

# THREE ESSAYS IN MACROECONOMICS

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**Title of Thesis**

*Three Essays In Macroeconomics*

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# Abstract

The first chapter of the thesis explores whether a limited participation model of the monetary transmission mechanism can account for the observed short run response of stock market returns to monetary policy shocks. The model predicts that a monetary tightening leads to higher short term interest rates via a liquidity effect. This increase in the interest rate raises the opportunity cost of holding stocks and at the same time decreases profits and dividends since firms have to borrow working capital. Both these effects lead to a decrease in the stock price. The predictions of the model are consistent with the data, although the model produces responses that are smaller than in the data.

The second chapter assesses whether differences in the degree to which firms depend on intermediated bank loans lead to quantitative differences in the responses of macroeconomic variables to monetary policy shocks in a limited participation model. The implications of the model are broadly consistent with what is observed empirically. The response of aggregate output depends on the importance of bank credit as a source of finance only if monetary policy is implemented according to an interest rate target.

The third chapter analyzes consumption risk sharing among the current member countries of the EU. It is found that the reaction of consumption growth rates to

idiosyncratic income growth is too sensitive to be consistent with perfect risk sharing. Moreover, the excess sensitivity of consumption shows no tendencies to decline over time and consequently, it appears that the process of European integration has not led to a more efficient allocation of consumption risk. Some indications are found that differences in institutional and legal aspects can explain part of the excess sensitivity.

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# Chapter 1

## The Response of Stock Market

## Returns to Monetary Policy Shocks

### 1.1 Introduction

Empirically, it appears that monetary policy influences real economic activity and asset prices in a systematic manner. The purpose of this chapter is to study the transmission of monetary policy shocks into stock prices in a dynamic general equilibrium model. In particular, it will be analyzed if a limited participation model of the monetary transmission mechanism can help to interpret empirical regularities about monetary policy shocks and stock market returns.

Monetary dynamic general equilibrium models have played a prominent role in the macroeconomic literature dealing with asset markets. The behavior of equity prices in cash-in-advance models has been studied by Labadie [48], Giovanni and Labadie [38] and Boyle and Peterson [12]. Giovanni and Labadie [38] study the correlations between stock returns, interest rates and inflation. In their simulations

real stock market returns are slightly negatively correlated with inflation, a result that is consistent with the data. Boyle and Peterson [12] examine the relationship between aggregate uncertainty and stock prices. They find that stock returns covary positively with inflation if monetary policy is strongly pro-cyclical. Finn, Hoffman, and Schlagenhauf [32] compare the empirical performance of monetary and real asset pricing models. They conclude that adding money via a cash-in-advance constraint does not significantly improve the fit of the model.

Marshall [55] analyzes equity prices in a model where money is used because it reduces transaction costs. In his model, the sign of the correlation coefficient between real returns and inflation is ambiguous and depends on whether the source of shocks to the economy is primarily real or monetary. Furthermore, he finds that the response of the real return on stocks to money growth shocks is substantially smaller than in the data.

Limited participation models have been used by Evans and Marshall [31] to study the dynamic response of the term structure to monetary policy shocks and by Jorda and Salyer [41] to analyze the impact of time varying policy uncertainty on nominal interest rates.

Broadly speaking, there are two channels through which monetary policy can influence stock prices. First, monetary policy might influence dividends that firms pay to the shareholders, and second, it might affect the rate at which dividends are discounted. In monetary asset pricing models that rely on an exogenous endowment process the first channel is absent. In the class of limited participation models, monetary shocks have an impact on nominal interest rates, output and profits through the liquidity effect. That is, output and also dividends are negatively affected by a monetary tightening. Hence, this class of models appears to be a promising starting

point for the study of asset prices in a monetary economy. Furthermore, as shown by Christiano, Eichenbaum and Evans [20] this class of models is in general rather successful in matching the results of the large empirical literature on the effects of monetary policy shocks.<sup>1</sup>

The main finding is that the asset pricing implications of a limited participation model are fairly consistent with empirical regularities for a plausible parameterization of the model. In particular, the model predicts that a monetary tightening leads to an increase in the interest rates, which increases the cost of working capital for firms and decreases the dividend that is paid to shareholders. This in turn will lead to lower stock prices and returns. Analyzing the quantitative implications of the model shows that the response of stock returns is smaller in magnitude than the corresponding response in the data, but still closer than in previous studies.

The remainder of this chapter is organized as follows: Section 2 presents some empirical evidence on the relationship between monetary policy shocks and stock returns. Section 3 describes the setup of a monetary equilibrium model with the limited participation feature. Section 4 discusses the calibration of the model to U.S. data and section 5 compares the properties of the model to the empirical results. Section 6 gives a summary.

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<sup>1</sup>See Leeper, Sims and Zha [51] and Christiano, Eichenbaum and Evans [22] for extensive surveys of the empirical literature.

## 1.2 The Empirical Effects of Monetary Policy Shocks on Stock Returns

The empirical strategy is to identify monetary policy shocks based on the methodology advocated by Christiano, Eichenbaum and Evans [19] and to study the dynamic responses of stock returns to these shocks. In particular, a version of the vector autoregression (VAR) analyzed by Evans and Marshall [31] will be adapted for this purpose. Consider a VAR that consists of the following variables: the logarithm of nonagricultural payroll employment, EM, the logarithm of the personal consumption expenditure deflator, P, the annual change in the price index for crude materials, PC, the Federal Funds rate, FF, the ratio of nonborrowed reserves plus extended credit to total reserves, NBRX, the monthly growth rate of M2 and the monthly nominal return on the Center for Research in Security Prices (CRSP) index, RET. All data, except for the CRSP index, are taken from the Economic Database of the Federal Reserve Bank of St. Louis. The VAR is estimated over the sample 1959:11 to 2001:11 and includes a constant and 12 lags of the variables.

Identification of the monetary policy shock is achieved by using the recursiveness assumption suggested in Christiano et al. [19]. In particular, it is assumed that the monetary authority can observe current prices and employment when setting the interest rate. However, prices and employment respond to changes in the interest rate only with a one month lag. A monetary policy shock is associated with the disturbance term in the policy rule

$$FF_t = \Psi(\Omega_t) + s\epsilon_t, \quad (1.1)$$

where  $FF_t$  is the Federal Funds rate,  $\Psi$  is a linear function,  $\Omega_t$  is the information set of the monetary authority at time  $t$ ,  $s$  is a scale parameter and  $\epsilon_t$  is an exogenous

shock with unit variance that is serially uncorrelated and orthogonal to the elements of  $\Omega_t$ . Let  $Z_t = (Z_{1t}, FF_t, Z_{2t})'$  be a partition of the vector of the variables in the VAR. Then the orthogonality restriction on  $\epsilon_t$  implies that  $\Omega_t = \{Z_{1t}, Z_{t-1}, Z_{t-2}, \dots\}$ . It follows that  $Z_{1t} = (EM_t, P_t, PC_t)'$  and  $Z_{2t} = (NBRX_t, M2_t, RET_t)'$  satisfy the recursiveness assumption. Hence, identification is achieved by the appropriate ordering of the variables and a Choleski decomposition to orthogonalize the innovations.

Figures 1.2 to 1.6 display the responses of the macroeconomic variables in the system to a one standard deviation shock to the Federal Funds rate equation along with Monte-Carlo standard error bands.<sup>2</sup> A contractionary monetary policy shock induces a decline in employment, a decline in NBRX and a decrease in the growth rate of M2. Prices rise slightly before they decline after 10 periods. However, the increase is not significantly different from zero. These dynamic responses are largely in line with those reported in the literature.<sup>3</sup>

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<sup>2</sup>Logged data has been multiplied by 100 so that the impulse responses can be interpreted as percentage deviations. The impulse response of the Federal Funds rate can be interpreted as percentage point deviation.

<sup>3</sup>The result that prices initially increase in response to a monetary tightening has been labelled the 'price puzzle' and is usually attributed to the belief that the Fed uses an indicator of future inflation that is not included in the VAR. In case the Fed reacts to an increase in the indicator by tightening monetary policy, this can appear to induce a contemporaneous increase in the price level if inflation is only affected with a lag. The standard remedy for the price puzzle is to include commodity prices in the VAR. However, the crude materials price index used here cannot completely eliminate the price puzzle.

Figure 1.1: Response of EM to a one Standard Deviation Shock to the FF. Dashed Lines give 2 Standard Error Bands.

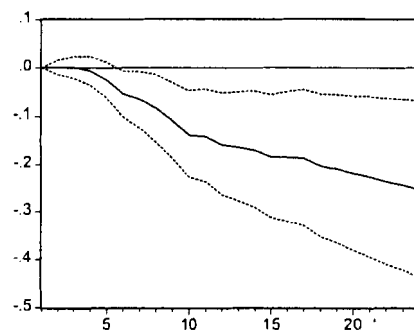


Figure 1.2: Response of P to a one Standard Deviation Shock to the FF Equation. Dashed Lines give 2 Standard Error Bands.

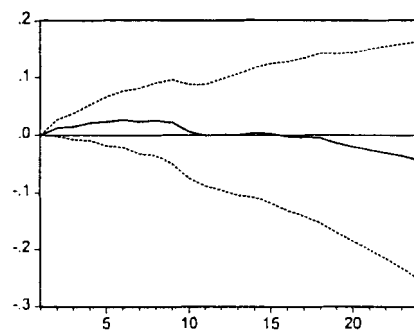




Figure 1.3: Response of PC to a one Standard Deviation Shock to the FF. Dashed Lines give 2 Standard Error Bands.

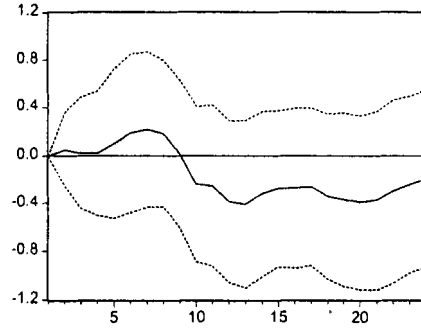


Figure 1.4: Response of FF to a one Standard Deviation Shock to the FF. Dashed Lines give 2 Standard Error Bands.

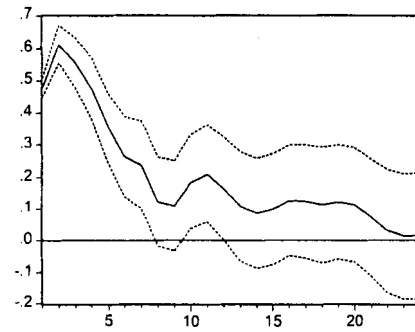


Figure 1.5: Response of NBRX to a one Standard Deviation Shock to the FF Equation. Dashed Lines give 2 Standard Error Bands.

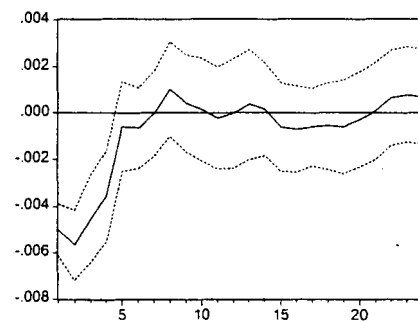


Figure 1.6: Response of M2 to a one Standard Deviation Shock to the FF Equation. Dashed Lines give 2 Standard Error Bands.

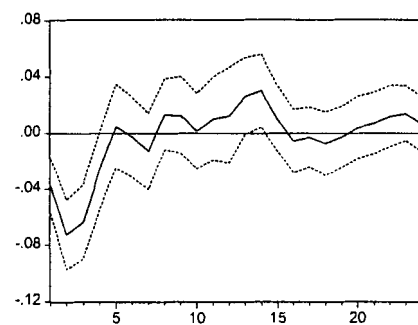
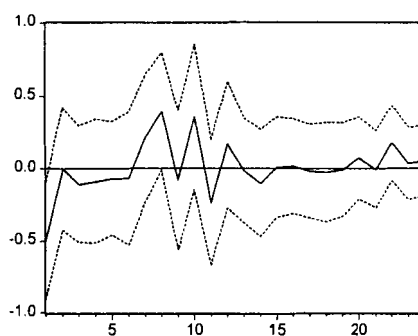


Figure 1.7 shows the response of the nominal return on the CRSP index to a one standard deviation monetary policy shock along with Monte-Carlo standard errors. The nominal CRSP return initially decreases by 0.49 percentage points in response to an increase in the Federal Funds rate of slightly below 0.5 percentage points. The response is significantly different from zero only in the impact period and reverts back to its pre-shock level in the second period following the shock. Hence, according to the impulse response function, monetary policy shocks appear to be a source of short run variation in asset prices. However, it has to be noted that the confidence bands are rather large and therefore this result to be interpreted with some caution. Reestimating the VAR with the real return calculated as the nominal return minus the inflation rate obtained from the personal consumption expenditure index leaves the results virtually unchanged.<sup>4</sup> This outcome can be attributed to the fact that the price level is only weakly affected over the first several months following a shock.

Figure 1.7: Response of the Nominal Return on the CRSP Index to a one Standard Deviation Shock to the FF Equation. Dashed Lines give 2 Standard Error Bands.




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<sup>4</sup>The response of real returns is almost identical to the response of nominal returns and is therefore not reported.

In general, the results for the reaction of stock returns confirm findings by Thorbecke [67], who analyzes the impact of monetary policy on the return on portfolios sorted by industry and by firm size measured by market capitalization. He finds that on average, portfolio returns decrease by 0.8 percentage points in response to a one standard deviation shock. Given that his sample ends in 1990 and that the size of monetary policy shocks is likely to have declined in recent years, the estimated responses in Thorbecke [67] appear to be fairly close to what is reported here. Lastrapes [50] estimates similar VAR models for different countries and finds that stock prices decrease initially in almost all the countries under consideration. Magnitudes vary, but lie in the range between one and three percent. Rigobon and Sack [65] employ an ‘event-study’ approach to analyze asset price movements around FOMC meeting dates and largely confirm the findings of the VAR based literature.

