect to compensate a worsening of the loan portfolio with an increase of the interest margin. This forces them to maintain the quality of the loan portfolio. Since the reaction of the default rate is more modest, the difference between the impulse response functions of the models for the rest of the variables is much lower. However, it is worth stressing that the response of hours to a technology shock is negative in the general model. As noted in Gali and Rabanal (2005) this is one of the main failures of the RBC literature, which predicts a positive comovement between output and hours, while they document empirically that hours decline after a positive technology shock. The impulse response functions of the general model point to the financial intermediaries as potential candidates to explain the empirical results obtained by Gali and Rabanal (2005).

2.5.2 Moments from the simulated model

This section analyses more accurately the magnitude of the fluctuations of each variable and the relation between them. The average moments are obtained from 200 simulations of the linearized model of 500 quarters each. The average correlations and the average standard deviations are computed after detrending all the variables using the Hodrick-Prescott filter. As in the previous section, the moments of the variables from the general model are compared to those of the one sector model.

To have a better assessment of the performance of the models, the moments are also compared with the moments of the real data. These are obtained using quarterly U.S. data for the period 1985:I–2007:IV. The series for output correspond to nonfarm business-sector output, labor input series is hours of all persons in the nonfarm business sector. Both series are expressed in per-capita terms, using a measure of civilian noninstitutional population aged 16 and over. The series for the interest margin are obtained after taking the difference between the reference rate for commercial loans (the prime rate) and the CD rate[3]. The stock of Commercial and Industrial loans outstanding is used to construct the series for the new loans made each quarter assuming an average maturity of the loan portfolio equal to 4 years, as in Van den Heuvel (2002). Finally, the series of the default rate correspond to the charge off rate of Commercial and Industrial loans. To obtain a comparable set of moments to those generated from the model, all series are logged and then detrended.

Correlations

The average correlations obtained from the model with the investment shock are presented in Figure (2.4). As it could be expected from the impulse response functions, both models are able to capture the positive correlation between output and lending that is observed in the data. The same happens with hours. The observed contemporaneous correlation between the default rate and output is negative. Ex-

[3]Using the federal funds rate delivers very similar results.

pansionary investment shocks incite loan officers to reduce their lending standards and to accept loans with a higher expected default rate. Since the model only has one period loans, the contemporaneous correlation between output and the default rate is also positive. However, as many authors have noted, bad loans do not default immediately (Berger and Udell (2004), Jimenez and Saurina (2006), Mian and Sufi (2007), Dell'Ariccia, Igan and Laeven (2008)). These papers draw a causal relationship between decreases in lending standards and increases of the default rate in future periods. Then, the correlation between output and the default rate obtained from the model should be compared with the correlation of output and the default rate in future periods. Figure (2.5) illustrates that future values of the default rate are positively and strongly correlated with current values of the GDP. The general model also matches the positive correlation between the interest margin and the default rate.

The average correlations obtained from simulating the model with the technology shock are presented in Figure (2.5). Again, both models replicate the procyclical behavior of lending and hours observed in the data. The same cannot be said for the default rate and the interest margin. Their correlations are now much lower. This is not surprising since the impulse response functions already showed that the low response of the return of capital was limiting the increase in the default rate and the lending rate.

Standard Deviations

The average standard deviations are presented in Figures (2.6) and (2.7) for the model with the investment shock and the model with the technology shock respectively. In general, the volatility generated by the one sector model is higher than the one generated by the general model. This is because financial intermediaries reduce the effect of shocks to the economy. The volatility of output produced by the investment shock in the general model is similar to the one observed in the data, while the volatility generated by the one sector model is higher. The general model explains about 25% of the variation of the default rate and about 90% of the interest margin volatility. Regarding hours and lending, the standard deviations generated by both models are higher than the ones observed.

The fact that the volatility of output generated by the general model is lower than the volatility of the RBC model might look at odds with the financial accelerator literature, which claims that the financial sector amplifies business cycle fluctuations. However, it is worth noting that the model is based on one period loans and that the default rate is realized at the end of the credit contract. Just adding time delays to the repayment of loans would certainly produce a negative contemporaneous correlation of output and the default rate, which would soar when the positive effects of the shock would be gone. The interaction of the dynamics presented with other amplification mechanisms, the myopia of loan officers as suggested by Rajan (1994) or the collateral effects suggested by Kiyotaki and Moore (1997) could result into further amplification of shocks. This is left for further research, but both mechanisms should be seen as complementary.

Concerning the technology shock, both models produce similar standard deviations of output, but the volatility of the rest of the variables decreases substantially. This is specially the case for the default rate and the interest margin, for which it only generates a 2% and 3% of the observed volatility respectively.

2.6 Robustness checks

2.6.1 The effect of labor market rigidities

The parameter ι measures the degree of labor market rigidities. It captures the speed at which the labor force can be reallocated across sectors. If $\iota = 0$, labor can be reallocated across sectors freely. Greater values of it reduce the speed of adjustment of the labor market. Iacoviello and Neri (2008) estimate a value of $\iota = 1$ for the US, in a model with a sector that produces durable goods and a sector that produces non-durable goods. This is the value that has been used for the calibration. The absence of a direct estimate of the labor rigidities in the financial sector obliges us to check their effect for the transmission mechanism of shocks. It is worth noting that Berger and Udell (2004) argue that the strong reliance of financial intermediaries in human capital makes this sector especially sluggish when it has to adjust the labor force after a negative shock. The difficulty of financial intermediaries to hire and train loan officers reduces their capacity to appropriately screen loan applications, which translates into an increase of the default rate.

Therefore, this section analyses how the impulse response functions and the moments from the simulated model change when the degree of labor market rigidities changes. Two alternative economies are considered: one with a more flexible labor market, with $\iota = 0.5$, and another one with a more rigid labor market, with $\iota = 2$.

The impulse response functions of an investment specific shock and a neutral technology shock are presented in Figures (2.3) and (2.4), respectively. The first thing to notice is that the main results presented above do not change substantially. For the neutral technology shock, the impulse response functions are very similar to those presented in the benchmark calibration, both quantitatively and qualitatively. This could be expected since the shock has a minor effect on the credit standard policies.

For the investment specific shock, the qualitative results do not change, but quantitatively they vary slightly. The argument is similar to the one presented by Berger and Udell (2004): labor market rigidities reduce the capacity of financial intermediaries to adjust to the shock. This increases the effect of the shock on the default rate and hence, it worsens the performance of the rest of the economy.

This results are confirmed by the moments from the simulation of the model. The variation of the correlations between the variables remains very similar to those obtained with the benchmark calibration. The standard deviations for the model with a technology shock also remain fairly constant. This is not the case for the investment shock. With a more rigid labor market the volatility of lending generated by the model decreases and becomes very close to the one observed in the data, while the standard deviation of the default rate increases substantially. The standard deviation of output and interest margin generated by the model are still very similar to those observed in the data, while the volatility of hours is still too large.

Overall, investment shocks seem to be a better candidate than technology shocks to explain the behavior of bank lending policies.

2.6.2 Sensitivity of the results to the Frisch Elasticity

The parameter φ measures the elasticity of the labor supply with respect to income. Given that the literature has not yet reached a consensus on its value, and the importance it may have for the dynamics generated by the model, this section checks the effect of using two extreme values, $\varphi = 0.5$ and $\varphi = 2$. The results are presented in columns "low Frisch" and "high Frisch" of tables (2.4), (2.5), (2.6) and (2.7). The qualitative results are maintained unaltered for both shocks. Quantitatively, the main changes occur for the investment shock. As expected, a greater value of the Frish elasticity reduces the variation of hours, which get closer to the observed standard deviation. The same happens for investment and output. The effect on the variation of the interest margin and the default rate is milder. The general model continues to match the variation of the interest margin and it still produces a significant variation in the default rate.

2.7 Concluding Remarks

The current global financial turmoil has shown, once again, how vulnerable economies are to the lending policies taken by financial intermediaries. It has also highlighted the lack of tools that economists in general, and monetary authorities in particular, have to analyze the financial sector. The reason: most of the macroeconomic models employed to analyze the effects of the financial sector define it as a clearing sector between the demand and the supply of lending. All the variation arises from changes of the borrowing capacity of agents, not from the financial sector itself. This is a crucial drawback to understand the effects of the existing financial regulation, or the effects of monetary policy. This paper takes a step in this direction by modeling explicitly the financial sector as a productive industry, as in Ruckes (2004) and Hauswald and Marquez (2003), in which loan officers decide the amount of lending as well as the risk of the loan portfolio. But in this paper the financial sector is integrated into a dynamic general equilibrium model. The mechanics of the model, the ability to replicate the actual policies taken by financial intermediaries and their economic impact are studied from the impulse response functions to an investment shock and a technology shock, and from the moments of the simulated model.

Investment shocks appear as a good candidate to explain the variation in bank lending policies since they are able to generate a counter-cyclical pattern of credit standards. Their effect on the return from capital incites loan officers to expand their lending even if it comes at the cost of a higher default rate. This is compensated by an increase in the interest margin. The increase in the default rate reduces considerably the positive effects of the shock. It reduces the efficiency with which the economy accumulates capital. And it also reduces the return from savings, which in turn reduces the positive wealth effect from the shock and hence, the supply of labor.

Despite being a very stylized model (there are no nominal frictions and there is no role for the collateral channel), the investment shock is able to match fairly well the standard deviation of output, lending and the interest margin, and it generates a 30% of the observed volatility in the default rate. Thus, this model can be useful to analyze the effects of monetary policy and financial regulation on bank lending policies, two areas were further research is needed.

2.A Appendix

2.A.1 Tables

Parameter	Symbol	Value
Depreciation rate	δ	0.01
Labor share in the FGP sector	α	0.63
Output to capital ratio	$\frac{Y}{K}$	0.45
Growth rate of technology	ψ_a	0.0044
St. Dev. of the technology shock	σ_a^2	0.89
Persistence of the investment shock	ψ_I	0.83
St. Dev. of the investment shock	σ_I^2	6.01
Recovery given default	τ	0.45
Frisch elasticity	φ	1
Labor market weights	$\varkappa$	0.1

Table 2.1: Values of the fixed parameters

Parameter	Symbol	Value
Default rate	$1-q$	0.0015
Lending rate	r_B	0.01
Deposit rate	r_D	0.005
Discount rate	β	0.99
Financial technology	λ	25.2
Return of investment	r_I	0.0958
Fraction of type H investment projects	p	0.72

Table 2.2: Values of the calibrated parameters

Parameter	Symbol	Value
Depreciation rate	δ	0.01
Output to capital ratio	$\frac{Y}{K}$	0.45
Deposit rate	r_D	1.005
Discount rate	β	0.99
Retrun of capital	r_K	0.0151
Labor share in the FGP sector	α	0.63
Output to capital ratio	$\frac{Y}{K}$	0.45
Growth rate of technology	ψ_a	0.0044
St. Dev. of the technology shock	σ_a^2	0.89
Persistence of the investment shock	ψ_I	0.83
St. Dev. of the investment shock	σ_I^2	6.01

Table 2.3: Parameters of the One Sector Model

Correlations of the variables

		Average Correlations of the model with an investment shock							
		General model					One Sector model		
	Data	Benchmark	Flexible	Tight	Low Frisch	High Frisch	Benchmark	Low Frisch	High Frisch
L,Y	0.56	0.97	0.97	0.96	0.98	0.92	0.99	0.99	0.98
		(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
N,Y	0.77	0.96	0.97	0.95	0.98	0.92	0.99	0.99	0.97
		(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
PD,Y	-0.45	0.98	0.99	0.96	0.99	0.93			
		(0.00)	(0.00)	(0.00)	(0.00)	(0.01)			
PD,IM	0.32	1.00	0.99	1.00	1.00	1.00			
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			

Table 2.4: Average correlations from 200 simulations of 500 quarters each. Standard deviations are in parenthesis. L stands for lending, Y for Output, N for total hours, PD for the default rate and IM for the interest margin. The Benchmark colum presents the results using the benchmark calibration of each model. The Flexible colum presents the results using a lower value of the degree of rigidities in the labor market, and the Tight one does the opposite. The Low Frisch colum presents the results using a lower value of the Frisch elasticity, while the High Frisch does the opposite.

Correlations of the variables

		Average Correlations of the model with a technology shock							
		General model					One Sector model		
	Data	Benchmark	Flexible	Tight	Low Frisch	High Frisch	Benchmark	Low Frisch	High Frisch
L,Y	0.56	0.85	0.84	0.86	0.85	0.85	0.99	0.99	0.99
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)
N,Y	0.77	0.64	0.64	0.65	0.65	0.64	0.96	0.96	0.96
		(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.01)	(0.01)	(0.00)
PD,Y	-0.45	0.01	-0.16	0.24	-0.03	0.04			
		(0.01)	(0.02)	(0.01)	(0.01)	(0.02)			
PD,IM	0.32	0.99	0.99	0.96	0.99	0.99			
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			

Table 2.5: Average correlations from 200 simulations of 500 quarters each. Standard deviations are in parenthesis. L stands for lending, Y for Output, N for total hours, PD for the default rate and IM for the interest margin. The Benchmark colum presents the results using the benchmark calibration of each model. The Flexible colum presents the results using a lower value of the degree of rigidities in the labor market, and the Tight one does the opposite. The Low Frisch colum presents the results using a lower value of the Frisch elasticity, while the High Frisch does the opposite.

Standard Deviations of the main macro-economic variables

		Average Standard Deviations from the model with an investment shock							
		General model					One Sector model		
	Data	Benchmark	Flexible	Tight	Low Frisch	High Frisch	Benchmark	Low Frisch	High Frisch
Y	0.82	1.14	1.62	0.79	1.66	0.72	2.79	4.37	1.64
		(0.06)	(0.09)	(0.05)	(0.10)	(0.04)	(0.16)	(0.23)	(0.11)
L	7.86	13.79	19.67	9.48	15.52	12.40	20.14	24.72	16.81
		(0.65)	(1.00)	(0.55)	(0.87)	(0.69)	(1.13)	(1.32)	(1.06)
N	1.15	3.01	3.03	3.39	3.92	2.25	4.33	6.78	2.53
		(0.14)	(0.15)	(0.20)	(0.22)	(0.13)	(0.24)	(0.36)	(0.16)
PD	35.60	8.52	5.61	10.82	9.07	8.10			
		(0.40)	(0.29)	(0.63)	(0.51)	(0.45)			
IM	9.27	8.21	6.15	9.86	8.63	7.90			
		(0.38)	(0.31)	(0.58)	(0.48)	(0.44)			

Table 2.6: Average standard deviations from 200 simulations of 500 quarters each. Standard deviations are in parenthesis. L stands for lending, Y for Output, N for total hours, PD for the default rate and IM for the interest margin. The Benchmark colum presents the results using the benchmark calibration of each model. The Flexible colum presents the results using a lower value of the degree of rigidities in the labor market, and the Tight one does the opposite. The Low Frisch colum presents the results using a lower value of the Frisch elasticity, while the High Frisch does the opposite.

Standard Deviations of the main macro-economic variables

		Average Standard Deviations of the model with a technology shock							
		General model					One Sector model		
	Data	Benchmark	Flexible	Tight	Low Frisch	High Frisch	Benchmark	Low Frisch	High Frisch
Y	0.82	0.96	0.97	0.95	1.00	0.94	0.92	1.04	0.93
		(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.10)	(0.07)	(0.06)
L	7.86	2.21	2.52	1.97	2.40	2.08	1.62	1.86	1.60
		(0.14)	(0.15)	(0.12)	(0.14)	(0.13)	(0.18)	(0.13)	(0.11)
N	1.15	0.29	0.28	0.31	0.39	0.20	0.18	0.28	0.11
		(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
PD	35.60	0.64	0.85	0.50	0.56	0.71			
		(0.02)	(0.03)	(0.02)	(0.02)	(0.02)			
IM	9.27	0.27	0.36	0.25	0.24	0.30			
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)			

Table 2.7: Average standard deviations from 200 simulations of 500 quarters each. Standard deviations are in parenthesis. L stands for lending, Y for Output, N for total hours, PD for the default rate and IM for the interest margin. The Benchmark colum presents the results using the benchmark calibration of each model. The Flexible colum presents the results using a lower value of the degree of rigidities in the labor market, and the Tight one does the opposite. The Low Frisch colum presents the results using a lower value of the Frisch elasticity, while the High Frisch does the opposite.

