

Financial Frictions and Business Cycles

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To my parents

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Introduction

Exploring the potential links between the financial structure and aggregate economic behavior has long been a topic of interest in the literature.¹ This is partly due to the fact that financial markets and institutions have been considered to have significant effects on economic growth and output fluctuations.² It is also the consequence of developments in the academic work: empirically, the historical and postwar data providing support for further research in this area; theoretically, advances in the macroeconomic modelling allowing analyses of such issues. The importance of the functioning of financial markets in explaining economic phenomena has been pointed out by economists since the Great Depression, as discussed below. The behavior of the financial markets was claimed to be responsible for the extraordinary events of the time during the Great Depression. However, the Keynesian revolution interrupted the line of research in this direction, attracting attention to other issues like market imperfections and state intervention, while admitting the relevance of financial elements. The strong emphasis on money and monetary issues, following Keynes' liquidity preference theory, overshadowed the relevance of the financial markets for aggregate economic activity until the late 1970s. The methodological developments in the theory and new empirical work aroused interest again in studying the financial aspects of the business cycle through the end of 1970s. However, the real business cycle (RBC, henceforth) literature that was set off by the pioneering works by Kydland and Prescott (1982) and Prescott (1986) continued to assume perfect financial markets, ignoring the relevance of financial structure. It was not before the 1990s that models featuring both heterogeneity and frictions such as asymmetric information or costly contract enforcement (required to make financial structure relevant) were started to be developed.

The literature on the interaction between financial structure and aggregate fluctuations goes back to the time of the Great Depression. The simultaneous collapse of the financial system and the destruction of the real economic activity attracted the attention of economists. Fisher (1933) argued that the severe consequences of the economic crash were mainly due to the poorly functioning financial markets. The importance of the financial system in shaping the aggregate economic activity was not

¹For a comprehensive survey on the interaction between financial structure and aggregate economic activity, see Gertler (1988). For an analysis on the interaction between financial intermediation and aggregate fluctuations, see Cooley and Nam (1998).

²See, among others, Levine (1997).

explicitly stated in Keynes' theory of output determination. However, it constituted a part of the theory of investment behavior introduced in the General Theory. Keynesian investment theory emphasized the importance of lender-borrower confidence as a key determinant of investment. The literature following the General Theory concentrated mainly on money as the most relevant financial variable to aggregate economic behavior, ignoring the links between output behavior and the rest of the financial fundamentals. Hicks (1937) and Modigliani (1944), among others, showed the relationship between the demand for and the supply of real money balances, and the real interest rate.

Regarding the mechanism linking money to the real economy, different approaches were taken by the early Keynesians and the Monetarists. The former emphasized the role of real factors such as the multiplier/accelerator mechanism and fiscal policy, whereas the latter advocated the importance of the monetary mechanism. The famous time series study by Friedman and Schwartz (1963) provided evidence for the fact that money supply declined dramatically together with output during the Great Depression. This empirical evidence and the liquidity preference theory of Keynes created a research environment in favor of monetary issues, distracting the interest on the other aspects of the financial system.

Starting with the study by Gurley and Shaw (1955), the interaction between financial structure and real activity became an attractive research topic again. Gurley and Shaw stressed especially the significance of financial intermediation in the credit supply process as opposed to the money supply process. They argued that financial intermediaries improved the efficiency of intertemporal trade and thereby affected general economic activity. They also noted that, as financial intermediation evolved due to financial development, lending institutions with nonmonetary liabilities arose, and therefore, the importance of money diminished. Furthermore, they referred to the "overall financial capacity" of the economy as one of the most important determinants of aggregate demand and claimed that financial intermediaries were crucial for the system due to the fact that they extended borrowers' financial capacity.

The potential relevance of financial structure for real economy received a blow, however, shortly after the study of Gurley and Shaw, as Modigliani and Miller (MM, henceforth) (1958) provided a formal proposition showing that real economic decisions were independent of financial structure. Although the framework of the MM theorem, which was based on the Arrow-Debreu world, was different than that Gurley

and Shaw had in mind, the theorem was formally powerful enough to convince the researchers to abstract from the complications resulting from financial considerations. The fact that the only available and tractable model, which the stochastic competitive equilibrium growth models of the time were based on, was the Arrow-Debreu model that ignored the relevance of financial structure for aggregate economic activity, led to further disregard of financial aspects of the economy in the academic world. Another reason behind the fact that financial structure was neglected was the technical difficulty of endogenizing the financial system, i.e., the financial institutions. The theoretical techniques required for modeling were not adequately developed; therefore, heterogeneity (needed to be able to motivate trade/borrowing-lending among agents) and financial frictions could not be captured analytically. Finally, developments in the empirical literature also affected the research agenda of the economists. More specifically, the increasing use of vector autoregressions of time series to investigate links between money and output, initiated by Sims (1972), deemphasized the potential role of the rest of the financial system on real economy.