### **1.3 The Model**

The setup of the model is similar to the limited participation model presented in Christiano, Evans, Eichenbaum [20]. The economy is populated by four types of agents: Households, firms, financial intermediaries and a monetary authority. Households face a cash-in-advance constraint and must make a portfolio decision before the state of the world is revealed. Hence, any liquidity that is injected by the monetary authority has to be absorbed by the business sector since households cannot adjust their portfolios. This portfolio rigidity and the implied asymmetric reaction of the different sectors in the economy is responsible for the liquidity effect. Output is produced by a large number of identical firms that behave competitively in input and

output markets. Firms must borrow working capital in the form of cash from the financial intermediaries before production begins. The monetary authority distributes liquidity injections to the financial intermediaries. Equity shares, which are claims to the dividends of the firms, are traded on an asset market. The timing of events is as follows: At the beginning of the period households deposit funds at the financial intermediaries. The monetary policy shock is realized and the state of the world is revealed. After all uncertainty is resolved, all other decisions are made, in particular, firms hire workers and households supply labor and consume. Furthermore, households can rebalance their portfolios by using the funds deposited at the intermediaries to buy stocks. It is important to note that funds that have been deposited at the beginning of the period can only be exchanged for another financial instrument and not for consumption goods in the current period. Therefore the rigidity that is necessary for the liquidity effect is still in place, although households can adjust their asset holdings.

The limited participation feature is sometimes motivated by the idea that households are not as connected to financial markets as they are to goods markets, and therefore they do not react to liquidity injections as fast as the financial and the business sector do. From this point of view the structure assumed here, namely the fact that households can exchange bank deposits for stocks but not for consumption goods might appear to be inconsistent with this story. However, one could simply assume that the households are not managing their asset portfolios themselves, but delegate this task to a mutual fund at the beginning of each period. Assuming that the mutual fund acts in the best interest of the households and maximizes their lifetime utilities, the mutual fund will make the same choices as the households would, implying that the same equilibrium allocations will be obtained. With this interpretation the results

are unchanged and the usual intuition for the limited participation friction still holds.

At the end of the period, firms repay loans to the financial intermediaries and distribute profits in the form of dividends. Financial intermediaries repay deposits and make interest payments to the households.

### 1.3.1 Households

Households maximize their expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, 1 - L_t) \quad (1.2)$$

where  $\beta$  is a discount factor,  $C_t$  is consumption in period  $t$ ,  $L_t$  denotes labor supply in period  $t$ , and

$$u(C_t, 1 - L_t) = \frac{C_t^{1-\gamma}}{1-\gamma} + \chi(1 - L_t), \quad (1.3)$$

$\gamma \geq 1$  and  $\chi > 0$ . At the beginning of every period, households hold the entire stock of money  $M_{t-1}$  and must decide how much of their money holdings to deposit at the financial intermediary. Funds that are deposited at the beginning of the period are denoted by  $N_t$ . Deposits yield a gross interest rate of  $R_t$ , which is determined after the state of the world is revealed. Households supply  $L_t$  units of labor at a nominal wage  $W_t$ . Labor income,  $L_t W_t$ , is paid in advance of production and can be used for purchases in the goods market in the current period. Hence, the households face the following cash-in-advance constraint:

$$P_t C_t \leq M_{t-1} - N_t + W_t L_t. \quad (1.4)$$

After the state of the world is revealed, households can adjust their portfolio by using the funds deposited at the beginning of the period to buy stocks. They face the

following constraint in the asset market:

$$S_t q_t + A_t = N_t + S_{t-1} q_t, \quad (1.5)$$

where  $S_{t-1}$  are stock holdings carried over from period  $t - 1$  and  $q_t$  denotes the price of a stock in nominal terms. Funds that are left with the financial intermediary are denoted by  $A_t$ . The amount of money the households carry over into the next period is

$$M_t = W_t L_t + M_{t-1} - N_t - P_t C_t + R_t (A_t + X_t) + q_t (S_{t-1} - S_t) + S_t D_t, \quad (1.6)$$

where  $D_t$  are current period profits distributed as dividends at the end of period  $t$  and  $X_t$  represents a cash injection by the central bank.

The household solves the dynamic programming problem:

$$V\left(\frac{M_{t-1}}{P_t}, S_{t-1}\right) = \max_{N_t} E_{t-1} \left\{ \max_{C_t, L_t, A_t, M_t, S_t} [u(C_t, 1 - L_t) + \beta E_t V\left(\frac{M_t}{P_{t+1}}, S_t\right)] \right\} \quad (1.7)$$

subject to (1.4), (1.5) and (1.6). Moreover, the optimal solution to this maximization problem must also satisfy the transversality condition:

$$\lim_{k \rightarrow \infty} u_{c,t+k} q_{t+k} S_{t+k} = 0 \quad (1.8)$$

The necessary conditions associated with this maximization problem are:

$$\beta E_{t-1} \left( R_t \frac{u_{c,t+1}}{P_{t+1}} \right) = E_{t-1} \left( \frac{u_{c,t}}{P_t} \right), \quad (1.9)$$

$$\frac{W_t}{P_t} = \frac{u_{L,t}}{u_{c,t}}, \quad (1.10)$$

$$\beta E_t \left( \frac{u_{c,t+2}}{P_{t+2}} q_{t+1} R_{t+1} \right) = E_t \left( \frac{u_{c,t+1}}{P_{t+1}} \right) (q_t R_t - D_t). \quad (1.11)$$

Equation (1.9) describes the costs and benefits in terms of utility of depositing funds at the financial intermediary. Note that this decision is made before the period  $t$  money growth rate is realized and therefore it has to be based on information available in period  $t - 1$ . Equation (1.10) expresses the result that households equate their marginal rates of substitution between labor and leisure to the real wage when making their labor supply decisions. In contrast to (1.9), in equation (1.11) the expectation is taken with respect to period  $t$  information since asset markets are assumed to open after the period  $t$  shock has been realized. The right hand side of equation (1.11) shows the utility cost of increasing stock holdings in period  $t$ . Buying one additional stock reduces the money that can be used for consumption in  $t + 1$  by  $R_t q_t$ . However, since dividends are paid at the end of the period, they can be used for consumption in the next period and are therefore subtracted. If these additional shares are sold in  $t + 1$  these funds can be deposited and will earn interest. Thus consumption in  $t + 2$  is increased by  $q_{t+1} R_{t+1} / P_{t+2}$ . It follows that the stock price is affected by four factors: current and expected dividends, the interest rate, which influences the opportunity cost of buying shares, the expected inflation rate and the marginal utility of consumption.

### 1.3.2 Firms

Firms are described by a constant returns to scale production function. They own the economy's capital stock and hire labor,  $H_t$ , in order to produce output:

$$Y_t = F(H_t) = H_t^{1-\alpha} \tag{1.12}$$



where  $\alpha \in (0, 1)$ . Since the emphasis is on business cycles, it is assumed that capital is fixed at the value of one in all periods.<sup>5</sup> Period  $t$  profits are distributed to the shareholders at the end of the period. Moreover, it is assumed that firms cannot issue new shares, an assumption that is usually made in asset pricing models.<sup>6</sup> Hence, firms do not have any funds available at the beginning of the production process. Thus, they have to borrow from the financial intermediary in order to finance the wage bill:  $W_t H_t$ .

Dividends are given by:

$$D_t = P_t Y_t - R_t W_t H_t. \quad (1.13)$$

The objective of the firm is to maximize its value of the firm to the shareholders. Hence it hires labor such that

$$E_0 \sum_{t=0}^{\infty} (\beta^{t+1} u_{c,t+1} / P_{t+1}) D_t \quad (1.14)$$

is maximized. The stochastic discount factor  $\beta^{t+1} u_{c,t+1} / P_{t+1}$  corresponds to the valuation of dividends by the households. The necessary first order condition that characterizes a solution to this maximization problem is:

$$\frac{R_t W_t}{P_t} = F_{H,t}. \quad (1.15)$$

Equation (1.15) defines labor demand for this economy and states that the marginal product of labor has to be equated to the real cost of hiring an additional unit of labor.

---

<sup>5</sup>As shown by Cogley and Nason [26], capital accumulation does not add much to the amplification and propagation of business cycles.

<sup>6</sup>Note that the Modigliani Miller Theorem holds in this model and consequently the firms are indifferent between issuing new shares or debt instruments. Thus, this assumption is less restrictive than it might appear.

### 1.3.3 Financial Intermediaries

Financial intermediaries receive deposits from the households and cash injections from the monetary authority. These funds are used to provide loans to the firms. It is assumed that financial intermediation is costless and competitive. The financial intermediaries are owned by the households, however for simplicity it is assumed that the shares are not traded. After the firms repay their loans at the end of the period, the financial intermediaries pay  $R_t A_t$  in return for the deposits to households. All profits, i.e.  $R_t X_t$ , are also paid to the households.

### 1.3.4 Monetary Authority

The monetary authority provides money to the financial sector of the economy. The monetary growth rate is defined as:

$$x_t = \frac{X_t}{M_{t-1}} = \frac{M_t - M_{t-1}}{M_{t-1}}. \quad (1.16)$$

The money supply process is assumed to be exogenous and the monetary growth rate follows a three-state Markov process. In particular, suppose that  $x_t \in \{\mu + \sigma, \mu, \mu - \sigma\}$ .

The transition probability matrix is

$$\Pi = \begin{pmatrix} \pi & \frac{1-\pi}{2} & \frac{1-\pi}{2} \\ \frac{1-\pi}{2} & \pi & \frac{1-\pi}{2} \\ \frac{1-\pi}{2} & \frac{1-\pi}{2} & \pi \end{pmatrix}.$$

This specification implies that  $E(x_t) = \mu$ ,  $Var(x_t) = \frac{2}{3}\sigma^2$  and the first order autocorrelation of the money growth process is given by  $Corr(x_t, x_{t-1}) = (3\pi - 1)/2$ . Note that the specification of monetary policy as an exogenous stochastic process might appear to be inconsistent with the empirical analysis in section 2 where the monetary

authority was assumed to be highly reactive to output and price level. However, as shown in Christiano, Eichenbaum and Evans [21] explicit interest rate rules can be represented by observationally equivalent, univariate processes for broad monetary aggregates. Basically, the idea is that although the monetary authority uses an endogenous interest rule to set the Federal Funds rate, it can only do so by adjusting the monetary base. Consequently, broad monetary aggregates will react in a certain way to exogenous shocks to the policy rule. Hence, monetary policy can be equivalently modelled as a univariate process for broad monetary aggregates as long as the process is consistent with the reaction of the monetary aggregate to Federal Funds rate shocks. The calibration of the process to match the empirical response of the monthly growth rate of M2 will be discussed in the next section.

### 1.3.5 Equilibrium

An equilibrium for the model economy is characterized by stochastic sequences of allocations  $\{C_t, H_t, M_t, A_t, S_t, D_t\}_{t=0}^{\infty}$ , prices  $\{R_t, P_t, W_t, q_t\}_{t=0}^{\infty}$  and monetary growth rates  $\{x_t\}_{t=0}^{\infty}$  such that: (i) The household's necessary conditions (1.9), (1.10), (1.11), the transversality condition (1.8) and the constraints (1.4), (1.5), (1.6) are satisfied. (ii) The firm's necessary condition (1.15) holds. (iii) The labor market, the goods market, the market for intermediated funds and the asset market clear:

$$L_t = H_t, \quad C_t = H_t^{1-\alpha},$$

$$A_t + X_t = W_t H_t, \quad S_t = S.$$

Note that the number of shares is assumed to be constant at  $S$ .

## 1.4 Calibration

In order to characterize the equilibrium of the model and study its quantitative implications parameter values have to be assigned. Most of the chosen values are standard in the literature. The discount factor is set to  $\beta = 0.995$ , and the risk aversion parameter is set to  $\gamma = 2$ , a value that is usually chosen in the asset pricing literature.<sup>7</sup> The parameter  $\chi$  is adjusted so that labor supply is approximately 35 percent of the time endowment in the steady state. The parameter  $\alpha$  in the production function is set to 0.36.

The money growth process is calibrated such that the response of M2 in the VAR in section 2 to a policy shock is matched. That is, the statistical properties of the Markov process for  $x_t$  have to be chosen such that they are consistent with the response of M2 growth to Federal Fund rate shocks in the VAR. Note that the impulse response function suggests that the money growth process can be represented as a MA(4) process, since only the first four impulse response coefficients are significantly different from zero. It is straightforward to show that the standard deviation of this MA(4) process is equal to 0.0010685 which implies that  $\sigma$  has to be set to 0.0008724. Similarly the first order autocorrelation of the MA(4) process is 0.8. Thus,  $\pi$  is set equal to 0.87. With respect to the autocorrelation of the money growth process, the response of stock prices and returns is considered for two additional parameterizations:  $\pi = 1/3$ , which implies an autocorrelation coefficient of zero, and  $\pi = 0.9995$ , which makes autocorrelation equal to 0.99925. The unconditional monetary growth rate is set to the sample mean of  $\mu = 0.0057$ .<sup>8</sup>

As in Christiano, Eichenbaum and Evans [20], the impact responses generated by

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<sup>7</sup>See for instance Campbell and Cochrane [14].