2.A.2 Figures

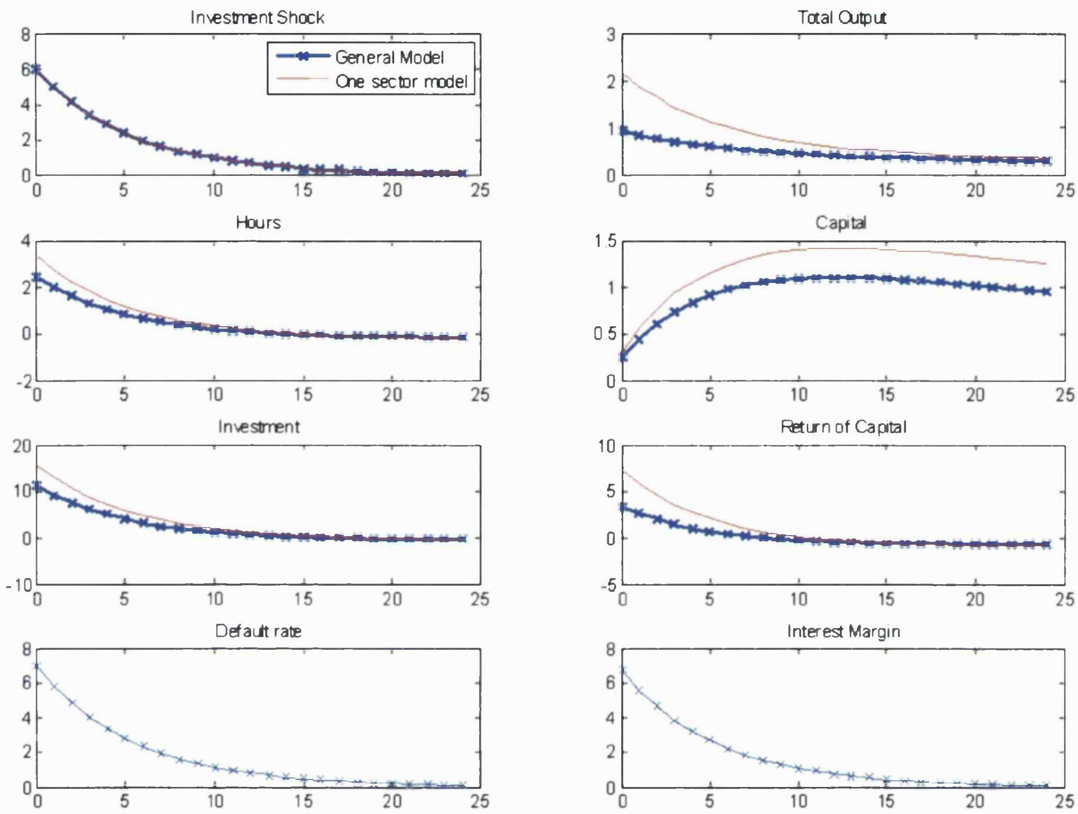

Figure 2.1: Impulse Response functions for a positive investment shock. General Model vs. One Sector Model.

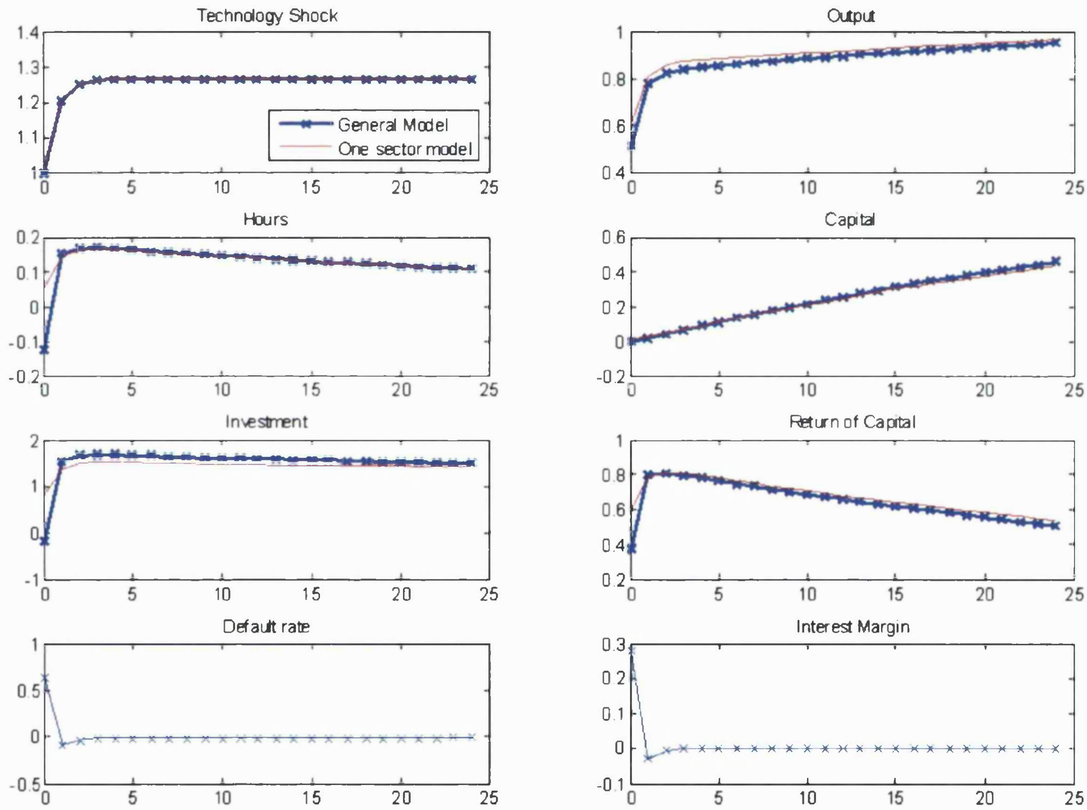

Figure 2.2: Impulse Response functions for a positive technology shock. General Model vs. One Sector Model.

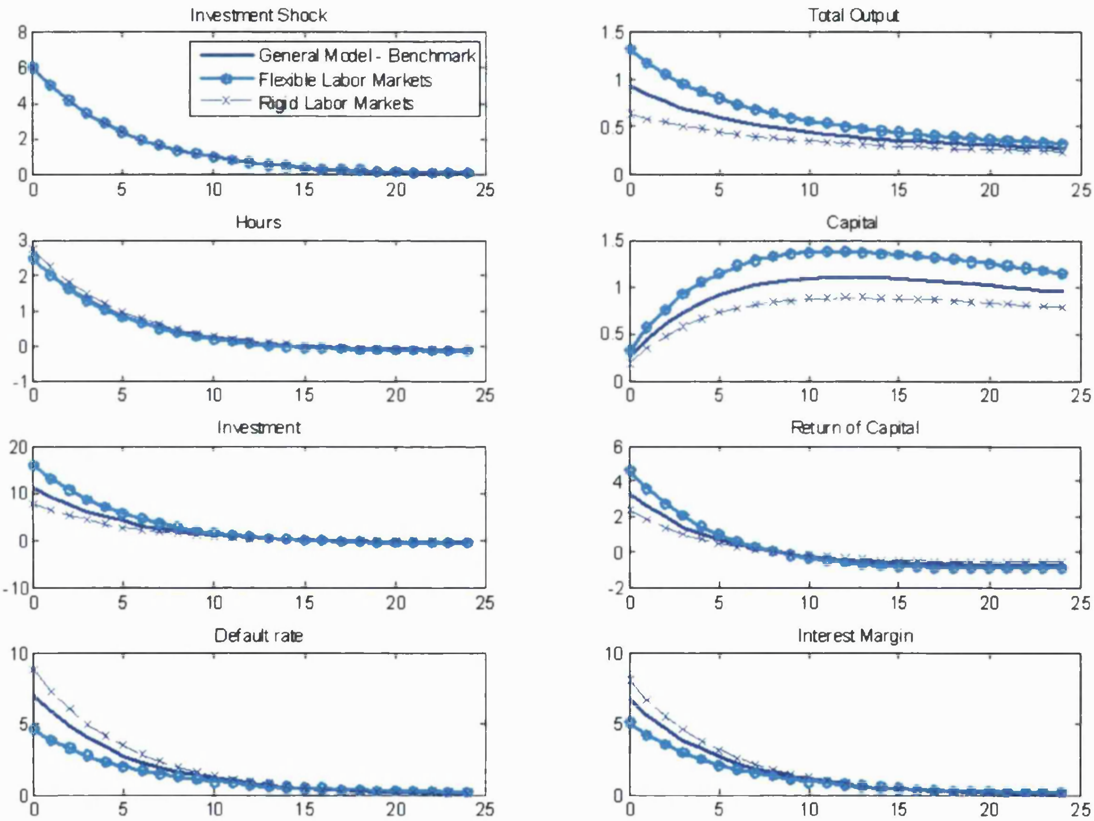

Figure 2.3: Impulse Response functions for a positive investment shock with different degrees of labor market rigidities.

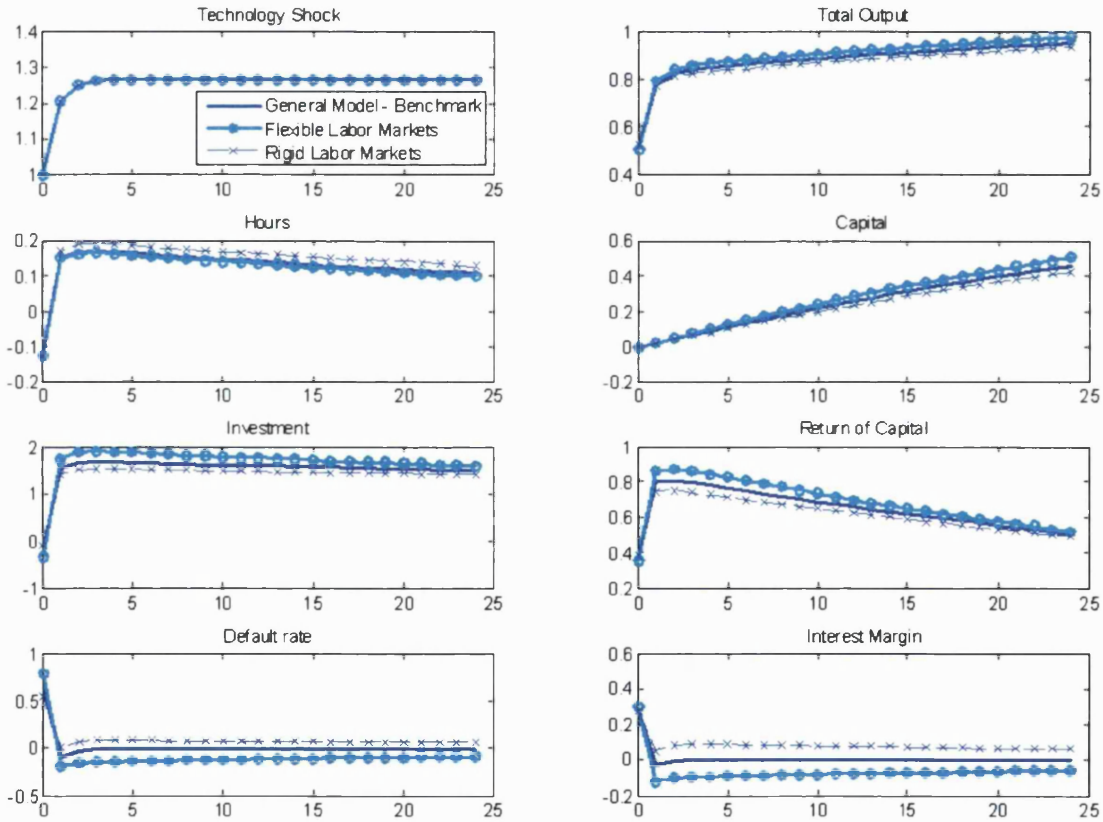

Figure 2.4: Impulse Response functions for a positive technology shock with different degrees of labor market rigidities.

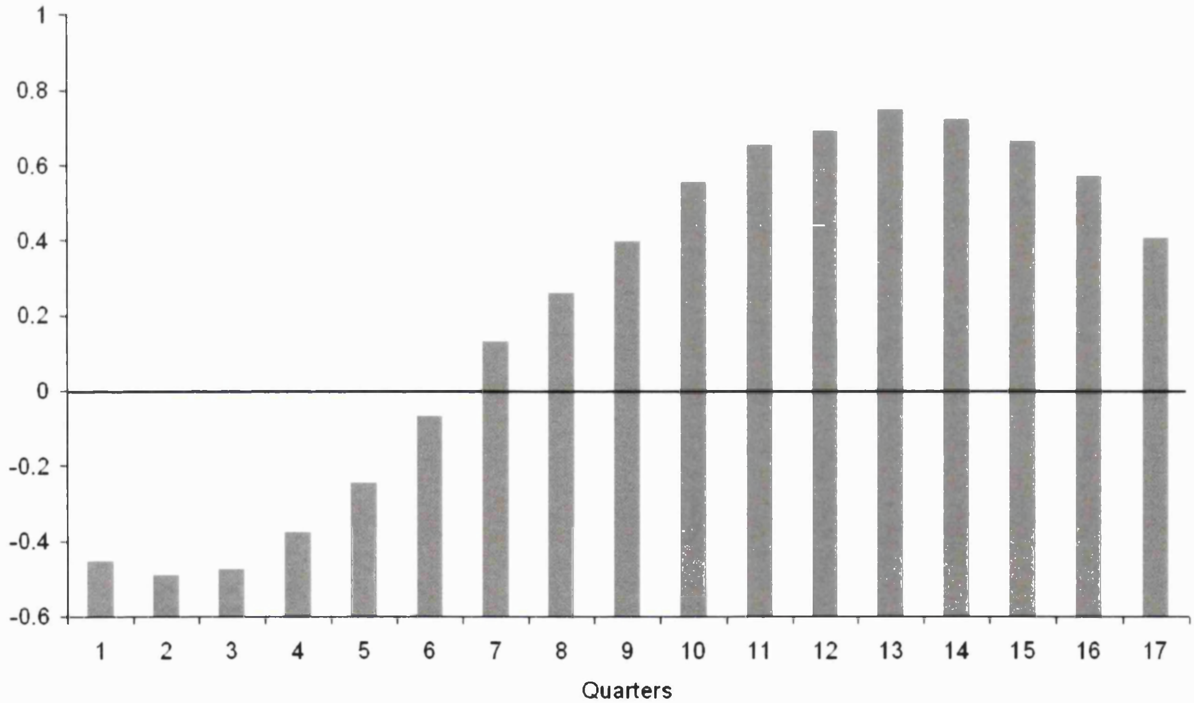

Figure 2.5: Cross-correlation of acual GDP with future values of the Default Rate

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Chapter 3

The Effects of Housing Prices and Monetary Policy in a Currency Union

The recent increase in housing prices has refreshed the debate on the drivers of housing cycles as well as the appropriate policy response. We analyze the case of Spain, where housing prices have soared since it joined the EMU. We present evidence based on a VAR model, and we calibrate a New Keynesian model of a currency area with durable goods. We find that loosing monetary policy autonomy is of first order importance to cushion risk premium shocks, while this is not the case for housing demand shocks. In addition, labor market rigidities provide stronger amplification effects to all type of shocks than financial frictions do.

3.1 Introduction

During the last two decades, the economic importance of the housing sector has reached unprecedented levels. In most developed countries, housing wealth is above 100 percent of GDP, as for instance in the US, the UK, or Spain, and it represents the bulk of households' assets. Moreover, residential investment is highly pro-cyclical and more volatile than GDP. As a result, the recent boom in housing prices in many advanced economies has refreshed the debate on the drivers of housing cycles and the role of the housing sector in amplifying economic volatility, as well as the appropriate response of the monetary authorities.[1]

The case of Spain is of special interest since its recent economic expansion has been characterised by sustained growth of residential investment, private consumption, credit and housing prices for more than a decade. Moreover, during this period nominal and real interest rates have fallen to exceptional low levels during the convergence period to enter the European Economic and Monetary Union (EMU). As a result, a growing current account deficit has emerged, reaching almost 10 per cent of GDP by 2007. In addition to growing imbalances, a special source of concern for the Spanish economy is the loss of monetary policy autonomy after entering the EMU. In the UK or the US, the central bank can increase interest rates to slow down the growth rate of housing prices, and also respond to a housing price collapse. However, Spain belongs to the EMU, and the European Central Bank sets rates according to the inflation rate of the Harmonised Index of Consumer Prices (HICP) of the Euro area as a whole.

The recent evolution of the Spanish economy including the housing market is shown in Figures (3.1) to (3.5). The large decline of interest rates, with an already booming Spanish economy, discouraged households from saving and increased the demand of mortgage and consumption credit. The demand for housing was further increased

[1] A recent paper by Federal Reserve Governor Mishkin (2007) suggests that in response to a housing price drop in the United States of 20 percent, the Federal Reserve should cut its interest rates between 75 and 175 basis points, depending on the assumptions about the transmission mechanism.

by the high levels of inmigration and the baby boom generation, fuelling residential investment in particular and economic growth. The increase in the demand for housing, in turn, caused house prices to rise, augmenting the wealth and borrowing capacity of house owners who could in principle increase their consumption.[2] The growing current account deficit is the other indicator of the magnitude of the consumption and borrowing boom, since the savings-investment imbalance lead Spanish households and firms to obtain financing from abroad.