Starting from the late 1970s, new developments in both the theoretical and the empirical literature managed to attract the attention of the economists to the aspects of the financial system other than money. The new empirical literature investigating the relationship between the financial markets and the business cycle concentrated first on the interaction between financial factors, output and consumer spending. Mishkin (1978) analyzed data from the Great Depression to uncover, if there are any, the effects of financial factors on output and consumption. He found that the net financial positions of households did have a significant impact on consumer demand. Additionally, he provided evidence for a financial propagation mechanism, according to which the decline in demand was amplified by the rise in consumer real indebtedness resulting from decreasing income levels and deflation. In his famous paper, Bernanke (1983) examined the role played by financial factors during the Great Depression. He showed that financial collapse had a significant impact on the economy and that the depression could not be explained quantitatively by monetary factors only. He argued that the crash of financial intermediation had real implications for the economy since it destroyed the channels through which financial resources were transferred among the sectors of the economy. Sims (1980) provided new empirical evidence from the postwar data suggesting that money could be less important in explaining output fluctuations than has been considered to be.

Theoretical progress as a result of the developments in the economics of information

and incentives, on the other hand, made it possible to analyze informational asymmetries and financial market imperfections, which are required to justify the need for financial intermediation. The inefficiencies in trade due to informational frictions and institutional devices such as contracts, screening or monitoring needed to structure incentives in such a way that these inefficiencies are minimized, were among the research topics studied by the economics of information and incentives. As the tools and techniques necessary to analyze imperfect financial markets were developed, macroeconomists started to pay attention to that part of the financial system other than money as well.

Among the recent literature on the interaction between financial markets and aggregate economic activity, the studies by Sutherland (1996), Senay (1998), and Buch et al. (2005) are similar in spirit to the chapters of this thesis in terms of their motivation. These studies investigated the business cycle implications of financial integration in the case of certain exogenous shocks. They all modeled, in an intertemporal general equilibrium framework, the process of financial integration as the elimination of trading frictions between financial markets in different countries. The model economy employed in these studies consisted of households, firms and government. Financial integration was captured through introduction of adjustment costs that households had to face while transferring funds from domestic bond market to foreign bond market. Reduction in these costs implied increasing financial integration. Sutherland (1996) analyzed three asymmetric shocks; namely, money supply, government purchases and labor supply shocks in terms of their impact on the economy under increasing financial integration. He showed that increasing financial market integration increased the volatility of a number of variables such as nominal exchange rate and output when shocks originated from the money market, but decreased the volatility of most variables when shocks originated from real demand or supply. Senay (1998) investigated how increasing financial and goods market integration changed the effectiveness of fiscal and monetary policies. She found that increasing financial integration increased the effectiveness of monetary policy while it decreased that of fiscal policy. In addition, she showed that the effectiveness of both monetary and fiscal policies rose in response to goods market integration. She attributed that to the greater role of expenditure switching effects in the case of greater goods markets integration. Finally, Buch et al. (2005) developed a theoretical model based on that by Sutherland to derive empirically testable hypotheses on how financial market integration might influence the impact of macroeconomic shocks on business cycle volatility. They showed that the link between financial openness and business cycle volatility depended on the

nature of the underlying shock. More specifically, they found that increasing financial openness magnified output volatility in the presence of monetary, productivity and risk premium shocks. Moreover, they provided empirical evidence for the fact that the impact of interest rate volatility on output volatility was enhanced under increasing financial openness while the impact of government spending volatility was diminished. They interpreted this finding as increasing monetary policy effectiveness and decreasing fiscal policy effectiveness in the case of financially integrated markets.

This thesis concentrates on one particular aspect of the financial markets; namely, financial integration. More specifically, the business cycle implications of increasing financial integration, captured here as decreasing financial frictions, are investigated for small open economies. Aggregate fluctuations and propagation mechanisms under increasing financial integration are analyzed in the case of monetary, technology, and risk premium shocks for small open economies. Dynamic, stochastic, general equilibrium (DSGE, henceforth) frameworks with financial and informational frictions are developed and employed in order to examine how the response of a small open economy to exogenous shocks is affected by varying degrees of financial integration. In the first chapter of the thesis, a real, small open economy framework is set to explore the influence of increasing financial integration on the economy in the case of temporary technology shocks. The model economy consists of households, firms, financial intermediaries and foreign lenders. Abstraction from money both makes it possible to concentrate on the real implications of financial integration for the business cycle and makes the setup comparable to those in the standard RBC literature. The second chapter of the thesis is an extension of the first chapter in such a way that money is incorporated into the model economy. A major novelty of this chapter is that it combines two strands of literature: the cash-in-advance (CIA, henceforth) and the collateralized borrowing. Through introduction of a central bank that is responsible for the monetary injection into the economy, the framework is enriched such that money growth shocks as well as technology shocks can be analyzed under increasing financial integration. Finally, in the third chapter of the thesis, government sector is integrated into the model in order to allow for fiscal policy and risk premium analyses. To be more specific, a government subject to endogenous default risk while borrowing is introduced into the economy such that shocks to the risk premium it has to pay to the lenders in order to compensate for the risk of default can be investigated.