<sup>8</sup>Appendix A contains a detailed description of the solution to the model.

the model are reported as elasticities with respect to the end-of-period money stock:  $dz = \log(z'/z)/\log((1 + \mu)/(1 + \mu - \sigma))$ , where  $z'$  denotes the value of a variable in state  $(\mu, \mu - \sigma)$  and  $z$  denotes the value in state  $(\mu, \mu)$ , for  $z \in \{H, Y, D, q\}$ . The responses of the nominal interest rate,  $dR$ , the ex-post inflation rate,  $dInf$ , and stock return,  $dRet$  are reported as the differences  $R' - R$ ,  $Inf' - Inf$  and  $Ret' - Ret$  scaled by  $\log((1 + \mu)/(1 + \mu - \sigma))$ . The ex-post inflation rate is calculated as  $Inf_t = P_t/P_{t-1}$  and the nominal return is calculated as  $Ret_t = (q_t + D_t)/q_{t-1}$ . The real return is obtained by subtracting the rate of inflation from the nominal return. The response of the stock price,  $dq$ , is reported as a percentage change and the changes in nominal and real returns are reported as percentage point changes.

## 1.5 Results

The equilibrium responses of the macroeconomic variables to a fall in the monetary growth rate for the benchmark case where  $Corr(x_t, x_{t-1}) = 0.8$  are reported in Table 1.1.

Table 1.1: Responses of Macroeconomic Variables to a Monetary Contraction

$dR$	$dInf$	$dH$	$dY$	$dD$
0.59	-0.78	-0.35	-0.23	-1.00

Notes to Table 1.1:  $dR$  and  $dInf$  are the percentage point changes in the interest rate and the ex-post inflation rate in response to a one percent decrease in end-of-period money stock.  $dH$ ,  $dY$  and  $dD$  are percentage changes in labor, output and dividends in response to a one percent decrease in end-of-period money stock.

A negative money shock leads to a liquidity effect that increases the interest rate and decreases hours worked, output and dividends. Furthermore, due to lower money growth, inflation is lower. The one percent decrease in the end-of-period money stock

increases the nominal interest rate by 0.59 percentage points. The ex-post inflation rate is 0.78 percentage points lower than it would be if the shock had not occurred, and output falls by 0.23 percent. Note that most of the impact of the shock is on prices, whereas output falls only by a small amount, whereas the empirical analysis in section 2 suggests the opposite. The relatively strong reaction of nominal variables is a generally observed feature of limited participation models.<sup>9</sup> The nominal dividend falls by 1 percent. Qualitatively, the responses match those in Christiano, Evans and Eichenbaum [20]. They find that the real variables under consideration respond slightly stronger than here which is likely due to differences in the setup of the model and the calibration.

The reaction of the nominal stock price, the nominal return and the real return to a one standard deviation reduction in the money stock are displayed in Table 1.2 for the three different specifications of the autocorrelation structure of the shock process.

Table 1.2: Responses of Stock Prices and Returns to a Monetary Contraction

$\text{Corr}(x_t, x_{t-1})$	$dq$	$dRet$ (nominal)	$dRet$ (real)
0	-0.11	-0.11	-0.05
0.8	-0.15	-0.15	-0.09
0.99925	-0.12	-0.12	-0.06

Notes to Table 1.2:  $dq$  is the percentage change in the nominal stock price.  $dRet$  denotes percentage point changes in nominal and real rates of return. All changes are in response to a one standard deviation shock in the money stock.

The first line of the table reports the responses for the benchmark specification of the money growth process. The nominal stock price decreases by 0.15 percent and the ex-post return on stock holdings decreases by 0.15 and 0.09 percentage points in nominal and real terms. The intuition behind the reaction of stock prices to the

<sup>9</sup>See Hendry and Zhang [40] for a discussion.

liquidity shock is the following: The higher short term interest rates makes working capital more costly for the firm which is reflected in lower dividends payable at the end of the period. Furthermore, the higher short term interest rate increases the opportunity cost of holding stocks for the households. Both these factors have a negative impact on the current price of a stock.

Ultimately, the goal is to determine whether monetary shocks affect returns in accordance with the empirical evidence presented in section 2. This can be accomplished by comparing the impulse responses of nominal and real returns implied by the model to those observed in the data. Empirically, nominal returns decrease by 0.49 percentage points in the impact period compared to a decrease of 0.15 percentage points implied by the model. In the model real returns react relatively less and decrease by only 0.09 percentage points, whereas in the data real returns respond almost identically to nominal returns. The result that nominal returns react substantially stronger than real returns in the model is due to the fact that most of the impact of the monetary shock is on the price level. Thus, although the model produces responses with the correct sign, the magnitudes are somewhat too small. The reaction of nominal returns in the data is about three times as large as what the model suggests. Real returns in data react about five times stronger than in the model. However, it has proved hard for monetary and non-monetary asset pricing models to account for the observed high variability of stock returns. The limited participation model considered here manages to generate responses with magnitudes that are substantially closer to what is observed in the data than other models.<sup>10</sup>

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<sup>10</sup>For instance, Marshall [55] finds that the response of real returns to a money shock in his model is about ten times smaller than in the data.

Another interesting result concerns the correlation of real stock returns and inflation. As can be seen from Tables 1.1 and 1.2 the short run dynamics of the inflation rate and real stock returns are in opposite directions for plausible values of the autocorrelation coefficient. Put differently, the model suggests that stocks are a good hedge against inflation. This result is in contrast to the negative correlation between ex-post real stock returns and inflation that is documented in the empirical literature.<sup>11</sup> One conclusion that could be drawn from these results is that the observed negative correlation is due to the price level effects of real shocks and cannot be attributed to monetary shocks. This interpretation is consistent with the empirical evidence presented in section 2 and with the model in Marshall [55].<sup>12</sup>

Next, consider the remaining two specifications for the autocorrelation of the shock process. If the autocorrelation coefficient is set to zero, stock prices and returns respond by less than in the benchmark case, whereas increasing the autocorrelation of the shock process to 0.99925 results in responses that lie between the zero autocorrelation case and the benchmark specification. The logic for this result follows from the first-order condition for stock holdings derived in section 3. According to equation (1.11) next period's utility gain from buying stocks this period depends on the marginal utility and price level in two periods and the nominal interest rate and stock price in the next period. In the case of zero autocorrelation of shocks, the current realization of the money shock provides no information about the future values of the variables on the left hand side of equation (1.11). Hence, the current stock price is only influenced by time  $t$  dated variables that appear on the right hand side of the

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<sup>11</sup>See Giovanni and Labadie [38] and the references therein.

<sup>12</sup>An adverse effect of inflation on stock returns could be obtained in the model by allowing labor supply to be distorted by an inflation tax effect. However, the empirical relevance of the inflation tax is rather ambiguous.



necessary condition. In particular, the increase in the nominal interest rate and the decrease in the dividend will drive the stock price down. Moreover, this leads to a lower ex-post return. If the degree of persistence is increased, currently low money growth signals low future interest rates via the Fisher effect. Since the left hand side of equation (1.11) is decreasing in  $R_{t+1}$  this will put additional pressure on the current stock price and explains the stronger reaction for the case where  $Corr(x_t, x_{t-1}) = 0.8$ . However, a low future interest rate also implies that firms will have to pay lower interest on loans, which will result in higher future dividends and hence a higher stock price in  $t + 1$ . Thus, the value of the left hand side of equation (1.11) and therefore also the reaction of  $q_t$  depends on the relative sizes of these two counteracting effects. The last line of Table 1.2 shows that if the money shock is highly persistent with a first order autocorrelation of 0.99925 the expectation of high future dividends dominates and reduces the negative impact of the current monetary contraction as compared to the benchmark case.

These results can be summarized as follows: The transmission of monetary policy shocks into stock prices works primarily through changes in current and expected interest rates and dividends. A monetary contraction leads to a higher nominal interest rate, which in turn increases the opportunity cost of holding stocks and at the same time decreases current dividend payments since firms have to borrow working capital. Both these effects put pressure on the stock price. In case of persistent shocks, agents will revise their expectations about future realizations of the shock, which will have two counteracting effects on the stock price. Expected lower money growth will eventually lead to lower nominal interest rates and therefore higher future dividends. However, since in the present model the proceeds from selling stocks can only be used in the goods market after two periods, a lower future interest rate also means that

the proceeds earn less interest in the meantime. Hence, the magnitude of the short run response of nominal stock prices and returns to monetary shocks depends on the persistence of the shock.

## 1.6 Summary and Conclusion

This chapter has analyzed the reaction of stock market returns to monetary policy shocks. The empirical result is rather straightforward. Using a VAR approach it was demonstrated that a monetary contraction leads to an economically and statistically significant decline in ex-post returns. This reaction is only transitory and declines immediately after the impact period.

Furthermore, some evidence was presented that the transmission of monetary policy shocks into stock prices is well captured in a limited participation model. According to this model, a monetary policy shock affects the nominal interest rate via a liquidity effect. The change in the nominal interest rate has a direct and an indirect contemporaneous effect on stock prices. The direct effect works through the change in the opportunity cost of holding stocks caused by the change in the interest rate. The indirect effect operates through the impact that interest rates have on dividends and therefore stock prices, due to the assumption that firms are dependent on bank loans. If the monetary shock is highly persistent, expected future interest rates are affected via the Fisher effect, which will also lead to a change in expected future dividends. This counteracting effect can strongly reduce and potentially even overcompensate the impact of the change in current dividend payments on stock prices.

Analyzing the quantitative predictions of the models shows that the model is able to generate short run dynamic responses that are broadly consistent with the empirical

counterparts. However, the magnitudes of the responses are somewhat too small, for plausible parameter values.

## Chapter 2

# The Importance of Bank Credit as a Determinant of the Impact of Monetary Policy Shocks

### 2.1 Introduction

It is generally thought that the monetary transmission mechanism differs across countries. These differences are usually attributed to differences in financial structure and in particular to the relative importance of the banking sector as a source of external finance. The role of bank credit is also stressed by the bank lending view of the transmission mechanism as an important determinant of the impact of monetary policy shocks.<sup>1</sup> However, it has proved hard to find conclusive evidence on this issue. Although the large empirical literature on monetary economics has generated substantial evidence for the existence of a liquidity effect, cross-country comparisons

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<sup>1</sup>See Kashyap and Stein [42] and Cecchetti [17] for a discussion of the bank lending channel.

of the magnitudes of the responses of nominal interest rates, prices and real activity to monetary policy shocks appear to be inconclusive. Christiano, Evans and Eichenbaum [22] provide a survey of the VAR based literature using US data. Among others, Cushman and Zha [28], Fung and Kasumovich [35], and Grilli and Roubini [39] apply the identified VAR approach to countries besides the US. More recently, Mojon and Peersman [58] present evidence for the countries in the euro area and Peersman and Smets [63] use data for the euro area economy as a whole. Most of these studies find that the qualitative responses of output and prices are similar across countries. However, the confidence bands around the estimated responses of the macroeconomic variables are generally large. Hence, cross-country comparisons of magnitudes based on the results of the VAR based literature must be interpreted with caution. Moreover, Angeloni et al. [2], survey empirical evidence on the transmission mechanism in the euro area and conclude that the bank lending channel is not as substantial as one would have thought given the prominent role of banks as providers of finance in the euro area.

The goal of this chapter is to evaluate the dependence of firms on bank credit as a source of variation in the magnitude of the liquidity effect in a limited participation model. The use of a dynamic general equilibrium model allows us to simulate the effects of monetary policy shocks on economic activity under different financial structures, which will be associated with differences in the fraction of bank-dependent firms and in the default risk on loans. Given the limited cross-country comparability of the VAR studies, the simulation approach applied in this chapter appears to be a useful complement to the empirical literature for analyzing the question of what causes differences in the relationship between monetary policy shocks and business fluctuations across countries.

A limited participation model is chosen in this chapter because it is able to generate the empirically observed liquidity effect. Furthermore, as shown by Christiano, Evans and Eichenbaum [20] this class of models is in general rather successful in matching the results of the empirical literature on the effects of monetary policy shocks.

Credit market frictions and their impact on the transmission of monetary shocks in limited participation models have been explored by various authors. Closely related to this chapter is Fisher [33], who develops a model that incorporates various aspects of the bank lending channel in order to account for the heterogenous response of small and large firms to monetary shocks. This chapter differs from Fisher in the sense that the cross-country differences in financial structure and implications for aggregate variables are analyzed. Moreover, the model represented in this chapter analyzes the special role of the banking sector as a determinant of the size of the liquidity effect and does not include any effects that are usually associated with the broad credit channel. Cooley and Nam [27] incorporate asymmetric information, which gives rise to a credit market friction into an otherwise standard limited participation model and find that the impact of monetary shocks on the real economy is amplified.

The main result of this chapter is that differences in the degree to which the business sector of an economy depends on intermediated bank loans as opposed to directly placed debt instruments matter only little for how the aggregate economy responds to monetary shocks as long as the size of the monetary injections is held constant. When calibrated to match euro area and US data, the model predicts only small quantitative differences in the response of aggregate output in the two economies to monetary shocks of the same size, although the financial structures differ substantially. However, since interest rates respond very differently in the two simulated economies, the model suggests that if monetary policy is implemented according to an interest

rate target, the monetary injections that are necessary to achieve the target are substantially larger in the euro area. Consequently, aggregate variables in the euro area economy respond stronger than in the US to interest rate shocks of the same size.

The remainder of the chapter is organized as follows: Section 2 presents descriptive statistics on the financial structures for the euro area countries and the US. Section 3 describes the setup of a monetary general equilibrium model with the limited participation feature. Section 4 describes the calibration of the model and discusses various experiments. In section 5 the model is calibrated to euro area and US data. Section 6 summarizes and concludes the chapter.