Hence, in this paper we study the response of an economy such as the Spanish one to fluctuations in housing prices and residential investment, where the main tool of monetary policy, the nominal interest rate, only reacts to domestic conditions as long as they affect aggregate indices of the currency area as a whole. First, we present VAR evidence that shows the response of private consumption, residential investment, and real house prices to an interest rate shock and to a housing demand shock. We show that, as in the US, an increase of interest rates leads to a decline in both final consumption and residential investment, a finding labelled as "comovement" in the literature. On the other hand, we find that these two variables move in opposite directions following a housing demand shock.

Then, we rationalize our findings by building a two-country, two-sector model of a currency union, in the spirit of Benigno (2002) and Rabanal (2007). The model includes durable and non-durable goods. The utility derived from the consumption of the non-durable goods is given by its flow, while the utility derived from the consumption of the durables is given by its stock. As a result, holding durables not only provides utility to the consumer but also provides a wealth effect due to its reselling value. In addition, the international dimension of the model implies that the savings and investment balance need not hold period per period at the country level. This will allow us to explain how increased credit demand in one country of a currency union can be met through funds coming elsewhere in the union without

[2]However, we should note that estimates of the marginal propensity to consume out of housing wealth in Spain are lower than in other countries. Bover (2007) obtains estimates of about 0.01-0.02.

raising the domestic interest rate. We calibrate the model, and examine the reaction of domestic variables and the nominal interest rate to a monetary policy shock, a risk premium shock and a demand/preference shock in the durable sector. We find that shocks that hit Spain and the rest of countries in the currency area symmetrically, such as the monetary policy shock, produce smaller fluctuations than those that are country-specific, such as a risk premium or housing demand shocks. A negative risk premium shock generates larger fluctuations in output than the monetary policy shock, and also leads to a large and persistent deterioration of the net foreign asset position of Spain. The demand shock also ends up generating significant fluctuations on the non-durables sector and in the final output, since the interest rates are set according to Euro Area conditions and do not react importantly to country-specific shocks. Overall, we find that both the demand shock and the risk premium shock produce effects on the main aggregates of the economy similar to the ones observed in the data and in the VAR.

An additional source of concern are the accelerator effects that fluctuations in the housing sector might create. The nominal (and real) growth of the housing sector has increased the amount of collateral available, allowing households to borrow more (or to save less in other instruments) and hence stimulating private consumption. While this amplification effect during the booming side of the cycle may be welcome, the potential effects during a downturn are one of the main worries of many policymakers and households, especially if the effects are asymmetric and stronger during recessions.[3] There is a well established literature that highlights the role of collateral as a key element in the transmission mechanism of shocks and captures how economic cycle swings are amplified through the financial sector (Kiyotaki and Moore (1997) and Bernanke, Gertler and Gilchrist (1999)). More recently, a new strand of the literature has focused on the role that housing in particular plays in the transmission mechanism of shocks, confirming its importance (Aoki et. al. (2004), Iacoviello (2005), and Monacelli (2006)). We therefore proceed with our analysis

[3]See, for instance, the latest conference organized by the Federal Reserve Bank of Kansas City in Jackson Hole, Wyoming.

by studying how the impact of each shock changes when the fraction of credit constrained agents increase, and/or their pledging capacity changes. As expected, the responses of both non-durable and durable output are substantially larger when financial frictions are tighter. But, we find that under financial frictions both consumption and residential investment move in the same direction after a housing demand shock, contradicting our VAR evidence.

However, the most important element that arises from the model in determining the capacity of the economy to absorb those shocks is the flexibility of its labor market. This is key when shocks affect each sector with different intensities, or even with different sign. In our model economy this happens for two reasons. First, following Bils and Klenow (2004) prices are more flexible in the durables sector than in the non-durables sector. Second, the additional value of durables as a saving device makes this sector to be especially dependent on interest rate changes. We compare the impact of the monetary and housing demand shocks for different degrees of labor market frictions and different degrees of financial frictions. Quite surprisingly, and as opposed to the existing literature that stresses the role of financial frictions and borrowing constraints, we find that the effect of introducing these financial frictions is smaller than removing labor market rigidities. However, we find that in order to match our VAR-based evidence, a smaller degree of costly labor reallocation is needed, compared to the estimates for the US economy by Iacoviello and Neri (2008).

In order to analyse the additional volatility that belonging to the EMU might have caused, we compare the impulse response functions of a risk premium and housing demand shocks in the currency union benchmark case with those of running autonomous monetary policy with domestic inflation targeting. Under an inflation targeting regime with a pure floating exchange rate, the monetary policy reaction to a domestic shock is more aggressive than when belonging to a currency union. In addition, we also study the case of running an inflation targeting regime with a managed float. Our conclusion is that running an autonomous monetary policy allows the domestic economy to better cushion adverse shocks. This is specially important in the risk premium shock case since it has first order effects on output and inflation.

Our results are then suggestive of what can work and what cannot work when we estimate our model with Bayesian methods, which is the next step in the agenda. The rest of the paper is organized as follows. In section 3.2, we present some VAR-based evidence. In section 3.3, we present the model, and in section 3.4 we discuss at length the quantitative implications of the model, as well as several robustness checks. We leave section 3.5 for concluding remarks.

3.2 The VAR Response to Housing Demand and Interest Rate Shocks

In this section, we present some evidence on the response of main macroeconomic variables to housing demand and interest rate shocks with the help of a Vector Autoregressive (VAR) model. Several papers in the literature have studied the response of durable and non-durable consumption to a monetary policy shock using a VAR and the recursive identification scheme of Christiano, Eichenbaum, and Evans (1999, 2005). This approach consists in identifying the effect of the monetary policy shock by using the Cholesky decomposition of the variance-covariance matrix of the reduced form residuals of the VAR. Papers following this approach include Erceg and Levin (2006) and Monacelli (2006). In addition, we seek to identify a *housing demand* shock from the VAR. We do so by assuming that the housing demand shock affects the relative price of housing within a period, but it does not affect its quantity: in the short run the supply of housing is fixed, and demand shocks must be absorbed via price movements.

We estimate the following VAR using k variables:

$$Y_t = C + \sum_{j=1}^{L} A_j Y_{t-j} + Bu_t$$

where Y_t is a $kx1$ vector of observable variables, C is a $kx1$ vector of constants, A_j are kxk matrices that collect the effect of endogenous variables at lag j on current variables, L is the lag length in the VAR, B is a kxk lower triangular matrix with diagonal terms equal to unity, and u_t is a $kx1$ vector of zero-mean, serially uncorrelated shocks with diagonal variance-covariance matrix.

The vector of endogenous variables is divided as follows: $Y_t = \begin{bmatrix} Y_{1t} & R_t & Y_{2t} \end{bmatrix}'$, where Y_{1t} is a group of macroeconomic variables predetermined when monetary policy decisions are taken, R_t is a relevant interest rate, and Y_{2t} contains the variables affected contemporaneously by monetary policy decisions. As is costumary in the literature, to identify the interest rate shock we place the nominal interest rate after the macroeconomic variables. We place it before housing prices since we assume that they respond to changes in monetary policy within a period: as an asset price, housing prices are likely to respond contemporaneously to changes in the nominal interest rate. Hence, our housing demand shock is the shock that affects housing prices within a period, after taking into account the effect that changes in the interest rate have on housing prices.[4]

The vector of observable variables is divided the following way. In Y_{1t} we include: (i) household consumption of final goods in Spain, (ii) residential investment in Spain, and (iii) the harmonised index of consumer prices (HICP) in the Euro Area. We use as a relevant interest rate (R_t) the reference 12-month interbank rate.[5] We include Euro Area inflation in the VAR because nominal interest rates in the euro area should react to inflation in the euro area, given the inflation targeting mandate of the European Central Bank. Finally, we include in Y_{2t} real house prices in Spain. All variables are introduced after taking natural logarithms and first differences, except for the nominal interest rate that we introduce directly in levels.

Private consumption and residential investment come from Spanish national accounts data and are deflated by the Spanish GDP deflator. Spain and Euro Area

[4]We have also estimated a VAR with the ordering $Y_t = \begin{bmatrix} Y_{1t} & Y_{2t} & R_t \end{bmatrix}'$ and the results are very similar to the ones we present.

[5]Using the 3-month reference rate delivers very similar results.

HICP's come from Eurostat. Nominal housing price series come from the Spanish Ministry of Housing and is deflated by the HICP in Spain. In studies involving US data the Federal Funds rate is typically the variable used as an indicator of the stance of monetary policy, following the study of Bernanke and Blinder (1992). Spain relinquished its monetary policy autonomy when it joined the EMU in January 1st, 1999, and hence a domestic reference rate is no longer available. We choose the 12-month interbank rate because it is the reference interest rate for mortgages. From 1999 we use the 12-month Euribor rate, and before the EMU period we use the 12-month MIBOR rate. Note that because of this reason, we call our shock an interest rate shock rather than a monetary policy shock in the VAR. We must note, however, that the reference rate set by the European Central Bank, the 3-month interbank rate and the 12-month interbank rate move very closely together, such that changes in the 12-month rate reflect mostly policy actions taken by the ECB. We estimate the VAR from 1995:01 to 2007:03 at a quarterly frequency, with 4 lags. We are constrained by the availability of the housing price series.

In Figures (3.6) and (3.7) we present the impulse responses of interest rates and housing prices to an increase of interest rates and a housing demand shock, and the accumulated responses of the other variables with 90 percent confident bands.[6] The impulse responses are qualitatively similar to those shown by Monacelli (2006) for the US economy. The interest rate shock imples an increase of about 25 basis points in the nominal interest rate. The cumulative response of residential investment is about 5 times stronger than that of private consumption, and the effect is also faster. Also note that real house prices decline with an increase in the nominal interest rate. On the other hand, a housing demand shock increases real house prices and residential investment, and it reduces consumption by a small but significant amount during the first period. These are the features that we will ask our model to reproduce.

[6] Given our short sample it is difficult to obtain significance at 95 percent levels.

3.3 The Model

The theoretical framework consists of a general equilibrium two country, two sector model in a single currency area. The countries are of size n and $1-n$, and each of them produces two types of goods, durables and non-durables, under monopolistic competition and nominal rigidities. Only the non-durable goods are tradable. Producers of the final durable good sell its product to domestic households only in each country, which allows them to increase their housing stock. For this reason, we use the terms "durable good production" and "residential investment" interchangeably throughout the paper.

Since our VAR analysis has only focused on the effects of monetary and demand shocks on the housing sector and the spillover effects to the macroeconomy, the model will only include these shocks, so we leave aside technology shocks in the current analysis. Iacoviello and Neri (2008) attribute most of the variation in housing prices to a housing preference shock. In what follows, we present the home country block of the model. The analogous foreign-country variables will be denoted by an asterisk.

3.3.1 Households

Each household j in the home country maximizes the following utility function:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\gamma \log(C_t^j) + (1-\gamma)\xi_t \log(D_t^j) - \frac{\left(L_t^j\right)^{1+\varphi}}{1+\varphi} \right] \right\} \tag{3.1}$$

where C_t^j denotes consumption of non-durable goods, and D_t^j denotes consumption of durable goods. In addition, consumption of non-durables is an index composed of home and foreign consumption goods:

$$C_t^j = \frac{1}{\tau^\tau (1-\tau)^{1-\tau}} \left(C_{H,t}^j\right)^\tau \left(C_{F,t}^j\right)^{1-\tau} \tag{3.2}$$

where $C^j_{H,t}$ and $C^j_{F,t}$ are, respectively, consumption of the home non-durable goods and consumption of foreign non-durable goods by the home agent, and τ is the fraction of domestically produced non-durables at home. ξ_t is a housing preference shock that follows an AR(1) in logs. Finally, following Iacoviello and Neri (2006), we assume that there is imperfect substitutability of labor supply across sectors, such that the labor disutility index can be written as:

$$L^j_t = \left[\alpha^{-\iota}\left(L^{C,j}_t\right)^{1+\iota} + (1-\alpha)^{-\iota}\left(L^{D,j}_t\right)^{1+\iota}\right]^{\frac{1}{1+\iota}}, \text{ where } \iota > 0 \tag{3.3}$$

where $L^{i,j}_t$ denotes hours worked by household j in each sector $i = C, D$, and α is the economic size of each sector. This imperfect substitutability implies that there is a costly labor reallocation across sectors following a shock. The budget constraint of the home agent, in nominal terms, is given by:

$$P^C_t C^j_t + P^D_t\left[D^j_t - (1-\delta)D^j_{t-1}\right] + B^j_t \leq \tilde{R}_{t-1}B^j_{t-1} + W^C_t L^{C,j}_t + W^D_t L^{D,j}_t + \Pi^j_t \tag{3.4}$$

where P^C_t and P^D_t are the price indices of durable and non-durable goods, to be defined below, W^i_t is the nominal wage in each sector $i = C, D$, and B^j_t denotes uncontingent nominal assets that are traded among households across the monetary union, and that pays (or costs) a gross nominal interest rate $\tilde{R}_t > 1$. Π^j_t denotes nominal profits, because firms are ultimately owned by households.

We assume that households in the home country have to pay a premium above the union-wide riskless nominal interest rate if the country's debt level as percent of GDP increases. This assumption is useful to obtain a well-defined steady state for the aggregate level of debt as percent of nominal GDP.[7] The relevant interest rate for the home households and the union-wide interest are related as follows:

$$\tilde{R}_t = R_t - \vartheta_t \exp\left[\psi\left(\frac{B_t}{P_t Y_t} - \frac{B}{PY}\right)\right] - 1 \tag{3.5}$$

where P_t is the aggregate price level, to be defined below, and Y_t is real GDP, also to

[7] See Schmitt-Grohé and Uribe (2003).

be defined below. This risk premium depends on aggregate variables, such that each household takes this effect as given when choosing between consuming durables, non-durables, and saving. ϑ_t is a risk premium shock that affects the domestic interest rate but not the union-wide nominal interest rate. Note that the risk premium is declining in the net foreign asset position of the country as percent of GDP, $\frac{B_t}{P_t Y_t}$.

We can separate the household's decision as a two stage process. First, households choose the amount of labor to supply to each sector, and the consumption of durables and non-durables. Second, they allocate how much to spend in home and foreign produced goods, taking into account that $P_t^C C_t = P_{H,t} C_{H,t} + P_{F,t} C_{F,t}$. Note that prices of foreign non-durable consumption goods do not carry an asterisk because they are also set in euros, and there is no price discrimination across countries.

The first order conditions to the household problem are given by:[8]

$$\frac{P_t^D}{P_t^C} = \frac{1-\gamma}{\gamma} \frac{\xi_t C_t}{D_t} + \beta(1-\delta) E_t \left(\frac{C_t}{C_{t+1}} \frac{P_{t+1}^D}{P_{t+1}^C} \right) \tag{3.6}$$

Note that if the durable good was in fact non-durable (i.e. $\delta = 1$), this condition simply states that the marginal utilities of consumption should equal relative prices. Since the durable good has a residual value the following period, this induces the extra-term of holding an additional unit of the durable good.

A standard Euler equation for the consumption of non-durable goods is:

$$1 = \beta \tilde{R}_t E_t \left(\frac{P_t^C}{P_{t+1}^C} \frac{C_t}{C_{t+1}} \right) \tag{3.7}$$

The labor supply conditions to both sectors are given by:

$$L_t^{\varphi-\iota} \alpha^{-\iota} \left(L_t^C\right)^{\iota} = \frac{\gamma}{C_t} \frac{W_t^C}{P_t^C} \tag{3.8}$$

$$L_t^{\varphi-\iota} (1-\alpha)^{-\iota} \left(L_t^D\right)^{\iota} = \frac{\gamma}{C_t} \frac{W_t^D}{P_t^C} \tag{3.9}$$

[8]Since all households behave the same way, we drop the j subscripts in what follows.

The allocation of expenditures between home and foreign-produced goods is:

$$C_{H,t} = \tau \left(\frac{P_{H,t}}{P_t^C} \right)^{-1} C_t \tag{3.10}$$

$$C_{F,t} = (1-\tau) \left(\frac{P_{F,t}}{P_t^C} \right)^{-1} C_t. \tag{3.11}$$

The price index for non-durables is given by

$$P_t^C = P_{H,t}^{\tau} P_{F,t}^{1-\tau} \tag{3.12}$$

and the CPI is

$$P_t = \left(P_t^C\right)^{\gamma} \left(P_t^D\right)^{1-\gamma} \tag{3.13}$$

The utility maximization problem of foreign country households is quite similar. We assume that the functional forms for preferences are the same across countries, but allow for different parameter values. That is, γ^* is the weight of non-durables in the utility function, and τ^* the fraction of domestically produced non-durables.