The term "business cycle" refers to aggregate fluctuations in economic activity or production over periods of months or years. These fluctuations occur around a long-term

growth trend and usually include shifts between periods of relatively rapid economic growth; namely, expansion, and periods of relative stagnation; namely, contraction. Fluctuations are often measured using the growth rate of real output. Historically, short-term fluctuations were attributed to external factors, such as war, rather than to business cycles by the economists, who studied mainly the long term. Starting with the Panic of 1825, which was the first notable internal economic crisis occurring in peacetime, attention was devoted to analyses of economic cycles. In 1860, French economist Clement Juglar identified the average duration of business cycles as 8 to 11 years. Later in the mid-20th century, Austrian economist Joseph Schumpeter specified the four stages of Juglar cycles: expansion, crisis, recession and recovery. Schumpeter associated recovery and expansion with aggregate demand, consumer confidence and productivity. In 1946, Burns and Mitchell made a now standard definition of business cycles as "a type of fluctuation in the aggregate economic activity of nations that organize their work mainly in business enterprises". They claimed that cycles consist of expansions occurring simultaneously in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle.

The RBC theory, initiated mainly by the pioneering study by Kydland and Prescott (1982), is the school of thought in the business cycle literature that suggests random fluctuations in productivity to be the basic determinant of business cycles. The random fluctuations in the productivity level, i.e., technology shocks, are asserted to shift the constant growth trend of an economy up or down through directly changing the effectiveness of capital and/or labor. The change in the productivity of factors of production affects the behavior of the agents in the economy, leading to changes in the levels of consumption and production, and eventually output. In contrast to the other theories of the business cycle, RBC theory sees recessions and expansions as the efficient response of the economy to exogenous shocks. Therefore, the need for government intervention is rejected by RBC theorists, who do not regard business cycles as the failure of markets to clear, as the Keynesians or the Monetarists do. According to the RBC theory, the issue is one of efficient fluctuation, not of elimination of business cycles through economic policy.

There are also economists, who take a stand between the RBC theorists and the government interventionists in that they advocate both the necessity of government policies and the importance of uncovering the relative contribution of different sources of economic fluctuations. Aiyagari (1994) discusses that the choice of a policy instru-

ment can depend on the relative impact of different shocks on fluctuations. He argues that, sometimes, the exact nature of a desirable policy rule can be dependent on the nature of the shock.³ More specifically, the way government policy variables should respond to observable variables such as output, consumption, investment etc. might depend on the exact source of the fluctuations. In the case of uncertainty regarding the sources of the fluctuations, governments might have to develop signal extraction mechanisms in order to be able to design optimal policies. Such mechanisms would in turn depend on the relative contribution of possible sources of fluctuations to the observables.

The business cycle statistics for the U.S. economy that are attempted to be predicted correctly by the RBC models involve volatility, persistence, and cyclicalities of the basic macroeconomic variables. As far as volatility is concerned, the empirical evidence suggests that consumption, wages, labor productivity, capital stock, total factor productivity (TFP, henceforth) and government expenditures are less volatile than output; whereas investment and capital utilization are more volatile than output. According to the data regarding employment, total hours worked and employment are almost as volatile as output, while hours per worker is much less volatile than output. The U.S. data exhibits strong procyclicality of consumption, investment, total hours worked, labor productivity and TFP. Wages, capital stock and government expenditures turn out to be acyclical; whereas real interest rate data shows countercyclicality. Regarding persistence, first-order autocorrelations are high and positive for all macroeconomic aggregates. The high serial correlation is the reason why there is some predictability to the business cycle.⁴

As both the theoretical and the empirical literature using the RBC approach grew, the methods of the RBC research program were started to be applied in international economics, monetary economics, public finance, labor economics, asset pricing and so on. In contrast to previous studies, many of these new model economies included market imperfections, making government intervention not only desirable, but also

³For an analysis on macroeconomic policies and business cycles in emerging economies, see Lane (2003).

⁴Backus et al. (1992) provide an extension of the RBC theory to open economies through analyzing whether a two-country RBC model can account simultaneously for domestic and international aspects of business cycles. More specifically, they question whether the RBC theory can account for both the comovements studied in closed-economy macroeconomics and international comovements such as correlations across countries of fluctuations in macroeconomic aggregates and movements in the balance of trade.

necessary. In others, business cycles were driven by the shocks to the monetary sector. DSGE models were established as the frameworks to conduct macroeconomic analyses. The DSGE methodology and literature are discussed in detail below.

The RBC theory has been criticized on several different grounds. One major criticism, namely, that it neglects the impact of monetary policy on business cycles, is due to the fact that economic fluctuations are modeled in a nonmonetary framework. Moreover, many researchers argue that it downplays the role of market inefficiencies and minimizes the importance of unemployment. Furthermore, statistics such as the correlation between wage rate and output, the correlation between wage rate and labor supply, and the labor supply elasticity turn out to be much higher in the standard RBC model than in the data. Last but not least, it has been claimed that the RBC models require shocks of unrealistic magnitudes and volatility to be able to match the empirical evidence. More specifically, the standard RBC model assumes large and volatile productivity shocks, i.e., considerable variability in productivity, to be able to explain the fluctuations seen in the data.