## 2.2 Some Stylized Facts

This section aims at presenting some stylized facts that characterize the financial systems of the euro area countries and the US. Table 2.1 shows bank loans as a percentage of all finance and loan loss provisions as a percentage of loans for the euro area countries and the US. The importance of loans as a source of finance varies greatly across euro area countries and ranges from 39 percent in Finland to 80 percent in Ireland. Furthermore, loans account on average for 53 percent of all finance in the euro area whereas only for 21 percent in the US.

Loan loss provisions as a percentage of loans are also highly dissimilar across countries. This ratio appears to be the lowest in Ireland (0.22 percent) and the highest in France (2.28 percent). The euro area average is 1.21 percent and therefore substantially higher than the corresponding value for the US, which is 0.77 percent. In general, bank loans seem to be more important in the euro area than in the US. Moreover, the default risk on loans, as measured by the ratio of loan loss provisions to loans

Table 2.1: Financial Structure Descriptive Statistics

Country	Bank Loans as a Percentage of all Finance	Loan Loss Provisions as a Percentage of Loans
Austria	65	0.72
Belgium	49	0.38
Finland	39	0.48
France	49	2.28
Germany	55	0.78
Greece	48	1.39
Ireland	80	0.22
Italy	50	1.18
Luxembourg	-	0.97
Netherlands	53	0.29
Portugal	62	2.13
Spain	58	1.22
Euro area	53	1.21
US	21	0.77

Notes to Table 2.1: Loans as a percentage of all Finance are taken from Cecchetti [18] and refers to 1996 data. Loans and Loan Loss Provisions are taken from the OECD Bank Profitability Report 2000 and are averages taken over 1990 - 1999. Euro area wide numbers are population weighted averages.

seems to be higher in the euro area as well. However, this ratio varies substantially across the euro area countries and lies well below the US value in Belgium, Finland, Ireland, and the Netherlands.

These numbers suggest that financial structures vary across countries and might therefore give rise to differences in the monetary transmission mechanism. Whether these differences lead to quantitatively significant variations in the transmission mechanism will be analyzed in section 4.



## 2.3 Model

The model presented in this section is a variant of the limited participation model in Christiano, Evans, and Eichenbaum [20]. The economy consists of households, financial intermediaries, a monetary authority and a business sector. Some firms are subject to idiosyncratic shocks which are not verifiable by the households. This assumption ensures that these firms have to borrow from the financial intermediaries. The remaining firms can issue directly placed debt instruments. Both types of firms have to borrow working capital in the form of cash at the beginning of the period in order to finance the wage bill which is paid in advance of production. Monetary policy is conducted in terms of cash injections which are placed in the household's accounts at the financial intermediaries. Households have to decide on deposits, bond and money holdings before the monetary shocks are realized. Hence, monetary injections have to be absorbed by the firms that depend on intermediated loans which gives rise to the liquidity effect. At the end of each period, solvent bank-dependent firms repay their loans to the financial intermediaries and pay dividends to the households. Bond-issuing firms repay their debts with interest and make dividend payments to the households. Furthermore, financial intermediaries repay deposits with interest and distribute their profits to the households.

### 2.3.1 Firms

The business sector of the economy consists of a continuum of firms normalized to have unit mass. The firms produce a homogenous consumption good and own the economy's capital stock which is assumed to be constant and normalized to unity. The firms are of two types, depending on whether their output is subject to idiosyncratic

shocks. Each firm  $i$  hires labor,  $H_{it}$ , and produces output according to:

$$Y_{it} = \theta_i H_{it}^{1-\alpha}, \quad (2.1)$$

where  $\alpha \in (0, 1)$ . The parameter  $\theta_i$  represents an idiosyncratic shock, in particular

$$\theta_i = \begin{cases} 1 & \text{with probability } \pi \\ 0 & \text{with probability } 1 - \pi \end{cases}$$

for  $i \in [0, \lambda]$  and  $\theta_i = 1$  for  $i \in [\lambda, 1]$ . Hence, firms in the interval  $[0, \lambda]$  can only repay their debt with probability  $\pi$ . In case of default, firms can walk away from their debt obligations. Moreover, the realizations of  $\theta_i$  are not publicly observable for  $i \in [0, \lambda]$ , only the financial intermediaries have access to a monitoring technology that allows to verify realizations of  $\theta_i$ . Due to the assumption that labor is paid in advance of production, firms have to borrow working capital in order to finance the wage bill. In principle, each firm has two sources of credit. They can either issue nominal bonds which are sold directly to the households and redeemed at the end of the period, or they can enter into debt contracts with a financial intermediary. However, since the realizations of the idiosyncratic shocks are not public knowledge, firms in the interval  $[0, \lambda]$  have an incentive to misreport their output and default on bonds owned by households. Consequently, these firms will not be able to issue bonds in the first place and will be forced to borrow from the financial intermediaries instead. Let  $R_t^L$  denote the interest rate charged on bank loans. Since all borrowing and hiring decisions are made after the monetary shock has occurred, optimality requires:

$$R_t^L \frac{W_t}{P_t} = (1 - \alpha) H_{it}^{-\alpha}, \quad (2.2)$$

for  $i \in [0, \lambda]$ , where  $W_t$  is the nominal wage and  $P_t$  denotes the price level.

For firms in the interval  $i \in [\lambda, 1]$ , the fact that  $\theta_i = 1$  is common knowledge, therefore debt contracts do not involve any default risk. Hence, these firms are able

to sell bonds directly to the households without the need for a financial intermediary. The interest rate on directly placed debt is denoted by  $R_t^B$ . Assuming that  $R_t^L > R_t^B$ , the optimal amount of bonds to be issued is determined by

$$R_t^B \frac{W_t}{P_t} = (1 - \alpha) H_{it}^{-\alpha}, \quad (2.3)$$

for  $i \in [\lambda, 1]$ .<sup>2</sup> At the end of the period loans and bonds are repaid and profits are distributed to the households.

### 2.3.2 Households

Households maximize their expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, L_t), \quad (2.4)$$

where  $\beta$  is a discount factor,  $C_t$  is consumption in period  $t$ ,  $L_t$  denotes labor supply in period  $t$ , and

$$u(C_t, L_t) = \log \left[ C_t - \frac{\psi_0}{1 + \psi} L_t^{1+\psi} \right], \quad (2.5)$$

$\psi, \psi_0 > 0$ . This specification of the period utility function has the property that the household's labor supply function has a constant real wage elasticity of  $1/\psi$ .

At the beginning of each period households hold the entire stock of money,  $M_{t-1}$ , and must decide how much money to use for consumption in the current period, for deposits at the financial intermediaries,  $A_t$ , and for purchases of bonds,  $B_t$ , issued by firms. Deposits yield a gross interest rate of  $R_t^D$ . Interest rates are determined after the state of the world is revealed. Households supply  $L_t$  units of labor at a nominal wage of  $W_t$ . Labor income,  $L_t W_t$ , can be used for purchases in the goods market in the

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<sup>2</sup>Note that  $R_t^L > R_t^B$  will always be satisfied in equilibrium.

current period. Hence, the households face the following cash-in-advance constraint:

$$P_t C_t \leq M_{t-1} - A_t - B_t + W_t L_t. \quad (2.6)$$

The amount of money the households carry over into the next period is

$$M_t = M_{t-1} - A_t - B_t + W_t L_t - P_t C_t + R_t^D (A_t + X_t) + R_t^B B_t + D_t, \quad (2.7)$$

where  $D_t$  is the sum of all profits of the firms distributed at the end of period  $t$  and  $X_t$  represents a cash injection by the central bank.

The household solves the dynamic programming problem:

$$V \left( \frac{M_{t-1}}{P_t} \right) = \max_{A_t, B_t} E_{t-1} \left\{ \max_{C_t, L_t, M_t} \left[ u(C_t, L_t) + \beta E_t V \left( \frac{M_t}{P_{t+1}} \right) \right] \right\} \quad (2.8)$$

subject to (2.6) and (2.7). The necessary conditions associated with this maximization problem are:

$$\beta E_{t-1} \left( R_t^D \frac{u_{c,t+1}}{P_{t+1}} \right) = E_{t-1} \left( \frac{u_{c,t}}{P_t} \right), \quad (2.9)$$

$$\beta E_{t-1} \left( R_t^B \frac{u_{c,t+1}}{P_{t+1}} \right) = E_{t-1} \left( \frac{u_{c,t}}{P_t} \right), \quad (2.10)$$

$$\frac{W_t}{P_t} = \frac{u_{L,t}}{u_{c,t}}. \quad (2.11)$$

Equations (2.9) and (2.10) determine optimal deposits and bond holdings. Note that these decisions are made before the period  $t$  money growth rate is realized and therefore they have to be based on information available in period  $t - 1$ . Equation (2.11) expresses the result that households equate their marginal rate of substitution between labor and leisure to the real wage when making their labor supply decisions.

### 2.3.3 Financial Intermediaries

At the beginning of the period, financial intermediaries receive deposits from the households and cash injections from the monetary authority. The total amount of

loanable funds,  $A_t + X_t$ , is used to provide loans to firms which cannot borrow from households directly. In contrast to households, financial intermediaries can observe the realization of idiosyncratic shocks and are therefore able to enforce debt contracts. For simplicity, it is assumed that financial intermediation and monitoring are costless and competitive. At the end of the period, the financial intermediaries receive payments from their solvent borrowers and return deposits with interest to the household. The remaining profits are paid to the households as dividends.

The objective of the financial intermediary is to choose the optimal amount of loans such that the expected present value of the dividend stream is maximized. The dividend is given by

$$F_t = \pi(A_t + X_t)R_t^L - (A_t + X_t)R_t^D. \quad (2.12)$$

Free entry into the banking sector ensures that  $R_t^D = \pi R_t^L$  and that  $F_t = R_t^D X_t$  will be paid to the households in form of dividends.

There is a clear role for financial intermediaries in this environment since without the intermediaries, bank-dependent firms would have no opportunity to borrow working capital and would be cut off from production. Furthermore, the financial intermediaries can eliminate idiosyncratic default risk by lending to an infinite number of borrowers.<sup>3</sup>

### 2.3.4 Monetary Authority

The monetary authority provides liquidity to the financial sector of the economy. The monetary growth rate is defined as:

$$x_t = \frac{X_t}{M_{t-1}} = \frac{M_t - M_{t-1}}{M_{t-1}}. \quad (2.13)$$

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<sup>3</sup>See Diamond [29].

The money supply process is assumed to be exogenous and the monetary growth rate follows a three-state Markov process. In particular, suppose that  $x_t \in \{\mu + \sigma, \mu, \mu - \sigma\}$  and let  $q_{ij} = \text{Prob}(x_{t+1} = x_j | x_t = x_i)$  where  $q_{ij} = \bar{q}$  for  $i = j$  and  $q_{ij} = (1 - \bar{q})/2$  for  $i \neq j$ . This specification implies that  $E(x_t) = \mu$ ,  $\text{Var}(x_t) = \frac{2}{3}\sigma^2$  and the first order autocorrelation of the money growth process is given by  $\text{Corr}(x_t, x_{t-1}) = (3\bar{q} - 1)/2$ .

### 2.3.5 Equilibrium

A stationary competitive equilibrium for the model is characterized by stochastic sequences of allocations  $\{C_t, H_{it}, M_t, A_t, B_t\}_{t=0}^{\infty}$ , prices  $\{R_t^D, R_t^L, R_t^B, P_t, W_t\}_{t=0}^{\infty}$  and monetary growth rates  $\{x_t\}_{t=0}^{\infty}$  such that: (i) The household's necessary conditions (2.9), (2.10), (2.11), and the constraints (2.6), (2.7) are satisfied. (ii) The necessary conditions (2.2) and (2.3) which determine optimal borrowing for bank-dependent firms and for bond-issuing firms hold. (iii) The markets for labor, goods, loans and bonds clear:

$$L_t = \int_0^1 H_{it} di, \quad C_t = \int_0^1 H_{it}^{1-\alpha} di,$$

$$A_t + X_t = W_t \int_0^\lambda H_{it} di, \quad B_t = W_t \int_\lambda^1 H_{it} di.$$

## 2.4 Calibration and Results

In order to explore the quantitative properties of the model, parameter values have to be assigned. As it is standard in the literature, the discount factor is set to  $\beta = 0.99$ . For the labor supply elasticity,  $1/\psi$ , a value of unity is chosen and  $\psi_0$  is adjusted such that labor supply is equal to unity in each simulation. The parameter  $\alpha$  in the production function is set to 0.36. The unconditional monetary growth rate is set

to  $\mu = 0.02$  and for  $\sigma$  the value 0.015 is chosen, which implies that the standard deviation of the process is equal to 0.012. The first order autocorrelation coefficient of the process is set to 0.75. This parameterization of the money growth process is broadly consistent with money growth data for the euro area and the US.

The model will be simulated under various financial structures summarized by the parameters  $\pi$  and  $\lambda$ . These two parameters will be calibrated to match the descriptive statistics presented in Table 2.1, which imply values of around 99 percent for  $\pi$  and a range of 0.21 to 0.80 for  $\lambda$ .<sup>4</sup> The resulting default probability of approximately 1 percent is close to the values chosen by Cooley and Nam [27] and by Carlstrom and Fuerst [16] who set this parameter to 2 percent and 0.974 percent respectively.

Table 2.2 reports the impact responses of the model to an unanticipated fall in the monetary growth rate for  $\pi = 0.99$  and different values of  $\lambda$ . All responses are reported as elasticities with respect to a 1 percent reduction in the end-of-period money stock. Interest rates and the risk premium are reported as semi-elasticities and can be interpreted as percentage point changes in response to a 1 percent reduction in the end-of-period money stock.