3.3.2 Producers

There is a continuum of intermediate goods producers, indexed by $h \in [0, n]$ in the home country, and by $f \in [n, 1]$ in the foreign country, that are imperfect substitutes of each other, and that supply final goods producers in each sector. There is a continuum of final goods producers in the two sectors that operate under perfect competition and flexible prices. Producers of the final durable good sell its product to domestic households only in each country. Producers of the final non-durable good sell their product to domestic and foreign households. Hence, it is important to distinguish the price level of domestic non-durable consumption goods, $P_{H,t}$, which does not coincide with the price level of non-durables (P_t^C) because of the presence of imported non-durable goods, whose price is $P_{F,t}$.

Final Goods Producers

In the durable sector, final goods producers purchase intermediate goods producers and aggregate them according to the following production function:

$$Y_t^D \equiv \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma_D}} \int_0^n Y_t^D(h)^{\frac{\sigma_D - 1}{\sigma_D}} dh \right]^{\frac{\sigma_D}{\sigma_D - 1}} \tag{3.14}$$

Profit maximization delivers the following demand for individual intermediate non-durable goods:

$$Y_t^D(h) = \left(\frac{P_t^D(h)}{P_t^D} \right)^{-\sigma_D} Y_t^D, \tag{3.15}$$

where the price level is given by imposing the zero-profit condition.

$$P_t^D \equiv \left\{ \frac{1}{n} \int_0^n \left[P_t^D(h) \right]^{1-\sigma_D} dh \right\}^{\frac{1}{1-\sigma_D}}.$$

In the non-durable goods sector, expressions are similar but with an appropiate change of notation since the price level of domestic non-durables and of a basket of durables is not the same. The aggregate production function is:

$$Y_t^C \equiv \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma_C}} \int_0^n Y_t^C(h)^{\frac{\sigma_C - 1}{\sigma_C}} dh \right]^{\frac{\sigma_C}{\sigma_C - 1}}, \tag{3.16}$$

individual intermediate non-durable goods demand is:

$$Y_t^C(h) = \left(\frac{P_t^H(h)}{P_t^H} \right)^{-\sigma_C} Y_t^C, \tag{3.17}$$

where the price level is:

$$P_t^H \equiv \left\{ \frac{1}{n} \int_0^n \left[P_t^H(h) \right]^{1-\sigma_C} dh \right\}^{\frac{1}{1-\sigma_C}}.$$

Intermediate Goods Producers

There is a continuum of intermediate goods producers, indexed by $h \in [0, n]$ in the home country, and by $f \in [n, 1]$ in the foreign country, that are imperfect substitutes of each other, and that supply final goods producers in each sector. Intermediate goods producers face a Calvo-type restriction when setting their price. In each period, a fraction $1 - \theta_j$ in each sector receive a signal to reset their price optimally.

Intermediate goods are produced with labor:

$$Y_t^i(h) = L_t^i(h), \text{ for all } h \in [0, n], \text{ and } i = C, D. \tag{3.18}$$

In each sector, cost minimization implies that the nominal marginal cost of production equals the nominal wage in each sector:

$$MC_t^i = W_t^i, \; i = C, D.$$

Note that even though labor is the only production input, labor costs may differ across sectors because of imperfect labor substitutability. Hence, this effect induces an additional channel of heterogeneous inflation responses across sectors, even when the parameters governing nominal rigidities are similar across sectors.

Firms in the durable sector face the following maximization problem:

$$Max_{P_t^D(h)} E_t \sum_{k=0}^{\infty} \theta_D^k \Lambda_{t,t+k} \left\{ \left[\frac{P_t^D(h) - MC_{t+k}^D}{P_{t+k}^D} \right] Y_{t+k}^D(h) \right\}$$

subject to future demand

$$Y_{t+k}^D(h) = \left(\frac{P_t^D(h)}{P_{t+k}^D} \right)^{-\sigma_D} Y_{t+k}^D$$

where $\Lambda_{t,t+k} = \beta^k \frac{\lambda_{t+k}}{\lambda_t}$ is the stochastic discount factor, and λ_t is the marginal utility of non-durable consumption.

The optimal choice is given by:

$$\frac{\hat{P}_t^D}{P_t^D} = \frac{\sigma_D}{(\sigma_D - 1)} E_t \left\{ \frac{\sum_{k=0}^{\infty} \beta^k \theta_D^k \lambda_{t+k} \left(\prod_{s=1}^{k} \frac{1}{\Pi_{t+s}^D} \right)^{-\sigma_D} \frac{MC_{t+k}^D Y_{t+k}^D}{P_{t+k}^D}}{\sum_{k=0}^{\infty} \beta^k \theta_D^k \lambda_{t+k} \left(\prod_{s=1}^{k} \frac{1}{\Pi_{t+s}^D} \right)^{1-\sigma_D} Y_{t+k}^D} \right\} \tag{3.19}$$

Given the assumptions about Calvo pricing, the evolution of the price level is:

$$P_t^D = \left\{ \theta_D \left(P_{t-1}^D\right)^{1-\sigma_D} + (1-\theta_D) \left(\hat{P}_t^D\right)^{1-\sigma_D} \right\}^{\frac{1}{1-\sigma_D}}. \tag{3.20}$$

Firms in the non-durable sector face a similar maximization problem, and hence the optimal price and the evolution of the price level have similar expressions, with the appropiate change of notation.

3.3.3 Closing the Model

Market Clearing Conditions

In each intermediate good, supply equals demand. We write the market clearing conditions in terms of aggregate quantities. Hence, we multiply per-capita quantities by population size of each country. Total production in the non-durable sector is equal to total domestic consumption and exports:

$$Y_t^C = nC_{H,t} + (1-n)\, C_{H,t}^* \tag{3.21}$$

while residential investment is used to increase the domestic housing stock:

$$Y_t^D = n\left[D_t - (1-\delta)D_{t-1}\right] \tag{3.22}$$

For the foreign country, the analogous conditions are:

$$Y_t^{*C} = nC_{F,t} + (1-n)\, C_{F,t}^* \tag{3.23}$$

$$Y_t^{*D} = (1-n)\left[D_t^* - (1-\delta)D_{t-1}^*\right] \tag{3.24}$$

Total hours worked equals labor supply in each sector:

$$\int_0^n L_t^C(h)dh = \int_0^n L_t^{C,j}dj \tag{3.25}$$

$$\int_0^n L_t^D(h)dh = \int_0^n L_t^{D,j}dj \tag{3.26}$$

Market clearing in the international bonds market is:

$$nB_t + (1-n)B_t^* = 0 \tag{3.27}$$

Finally, the evolution of aggregate net foreign assets is:

$$nB_t = n\tilde{R}_{t-1}B_{t-1} + (1-n)\,P_{H,t}C_{H,t}^* - nP_{F,t}C_{F,t} \tag{3.28}$$

Monetary Policy Rule

In order to close the model, we need to specify a rule for monetary policy, which is conducted by the European Central Bank with an interest rate rule that targets CPI inflation and also exhibits interest rate inertia:

$$R_t = \left[\bar{R}\left(\frac{P_t^{EMU}/P_{t-1}^{EMU}}{\bar{\Pi}^{EMU}}\right)^{\gamma_\Pi}\right]^{1-\gamma_R} R_{t-1}^{\gamma_R}\exp(\varepsilon_t^m) \tag{3.29}$$

where the euro area CPI is given by a geometric average of the home and foreign country CPIs, using the country size as a weight:

$$P_t^{EMU} = P_t^n\left(P_t^*\right)^{1-n}$$

3.4 Quantitative Implications of the Model

3.4.1 Calibration

In the steady state, we assume zero inflation, that the trade balance is zero, and that the net international position of both economies is zero. Therefore, we only need to solve for the per-capita values of the home country, which are the same as those in the foreign country. We also assume that the degree of monopolistic competition in both types of goods is the same ($\sigma_C = \sigma_D = \sigma$), and hence the ratio of prices is one. The real interest rate in the currency union is given by the discount factor:

$$R = \frac{1}{\beta} \tag{3.30}$$

Now, we solve for the levels of consumption of durables, non-durables, debt, total hours, and the economic size of each sector. The optimal steady-state ratio of durable to non-durable consumption is:

$$\frac{C}{D} = \frac{\gamma\left[1-\beta(1-\delta)\right]}{1-\gamma} = \Omega \tag{3.31}$$

In a standard model with homogeneous agents and non-durable goods ($\delta \to 1$), the optimal steady state ratio of the two types of goods would be equal to the ratio of relative weights in the utility function. Because of durability, the ratio is higher than otherwise. The fraction of spending allocated to non-durable consumption over total spending (α) is equal to:

$$\frac{C}{C+\delta D} = \alpha$$

Note that γ and α cannot be calibrated independently. Given values for α, δ, β, we can solve for the value of γ in the utility function. From the pricing equations and assuming that the level of monopolistic competition is the same in both sectors, we have that:

$$W^C = W^D = \frac{\sigma-1}{\sigma}$$

As a result, from the optimizing conditions for households,

$$(1-\alpha)L^C = \alpha L^D \tag{3.32}$$

which means that agents spend a fraction α of time working in the non-durable sector, and a fraction $1-\alpha$ in the durable sector. Therefore aggregate production levels are given by

$$\bar{Y}^C = \alpha n L \tag{3.33}$$

$$\bar{Y}^D = (1-\alpha) n L \tag{3.34}$$

Table (3.1) summarises the values of the exogenous and endogenous parameters of the model. We set as the home country Spain, and the foreign country the rest of the euro area. Hence, we set the size of the home economy to $n = 0.1$. We set the size of the construction sector at $1-\alpha = 0.1$, both in Spain and in the EMU, which is roughly the average size for the value added of the construction sector in the last decade. We calibrate the bilateral trade parameter (τ) based on total imports from the EMU to Spain over total spending, and calibrate its analogous parameter in the EMU (τ^*) in a similar way. Finally, we calibrate the debt elasticity parameter to the domestic interest rate to a small value of $\kappa = 0.001$. This value is smaller to the one estimated by Rabanal and Tuesta (2007), but captures the idea that interest rates spreads between Spain and the EMU have been negligible during this period. We calibrate the parameters concerning technology and preferences based on standard values in the literature or on the estimates of Iacoviello and Neri (2008) using US data, except for the degree of substitutability across labor types, that we set to $\iota, \iota^* = 0.5$, which is in between Iacoviello and Neri (2008) and Monacelli (2006) . As we explained previosuly, based on all the other structural parameters of the economy, we solve for the weight of the housing stock in the utility function.

Having calibrated the real side of the economy, we now proceed to discuss the calibration of the degree of nominal rigidity in each sector and country, which is not free of controversy. In the literature, there is a long standing debate on the degree of nominal rigidities between housing and the other sectors of the economy, and how this might affect the transmission mechanism of monetary policy. For instance, Carlstrom and Fuerst (2007) use the evidence on frequency of price adjustments in the durable and non-durable sectors of Bils and Klenow (2004) to argue that prices in the housing sector are more flexible than in the consumption goods sector. Using this calibration is problematic because, in the model, a monetary contraction causes an expansion of residential investment. This result arises because the different degree of nominal rigidity across sectors causes a strong movement of relative prices.

Since we do not have similar survey evidence for the Euro Area and Spain, we calibrate the non-durable sector following the estimates of Rabanal (2007) in a model with tradable and non-tradable goods. Hence, we set prices to be more sticky in the non-durable sector in the euro area ($\theta^{C^*} = 0.75$) than in Spain ($\theta^{C} = 0.5$). To capture the notion that durable goods (housing prices) might be more flexible, we set lower Calvo probabilities in both countries without assuming full flexibility ($\theta^{D} = \theta^{D^*} = 0.25$). We conduct a thorough robustness exercise in the following section. Finally, we calibrate the parameters of the Taylor rule to estimates obtained in the empirical literature in the Euro Area (see, for instance, Rabanal, 2007).

3.4.2 Impulse response functions

In this section, we discuss the main features of the model by presenting the impulse response functions of a monetary policy shock, a risk premium shock, and a housing preference shock. We obtain the model's dynamics by taking a log-linear approximation around the steady state. In Appendix A we detail the full set of linear equations of the model.

Monetary policy (ε_t^m) and risk premium (ϑ_t) shocks

In the VAR analysis section, we showed impulse responses to an interest rate shock. Without further information, we could not tell if it was a monetary policy shock or a movement in market interest rates determined by other factors. However, in the context of our model, we can discrimante between monetary policy shocks that affect the whole of the euro area, or just Spain. Figure (3.7) presents the impulse response functions of the main variables in Spain to an expansionary monetary policy shock in the euro area. We choose the size of the shock ε_t^m in the Taylor rule expression (3.29) to obtain a decline of 25 basis points on impact in the nominal interest rate. Following the shock, consumption of both good types raises, leading to an increase of production in both sectors, but it is stronger in the durable sector. We obtain a strong comovement between both sectors even though the degrees of nominal rigidity are different across sectors. Why is this the case? After a monetary policy easing, and as a response to the higher demand, durable good producers can increase the price quicker than the non-durable producers and hence, the relative price between durables and non-durables increases. This, in turn, reduces the demand of durables and it further raises the demand for non-durables. However, the additional value that the durable good has as a storage device makes it especially sensible to changes in its relative price due to monetary policy shocks and more than offsets the initial negative effect. Labor market rigidities also limit de degree of reallocation across sectors.

Note also that Spain runs a small trade deficit with the rest of the EMU and hence the net foreign asset position becomes negative, but the effect is quantitatively small. As a result the euro area interest rate and the interest rate in Spain are numerically the same. The small response of the trade balance is due to the fact that the shock is symmetric and affects the two countries similarly, given similar production structures and preferences. The degrees of nominal rigidity are not so different to create quantitatively different responses in Spain and in the rest of the euro area.

Therefore, in Figure (3.8) we inspect the effects of a risk-premium shock in Spain. This shock can be justified as a shifting in market sentiment that would imply that inverstors are willing to lend to Spain at a lower rate than the euro area. On historical grounds, it can also be justified due to the decline in risk premia (less exchange rate and inflation uncertainty) and convergence of nominal interest rates prior to the introduction of the euro. We assume that the risk premium shock has a persistence coefficient of 0.9.

Since this shock also implies a reduction of the relevant nominal interest rate, it is also followed by higher levels of all consumption goods in the Spanish economy, with a stronger effect on the durable sector. Since Spain's growth and inflation increase, the ECB raises interest rates mildly. Also, since the shock is only expansionary for Spain and not the rest of the EMU, a large trade deficit arises, because the increase of imports in Spain is not matched by an increase of exports to the euro area, as it was the case for the Euro Area-wide monetary policy shock. Therefore, a decline in risk premia does fit the Spanish experience fairly well.

Housing preference shock (ξ_t)

Next, we examine the effects of a housing preference shock. In their study of the US economy, Iacoviello and Neri (2008) conclude that these type of shocks explain a significant fraction of the volatility of house prices and residential investment. In the context of our model, one could see these demand pressures as stemming from population changes: increased immigration, the "baby boom" generation that in Spain peaked in the 1970s, and changes in social attitudes that reduce the number of persons per households.

The housing demand shock is normalized such that residential investment increases about 10 percent above its long-run value, and the shock has a persistence coefficient of 0.9. The preference shock in the durables sector leads to an increase in the relative price of durables. Given the small size of the Spanish economy with respect to the Euro area, interest rates barely react to the greater levels of inflation in the Spanish economy, allowing it to experience a long lived expansion in this sector together with moderate levels of inflation. Note also that non-durable output slightly decreases with the housing demand shock, which coincides with the VAR evidence presented above. We seek to understand this lack of comovement between the two sectors in the following subsection.

The effects of belonging to the EMU

As argued in the introduction, the capacity of the Spanish economy of reacting to idiosyncratic shocks was reduced substantially when joining the EMU due to the loss of monetary policy autonomy. To analyze the consequences of abandoning monetary policy independence, we extend the model of section 3.3 by assuming that both countries can run an autonomous monetary policy with different national currencies as units of account. We therefore introduce Taylor rules for both countries, an uncovered interest rate parity condition, and we assume producer currency pricing for imports and exports of non-durable goods, as in Lubik and Schorfheide (2005) and Rabanal and Tuesta (2007). The goal is to study how would a small open economy react in a two country model when faced with risk premia and housing demand shocks.

In log linear terms, the uncovered interest rate parity reads as follows:

$$r_t - r_t^* = E_t s_{t+1} - s_t - \kappa b_t - \vartheta_t \tag{3.35}$$

where s_t is the log of the nominal exchange rate, defined as units of home country currency per unit of foreign country currency. This equation links the interest rate differential to the expected depreciation of the currency, and also includes the endogenous risk premium depending on the net foreign asset position of the economy (b_t).