The last criticism mentioned above, that RBC models require large and persistent productivity shocks to be able to explain business cycle fluctuations, led to the birth of a new research area within the RBC theory: the amplification/propagation mechanisms in the RBC framework. In order for simulated time paths of output, consumption, investment and labor input to be consistent with actual U.S. business cycles, mechanisms through which small productivity shocks can be amplified were searched by researchers. In other words, the idea was to find processes that generate empirically reasonable business cycles out of reasonably small productivity shocks. In order to do that, several different modifications of the standard RBC model were undertaken, including unobserved factor variation and capacity utilization. The modified RBC model with the assumptions of indivisible labor and costly variation in capital utilization turned out to better mimic actual U.S. business cycles than the standard RBC model. Through amplification mechanisms, variable capital utilization and a highly elastic labor supply caused small changes in productivity to have substantial effects on macroeconomic activity. The basic neoclassical growth model, however, does not produce substantial internal propagation of temporary productivity shocks in the sense that there is no tendency for the economy to exhibit a period of high output and work effort followed by another period with similarly high output in response to a one-time, positive productivity shock. The effects of the one-time shock in period 1 are propagated over time; the large investment in period 1 leads to high values of the

capital stock that keep output above its steady-state level in the following periods. However, this propagation mechanism is rather weak.

Kydland and Prescott also developed "quantitative theory" as an alternative to traditional methods of analyzing data in economics. The idea was that any good model should also generate business cycles that quantitatively match the stylized facts in the data, in addition to qualitatively explaining key business cycle regularities. This approach, also known as "calibration", aims to formulate theoretical models in terms of parameters that can be measured relatively easily. It is based on the idea of estimating parameters from data different than the data to be explained. In practice, one of the major focuses is to reconcile long-run time series behavior (growth) with short-run behavior (business cycles). As the seminal 1982 paper was written by Kydland and Prescott, the foundation of dynamic macroeconomics had already been laid, and the next goal was to understand how to use the theory to study quantitative fluctuations. Kydland and Prescott developed practical methods in order to be able to draw inferences about the implications of the growth theory for quantitative fluctuations. The insistence on explaining quantitative features of the data as well as the qualitative ones has changed the focus of the macroeconomic research from qualitative to quantitative analysis.

As stated above, the models developed and analyzed in the chapters of this thesis are DSGE models. DSGE models constitute a branch of general equilibrium theory that attempts to explain aggregate economic phenomena such as economic growth, business cycles, effects of monetary and fiscal policies, on the basis of macroeconomic models derived from microeconomic principles. As the name, DSGE, suggests, macroeconomic behavior is derived in these models from the interaction of the decisions of all the agents in the economy, acting over time, in the face of uncertainty about future conditions. More specifically, DSGE models are dynamic; studying how the economy evolves over time, stochastic; taking into account the fact that the economy is affected by random shocks such as technological change, general equilibrium models; seeking to explain the behavior of supply, demand and prices through considering all markets in an economy simultaneously.⁵

DSGE models have been employed extensively in the literature, especially over the last decade, in order to analyze business cycles, aggregate fluctuations and propa-

⁵Woodford (2003) provides an elaborate survey of the DSGE modeling.

gation mechanisms. Smets and Wouters (2007) estimated a DSGE model for the US economy using seven macroeconomic time series. They employed a model that incorporates many types of real and nominal frictions and seven types of structural shocks. They investigated empirically the relative importance of the various frictions using a Bayesian likelihood approach. The authors showed that their model was able to compete with Bayesian Vector Autoregression models in out-of-sample prediction. They also addressed, using the estimated model, some of the key issues in the business cycle analysis such as the sources of business cycle fluctuations, the cross correlation between output and inflation, and the effects of productivity on hours worked. Kim (2003) examined the basic features of business cycles under exogenous and endogenous monetary policy rules in DSGE models with nominal rigidities. The calibration experiments showed that business cycles featured differences depending on whether the monetary policy rules were exogenous or endogenous, and that these differences were as large as those generated by nominal rigidities and monetary disturbances. Kim argued, therefore, that developing a proper way to incorporate endogenous monetary policy rules might be as important as developing new transmission mechanisms of monetary policy disturbances.

In an earlier paper, Smets and Wouters (2003) developed and estimated a DSGE model with sticky prices and wages for the euro area. Using a model incorporating habit formation, costs of adjustment in capital accumulation and variable capacity utilization, they analyzed the effects of ten orthogonal structural shocks including productivity, labor supply, investment and monetary policy shocks on the business cycle fluctuations in the euro area. In a followup study, Smets and Wouters (2005) estimated a DSGE model with many types of shocks and frictions for both the US and the euro area economy in order to compare the business cycle characteristics of the two economies. The structural Bayesian estimation procedure they employed allowed them to investigate whether the differences in business cycle behavior were due to the differences in the types of shocks that hit those economies, the differences in the propagation mechanisms of those shocks or the differences in the ways the central banks responded to those shocks. They concluded that each of these characteristics was similar across the two currency areas.

As mentioned earlier, the models developed and analyzed in the second and in the third chapters of this thesis involve money, where money is introduced into the economy through CIA constraints. CIA modelling is not the only way to incorporate money into real frameworks, yet it has several advantages that are worth mentioning.

The neoclassical growth model, pioneered by Ramsey (1928) and Solow (1956), constitutes the basic framework for much of modern macroeconomics. Solow's growth model shows that, under certain assumptions, an economy converges to a steady-state growth path along which output, capital stock and effective labor supply all grow at the same rate. One of these key assumptions is that the capital accumulation process is defined in such a way that a fixed fraction of output is devoted to investment each period. When this assumption of a fixed savings rate is relaxed and the economy consists of forward-looking households choosing the amount of savings and labor supply to maximize lifetime utility, the Solow model lays out the basic framework for analyzing business cycles with the use of dynamic stochastic models. Real disturbances such as productivity shocks affect output and savings, with the resulting capital accumulation propagating the impact of the initial shock on the economy in ways that are similar to some empirical features of the business cycles.