For all values of  $\lambda$  considered, the model produces qualitatively similar results. A monetary contraction leads to a liquidity effect that increases the interest rate on bank loans, which in turn decreases aggregate hours worked and aggregate output. The interest rate on bonds and the risk premium defined as  $R^L - R^B$  both increase with the bond rate responding by less than the risk premium. For extremely low values of  $\lambda$ , aggregate output and hours respond somewhat stronger than for high values of this parameter. However, the response of aggregate output varies only from

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<sup>4</sup>Note that the fraction of bank-dependent firms does not necessarily correspond exactly to bank loans as a fraction of all financing. However, in the model, the difference is quantitatively negligible.

Table 2.2: Responses to a Monetary Contraction

	$\lambda$							
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$dY$	-0.33	-0.31	-0.30	-0.30	-0.29	-0.29	-0.29	-0.29
$dH$	-0.49	-0.46	-0.46	-0.46	-0.46	-0.45	-0.45	-0.45
$dR^L$	3.41	2.20	1.63	1.30	1.08	0.92	0.81	0.71
$dR^B$	0.09	0.05	0.04	0.04	0.04	0.04	0.04	0.03
$d(R^L - R^B)$	3.33	2.16	1.59	1.26	1.04	0.88	0.77	0.68

Notes to Table 2.2:  $dY, dH$  are the percentage changes of output and labor in response to a one percent decrease in the end-of-period-money stock.  $dR^L, dR^B$  and  $d(R^L - R^B)$  are the percentage point changes in the loan rate, the bond rate and the risk premium in response to a one percent decrease in the end-of-period-money stock.

-0.33 percent for  $\lambda = 0.2$  to -0.29 percent for  $\lambda = 0.9$ , which appears to be a small range. The impact on the interest rate on loans depends more strongly on the fraction of bank-dependent firms and varies from 3.41 percentage points to 0.71 percentage points, whereas the response of the bond rate varies from 0.09 percentage points to 0.03 percentage points. Consequently, the risk premium also responds rather strongly in the case of a low value for  $\lambda$ .

Thus, the model predicts that the aggregate output response to a monetary contraction of a given size does not vary substantially with the fraction of bank-dependent firms in the economy. This somewhat surprising result can be explained by looking at the labor demand and output responses of individual bank-dependent and bond-issuing firms presented in Table 2.3, where  $dH_i$  and  $dY_i$  denote the elasticities of labor demand and output of bank-dependent firms ( $i = 1$ ) and bond-issuing firms ( $i = 2$ ) to a 1 percent increase in end-of-the-period money. Output and labor demand of bank-dependent firms respond negatively to a monetary contraction and the magnitude of the response varies strongly with the fraction of bank-dependent firms in the economy.



Table 2.3: Labor Demand and Output Responses of Bank-Dependent and Bond-Issuing Firms to a Monetary Contraction

	$\lambda$							
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$dY_1$	-4.84	-2.88	-1.94	-1.38	-1.02	-0.75	-0.56	-0.41
$dH_1$	-7.56	-4.51	-3.03	-2.16	-1.59	-1.18	-0.88	-0.64
$dY_2$	0.72	0.74	0.74	0.74	0.74	0.74	0.74	0.75
$dH_2$	1.13	1.15	1.16	1.16	1.16	1.16	1.16	1.16

Notes to Table 2.3:  $dH_1$  and  $dY_1$  denote the elasticities of labor demand and output of bank-dependent firms and  $dH_2$  and  $dY_2$  denote the elasticities of labor demand and output of bond-issuing firms in response to a one percent decrease in the end-of-period-money stock.

The reason is that for low values of  $\lambda$ , only a small number of firms competes for bank loans and since the size of the monetary shocks is constant across the experiments considered, each bank-dependent firm has to absorb a relatively large amount of the monetary injection. Hence,  $\lambda$  has a strong impact on the borrowing decision and consequently on the output of each individual bank-dependent firm. Bond-issuing firms on the other hand respond positively to a monetary contraction and the output and labor demand responses are rather stable across different values for  $\lambda$ . It follows that most of the variation in the output effect comes from bank-dependent firms with the largest impact on these firms for low values of  $\lambda$ . However, low values of  $\lambda$  also imply that the output responses of bank-dependent firms only have a small impact on aggregate output. A higher value for  $\lambda$  increases the degree to which aggregate output is influenced by the output responses of bank-dependent firms, but at the same time decreases the effect a monetary shock has on these firms. For plausible values of  $\lambda$  these two effects largely cancel out in the aggregate. Consequently, the impact of a monetary contraction on aggregate output is only slightly influenced by the fraction of bank-dependent firms in the economy.

These results can be summarized as follows. A monetary contraction leads to a liquidity effect that increases the interest rate on loans. The higher interest rate makes working capital more costly for bank-dependent firms which results in lower labor demand and lower output for these firms. The remaining firms which can directly issue bonds are only marginally affected by the monetary policy shock and increase labor demand and output. Since the demand for labor declines in the bank-dependent sector, labor resources are reallocated to the firms that do not depend on bank credit which in turn leads to an expansion in output of these firms. It appears plausible however, that this reallocation effect is rather small in reality due to labor adjustment costs which are absent from the model.

Moreover, the risk premium increases in response to a monetary policy shock. Although the magnitude of the output response of bank-dependent firms depends on the fraction of bank-dependent firms, the impact on aggregate output varies only little with the dependence on bank credit. Note that interest rates, in particular the loan rate, vary substantially with the fraction of bank-dependent firms. This suggests that if the monetary authority follows an interest rate target and adjusts the monetary supply endogenously to achieve the target, the monetary injections necessary to do so will vary with  $\lambda$ . Hence, in this case an interest rate shock of a given size will be associated with different liquidity injections and therefore the response of aggregate output will vary with  $\lambda$ . This aspect will be explored in detail in the next section.

In the experiments considered so far, the default probability,  $\pi$ , has been held constant at the value of 0.99. To explore how this parameter influences the results, Table 2.4 reports the response of aggregate output to a monetary contraction for different combinations of  $\pi$  and  $\lambda$ .

As is evident from the table, the response of aggregate output is only slightly

Table 2.4: The Response of Aggregate Output to a Monetary Contraction

	$\lambda$							
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$\pi=0.99$	-0.33	-0.31	-0.30	-0.30	-0.29	-0.29	-0.29	-0.29
$\pi=0.97$	-0.34	-0.30	-0.30	-0.30	-0.29	-0.29	-0.29	-0.29
$\pi=0.95$	-0.35	-0.30	-0.30	-0.30	-0.29	-0.29	-0.29	-0.29
$\pi=0.93$	-0.36	-0.32	-0.29	-0.30	-0.30	-0.29	-0.29	-0.29

Notes to Table 2.4: Percentage change in aggregate output,  $dY$ , to a one percent decrease in the end-of-period-money stock.

influenced by  $\pi$ . Lower values of  $\pi$  lead to a somewhat larger change in aggregate output for low values of  $\lambda$  and have virtually no effect for high values of  $\lambda$ . The reason is again that bank-dependent and bond-issuing firms react differently to monetary shocks in this model. Increasing the probability of default leads to a higher spread between the loan and the bond rate. This in turn implies that bank-dependent firms are forced to operate in a range where their marginal products and their outputs are highly reactive to changes in the labor input, but leaves bond-issuing firms mostly unaffected. Hence, a high default probability amplifies the already relatively strong reaction of bank-dependent firms leading to a somewhat stronger reaction of aggregate output. However, this effect is only strong enough to have a noticeable impact on aggregate output for very low values of  $\lambda$ , i.e. when monetary injections have to be absorbed by a small number of firms.

In general, the model's implications are consistent with the bank lending channel. The result that bank-dependent firms reduce labor demand and output during a monetary contraction, whereas bond-issuing firms increase their level of activity is consistent with empirical evidence presented in Gertler and Gilchrist [36], who show that bank loans to small manufacturing firms decline when the Fed tightens monetary

policy, whereas large firms actually increase their external financing by issuing commercial paper. Similar evidence is provided by Peersman and Smets [64] for the euro area. They find that a large part of the cross-industry differences in the response to monetary shocks can be attributed to variables that are related to financial structure and firm size. The reaction of the risk premium is in line with results in Berger and Udell [8], who find that the spread between the bank loan rate and the Treasury Bill rate increases during a credit crunch. Similar results are presented in Kashyap, Stein, and Wilcox [44] for the spread between the prime rate and the commercial paper rate.

## **2.5 Comparing the Euro Area and the US Transmission Mechanism**

In order to see what the model predicts for the transmission of monetary shocks in the euro area and in the US, the model is now calibrated to match the financial structure characteristics of these two economies. With the calibrated model, two experiments will be conducted. In the first experiment the reaction of the two economies to a monetary injection of the same size will be analyzed. In the second experiment both economies will be subject to an interest rate shock of the same size, that is, monetary injections are determined endogenously in order to achieve a given response in the interest rate. The idea behind the second experiment is that the monetary authority implements monetary policy according to an interest rate target. However, the only thing that policymakers can directly control is the monetary base. In order to implement an interest rate target, the growth rate of the money supply has to respond in a particular way.

The model is calibrated as follows. The default probabilities are set to 1.21 percent

for the euro area and to 0.77 percent for the US. The fraction of bank-dependent firms is 0.53 for the euro area and 0.21 for the US. Table 2.5 reports the resulting steady-state risk premia generated by the model.

Table 2.5: Steady State Properties of the Model Calibrated to Euro Area and US Data

	$\lambda$	$\pi$	$R^L - R^B$
euro area	0.53	0.988	1.24
US	0.21	0.993	0.67

Notes to Table 2.5: The risk premium,  $R^L - R^B$ , is measured in percentage points.

The table shows that the model generates steady-state risk premia of 1.24 percentage points and 0.67 percentage points for the euro area and the US respectively. In US time series data, the average spread between the prime rate and the three-month Treasury Bill rate is 0.7 percentage points on a quarterly basis (for the period between January 1985 and August 2002). For the euro area, the spread between the rate on short-term loans to enterprises and the three-month money market rate is 0.73 percentage points for the sample from December 1995 to June 2002. Hence, the model overestimates the impact of the slightly higher default probability for the interest rate spread in the euro area.

Table 2.6 shows the equilibrium responses to a monetary contraction when the model is calibrated to euro area and US data. Both economies are hit by a monetary injection of the same size. The model predicts that aggregate output and hours worked respond almost identically in both economies.

Aggregate output falls by 0.30 and 0.31 percent and hours worked fall by 0.46 percent in response to a one percent decrease in the end-of-period money stock. Thus, the effect of a monetary contraction of the same size on aggregate output is rather

Table 2.6: Equilibrium Responses of the Model Calibrated to Euro Area and US Data

	$dY$	$dH$	$dR^L$	$d(R^L - R^B)$
euro area	-0.30	-0.46	1.18	1.14
US	-0.31	-0.46	3.02	2.98

Notes to Table 2.6:  $dY$  and  $dH$  are percentage changes in output and labor.  $dR^L$  and  $d(R^L - R^B)$  are percentage point changes in the loan rate and the default premium in response to a one percent decrease in the end-of-period-money stock.

similar in both economies, as one would expect given the discussion in the last Section. However, a low fraction of bank-dependent firms results in a relatively strong reaction of the interest rate on loans and the risk premium to a monetary contraction.

Next, the responses of the two economies to an interest rate shock of the same size are explored, that is the monetary authority varies the growth rate of the monetary supply endogenously in order to achieve a given change in interest rates. Since, the model has two markets for debt instruments and consequently two interest rates, the question arises which interest rate is targeted by the monetary authority. In this experiment it will be assumed that monetary policy is conducted such that the loan rate increases by one percentage point. Although central banks are usually described as following a policy that targets a short term interest rate on risk free debt and not the rate for risky corporate debt, the loan rate is chosen here for two reasons. First, although central banks do not target interest rates on corporate debt directly, the goal still is to influence market interest rates and ultimately, borrowing by the business sector. And second, the previous experiment has shown that the reaction of the rate on risk free bonds does not vary with the different financial characteristics of the two economies under consideration. Hence, the conclusions from the previous experiments would still apply if the bond rate is targeted.

Table 2.7 reports the results when both economies are hit with a monetary shock

that leads to an increase in  $R^L$  of one percentage point. As expected, in the US the necessary liquidity injection, denoted by  $\sigma$ , is substantially smaller than in the euro area. Consequently, aggregate hours and output decrease by more in the euro area than in the US. The interest rate on bonds increases slightly in the euro area and remains unchanged in the US.

Table 2.7: Equilibrium Responses to a One Percentage Point Increase in the Loan Rate for the Model Calibrated to Euro Area and US Data

	$dY$	$dH$	$\sigma$	$dR^B$	$d(R^L - R^B)$
euro area	-0.25	-0.39	0.008	0.03	0.97
US	-0.10	-0.16	0.003	0.00	1.00

Notes to Table 2.7:  $dY$  and  $dH$  are percentage changes in output and labor.  $dR^L$  and  $d(R^L - R^B)$  are percentage point changes in the loan rate and the default premium in response to a one percentage point increase in the loan rate.  $\sigma$  denotes the size of the shock to the monetary growth rate necessary to achieve the percentage point change in the loan rate.

The simulations show that different degrees of bank-dependence in the euro area and the US economy are not likely to be a source of quantitatively significant differences in the transmission mechanism as long as both economies are subject to liquidity injections of the same size. The interest rate on bank loans on the other hand responds substantially stronger in the US. Consequently, liquidity injections have a strong impact on bank-dependent firms in the US economy. In case that monetary policy aims at achieving a certain change in interest rates, the two economies respond rather differently, since a given change in the loan rate in the euro area requires a monetary injection which is approximately three times larger than in the US. And consequently, aggregate hours and output respond substantially stronger in the euro area. Hence, these results suggest that differences in the importance of bank loans across countries should be expected to result in different responses of aggregate variables to monetary

shocks only if monetary policy is implemented according to an interest rate target. This finding is in contrast to the view that the more important bank credit is as a means of obtaining finance, the larger the impact of monetary policy on real economic activity should be.<sup>5</sup> The general equilibrium model presented here, shows that this is not necessarily the case, since a large number of bank-dependent firms also implies that liquidity that is injected by the monetary authority is absorbed by a large number of firms which makes these monetary transfers relatively unimportant for the individual firms. Put differently, at the level of the individual firm, the available amount of loanable funds is strongly influenced by monetary injections only if the number of firms is small.