In this case, the domestic interest rate becomes r_t, while the foreign interest rate is r_t^*, and both follow Taylor rules targeting domestic inflation:

$$\begin{aligned} r_t &= \gamma_R r_{t-1} + (1-\gamma_R)\gamma_\pi \Delta p_t + (1-\gamma_R)\gamma_s \Delta s_t && (3.36) \\ r_t^* &= \gamma_R^* r_{t-1}^* + (1-\gamma_R^*)\gamma_\pi \Delta p_t^* && (3.37) \end{aligned}$$

Note that we assume that the coefficients of the Taylor rule (γ_R and γ_π) are the same across countries. In addition, we consider that the home country can either run a pure float, or put some weight on exchange rate depreciation, which is controlled by the γ_s parameter. That is, the domestic country (Spain) could either run a purely domestic inflation targeting regime ($\gamma_s = 0$), or manage the exchange rate vis-à-vis the currency of the rest of the Euro Area by setting $\gamma_s > 0$. In the limiting case where $\gamma_s \to \infty$, the domestic country pegs the exchange rate with the foreign country, and the model would behave exactly like the one we have presented in section 3.3.

Finally, since we have assumed that there is producer currency pricing and the law of one price holds, durables inflation in both countries is given by:

$$\Delta p_t^C = \tau \Delta p_{H,t} + (1-\tau)(\Delta p_{F,t} + \Delta s_t) \tag{3.38}$$

$$\Delta p_t^{C*} = (1-\tau^*)(\Delta p_{H,t} - \Delta s_t) + \tau^* \Delta p_{F,t} \tag{3.39}$$

such that movements in the nominal exchange rate affect directly the price of imports and exports.

In Figures (3.11) and (3.12) we compare the impulse response functions of the risk premium and housing demand shocks under three different exchange rate regimes: a fixed exchange rate, a pure floating inflation targeting regime and a managed floating regime. We use the same calibrations that we discussed in Table (3.1). When we refer to the "No EMU Pure float" we set the parameter to $\gamma_s = 0$, while in the "No EMU Man. float" we set the parameter to $\gamma_s = 1$.

The impulse response functions for a risk premium shock are shown in Figure (3.11). Under a pure float, a favorable (negative) risk premium shock increases the appetite for investment in assets denominated in the home country's currency, thereby pushing interest rates down and causing an appreciation. This worsens the terms of trade, implying that the price of exports increases and the price of imports falls, by a far larger amount than under the EMU or managed float cases. The fall of interest rates causes consumption in both durables and non-durables to expand, while the production of durables increases but the production of non-durables decreases due to the competitiveness loss. This causes aggregate output to fall as well. A large trade deficit emerges under a pure float, which causes the NFA position to worsen much more than under a managed float, or belonging to the EMU. Under a managed float regime output increases because the central bank does not allow such an appreciation to happen, preventing the deterioration of the termos of trade.

Under a housing demand shock of equal magnitude (Figure (3.12)), the response of output is largest in the EMU. The small impact of this shock into the euro area economy produces no reaction of the monetary authority, and the Spanish economy experiences all the consequences of the shock: high growth in the durable sector, almost no effect in the non-durable sector, and moderate levels of inflation. On the contrary, in the "No-EMU pure float" case, since monetary policy is set at the local level, in response to the demand pressures the central bank increases the interest rates, causes an exchange rate appreciation, and output declines in the non-durable sector. However, inflation pressures are not high enough to force the Spanish monetary authoirty to increase the interest rates agressively, and hence the effects on total output do not differ much in either case.

Note that, by the same token, if prices where to collapse due to a negative housing demand shock, running an autonomus monetary would certainly be more helpful to stimulate the economy. However, the differences are quantitatively small. The managed float is again an in-between of the two extreme case. At any rate, in all cases we are able to explain the lack of comovement, but the intensity is different depending on whether we model the small open economy as belonging to a currency area or running an autonomous monetary policy.

3.4.3 Robustness checks

The effects of financial frictions

As it has been widely argued in the literature, the presence of financial frictions might amplify the shocks to the economy since the consumption behaviour of credit constrained agents is especially dependent on changes of interest rates and durable good prices. For instance, Iacoviello and Neri (2008), Carlstrom and Fuerst (2006) and Monacelli (2006) have suggested that in order to explain a positive comovement between the two sectors it is crucial to introduce credit constraints into the model. Note, however, that we are able to explain the behavior of Spanish variables with a baseline model without credit constraints. One possible reason could be the low estimated marginal propensity to consume out of housing wealth in Spain (Bover, 2007).

To evaluate the importance of financial frictions we analyse how the impact of a monetary policy and housing preference shocks varies as the fraction of agents with limited borrowing capacity increases, and their pledging capacity changes. We extend the model of section 3.2 by assuming that a fraction $1-\lambda$ of agents face credit constraints. In particular, we assume that these agents, which are typically labelled as *borrowers* in the literature (see Monacelli, 2006), are more impatient than the regular agents and have a smaller discount factor than the unconstrained agents of $\tilde{\beta} < \beta$. The maximum amount these households can borrow ($\tilde{S}_t^j$) is linked to their repayment capacity based on their housing collateral as follows:

$$\tilde{S}_t^j \leq (1-\chi)E_t\left(\tilde{D}_t^j P_t^D\right) \tag{3.40}$$

where $(1-\chi)$ is the loan-to-value ratio. We assume that the financially constraint households can borrow from unconstrained households within a country only, and that unconstrained households can borrow and lend at the national and international levels.

We present the impact effect of monetary and housing demand shocks as a function of λ and χ in Figures (3.13) and (3.14). All other parameter values are set to those in Table (3.1). We obtain similar results to those reported in the existing literature, in the sense that the response of both non-durables and durables output are substantially larger when financial frictions are tighter. By financial frictions being tighter we mean that either there is a larger fraction of credit constrained agents (lower λ) in the economy and/or their borrowing capacity is more restricted (higher χ). After a monetary policy shock, non-durable output always increases when financial frictions are present, with the impact effect depending in an important way on λ and χ. The effects on durable output are less dramatic, and they can be nonmonotonic with respect to λ when the loan-to-value ratio is high (χ is low). The consequences of having tighter financial frictions on output change critically when the model economy experiences a positive housing preference shock. Under our baseline calibration, non-durable output experiences a small decline after a positive housing demand shock, which coincides with the VAR evidence. However, as financial constraints become tighter, a positive comovement between durable and non-durable output emerges. Hence, we conclude that introducing financial constraints does not help the model explain the data. This result is of course Spain-specific, and is somewhat expected due to the low marginal propensity to consume out of wealth. It does not mean that financial frictions cannot be helpful to explain other countries' experiences.

The effect of labor market rigidities

The ι parameter in the model measures the degree of labor market rigidity in reallocating the labor force instantaneously across sectors. In the case that $\iota = 0$, which is the case analyzed by Monacelli (2006), labor can be reallocated across sectors freely. On the other hand, Iacoviello and Neri (2008) estimate a value of $\iota = 1$. Our benchmark calibration is in between, since we pick a value of $\iota = 0.5$. Given that the shocks that we are analysing imply substantial reallocation of the labor force across sectors, we study how the role of these rigidities alters the transmission mechanism. The reasons to study the interaction between labor and financial market frictions are two: first, we want to capture the importance of the reallocation rigidity across sectors that might arise as a result of the growing importance of the non-durable sector when the share of credit-constrained agents increases; second, it allows us to better grasp the relative importance that each friction plays in the transmission mechanism of shocks.

In Figures (3.15) and (3.16) we repeat the same analysis than in Figures (3.13) and (3.14) in the (λ, ι) space, and setting $\chi = 0.25$. These figures show that, for both types of shocks, the effect of having a fully flexible labor market on durables output is quite remarkable, and it is far more important than any gain from a reduction of financial frictions. More concretely, if labor reallocation was costless, the response of investment in durable goods under either shock becomes highly volatile. On the other hand, the reponse of non-durable output decreases with more labor market flexibility under a monetary shock, and it is pretty much unaltered under a housing preference shock. Possibly, the fact the latter is 90 percent of the economy contributes to its relative stability. Note that our baseline calibration allows us to explain a positive comovement of variables under a monetary policy shock but a negative comovement under a housing demand shock. Using the value suggested by Iacoviello and Neri (2008) of $\iota = 1$ delivers a positive comovement under either shock contradicting our VAR evidence, while using the costless value suggested by Monacelli (2006) delivers too high volatility of durable output. Hence, it seems that to explain the evidence in Spain a lower degree of labor market rigidity is needed than in the US.

The Role of Nominal Rigidities

The higher price flexibility of the durable sector with respect to the non-durable sector documented by Bils and Klenow (2004) has tested the capacity of new Keynesian models to replicate the observed co-movement between the durable and non-durable sectors after a monetary policy shock. As argued by Calstrom and Fuerst (2007) and Monacelli (2006), if prices are flexible in one sector but sticky in the other, then a monetary policy contraction will imply that output falls in the sticky price sector but will increase in the flexible price sector, contradicting VAR evidence using US data. These papers suggest that introducing credit constraints and/or labor market rigidities might help solve the comovement problem even under heterogeneous degrees of nominal rigidity. Hence, we study how the impact of a monetary and demand shocks changes for different degrees of price rigidities in the context of our model.

In Figures (3.17) and (3.18) we plot how the effect of the model's shocks changes as we change the probability of the Calvo lottery in both sectors. The first result to notice is that we do not find a problem of lack of comovement under a monetary policy shock: even when one sector is very flexible and the other is not, the response of both sectors to a monetary policy shock has the same sign. What is behind this result is the role of labor market rigidities: since labor reallocation is costly, there is no combination of parameters that deliver a "comovement problem". Actually, when we repeat the same exercise as in Figure (3.17) but with $\iota = 0$, we do find a "comovement problem" for some parameter combinations. On the other hand, we do find opposite signs in the response of the two sectors under a housing preference shock when the non-durable sector is very sticky and the durable sector is almost flexible: in this case, the relative price effect dominates the costly labor reallocation effect. Also, the effect of changing the degree of nominal rigidity in the durable sector θ_d is much more important than changing the degree of rigidity in the non-durable sector θ_c.

Overall, the conclusion to all the robustness exercises is that in the neighborhood of our calibration, the most important rigidities are the degree of nominal rigidity in the durable sector, and the degree of costly labor reallocation. Financial frictions and nominal rigidites play a stronger role in determining the quantitative results, but not the qualitative ones. Bayesian estimation of the model, which is the next step in our research agenda, will allow us to obtain a better grasp of which parameter estimates are necessary to explain, and how they differ from those estimated or calibrated for the United States, for instance.

3.5 Concluding Remarks

In this paper we have reviewed the recent evidence on interest rates, housing prices, residential investment and current account deficits in Spain. We have presented some evidence based on a VAR model, and then we have rationalized our findings with a two-country two-sector model with demand and monetary shocks. In particular, we have shown that declining risk premium in the convergence process with the partners in the euro area has fueled residential investment and the current account deficit. Positive housing demand shocks are also good candidates to explain part of the recent housing boom.

We have also examined the costs of losing monetary autonomy by belonging to a currency union. We conclude that the behavior of the Spanish economy under autonomous monetary policy, or by belonging to the euro area does not differ much when the economy faces a housing demand shock. The reason: even if the shock has important effects on output, Spanish inflation does not exceed moderate levels, and hence an inflation targeting monetary authority remains passive in either case. However, the ability to run autonomous monetary policy is important when the economy is hit by a risk premium shock. This shock produces first order effects to Spanish inflation and output, and the ability to run an independent monetary policy is fundamental to cushion them.

We have also examined the key features of the model driving the results. Out of all the mechanisms suggested in the literature, labor market rigidities appear to be very important to obtain the right comovement between the two sectors of the economy. The role of financial frictions are more related with increasing the response of non-durable goods output to both shocks, but this increase can also be achieved under other modelling assumptions.

3.A Appendix

3.A.1 Linear approximation

Here we present the loglinear conditions. Also, we define the relative price of durables in terms of non-durables as $Q_t = \frac{P_t^D}{P_t^C}$, and the terms of trade as $T_t = \frac{P_{F,t}}{P_{H,t}}$. Also, ω_t^i denotes deviations from the real wage from steady-state values, defined as nominal wage (W_t^i) divided by the CPI (P_t), for $i = C, D$.

$$q_t = c_t - [1 - \beta(1-\delta)]\, d_t + \beta(1-\delta)E_t(q_{t+1} - c_{t+1}) + \xi_t \tag{3.41}$$

$$q_t = q_{t-1} + \Delta p_t^D - \Delta p_t^C \tag{3.42}$$

$$c_t = E_t c_{t+1} - (\tilde{r}_t - E_t \Delta p_{t+1}^C) \tag{3.43}$$

$$c_t + [(\varphi - \iota)\alpha + \iota]\, l_t^C + (\varphi - \iota)(1-\alpha) l_t^D = \omega_t^C + (1-\gamma) q_t \tag{3.44}$$

$$c_t + [(\varphi - \iota)(1-\alpha) + \iota]\, l_t^D + (\varphi - \iota)\alpha l_t^C = \omega_t^D + (1-\gamma) q_t \tag{3.45}$$

The relationship between the two nominal interest rates is as follows:

$$\tilde{r}_t = r_t - \bar{\kappa}\hat{b}_t + \vartheta_t \tag{3.46}$$

where $\hat{b}_t = (B_t/Y_tP_t)$ denotes the deviation of foreign assets as percent of GDP from its steady-state value of zero, and $\bar{\kappa} = \kappa\beta$. In practice we calibrate $\bar{\kappa}$ instead of κ and β separately.

The evolution of net foreign assets is:

$$\hat{b}_t = \frac{1}{\beta}\hat{b}_{t-1} + \frac{(1-n)(1-\tau^*)}{n}\left(c_{H,t}^* - t_t\right) - (1-\tau) c_{F,t} \tag{3.47}$$

The evolution of domestic and imported non-durable consumption is

$$c_{H,t} = (1-\tau)t_t + c_t \tag{3.48}$$

$$c_{F,t} = -\tau t_t + c_t \tag{3.49}$$

Here we list the evolution of the foreign country variables for households:

$$q_t^* = c_t^* - [1-\beta^*(1-\delta)]\, d_t^* + \beta(1-\delta)E_t(q_{t+1}^* - c_{t+1}^*) \tag{3.50}$$

$$c_t^* = E_t c_{t+1}^* - (r_t - E_t \Delta p_{t+1}^{C^*}) \tag{3.51}$$

$$q_t^* = q_{t-1}^* + \Delta p_t^{D^*} - \Delta p_t^{C^*}. \tag{3.52}$$

$$c_t^* + [(\varphi^* - \iota^*)\alpha^* + \iota^*]\, l_t^{C^*} + (\varphi^* - \iota^*)(1-\alpha^*) l_t^{D^*} = \omega_t^{C,*} + (1-\gamma^*)q_t^* \tag{3.53}$$

$$c_t^* + [(\varphi^* - \iota^*)(1-\alpha^*) + \iota^*]\, l_t^{D^*} + (\varphi^* - \iota^*)\alpha^* l_t^{C^*} = \omega_t^{D,*} + (1-\gamma^*)q_t^* \tag{3.54}$$

$$c_{H,t}^* = \tau^* t_t + c_t^* \tag{3.55}$$

$$c_{F,t}^* = -(1-\tau^*)t_t + c_t^* \tag{3.56}$$

where we have used the definition of the terms of trade, the fact that $t_t = -t_t^*$, and the evolution of the terms of trade is given by:

$$t_t = t_{t-1} + \Delta p_t^F - \Delta p_t^H. \tag{3.57}$$

The consumer price indices are:

$$\Delta p_t = \gamma \Delta p_t^C + (1-\gamma)\Delta p_t^D \tag{3.58}$$

$$\Delta p_t^* = \gamma^* \Delta p_t^{C^*} + (1-\gamma^*)\Delta p_t^{D^*} \tag{3.59}$$

where

$$\Delta p_t^C = \tau \Delta p_{H,t} + (1-\tau)\Delta p_{F,t} \tag{3.60}$$

$$\Delta p_t^{C^*} = (1-\tau^*)\Delta p_{H,t} + \tau^* \Delta p_{F,t} \tag{3.61}$$

The production functions are given by:

$$y_t^C = l_t^C \tag{3.62}$$

$$y_t^D = l_t^D \tag{3.63}$$

$$y_t^{C^*} = l_t^{C^*} \tag{3.64}$$

$$y_t^{D^*} = l_t^{D^*} \tag{3.65}$$

And the pricing equations are given by

$$\Delta p_t^H - \varphi_C \Delta p_{t-1}^H = \beta E_t(\Delta p_{t+1}^H - \varphi_C \Delta p_t^H) + \kappa^C \left[\omega_t^C + (1-\gamma)q_t + (1-\tau)t_t\right] \tag{3.66}$$

where $\kappa^C = \frac{(1-\theta_C)(1-\beta\theta_C)}{\theta_C}$.

$$\Delta p_t^D - \varphi_D \Delta p_{t-1}^D = \beta E_t(\Delta p_{t+1}^D - \varphi_D \Delta p_t^D) + \kappa^D \left[\omega_t^D - \gamma q_t\right] \tag{3.67}$$

where $\kappa^D = \frac{(1-\theta_D)(1-\beta\theta_D)}{\theta_D}$.

$$\Delta p_t^F - \varphi_{C^*} \Delta p_{t-1}^F = \beta E_t(\Delta p_{t+1}^F - \varphi_{C^*} \Delta p_t^F) + \kappa^{C^*} \left[\omega_t^{C,*} + (1-\gamma^*)q_t^* - (1-\tau^*)t_t\right] \tag{3.68}$$

where $\kappa^{C^*} = \frac{(1-\theta_{C^*})(1-\beta\theta_{C^*})}{\theta_{C^*}}$.

$$\Delta p_t^{D^*} - \varphi_{D^*} \Delta p_{t-1}^{D^*} = \beta E_t(\Delta p_{t+1}^{D^*} - \varphi_{D^*} \Delta p_t^{D^*}) + \kappa^{D^*} \left[\omega_t^{D,*} - \gamma^* q_t^*\right] \tag{3.69}$$

where $\kappa^{D^*} = \frac{(1-\theta_{D^*})(1-\beta\theta_{D^*})}{\theta_{D^*}}$.