The neoclassical growth model is a real economy model without any sort of medium of exchange, i.e., money, to be used for the transactions taking place in the economy. In this nonmonetary economy, goods are exchanged with each other. In order to be able to examine monetary issues within the framework of the neoclassical growth model, money has to be attributed a role in the economy so that agents would like to hold positive quantities of money. In other words, there should be some mechanism that creates positive demand for money in the economy. There have been three approaches in the literature to incorporate money into general equilibrium models: 1. assuming that money yields direct utility to the agents in the model through having money embodied in the utility functions of the agents (Sidrauski (1967)); 2. imposing some forms of transaction costs that create demand for money; 3. treating money like any other asset that is used to transfer resources intertemporally (Samuelson (1958)). The first approach refers to the so-called "money-in-the-utility function" methodology, in which agents' utilities depend directly on their consumption of goods and their holdings of money. Regarding the second approach, there are several possibilities such as making asset exchanges costly (Baumol (1952), Tobin (1956)), requiring that money is used for certain types of transactions (Clower (1967)), assuming that time and money can be combined to create transaction services that are necessary for obtaining consumption goods, or assuming that direct exchange of commodities is costly (Kiyotaki and Wright (1989)). The cash-in-advance (CIA, henceforth) modeling employs this second approach, requiring that money balances are held to finance certain types of

purchases.⁶

The money-in-the-utility (MIU) approach has been criticized for solving the problem of creating positive value for money by simply assuming the problem away; that is, assuming that money yields direct utility and thereby guaranteeing that money will be valued. In other words, there is a clearly defined reason for individuals to hold money in the MIU model; namely, the direct utility it yields. However, this essentially solves the problem of generating a positive demand for money by assumption; it does not address the reason why money might yield utility. Yet money is usually thought of as yielding utility through use; i.e., money facilitates transactions. Money serves as a medium of exchange that yields indirect utility through reducing costs of transactions or allowing certain purchases to be made. The demand for money is then determined by the nature of the transactions technology in the economy.

The CIA approach requires that money balances be held to finance certain types of purchases. CIA models assume that money has unique properties, unlike other financial assets, that allow it to be used to facilitate transactions. The CIA approach, proposed by Clower (1967) and developed by Lucas (1980a) and Grandmont and Younes (1972), captures the role of money as a medium of exchange by requiring explicitly that money be used to purchase consumption goods. According to the specification of the CIA models, individuals are assumed to face, in addition to a standard budget constraint, a CIA constraint, the exact form of which depends on the transactions or purchases that are subject to the CIA requirements. The timing assumptions regarding the order in which the markets in the model economy open are also important in CIA models. Agents determine their cash balances and relative asset holdings depending on when the asset and the goods markets open. The DSGE models developed and analyzed in the second and in the third chapters of this thesis employ CIA constraints, through which money is incorporated into the real framework of the first chapter.

In the first chapter of this thesis, aggregate fluctuations and propagation mechanisms under varying degrees of financial openness are analyzed for a real, small open economy. Using a dynamic, stochastic, general equilibrium framework with financial intermediation and foreign borrowing, the implications of increasing financial openness for the impact of temporary technology shocks on the economy are investigated.

⁶Walsh (2003) provides exhaustive information about CIA modeling.

Informational asymmetries among the agents in the economy and Holmstrom-Tirole type of uncertainty in the production process necessitate financial intermediation and collateralized borrowing in the economy. The simulation experiments with different levels of financial openness reveal that increasing financial openness amplifies the impact of positive, temporary technology shocks on output, investment, consumption, labor supply and net exports. This is mainly due to the fact that the promoting effect of a positive technology shock on the economy is coupled with the improving impact of increasing financial openness on output led by increasing access to cheaper foreign funds. The model confirms the findings of the real business cycle literature on small open economies and the empirical regularities typical of open economies in terms of the procyclicality of investment and labor supply and the countercyclicality of external trade. In addition, there is a positive correlation between savings and investment, which is in line with the empirical evidence pointed out in the business cycle literature for small open economies under imperfect capital mobility.

The second chapter of this thesis examines the business cycle implications of increasing financial integration for a small open economy. Extending the dynamic, stochastic, general equilibrium framework with financial and informational frictions in Chapter 1 in such a way as to incorporate money into the economy, the impact of money growth and technology shocks on the aggregate economic activity is investigated under varying degrees of financial integration. Financial frictions in the model are in the form of restrictions on the composition of deposits held by the financial intermediaries in the economy. More specifically, financial intermediaries are assumed to be able to hold no more than a certain fraction of their total deposits as foreign deposits. An increase in this fraction implies decreasing financial frictions that is interpreted as increasing financial integration here. A major novelty of this chapter is that it combines two strands of literature: the CIA and the collateralized borrowing. The small open economy DSGE model developed in the second chapter of this thesis predicts an expansion in output, consumption, investment, labor demand and loans in response to a positive, temporary monetary shock; whereas a positive, temporary technology shock leads to an increase in output, investment, domestic deposits, loans, labor demand and net exports, and a decrease in consumption. The simulation experiments with different levels of financial integration reveal that increasing financial integration amplifies the impact of temporary monetary shocks on output, consumption, investment, labor demand and loans. The amplification effect of increasing financial integration is due to the mechanism in which the output-promoting impact of positive monetary injection is coupled with increasing access to cheaper foreign funds that enhance production