## 2.6 Summary and Conclusions

Empirical evidence from VAR studies suggests that the macroeconomic effects of monetary policy shocks vary across countries. However, due to the high degree of uncertainty associated with monetary VAR models, these studies have not been able to deliver conclusive evidence on this issue. This chapter explores the role of different financial structures as a potential source of cross-country differences in the transmission mechanism and asks whether one should expect that varying degrees of bank-dependence are associated with quantitatively different responses of macroeconomic variables to monetary shocks.

The chapter has demonstrated that the responses of aggregate output and the price level are only to a small degree influenced by the dependence on bank credit if monetary injections are of a given size. This follows from the fact that although a large

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<sup>5</sup>See for instance Kashyap and Stein [43] and Cecchetti [18].



fraction of bank-dependent firms implies that aggregate output is strongly influenced by changes in the activity level of these firms, it also implies that monetary shocks are spread out over a large number of firms and consequently monetary shocks become relatively unimportant at the level of the individual firms. However, if monetary policy aims at achieving a certain interest rate target, the necessary monetary injections and therefore also the responses of aggregate variables depend on the importance of bank credit.

When calibrated to match features of the euro area and the US economies, the model predicts that both economies respond very similarly to monetary shocks as long as the shocks are of similar size. However, if both economies are subject to an interest rate shock of the same size, the euro area economy responds substantially stronger. These results provide some support for the bank lending view of the transmission mechanism according to which a strong dependence on bank loans is a prerequisite for the bank lending channel to operate.<sup>6</sup> The model suggests that bank dependence is only crucial in combination with an interest rate target.

The scope of this chapter is limited to the analysis of the importance of bank credit as a source of variation in the responsiveness to monetary shocks and therefore abstracts from various other factors that might lead to differences in the transmission mechanism across countries. Apart from the bank-dependence of firms, the lending behavior of banks can play a major role in the transmission of monetary shocks. Using data on US banks, Kashyap and Stein [45] document that the influence of monetary policy on the supply of bank loans depends to a large extent on the size of banks. Ehrmann et. al. [30] document similar differences in the lending behavior for the euro area. Hence a more detailed analysis of how the banking sector responds to monetary

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<sup>6</sup>See Kashyap and Stein [42].

injections might yield interesting insights.

The chapter has also abstracted from the broad credit channel and the role of net worth and collateral constraints.<sup>7</sup> Cooley and Nam [27] show that the real effects of monetary shocks are amplified in an environment where agency costs give rise to credit market frictions. Cross country differences in agency costs could therefore be a source of differences in the transmission mechanism.

Alternatively, differences in the monetary transmission mechanism could be the result of differences in the systematic part of monetary policy across countries. As shown by Christiano and Gust [23], the aggressiveness of monetary policy towards inflationary pressures largely determines the responsiveness of the economy to shocks in their monetary model. Moreover, Clarida, Gali and Gertler [24] present empirical evidence in favor of cross-country differences in the systematic conduct of monetary policy.

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<sup>7</sup>Bernanke and Gertler [9] and Carlstrom and Fuerst [16] among others, stress the importance of these factors for business fluctuations.

## Chapter 3

# International Risk Sharing in the European Union

### 3.1 Introduction

A central theme of international business cycle models is that if investors have access to markets for financial assets that are complete, then they can perfectly insure against country specific shocks. That is, consumption should only react to aggregate shocks that are uninsurable and consequently, one should observe that consumption is highly correlated across countries. Moreover, even if a complete set of contingent markets is not available, risk sharing is still possible either through a fiscal transfer system or through existing financial markets, e.g. cross-country ownership of productive assets, or trade in non-contingent assets. However, the empirical literature has largely rejected the implications of the theoretical models with complete markets, indicating that the amount of risk sharing is rather limited.<sup>1</sup> Backus et al. [5] find that the

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<sup>1</sup>For recent surveys see Obstfeld and Rogoff [61] and Lewis [52].

consumption correlations are too small in the data to be consistent with complete markets. French and Poterba [34] document a large home bias in equity holdings and therefore only a small degree of international diversification. In addition, consumption appears to be too sensitive to idiosyncratic income to be consistent with perfect risk sharing as shown by Obstfeld [59], Canova and Ravin [15] and Lewis [53] among others.

This chapter studies risk sharing among the EU member countries. More specifically, two questions are asked. First, has the integration of the European economies coincided with consumption allocations becoming less exposed to country specific risks, and second, is the remaining exposure to country specific shocks related to institutional aspects and characteristics of the legal system? Since it appears that capital mobility and the integration of international financial markets have increased over the last decades, one would expect that risk sharing has also improved.<sup>2</sup> This is particularly true for Europe since the tighter integration of the goods and financial markets has been a main motivation for the creation of the EU and EMU and according to most indicators, the financial markets in the EU have indeed become more integrated over the last decades. Adam et al. [1] argue that the convergence of interest rates and stock market returns in the EU points towards a higher degree of financial market integration. Blanchard and Giavazzi [10] find that the behavior of the current accounts in the EU countries is consistent with increased consumption smoothing over time and that the Feldstein Horioka puzzle has basically disappeared, suggesting that capital mobility in the EU has improved.

Risk sharing among European countries has been explored by various authors.<sup>3</sup>

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<sup>2</sup>See Lane and Milesi-Ferretti [49] and Obstfeld and Taylor [62] for discussions of how capital mobility and financial integration have developed.

<sup>3</sup>See among others Sorensen and Yosha [3], Melitz and Zumer [56], Bayoumi and MacDonald [7]

The general conclusion from this literature is that risk sharing is far from perfect and that it is exploited to a lesser extent than among the states in the US. However, it has so far not been analyzed whether the integration of the financial markets in the EU has led to more consumption risk sharing.

Moreover, the paper investigates the link between risk sharing and institutional aspects and is therefore related to the growing literature on law and finance initiated by La Porta et al. [46] and [47]. They show that legal aspects and in particular the degree of investor protection can explain differences in the size and scope of financial markets across countries. In a recent paper, Giannetti and Koskinen [37] argue that the observed home bias in equity holdings is related to the degree of investor protection. In this paper, I ask the related but distinct question whether institutional differences can explain differences in the amount of risk sharing that can be achieved.

As a first result, the hypothesis of perfect risk sharing is strongly rejected due to the sensitivity of consumption growth to idiosyncratic income growth. Moreover, no evidence is found that risk sharing has improved over time, which is interpreted as evidence against the hypothesis that European Integration has led to more intra-European risk sharing. In addition, no indications are found that EU membership is associated with less exposure to idiosyncratic shocks.

Some evidence is found that suggests that institutional and legal aspects appear to play a role in this respect. In particular, the degree of creditor protection and the efficiency of law enforcement seem to influence the sensitivity of consumption growth to idiosyncratic income growth. In particular, countries characterized by good creditor rights and efficient law enforcement are relatively more exposed to idiosyncratic

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and Atkeson and Bayoumi [4].

risks. This result is consistent with the idea that investors in countries that provide good investor protection prefer to invest domestically and will therefore not diversify country specific risks.

The remainder of the chapter is organized as follows: Section 2 discusses some theoretical implications of a model with complete markets for consumption allocations and the empirical specification that will be used in the paper. Section 3 explores whether risk sharing has changed over time along with the ongoing process of European Integration. In Section 4 the excess sensitivity of consumption growth to idiosyncratic income growth will be related to institutional and legal variables. Section 5 concludes the paper.

## 3.2 Theoretical Motivation and Empirical Implementation

The implications of complete asset markets for international consumption comovements can be illustrated by looking at a simple endowment model.<sup>4</sup> Consider a two country model, where each country is populated by an infinitely lived representative agent. The agents receive stochastic endowment streams  $y_{it}$ , where  $i = 1, 2$  indexes the country. It is assumed for simplicity that the endowment can not be stored. The agents maximize their expected lifetime utilities  $E_0 \sum_{t=0}^{\infty} \beta^t u(c_{it})$ , where  $E_0$  denotes the expectation conditional on period 0 information,  $\beta$  is the discount factor,  $u$  is the period utility function and  $c_{it}$  denotes the consumption of country  $i$  at time  $t$ .

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<sup>4</sup>For a related derivation see for instance Obstfeld and Rogoff [60] chapter 5.

In the case of complete markets, standard welfare theorems imply that the equilibrium allocation can be found by solving the social planner problem:

$$\max E_0 \left[ \omega_1 \sum_{t=0}^{\infty} \beta^t u(c_{1t}) + \omega_2 \sum_{t=0}^{\infty} \beta^t u(c_{2t}) \right], \quad (3.1)$$

subject to the constraint:

$$c_{1t} + c_{2t} = y_{1t} + y_{2t}, \quad (3.2)$$

where  $\omega_1$  and  $\omega_2$  are the weights attached to the respective country. Assuming identical CRRA type utility functions, the first-order conditions to this problem imply that the intertemporal rates of substitution have to be equalized across the agents in the two countries and therefore:

$$\Delta \log c_{1t} = \Delta \log c_{2t}, \quad (3.3)$$

where  $\Delta$  denotes the difference operator. This result implies that under complete markets, the ex post consumption growth rates of the two countries should be perfectly correlated. Thus, consumption growth, although individually stochastic, is fully determined by aggregate consumption growth. Moreover, a second implication of (3.3) is that idiosyncratic variables, in particular idiosyncratic income, do not influence relative consumption growth. Put differently, the influence of idiosyncratic shocks is diversified away.

On the other hand, if a complete set of Arrow Debreu securities is not available, consumption growth rates are likely to respond to shocks to idiosyncratic variables. For instance if agents face borrowing constraints or follow rule of thumb behavior as emphasized by Campbell and Mankiw [13] and Bayoumi [6], consumption growth will depend on idiosyncratic income growth. Thus, a more plausible specification for the empirical analysis is:

$$\Delta \log c_{it} = \beta_{i0} + \beta_1 \Delta \log c_t^a + \beta_2 (\Delta \log y_{it} - \Delta \log y_t^a) + e_{it}, \quad (3.4)$$

where  $y_{it}$  denotes real per capita output,  $y_t^a$  is aggregate output,  $\beta_{i0}$  capture country specific effects and  $\beta_1$  and  $\beta_2$  are coefficients. Equations similar to (3.4) have been estimated by Cochrane [25] and Mace [54] with micro data and by Lewis [53] with international data. Note that consumption growth in country  $i$  depends on aggregate consumption,  $c_t^a$ , which replaces ‘the other country’ in the empirical implementation. Idiosyncratic income growth is proxied by the term  $\Delta \log y_{it} - \Delta \log y_t^a$ . Subtracting aggregate income growth eliminates global shocks to some extent and it helps to reduce the amount of multicollinearity among the right hand side variables.

Under complete markets, agents are able to completely diversify away any idiosyncratic risk. Therefore,  $\Delta \log c_{it}$  should only depend on  $\Delta \log c_t^a$  but not on  $\Delta \log y_{it} - \Delta \log y_t^a$ . Thus, testing the joint hypothesis that  $\beta_1 = 1$  and  $\beta_2 = 0$  constitutes a test of perfect risk sharing.

Asdrubali, Sorensen and Yosha [3] suggest to interpret  $\beta_2$  as the fraction of shocks that is not smoothed. Define  $\tilde{y}_{it} \equiv y_{it}/y_t^a$  as the ratio of country  $i$  income to total income and similarly  $\tilde{c}_{it} \equiv c_{it}/c_t^a$  as the ratio of country  $i$  consumption to aggregate consumption. The argument is based on the following identity  $\tilde{y}_{it} = (\tilde{y}_{it}/\tilde{c}_{it})\tilde{c}_{it}$ . Taking logarithms and first differences of this identity gives:

$$\Delta \log \tilde{y}_{it} = (\Delta \log \tilde{y}_{it} - \Delta \log \tilde{c}_{it}) + \Delta \log \tilde{c}_{it}. \quad (3.5)$$

Multiplying both sides of (3.5) by  $\Delta \log \tilde{y}_{it}$ , subtracting the means from both sides and taking expectations results in

$$\begin{aligned} var(\Delta \log \tilde{y}_{it}) = cov(\Delta \log \tilde{y}_{it} - \Delta \log \tilde{c}_{it}, \Delta \log \tilde{y}_{it}) + \\ cov(\Delta \log \tilde{c}_{it}, \Delta \log \tilde{y}_{it}), \end{aligned} \quad (3.6)$$

where  $var$  and  $cov$  denote the variance and covariance in the cross section. Dividing



by  $var(\Delta \log y_{it})$  gives:

$$1 = \frac{cov(\Delta \log \tilde{y}_{it} - \Delta \log \tilde{c}_{it}, \Delta \log \tilde{y}_{it})}{var(\Delta \log \tilde{y}_{it})} + \frac{cov(\Delta \log \tilde{c}_{it}, \Delta \log \tilde{y}_{it})}{var(\Delta \log \tilde{y}_{it})}. \quad (3.7)$$

Consider the second term on the right hand side. Note that it involves the covariance between consumption growth and income growth. The case  $cov(\Delta \log \tilde{c}_{it}, \Delta \log \tilde{y}_{it}) = 0$  corresponds to perfect risk sharing since consumption growth is uncorrelated with income growth in this case. If  $cov(\Delta \log \tilde{c}_{it}, \Delta \log \tilde{y}_{it}) > 0$ , then risk sharing is limited since consumption growth comoves with income growth. Thus, the second term on the right hand side can be interpreted as a measure of the fraction of shocks that is not smoothed. Note furthermore that this measure of risk sharing is equal to the ordinary least squares estimate of  $\beta_2$  in equation (3.4) after imposing the restriction  $\beta_1 = 1$ .