The market clearing conditions for the goods sectors read as follows:

$$y_t^C = \tau c_{H,t} + \frac{(1-n)(1-\tau^*)}{n} c_{H,t}^* \tag{3.70}$$

$$y_t^{C*} = \tau^* c_{F,t}^* + \frac{n(1-\tau)}{1-n} c_{F,t} \quad (3.71)$$

$$d_t = (1-\delta)d_{t-1} + \delta y_t^D \quad (3.72)$$

$$d_t^* = (1-\delta)d_{t-1}^* + \delta^* y_t^{D*} \quad (3.73)$$

while for the labor market it is:

$$l_t^{tot} = \alpha l_t^C + (1-\alpha) l_t^D \quad (3.74)$$

$$l_t^{tot,*} = \alpha^* l_t^{C*} + (1-\alpha^*) l_t^{D*} \quad (3.75)$$

To close the model, we specify a monetary policy Taylor rule conducted by the ECB:

$$r_t = \gamma_R r_{t-1} + (1-\gamma_R)(\Delta p_t^{EMU}) + \varepsilon_t^m \quad (3.76)$$

where the euro area CPI is given by

$$\Delta p_t^{EMU} = n\Delta p_t + (1-n)\Delta p_t^* \quad (3.77)$$

3.A.2 Tables

Table 1: Calibrated Parameters of the Model

n	Size of Spain inside the EMU	0.1
α, α^*	Share of the non-durable sector in the GDP	0.9
$1-\tau$	Fraction of EMU imports consumed in Spain	0.15
$1-\tau^*$	Fraction of Spain imports goods consumed in the EMU	0.015
κ	Debt elasticity of the domestic interest rate	0.001
σ_C, σ_D	Elasticity of substitution between intermediate goods	10
β	Discount factor	0.99
δ	Depreciation rate of housing stock	0.025
φ, φ^*	Labor supply elasticity	0.5
ι, ι^*	Substitutability across labour types	0.5
γ, γ^*	Share of non-durable consumption in the CPI	0.82
θ^C	Calvo lottery for the non-durable sector in Spain	0.5
θ^D	Calvo lottery for the durable sector in Spain	0.25
θ^{C^*}	Calvo lottery for the non-durable sector in the EMU	0.75
θ^{D^*}	Calvo lottery for the durable sector in the EMU	0.25
γ^π	Inflation parameter of the Taylor rule	1.5
γ^R	Interest rate smoothing parameter of the Taylor rule	0.7

3.A.3 Figures

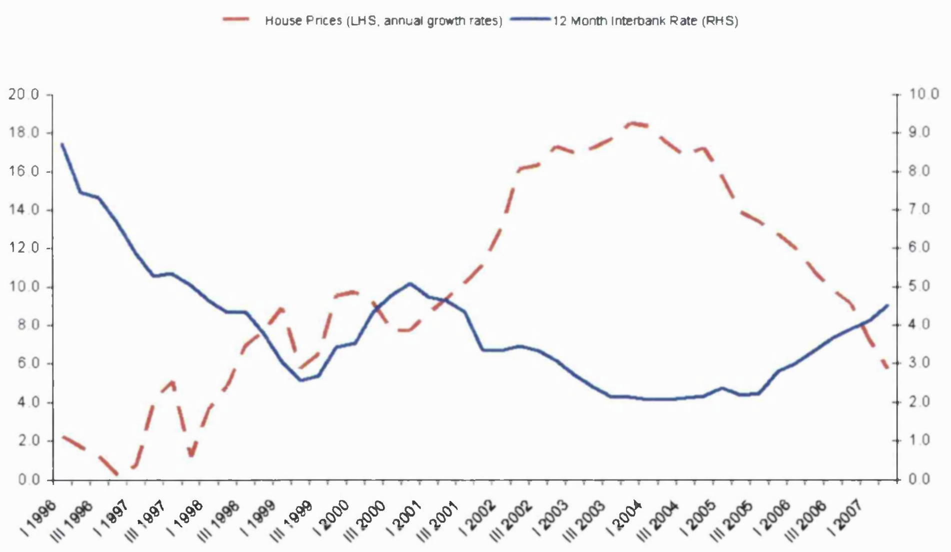

Figure 3.1: Nominal house prices and interest rates.

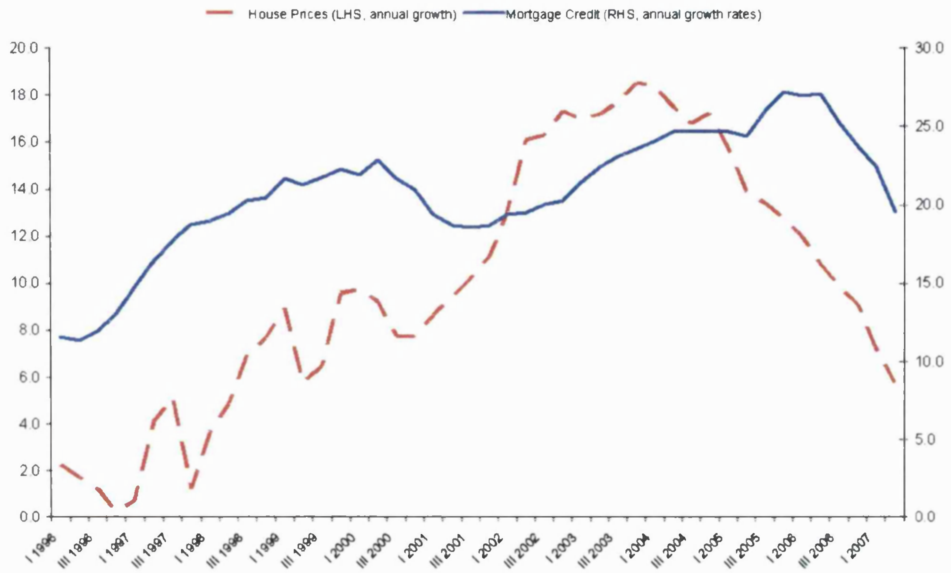

Figure 3.2: Nominal house prices and mortgage credit

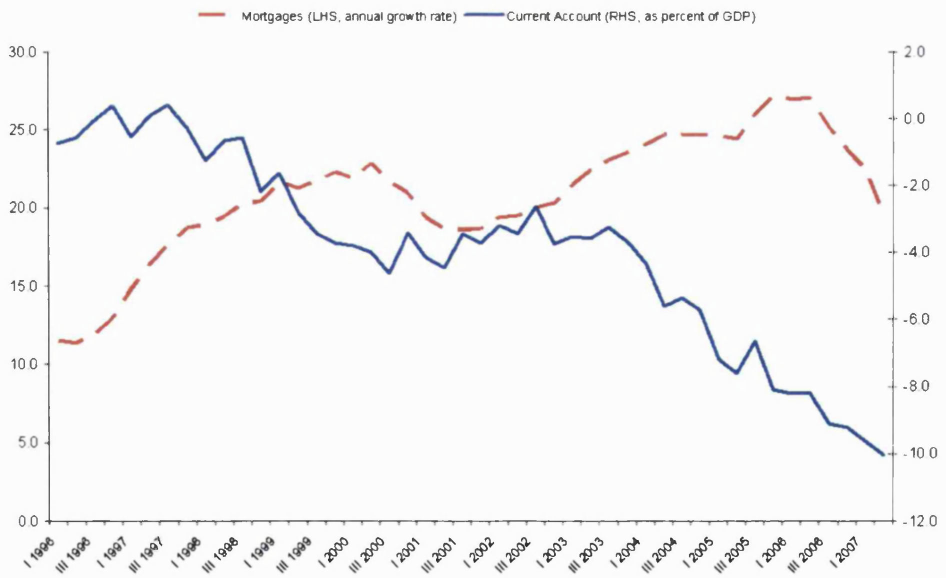

Figure 3.3: Mortgage credit and the current account.

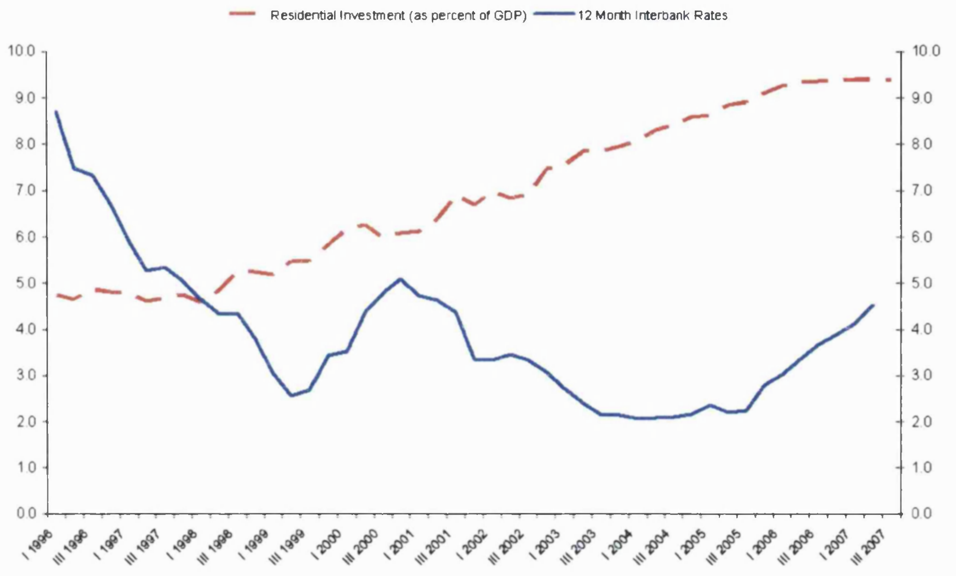

Figure 3.4: Resident investment and interest rates

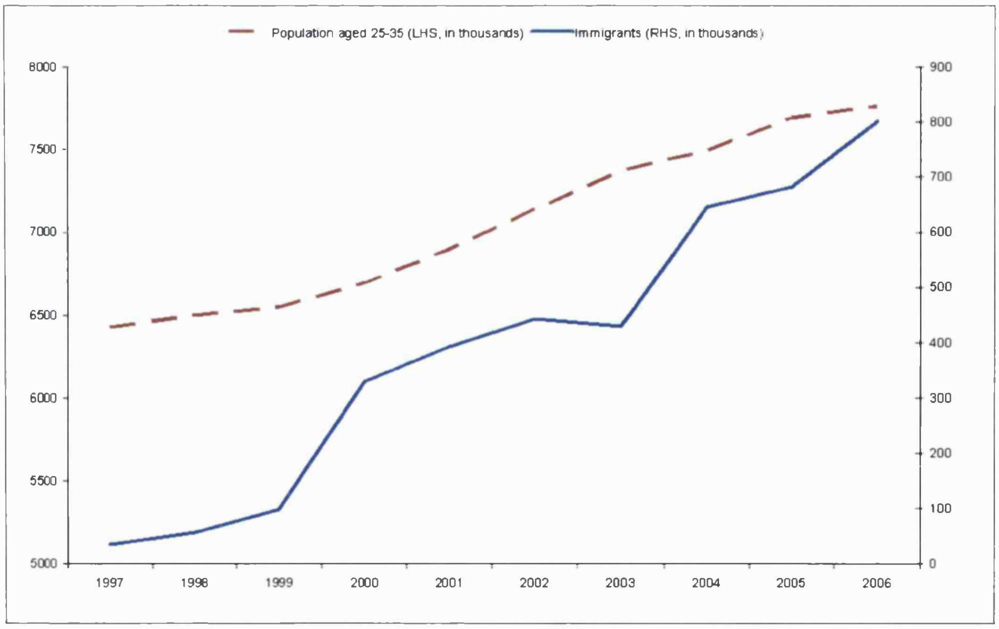

Figure 3.5: Demographic patterns

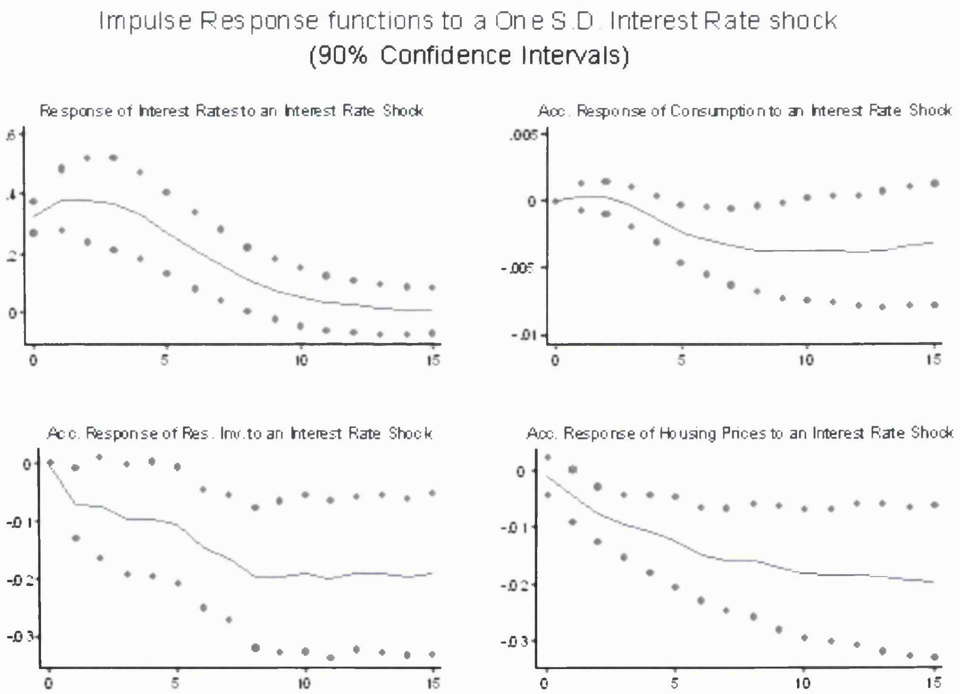

Figure 3.6: Impulse Response from VAR.