through leading to a rise in the loanable funds available for firms. The increase in the amount of funds available for firms due to a positive monetary injection leads to a rise in the amount of loans actually given to the firms through a fall in the loan rate, which is stimulated further by increasing financial integration that raises the volume of cheaper foreign funds held by financial intermediaries. The effect of increasing financial integration in the case of temporary technology shocks is found to be rather negligible. The sensitivity analyses undertaken reveal that our results regarding the impact of temporary monetary and technology shocks on a small open economy are robust.

Finally, in the third chapter of this thesis, risk premium shocks are investigated in terms of their implications for aggregate fluctuations in a small open economy. A government sector that borrows domestically with an endogenous partial default risk is incorporated into the dynamic, stochastic, general equilibrium framework in Chapter 2. The risk premium arises in the model due to the default risk, for which the domestic lenders, that also have the option of holding foreign securities, must be compensated by the government. A risk premium shock, therefore, affects the investment decisions of households in terms of relative asset holdings. It also has implications for government spending, which is supposed to be financed through domestic borrowing and taxation. In response to a positive, temporary risk premium shock, the model developed in Chapter 3 predicts an increase in the interest rate on government bonds and in the nominal exchange rate. The depreciation in the exchange rate increases the value of the government bonds in terms of the domestic currency, which leads to a rise in the tax rate due to the simple tax rule followed by the government. Determined partly by the size of the exchange rate depreciation and partly by the tax adjustment parameter, the increase in the amount of the tax revenue of the government, accompanied by a decrease in the government borrowing due to higher costs of repayment for the government, leads to an increase in the government spending. In response to the rise in the price level, households reduce their consumption. Domestic deposit holdings by households, on the other hand, increase since the supply of government bonds is lower. As deposits rise, so do total loans available for firms. However, the increase in the amount of loans does not consequently lead to an increase in employment, and subsequently in production, due to the rise in the distorting tax rate creating disincentives to work and thereby causing a fall in the labor supply. Therefore, output also falls in response to the positive risk premium shock.

Chapter 1

Technology Shocks Under Varying Degrees of Financial Openness

1.1 Introduction

The influences of international trade, both in goods and capital, and technology improvements on the business cycles of countries have long been issues of debate and increasingly attractive areas of research in the literature. Analyzing the impact of technological progress on an economy under varying degrees of openness might allow one to draw insights into policy and business cycle implications of varying levels of integration with the rest of the world, which could be crucial especially for emerging economies that are still in the process of liberalizing their capital and current accounts. With this motivation, financial openness is being focused in this chapter of the thesis in terms of its implications for the effect of temporary technology shocks on a small open economy.

In this chapter, aggregate fluctuations and propagation mechanisms under increasing financial openness are investigated in the case of technology shocks for a real, small open economy.¹ A dynamic, stochastic, general equilibrium framework with households, firms, financial intermediaries, foreign lenders and a financial regulator is developed. The existence of financial and informational frictions and uncertainty in the model necessitate financial intermediation in the economy. The uncertainty in the

¹For more details on output dynamics and propagation mechanisms in real business cycle models, see Nason and Cogley (1995). A comprehensive analysis of aggregate fluctuations in the case of financial frictions is provided by von Hagen and Zhang (2008b).

production process also leads to collateralized borrowing by the firms, with physical capital stock used as collateral. There is abstraction from money in the setup of the framework in order to be able to concentrate on the real implications of increasing financial openness for the economy in the case of technology shocks. It is shown that increasing financial openness amplifies the impact of a temporary, positive technology shock on output, investment, consumption, labor supply and net exports; whereas it diminishes that on domestic savings.

Discussions regarding the contribution of technology shocks to business cycles have been controversial since the pioneering work by Kydland and Prescott (1982).² Using a modified equilibrium growth model with non-time-separable utility function and the assumption that more than one time period is required for the construction of new productive capital, Kydland and Prescott explained the cyclical variances of a set of economic time series, the covariances between real output and the other series, and the autocovariance of output. In the much-cited paper leading this line of research, Prescott (1986) argued that technology shocks account for more than half of the fluctuations in real output in the post-war period. Since then, many economists have attempted to refine the estimate of Prescott as well as to uncover the impact of technology shocks on aggregate fluctuations by looking at more elaborate dynamic general equilibrium models.³ It has also been argued that the contribution of technology shocks to aggregate fluctuations depends on several factors including the extent of imperfect competition, external economies of scale, overtime wage premiums and measurement errors in labor input and output, as also pointed out by Aiyagari (1994). Consequently, in order to be able to determine the exact contribution of technology shocks to business cycles, precise quantitative measures of these factors would be required.⁴ In this chapter, the main objective is to analyze the implications of technology shocks for business cycle fluctuations taking into account the potential impact of degree of financial openness.