A potential problem with the estimation of equation (3.4) is that idiosyncratic income growth might be correlated with the error term. This could arise for instance if unobservable preference shocks that lead to an increase in consumption also increase idiosyncratic income.<sup>5</sup> Bayoumi and MacDonald [7] point out that as long as the stochastic process for income displays some persistence, shocks to idiosyncratic income will lead to higher consumption via the expectation of higher permanent income. A solution would be to estimate the regression by instrumental variables. Bayoumi and MacDonald [7] suggest to use second lags of income and consumption growth as instruments. However, the  $R^2$  and  $F$ -test in the first stage regression indicate that the relevance of these variables as instruments is rather limited for the dataset under consideration, and therefore equation (3.4) is estimated by ordinary least squares.

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<sup>5</sup>See also the discussion in Obstfeld [59].

### 3.3 The Impact of European Integration on Risk Sharing

The purpose of this Section is to analyze whether European Integration has influenced the amount of consumption risk sharing in Europe. The results from estimating equation (3.4) with annual data that cover the period 1960 - 2002 are presented in Table 3.1.<sup>6</sup> In order to account for autocorrelation, it is assumed that the error term follows an AR(1) process for each country. All reported test statistics and significance levels are calculated from a White corrected covariance matrix.

The first line of Table 3.1 shows the estimated coefficient for the whole sample period. The table also reports the marginal significance level for the joint hypothesis that  $\beta_1 = 1$  and  $\beta_2 = 0$ . The point estimate of 0.924 for  $\beta_1$  shows that idiosyncratic consumption growth closely comoves with aggregate consumption growth as suggested by models with complete markets. However, the estimate of  $\beta_2$  is significantly greater than zero and consequently domestic consumption growth also reacts to idiosyncratic income growth, which contradicts the hypothesis of perfect risk sharing. The null hypothesis of perfect consumption risk sharing is rejected at a high level of significance.

As discussed in Section 2, the coefficient on idiosyncratic income growth can be interpreted as the fraction of shocks that is not smoothed. Thus, approximately 34 percent of idiosyncratic income shocks are smoothed in the EU. This is slightly below what Sorensen and Yosha [66] report. They find that about 40 percent of income shocks are smoothed.<sup>7</sup> Asdrubali, Sorensen and Yosha [3] find that risk sharing among US states is considerably higher. In particular, about 75 percent of idiosyncratic

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<sup>6</sup>A detailed data description can be found in the appendix.

<sup>7</sup>Their sample consists of only eight of the currently 15 EU member countries and the sample period is slightly different.

Table 3.1: Testing for Risk Sharing

	$\beta_1$	$\beta_2$	$R^2$	$Prob(H_1)$
1961 - 2003	0.924 (17.13)	0.665 (14.72)	0.60	0.0
1963 - 1972	0.822 (14.08)	0.692 (7.44)	0.54	0.0
1973 - 1982	0.932 (9.61)	0.569 (6.52)	0.48	0.0
1983 - 1992	0.845 (9.51)	0.793 (8.09)	0.63	0.0
1993 - 2002	0.745 (7.91)	0.748 (9.06)	0.68	0.0
$Prob(H_2)$				0.15

Notes to Table 3.1: F-stat for the null that  $\beta_1 = 1$  and  $\beta_2 = 0$ . t-stats in parenthesis. Test statistics are calculated with White Heteroskedasticity-Consistent Covariance Matrix. The last column reports marginal significance levels for the hypothesis  $H_1 : \beta_1 = 1, \beta_2 = 0$ .  $Prob(H_2)$  denotes the marginal significance level for the hypothesis that  $\beta_1$  and  $\beta_2$  did not change over the subsamples.

income shocks are smoothed among the states in the US.

The remaining lines of Table 3.1 report the results from estimating equation (3.4) for different subperiods. If European Integration has so far led to consumption allocations which are less exposed to idiosyncratic shocks, one would expect the parameters in equation (3.4) to change over time. In particular, one should observe that  $\beta_1$  moves closer to unity and that  $\beta_2$  moves towards zero. The overall picture that emerges suggests that the coefficients do not appear to change in a way compatible with a higher degree of risk sharing. Moreover, the hypothesis that the coefficients remained stable across the subsamples cannot be rejected at conventional levels of significance. In particular, there appears to be no tendency for the coefficient on idiosyncratic income growth to decrease over time, suggesting that the exposure to idiosyncratic shocks has

not declined as one might expect, given that various measures indicate that the European financial markets have become more integrated. Moreover, the null of perfect risk sharing is strongly rejected for each subperiod.

In addition, it is tested whether membership in the EU influences the amount of risk sharing a country achieves. Let  $E_{it}$  be a dummy variable that takes on the value one if country  $i$  is a member of the EU at time  $t$  and zero otherwise. Consider the following augmented version of the regression in (3.4):

$$\begin{aligned} \Delta \log c_{it} = & \beta_{i0} + \beta_1 \Delta \log c_t^a + \beta_{EU} E_{it} (\Delta \log y_{it} - \Delta \log y_t^a) + \\ & \beta'_{EU} (1 - E_{it}) (\Delta \log y_{it} - \Delta \log y_t^a) + e_{it}, \end{aligned} \quad (3.8)$$

If EU membership is indeed associated with easier access to the financial markets of the EU then one would expect that consumption growth covaries less with idiosyncratic income growth for countries that have joined the EU. Thus, one would expect to find that  $\beta_{EU} < \beta'_{EU}$ .

The results are shown in Table 3.2. The coefficient on idiosyncratic income growth is slightly smaller for EU countries than for non EU countries, which is consistent with the idea that countries which are EU members can more easily diversify idiosyncratic risks. However, the reported marginal significance level for the hypothesis  $\beta_{EU} = \beta'_{EU}$  shows that the difference between the two coefficients is not significant. Thus, it appears that formal membership in the EU plays only a minor role for the allocation of consumption risk.

In sum, these results show that although the exposure of consumption growth to aggregate shocks captured by aggregate consumption growth is close to what the theory suggests. However, idiosyncratic income shocks also matter. These findings

Table 3.2: The Effect of EU Membership on Risk Sharing

Variable	Coefficient	t-Stat
$\Delta \log c_t^a$	0.923	17.37
$E_{it}(\Delta \log y_{it} - \Delta \log y_t^a)$	0.659	11.63
$(1 - E_{it})(\Delta \log y_{it} - \Delta \log y_t^a)$	0.670	9.82
$R^2$	0.60	
$Prob(H)$	0.90	

Notes to Table 3.2:  $Prob(H)$  is the marginal significance level for the null  $H : \beta_{EU} = \beta'_{EU}$ . Test statistics are calculated with White Heteroskedasticity-Consistent Covariance Matrix.

are in line with the literature and provide strong evidence against complete risk sharing among EU countries. Moreover, there are no indications that the sensitivity of consumption growth to idiosyncratic income growth has decreased over time. Put differently, the extent of risk sharing appears to have been rather constant over time. In particular, the exposure of consumption growth to idiosyncratic income growth remains high and is mainly responsible for the rejection of the null of perfect risk sharing. Membership in the EU is not associated with a lower sensitivity of consumption growth to idiosyncratic income growth.

A conclusion that can be drawn from these findings is that the process of European Integration has not yet resulted in more consumption risk sharing. Thus, although the financial markets in the EU appear to have become more integrated over the last decades the allocation of consumption risk has not become more efficient.

### 3.4 Institutional Aspects as Determinants of the Amount of Risk Sharing

Having established that consumption risk sharing is far from perfect and that there do not appear to be any signs of improvements, the question remains what causes this low degree of risk sharing. In the previous Section it was shown that perfect risk sharing is rejected mainly due to the excess sensitivity of consumption growth to idiosyncratic income growth. In this Section it will be examined whether institutional aspects and in particular characteristics of a country's legal system can help to explain the rejection of risk sharing.

The empirical strategy will be to augment equation (3.4) with interaction terms that capture the influence of the variables under consideration on the exposure to idiosyncratic income growth. The following specification will be used:

$$\Delta \log c_{it} = \beta_{i0} + \beta_1 \Delta \log c_t^a + \gamma(\Delta \log y_{it} - \Delta \log y_t^a)X_{it}' + e_{it}, \quad (3.9)$$

where  $X_{it}$  is a vector that contains variables that may influence the relationship between idiosyncratic income growth and consumption.

In a series of recent papers, La Porta et al. [46] and [47] argue that financial systems are to a large degree determined by the legal framework. Since the risk-return relationship that investors base their decisions on is likely to depend on the characteristics of the financial system and consequently also on legal aspects, it seems plausible that legal systems also determine the amount of risk sharing that can be achieved. Moreover, a certain degree of sophistication of the domestic financial system might be needed to fully exploit the gains from international asset trade. To the extent that institutional aspects also determine the development and sophistication

of the financial markets this provides another channel through which international risk sharing might be influenced.

In order to internationally diversify domestic risks, foreign investors must be willing to buy domestic assets and vice versa. However, countries with poor investor protection may not be able to sell assets abroad, which will reduce the amount of risk sharing that can be achieved through international financial markets. Moreover, a low level of investor protection can lead to less international diversification of domestic portfolios since domestic investors have an incentive to become controlling investors at home in order to protect their rights.<sup>8</sup>

Although countries with good investor protection should be able to attract foreign investors who are willing to buy domestic assets, international diversification might also be difficult to achieve since domestic agents might not be willing to invest in countries where investor rights are poorly protected. Thus, whether countries with good investor protection are characterized by more or less exposure to idiosyncratic risks is ambiguous.

La Porta et al. [47] classify countries according to the origin of their legal system. They distinguish between English common law, French civil law, Scandinavian civil law and German civil law countries. They find that English common law countries give investors the best protection, whereas French law countries provide the weakest protection. Countries with legal systems originating from German and Scandinavian law lie in between the other two.

In order to test whether the origin of the legal system influences the extent of

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<sup>8</sup>Giannetti and Koskinen [37] argue that the incentive to extract the benefits of control in the case of poor investor protection leads to a home bias in equity holdings. However in their model, investors, who can not afford to become controlling investors in countries with poor investor protection have an incentive to invest in foreign countries where investor rights are better protected. Thus, the home bias ultimately depends on the wealth distribution.

risk sharing, equation (3.9) is estimated with  $X_{it} = (D_{iE}, D_{iF}, D_{iS}, D_{iG})$ , where  $D_{iE}, D_{iF}, D_{iS}$  and  $D_{iG}$  are dummy variables for English, French, Scandinavian, and German origin of the legal system. These dummies take on the value one if the origin of the legal system of country  $i$  falls into the respective category and zero otherwise. Results are reported in Table 3.3. The coefficient on idiosyncratic income growth is substantially smaller, although still significantly larger than zero, for countries where the legal system originates from English common law than for the other categories. This is consistent with the hypothesis that good investor protection helps to reduce the exposure to idiosyncratic shocks. The hypothesis that all four coefficients are equal can be rejected at a high level of significance. Thus, it appears that the origin of the legal system plays a certain role in explaining how much consumption insurance can be obtained. However, it has to be noted that the coefficient on idiosyncratic income growth for French legal system countries is smaller than for those originating from German and Scandinavian, although these countries provide better investor protection than French law countries.

Table 3.3: The Origin of the Legal System and Risk Sharing

Variable	Coefficient	t-Stat
$\Delta \log c_t^a$	0.956	17.83
$D_E(\Delta \log y_{it} - \Delta \log y_t^a)$	0.175	7.11
$D_F(\Delta \log y_{it} - \Delta \log y_t^a)$	0.518	7.62
$D_S(\Delta \log y_{it} - \Delta \log y_t^a)$	0.847	11.27
$D_G(\Delta \log y_{it} - \Delta \log y_t^a)$	0.869	8.18
$\bar{R}^2$	0.60	
$Prob(H)$	0.00	

Notes to Table 3.3: Test statistics are calculated with White Heteroskedasticity-Consistent Covariance Matrix.  $Prob(H)$  denotes the marginal significance level for the hypothesis that the coefficients on idiosyncratic income growth are equal across the four categories.



Next, the influence of shareholder and creditor rights is examined in more detail. La Porta et al. [47] construct indices that can be used as proxies for these concepts. The shareholder rights index,  $SR_i$ , takes on higher values when shareholders find it less difficult to vote out directors. That is, larger values of this index imply more rights for shareholders. Similarly, a high value of the creditor rights index,  $CR_i$ , indicates that it is rather easy for creditors to take possession of collateral in case of default. Equation (3.9) is re-estimated with  $X_{it} = (SR_i, CR_i, IN_{it}, 1 - IN_{it})$ , where  $IN_{it}$  is a dummy that takes on the value one if insider trading laws are enforced. This dummy variable is included since protection against insider trading appears to be another important aspect of investor protection.

The interaction term involving  $SR_i$  is not significant at the 5 percent level, whereas  $CR_i$  is significantly greater than zero. In addition,  $SR_i$  enters with a coefficient that is substantially smaller than the coefficient of  $CR_i$ . Thus, it appears that countries that are characterized by a high level of shareholder protection can achieve more consumption risk sharing than countries with good creditor protection. However, the enforcement of insider trading laws does not influence the exposure to idiosyncratic income growth.