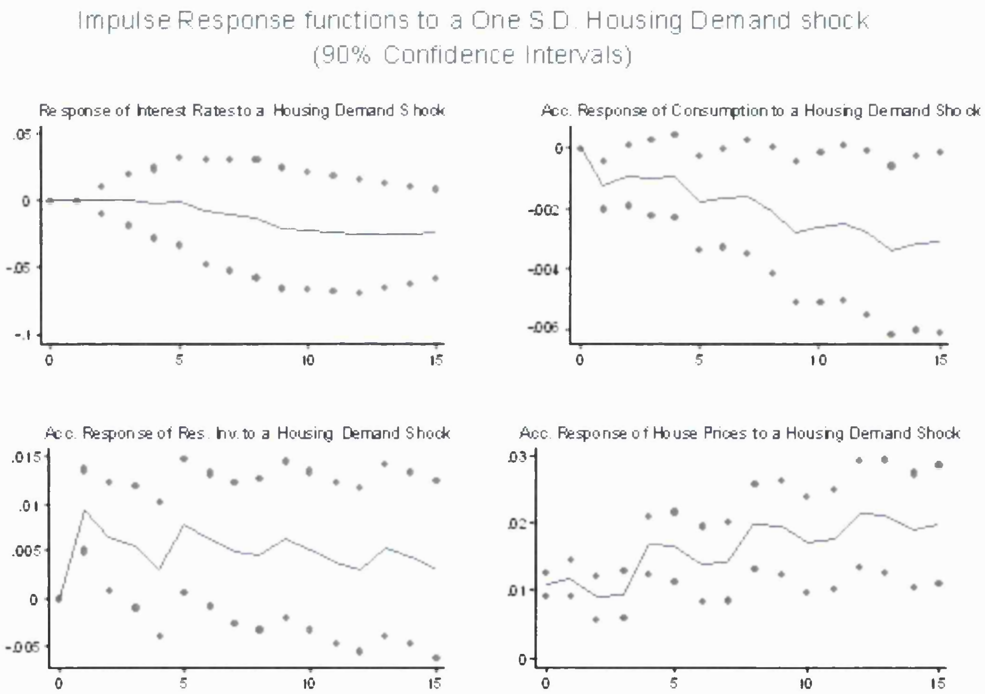

Figure 3.7: Impulse Response from VAR.

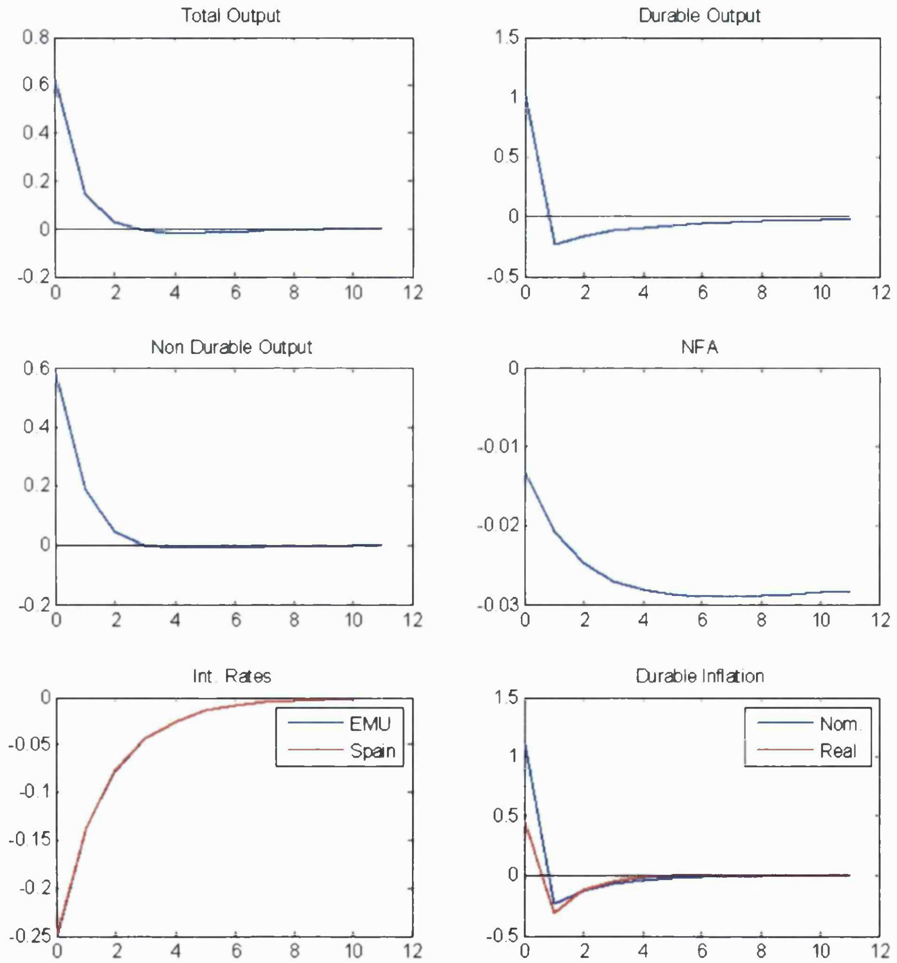

Figure 3.8: Impulse response to monetary policy shock. X axis: quarters after shock. Y axis: percent deviation from steady-state values.

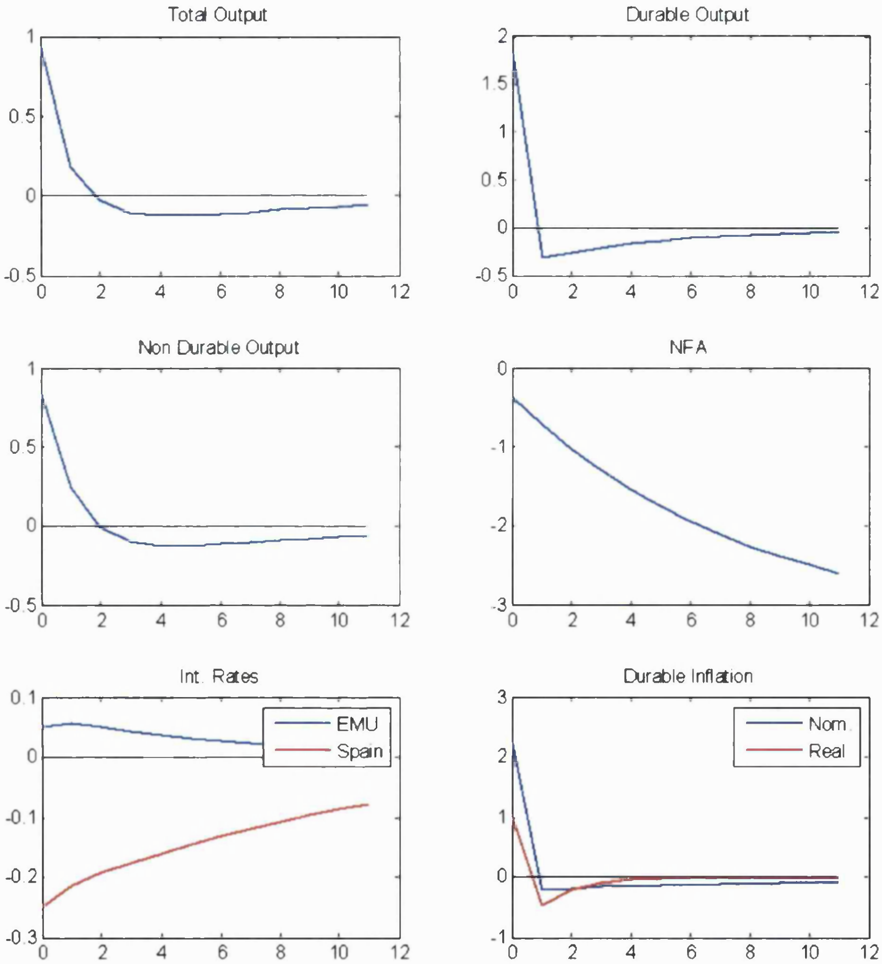

Figure 3.9: Impulse response to a risk premium shock. X axis: quarters after shock. Y axis: percent deviation from steady-state values.

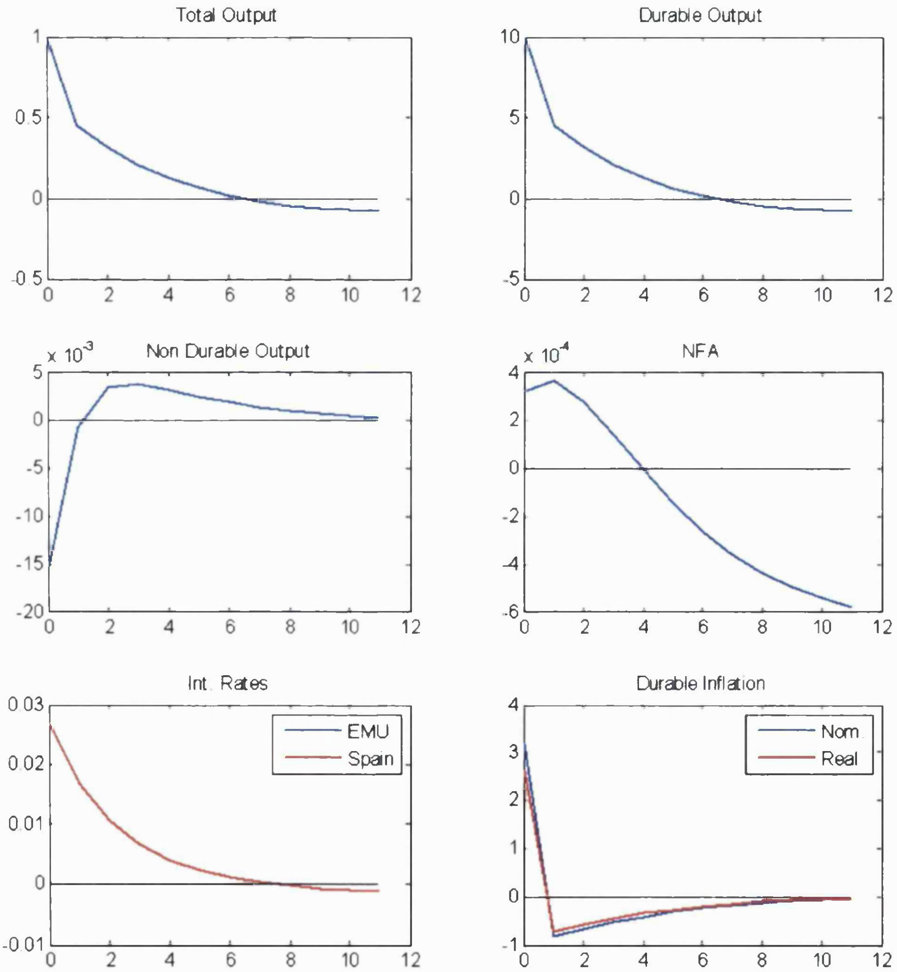

Figure 3.10: Impulse response to a housing preference shock. X axis: quarters after shock. Y axis: percent deviation from steady-state values.

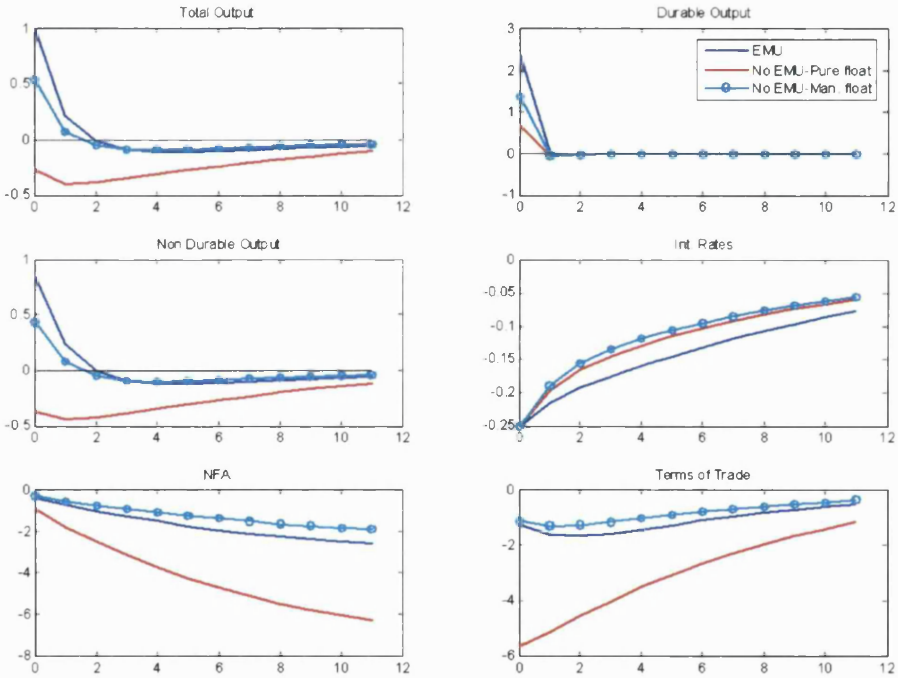

Figure 3.11: Impulse response to a risk premium shock. The effects of belonging to the EMU. X axis: quarters after shock. Y axis: percent deviation from steady-state values.

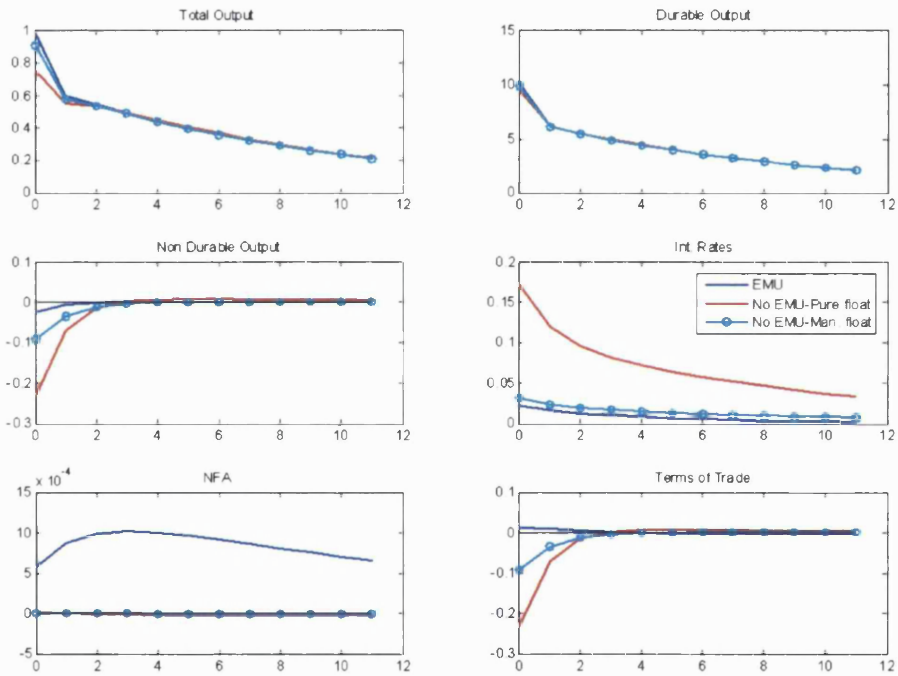

Figure 3.12: Impulse response to a housing demand shock. The effects of belonging to the EMU. X axis: quarters after shock. Y axis: percent deviation from steady-state values.

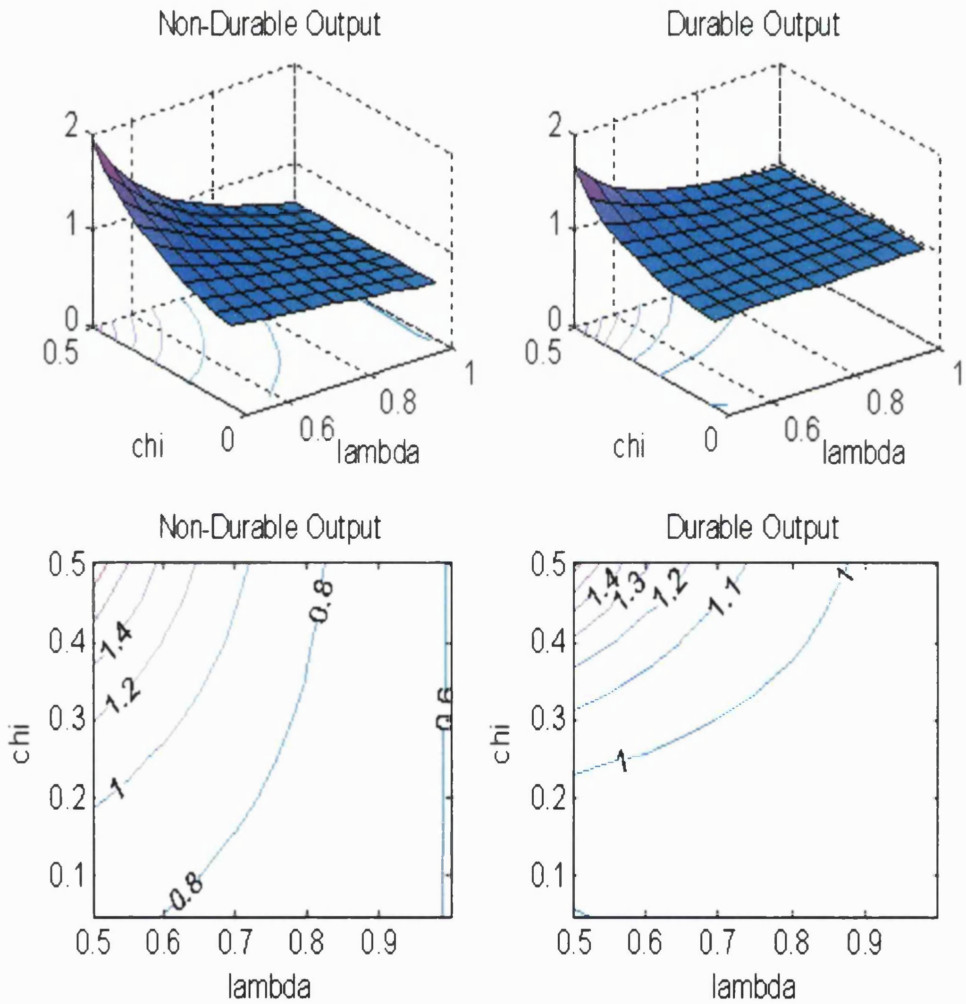

Figure 3.13: Impact response of a monetary policy shock. The role of financial frictions.