There are imperfections in the economy examined in this chapter in the form of

²For a comprehensive analysis of real business cycles in general, see King and Rebelo (1999) and McCandless (2008).

³See, among others, Gali (1999), Gali (2004) and Baxter (1995).

⁴The dynamic effects of technology shocks have also been investigated through taking into account the distinction between neutral and investment-specific technology shocks. Neutral technology shocks affect the production of all goods homogeneously, whereas investment-specific shocks affect only investment goods. Among others, see Fisher (2006) and Basu et al. (2006). For an in-depth analysis of the long-run implications of investment-specific technological change, see Greenwood et al. (1997).

Holmstrom-Tirole (1997) type of uncertainty in the production process, financial frictions restricting the amount of foreign borrowing, and informational asymmetries among the agents in the economy. Entrepreneurs that run the firms can choose between two different projects for production, both of which are subject to idiosyncratic risk. The projects yield positive output in the case of success and no output in the case of failure. The projects differ according to their probabilities of success and the private benefits they provide to the entrepreneurs. It is those private benefits that create incentives for the managers of the firms, inducing them to act against the interest of their creditors. The project choices of the entrepreneurs are private information, whereas the project outcomes are verifiable by the financial intermediaries. Households and foreign investors are assumed to lack the ability to verify the project outcomes. Therefore, domestic and foreign investors prefer lending to firms indirectly, through financial intermediaries, rather than directly.

Financial openness has become an increasingly attractive topic in both theoretical and empirical literature over the last couple of decades. This is partly because of its interaction with macroeconomic fundamentals, and partly due to its contradictory consequences, especially for emerging economies. On the one hand, it provides emerging economies with the funds that might be used to realize investment opportunities. On the other hand, it exposes them to increasing financial vulnerability against external shocks since the financial infrastructure in such economies is not adequately developed. Financial openness can be interpreted as the status of the financial markets determining the degree of financial integration with the rest of the world, which might in turn depend on the financial frictions that prevent capital from freely flowing across international borders.⁵ The impact of financial openness on economic growth, macroeconomic volatility, the effectiveness of government policy rules depends on many factors including the structure of the financial system, the quality of financial supervision and regulation, the soundness of financial institutions, and the rapidity of the integration process.⁶

Financial openness is incorporated into the model through the introduction of a reg-

⁵”Financial openness” and ”financial integration” are used interchangeably throughout this thesis, having mentioned the relationship between the two.

⁶See, among others, Arteta et al. (2003), Kaminsky and Schmukler (2003), Chinn and Ito (2006), and Alper and Cakici (2009). Lane and Milesi-Ferretti (2008) argue that also the degree of financial integration depends on factors such as financial infrastructure, financial innovation, sectoral trends like securitization that exhibit differences across advanced economies and emerging markets.

ulation in the economy that the financial intermediaries can hold no more than a certain fraction of their total deposits as foreign deposits. This fraction, higher levels of which imply higher degrees of financial openness, is assumed to be controlled by the financial regulator in the economy.

Analyzing technology shocks under varying degrees of financial openness for a small open economy might allow one to draw insights into the implications of increasing financial openness for the business cycles in emerging economies, which are still in the process of liberalizing their financial as well as current accounts. The rest of the chapter is structured as follows: Section 1.2 presents the model and the system of equations obtained as the solution of the model. The results regarding the simulation of the model, the impulse response functions and the sensitivity analyses are given in section 1.3. Finally, section 1.4 presents the concluding remarks.

1.2 The Model

The model developed here is a real, small open economy model incorporating financial and informational frictions as well as uncertainty in the production process. The economy consists of households, firms, financial intermediaries, foreign lenders and a financial regulator. Abstracting from money in the framework helps to concentrate on the real implications of varying degrees of financial openness for the impact of technology shocks on the economy. All decisions are made after, and therefore completely reflect, the current period surprise change in technology. For the timing of the stock variables, like the capital stock, "stock as of the end of the period" convention is used. For instance, K_t denotes the capital stock at the end of period t .

Infinitely lived households, that are assumed to be the owners of the financial intermediaries, maximize their utility functions that depend on consumption, C_t , and hours worked, H_t . They decide how much to deposit at the financial intermediaries, DD_t , how much to consume, and how much labor to supply to the firms. At the beginning of each period, households receive their previous period deposits plus the interest payment and make current period deposits at the financial intermediaries. They also supply labor, earn wage income and decide how much consumption to make. There is no bond market in the economy, therefore there are no bond holdings of households.