La Porta et al. [47] argue that a high quality of law enforcement might act as a substitute for low investor protection. They calculate an index that can be used as a proxy for the quality of law enforcement. In order to test for the influence of the quality of enforcement this additional index, denoted by  $EF_i$ , is also included in  $X_{it}$ . Another variable that is added is a measure of the accounting standard,  $AC_i$ , since low accounting standards might impose considerable information costs.

Column 2 of Table 3.4 shows the results when  $X_{it}$  also includes  $EF_i$  and  $AC_i$ . The

Table 3.4: Institutional Variables and Risk Sharing.

Variable	1	2	3
$\Delta \log c_t^a$	0.963 (18.57)	0.949 (19.78)	0.946 (19.81)
$SR_i(\Delta \log y_{it} - \Delta \log y_t^a)$	0.082 (1.78)	0.074 (1.54)	0.064 (1.33)
$CR_i(\Delta \log y_{it} - \Delta \log y_t^a)$	0.140 (3.16)	0.087 (1.79)	0.134 (2.57)
$IN_{it}(\Delta \log y_{it} - \Delta \log y_t^a)$	0.333 (3.01)	-0.341 (-1.20)	-0.761 (-1.71)
$(1 - IN_{it})(\Delta \log y_{it} - \Delta \log y_t^a)$	0.263 (2.70)	-0.284 (-1.08)	-0.714 (-1.65)
$AC_i(\Delta \log y_{it} - \Delta \log y_t^a)$		0.001 (0.29)	0.003 (0.69)
$EF_i(\Delta \log y_{it} - \Delta \log y_t^a)$		0.072 (2.31)	0.075 (2.35)
$L_i(\Delta \log y_{it} - \Delta \log y_t^a)$			0.145 (1.23)
$R^2$	0.61	0.63	0.63

Notes to Table 3.4: t-stats in parenthesis. Test statistics are calculated with White Heteroskedasticity-Consistent Covariance Matrix. Due to limited data availability, Ireland is excluded from the estimation when the index that proxies accounting standards is added.

interaction terms involving  $AC_{it}$  and  $EF_{it}$  both enter positively.  $AC_i$  is not significantly different from zero, but  $EF_{it}$  is significantly greater than zero. Thus, better accounting standards do not appear to influence the exposure to idiosyncratic shocks, whereas countries with a high quality of enforcement are relatively more exposed to idiosyncratic shocks.

Another aspect of the legal system that might influence the amount of risk sharing that can be achieved is the regulation of labor markets. Menil [57] argues that labor market regulations can explain to some extent differences in the return on FDI as well as the amount of FDI undertaken across EU countries. An index that measures

the degree of regulation of the labor market is provided by Botero et al. [11]. This index, denoted by  $LR_{it}$ , increases with the degree of regulation of the labor market. Given that more rigid labor markets make investments unattractive from the point of view of international investors, higher values of the index should be associated with more exposure to idiosyncratic shocks. Thus, the regression in (3.9) is estimated with  $X_{it} = (SR_{it}, CR_{it}, IN_{it}, 1 - IN_{it}, AC_{it}, EF_{it}, LR_{it})$ . As can be seen from the last column of Table 3.4,  $LR_{it}$  enters with the expected sign but is not significant, indicating that highly regulated labor markets do not significantly reduce the amount of risk sharing that can be achieved.

In short, some evidence is found that legal aspects are related to the sensitivity of consumption growth to idiosyncratic income growth and therefore to the amount of risk sharing that can be achieved. Countries that provide good protection for creditors are more exposed to idiosyncratic shocks than those that provide good protection for shareholders. Countries characterized by efficient law enforcement are more exposed than those with less efficient enforcement. The enforcement of insider trading laws and accounting standards do not appear to matter in this respect.

The protection of creditor rights and the efficiency of the legal system are negatively related to the amount of risk sharing that can be achieved. As already noted, this is plausible when investors from countries with good investor protection are not willing to invest in countries that provide poorer protection. Hence, investors in countries with good investor protection hold portfolios that are biased towards domestic assets which limits the amount of insurance against country specific, idiosyncratic shocks that can be achieved.

### 3.5 Summary and Conclusion

This paper has analyzed consumption risk sharing among EU countries. First, it was found that the extent of consumption risk sharing has been surprisingly stable over time. Hence, it appears that the tighter integration of the national economies in the EU has not resulted in a more efficient allocation of consumption risk. In particular, the null of perfect risk sharing is rejected mainly because consumption growth appears to react excessively sensitive to idiosyncratic income growth.

Next, it was explored whether the excess sensitivity of consumption growth to idiosyncratic income growth and the resulting degree of consumption risk sharing is related to institutional characteristics. Some indications are found that this is indeed the case. In particular it is found that countries with a high level of creditor protection and efficient law enforcement are characterized by consumption allocations that are more exposed to idiosyncratic income shocks, whereas shareholder protection, accounting standards and labor market regulation do not appear to influence the amount of risk sharing that can be achieved.

# Appendix A

## Solving for the Equilibrium

Let  $\lambda_{1t}$ ,  $\lambda_{2t}$  and  $\lambda_{3t}$  denote multipliers on the constraints (1.4), (1.5) and (1.6). The household has to solve the dynamic programming problem:

$$\begin{aligned} V\left(\frac{M_{t-1}}{P_t}, S_{t-1}\right) = \max_{N_t} E_{t-1} \left\{ \max_{C_t, L_t, A_t, M_t, S_t} \left[ u(C_t, 1 - L_t) + \beta E_t V\left(\frac{M_t}{P_{t+1}}, S_t\right) \right] \right\} \\ + \lambda_{1t} \left( \frac{M_{t-1}}{P_t} - \frac{N_t}{P_t} + \frac{W_t}{P_t} L_t - C_t \right) + \lambda_{2t} (S_t q_t + A_t - N_t - S_{t-1} q_t) \frac{1}{P_t} \\ + \lambda_{3t} \left( \frac{W_t}{P_t} L_t + \frac{M_{t-1}}{P_t} - \frac{N_t}{P_t} - C_t + R_t \frac{(A_t + X_t)}{P_t} + \frac{q_t}{P_t} (S_{t-1} - S_t) + S_t \frac{D_t}{P_t} - \frac{M_t}{P_t} \right). \end{aligned}$$

At an interior solution, the following first-order necessary conditions with respect to  $M_t$ ,  $C_t$ ,  $L_t$ ,  $A_t$ ,  $N_t$  and  $S_t$  have to hold:

$$\beta E_t \left( \frac{\partial V_{t+1}}{\partial (M_t/P_{t+1})} \frac{1}{P_{t+1}} \right) - \lambda_{3t} \frac{1}{P_t} = 0, \quad (\text{A.1})$$

$$u_{c,t} - \lambda_{1t} - \lambda_{3t} = 0, \quad (\text{A.2})$$

$$-u_{L,t} + \lambda_{1t} \frac{w_t}{p_t} + \lambda_{3t} \frac{w_t}{p_t} = 0, \quad (\text{A.3})$$

$$\lambda_{2t} + R_t \lambda_{3t} = 0, \quad (\text{A.4})$$

$$E_{t-1} (-\lambda_{1t} - \lambda_{2t} - \lambda_{3t}) \frac{1}{p_t} = 0, \quad (\text{A.5})$$

$$\beta E_t \left( \frac{\partial V_{t+1}}{\partial S_t} \right) + \lambda_{2t} \frac{q_t}{P_t} + \lambda_{3t} \frac{D_t}{P_t} = 0. \quad (\text{A.6})$$

It follows from the envelope theorem that

$$\frac{\partial V_{t+1}}{\partial (M_t/P_{t+1})} = \lambda_{1t} + \lambda_{3t}, \quad (\text{A.7})$$

$$\frac{\partial V_{t+1}}{\partial S_t} = -\lambda_{2t} \frac{q_t}{P_t}. \quad (\text{A.8})$$

Combining equations (A.2) and (A.3) leads to equation (1.10). Combining (A.1), (A.2) and (A.7) gives

$$\beta E_t \frac{u_{c,t+1}}{P_{t+1}} = \frac{\lambda_{3t}}{P_t}. \quad (\text{A.9})$$

Equation (A.4) implies that

$$-\lambda_{2t} = R_t \lambda_{3t}. \quad (\text{A.10})$$

Using this fact together with equations (A.2) and (A.5) gives

$$E_{t-1} \left( \frac{u_{c,t}}{p_t} \right) = E_{t-1} \left( R_t \frac{\lambda_{3t}}{P_t} \right). \quad (\text{A.11})$$

Substituting (A.9) into (A.11) and using the law of iterated expectations gives equation (1.9). Using equation (A.6) together with (A.8) gives:

$$\beta E_t \left( \lambda_{2t+1} \frac{q_{t+1}}{P_{t+1}} \right) = \lambda_{2t} \frac{q_t}{P_t} + \lambda_{3t} \frac{D_t}{P_t}. \quad (\text{A.12})$$

Rearranging and using (A.10) gives

$$\beta E_t \left( R_{t+1} \lambda_{3t+1} \frac{q_{t+1}}{P_{t+1}} \right) = \frac{\lambda_{3t}}{P_t} (R_t q_t - D_t). \quad (\text{A.13})$$

Substituting (A.9) into (A.13) yields the necessary condition for stock holdings in equation (1.11).

For the specified functional forms, the necessary conditions for the households and firms become:

$$\beta E_{t-1} \left[ \frac{C_t^{-\gamma}}{P_t} - \beta R_t E_t \left( \frac{C_{t+1}^{-\gamma}}{P_{t+1}} \right) \right] = 0, \quad (\text{A.14})$$

$$\frac{W_t}{P_t} = \chi C_t^\gamma, \quad (\text{A.15})$$

$$\beta E_t \left( \frac{C_{t+2}^{-\gamma}}{P_{t+2}} q_{t+1} R_{t+1} \right) = E_t \left( \frac{C_{t+1}^{-\gamma}}{P_{t+1}} \right) (q_t R_t - D_t), \quad (\text{A.16})$$

$$\frac{R_t W_t}{P_t} = (1 - \alpha) L_t^{-\alpha}. \quad (\text{A.17})$$

Since the money supply is growing over time, nominal variables are scaled by  $M_{t-1}$  in order to induce stationarity:

$$\tilde{A}_t = \frac{A_t}{M_{t-1}}, \quad \tilde{D}_t = \frac{D_t}{M_{t-1}}, \quad \tilde{q}_t = \frac{q_t}{M_{t-1}}.$$

Deposits are chosen at the beginning of the period before the state of the world is revealed, therefore  $A_t$  will be a function of the state at time  $t - 1$ , all other variables will be functions of the states at  $t$  and  $t + 1$ . Clearing of the market for bank loans together with the binding cash-in-advance constraint implies:<sup>1</sup>

$$P_t C_t = M_{t-1} + W_t H_t - A_t = M_{t-1} + X_t = M_t. \quad (\text{A.18})$$

Furthermore, note that

$$\frac{W_t H_t}{P_t C_t} = \frac{A_t + X_t}{M_t} = \frac{M_{t-1}(x_t + \tilde{A}_t)}{M_{t-1}(1 + x_t)} = \frac{\tilde{A}_t + x_t}{1 + x_t}. \quad (\text{A.19})$$

has to hold in equilibrium. Multiplying equation (1.10) by  $H_t/C_t$  and using the production function to eliminate consumption gives:

$$\frac{W_{ij} H_{ij}}{P_{ij} C_{ij}} = \chi H_{ij}^{1+(1-\alpha)(\gamma-1)} = \frac{\tilde{A}_i + x_j}{1 + x_j} \quad (\text{A.20})$$

for  $i, j = 1, 2, 3$ . By using the production function and the fact that  $P_t C_t = M_t$ , equation (1.9) becomes

$$\beta E_i \left( R_{ij} \frac{H_{jk}^{(1-\alpha)(1-\gamma)}}{(1 + x_j)(1 + x_k)} \right) = E_i \left( \frac{H_{ij}^{(1-\alpha)(1-\gamma)}}{1 + x_j} \right) \quad (\text{A.21})$$

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<sup>1</sup>Note that since the stocks are not traded in equilibrium it follows that  $N_t = A_t$ .

for  $i = 1, 2, 3$ . Furthermore, equilibrium in the labor market implies

$$R_{ij}\chi = (1 - \alpha)H_{ij}^{-\gamma(1-\alpha)-\alpha} \quad (\text{A.22})$$

for  $i, j = 1, 2, 3$ . Solutions to the 21 equations in (A.20), (A.21) and (A.22) characterize the equilibrium values for labor, deposits and the interest rate. Having pinned down these equilibrium values, dividends can be calculated as

$$\tilde{D}_{ij} = (1 + x_j) - R_{ij}(\tilde{A}_i - x_j) \quad (\text{A.23})$$

for  $i, j = 1, 2, 3$ , and according to equation (1.11) the price of a stock in any state  $ij$  is determined by

$$\beta E_j \left( \frac{H_{kl}^{(1-\alpha)(1-\gamma)}}{(1+x_k)(1+x_l)} \tilde{q}_{jk} R_{jk} \right) = E_j \left( \frac{H_{jk}^{(1-\alpha)(1-\gamma)}}{1+x_k} \right) (\tilde{q}_{ij} R_{ij} - \tilde{D}_{ij}) \quad (\text{A.24})$$

for  $i, j = 1, 2, 3$ . Hence, equilibrium stock prices are found as the values of  $\tilde{q}_{ij}$  that solve the 9 equations in (A.24).



# Appendix B

## Data Description

All data used in chapter 3 are annual. Series on real per capita consumption and real per capita income have been taken from the database of the European Commission. The indices for shareholder protection, creditor protection, accounting standards and efficiency of the legal system have been taken from La Porta et al. [47]. The index of labor regulation is from Botero [11].

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