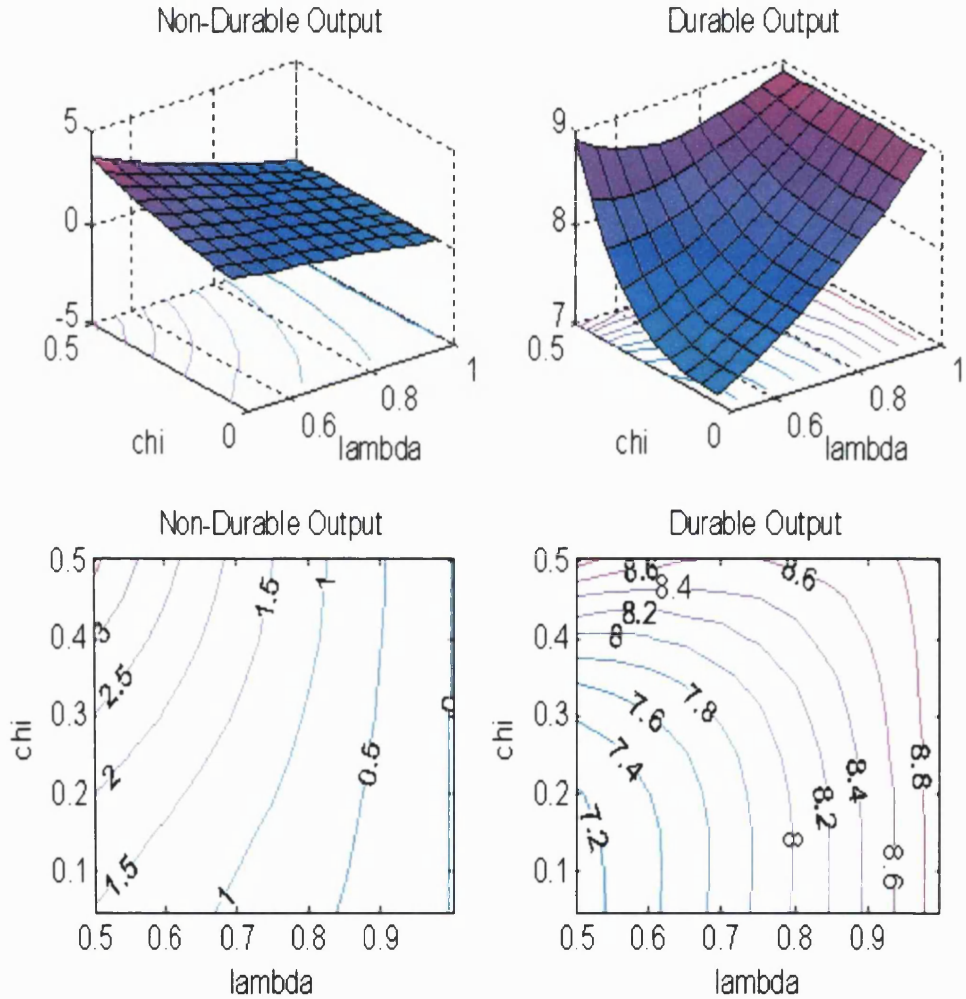

Figure 3.14: Impact response of a housing preference shock. The role of financial frictions.

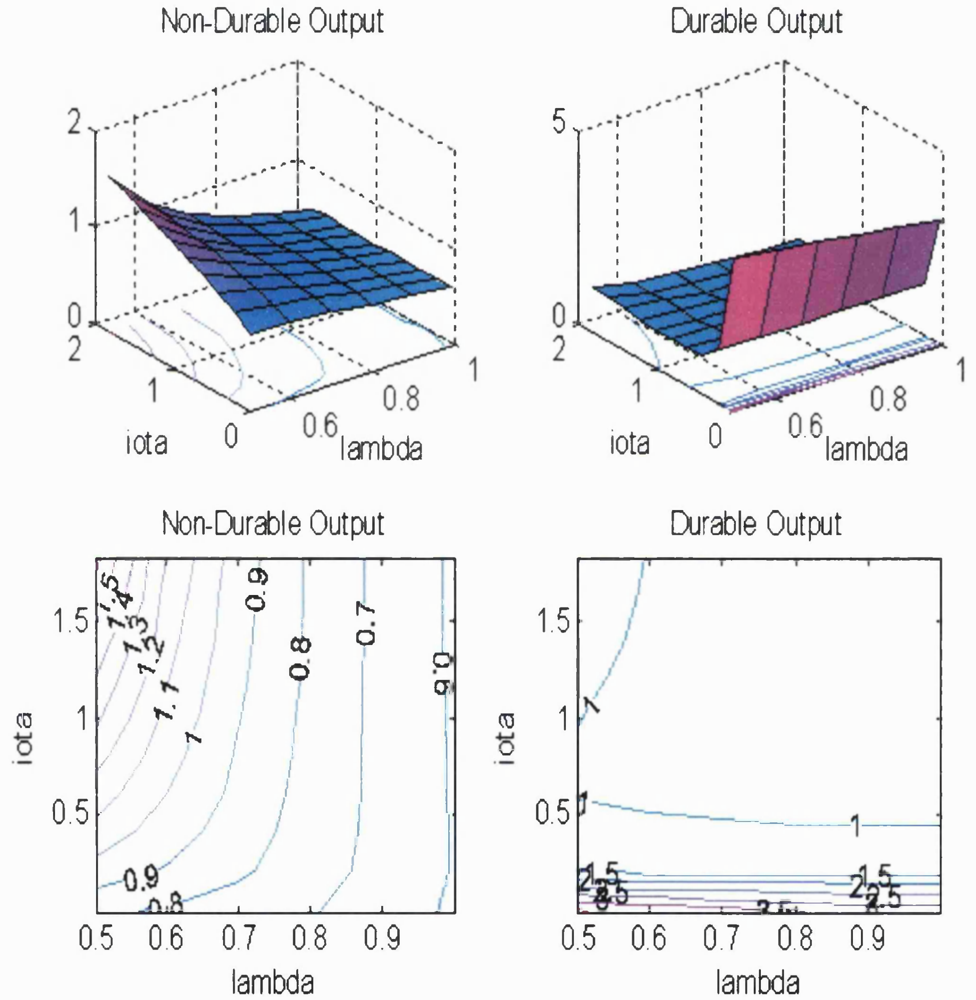

Figure 3.15: Impact response of a monetary policy shock. The role of financial and labor market frictions.

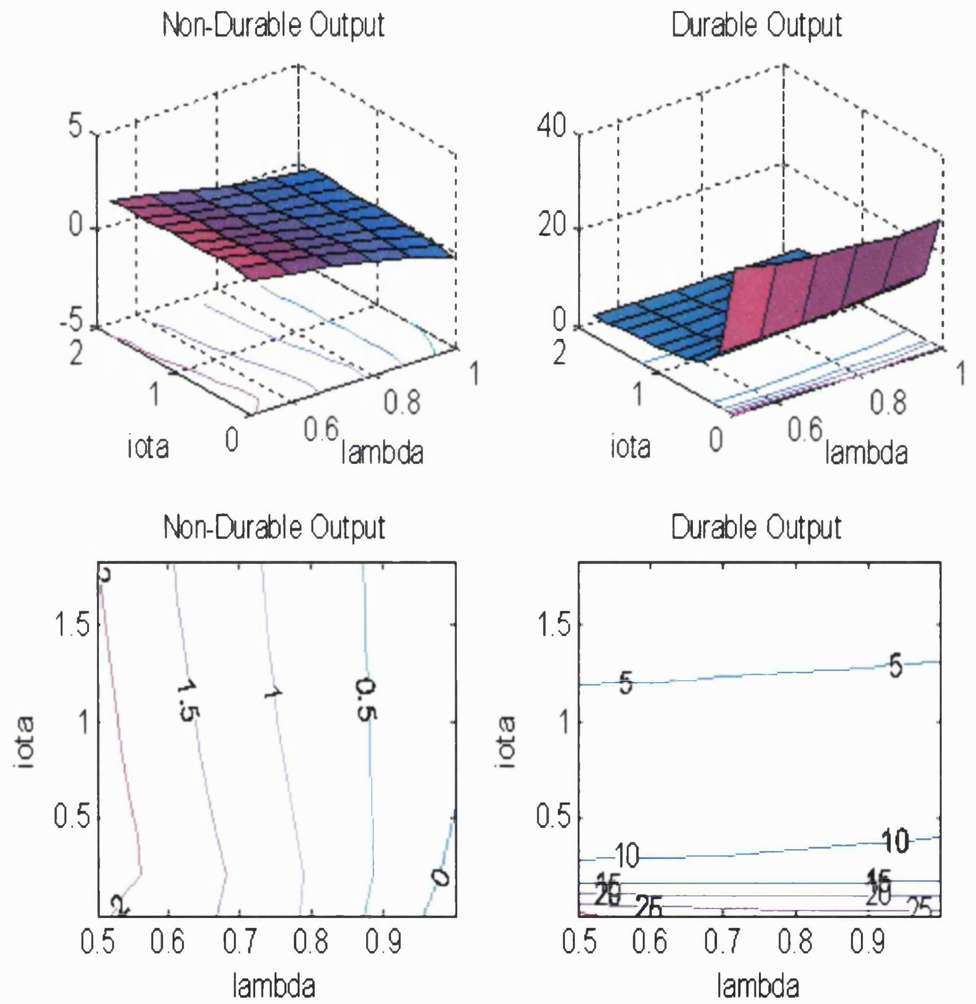

Figure 3.16: Impact response of a housing demand shock. The role of financial and labor market frictions.

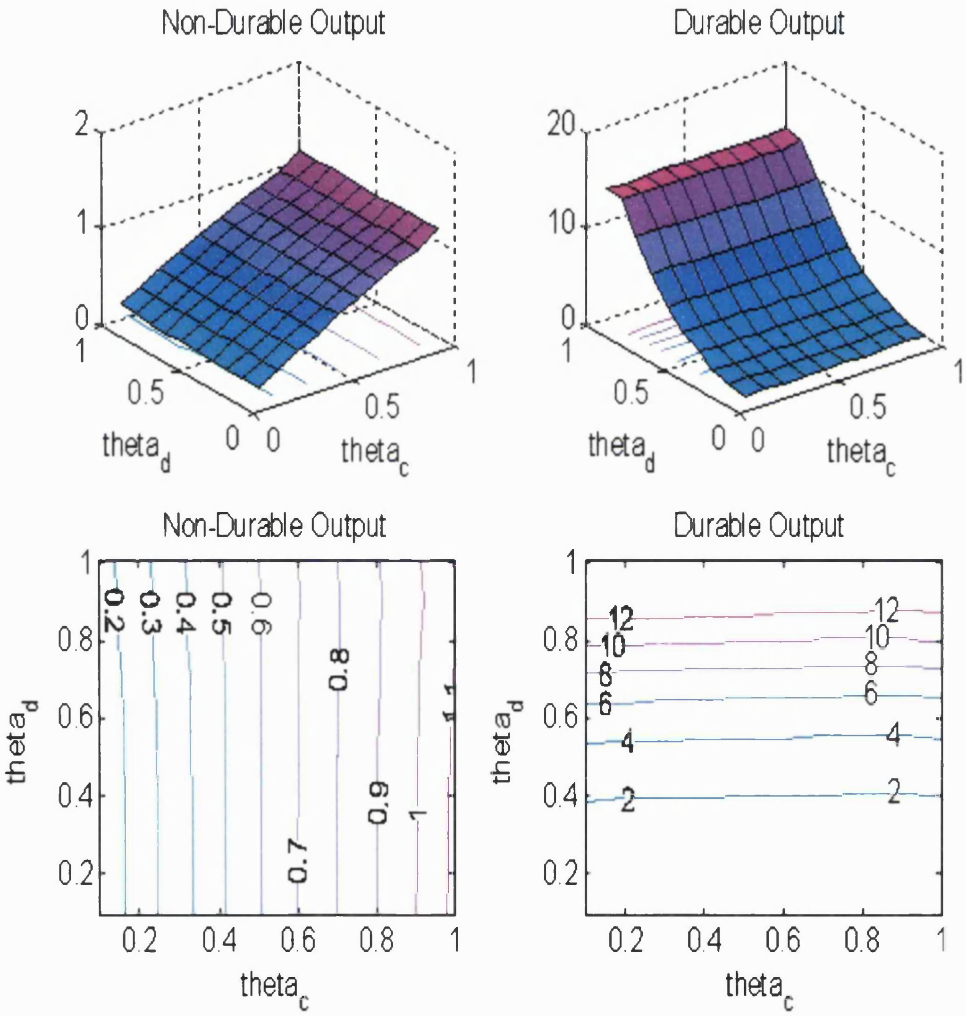

Figure 3.17: Impact response of a monetary policy shock. The role of nominal rigidities.

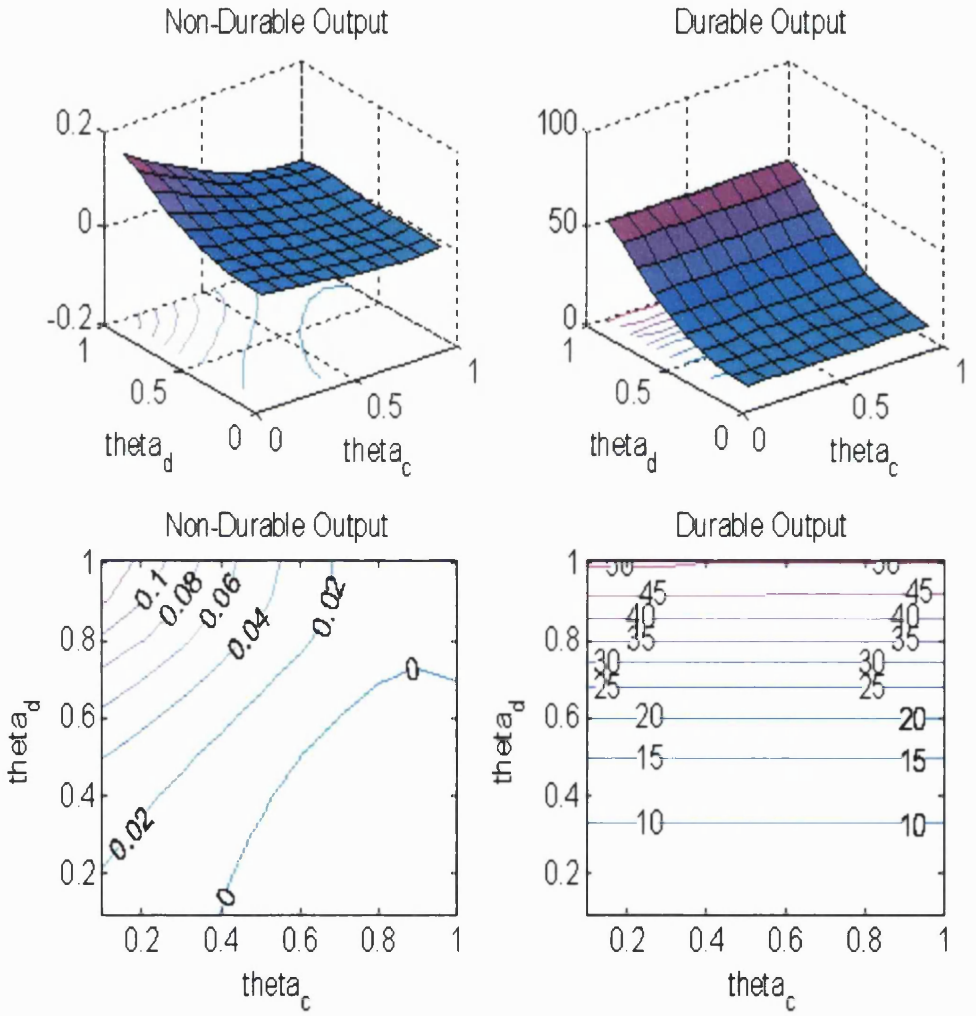

Figure 3.18: Impact response of a housing preference shock. The role of nominal rigidities.

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