Firms are owned by entrepreneurs, who have a finite but stochastic lifetime. Every period, a certain mass of entrepreneurs receives a signal of death and leaves the economy, whereas new entrepreneurs of equal mass enter the economy next period. In the aggregate, the share of entrepreneurs in the society is constant. Entrepreneurs maximize profits, F_t , by choosing next period's capital stock, K_t , labor demand, N_t , and loans, L_t , they borrow from financial intermediaries. At the beginning of every period, the existing entrepreneurs in the economy pay back the loans they borrowed in the previous period from the financial intermediaries including the interest and borrow new loans for the current period. Entrepreneurs then use these loans to hire labor for production. The new entrants, on the other hand, are assumed to bring along some initial wealth with which they can buy the capital stock they need for production from the financial intermediaries. There is Holmstrom-Tirole (1997) type of uncertainty in the production process. Entrepreneurs have two available project choices to produce the single consumption good⁷, both of which are subject to idiosyn-

⁷The consumption good and the capital good are assumed to be identical for analytical purposes.

cratic risk; namely, they yield positive return in the case of success and zero return in the case of failure. The projects differ according to their probabilities of success, with p^H in the case of project "good" and p^L in the case of project "bad". It is the private benefits, PB , that project "bad" yields that create incentives for firm managers to act against the interest of their creditors. Project "good" yields no private benefits. It is assumed that the project outcomes can be perfectly verified by the financial intermediaries while the project choices of the entrepreneurs are unobservable.

Foreign lenders are assumed to supply funds, FD_t , infinitely elastically at a constant interest rate, R^* , that is lower than the domestic loan rate.

Finally, financial intermediaries (FI henceforth) maximize the expected infinite horizon discounted stream of dividends, B_t , they pay to households. They receive deposits from households, DD_t , and deposits from foreign investors, FD_t . The FI then use these funds to give loans to firms. According to the loan contract between the FI and the firms, the FI gain a net return of $R_{Ft} - 1$ in the case of success of the firms' projects and a certain fraction, μ , of the capital stock of the firms in the case of failure. The FI are allowed to hold no more than a certain fraction of their total deposits as foreign deposits. In other words, there is an upper limit on the fraction of total deposits to be held as foreign deposits by the FI. At the beginning of each period, financial intermediaries receive the loans they lent to firms in the previous period inclusive of the interest payments, sell the capital stock they have acquired from firms whose projects failed, and pay back the domestic and foreign deposits they collected in the previous period together with the interest. Additionally, they accept current period deposits from households and foreign lenders and give current period loans to firms.

Financial openness is captured in this model by the parameter ψ that represents the fraction of foreign deposits over total deposits the FI collect. The parameter, higher levels of which imply higher degrees of financial openness, is assumed to be controlled by the financial regulator in the economy.

1.2.1 Households

A typical infinitely lived household maximizes an expected utility function of the form

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t [(1 - \phi) \ln C_t + \phi \ln(1 - H_t)] \right\}, 0 < \beta, \phi < 1 \quad (1.1)$$

where β is the time discount factor, subject to the budget constraint

$$C_t = W_t H_t + DD_{t-1} R_{H,t-1} - DD_t + B_t \quad (1.2)$$

where W_t represents the real wage rate and C_t denotes the purchase of the single consumption good that serves as the numeraire. DD_t and B_t denote domestic deposits and dividends from financial intermediaries, respectively. The households' problem is also subject to the following nonnegativity constraint

$$0 \leq DD_t \quad (1.3)$$

1.2.2 Firms

There is a certain mass of entrepreneurs in the population that runs the firms in the economy. Each period, π percent of them dies and an equal mass of new entrants are added to the population such that the size of the population remains the same.⁸ At the micro level, this means that, with probability π , each entrepreneur receives a signal every period that he will die at the end of the period. Entrepreneurs receiving this signal consume everything that is left of their wealth at the end of the period

⁸This assumption is needed in order to be able to prevent the entrepreneurs from accumulating too much profits that would invalidate the borrowing constraint of the firms. In the literature, part of profits accumulated by the firms is, alternatively, distributed to the households, that are assumed to own the firms, as dividends (see, among others, Feldstein and Green (1983)). However, in the current context, there are informational asymmetries in the sense that households are not able to observe firms' profits. Therefore, the assumption that firms are owned by households and that they distribute part of their profits to households as dividends is not reasonable here.

after paying back their debts. The new entrants bring along some initial wealth with which they can obtain the capital stock they need to start production. They buy this capital stock from the financial intermediaries, which receive capital stock as repayment of loans in the case of failure of the firms' projects. Entrepreneurs, therefore, maximize profits taking into account this probability of death. There is uncertainty involved in the production process of the firm, resulting from the fact that the entrepreneur has two available projects to produce goods, both of which are subject to idiosyncratic risk. More specifically, the entrepreneur has two project choices that differ according to their probabilities of success and the private benefits they provide to the entrepreneur, and there is positive output in the case of success of the projects while there is no output in the case of failure. p^H and p^L denote the probabilities of success of the "good" and the "bad" project, respectively, where $0 < p^L < p^H < 1$. The entrepreneur gets PB amount of private benefits per capital stock if he chooses the project "bad" whereas there is no private benefit obtained from the project "good". The entrepreneur's payoffs from the projects can be summarized as follows:

In the case of "good project":

$$p^H[Y_t - R_{Ft}L_t] + (1 - p^H)[0 - \mu(1 - \delta)K_{t-1}]$$

In the case of "bad project":

$$p^L[Y_t - R_{Ft}L_t] + (1 - p^L)[0 - \mu(1 - \delta)K_{t-1}] + PBK_t$$

where L_t represents loans that firms borrow from financial intermediaries at a gross interest rate of R_{Ft} . μ is the parameter measuring the fraction of the capital stock of firms to be handed over to financial intermediaries in the case of failure of the projects. This is going to be mentioned in more detail below. The entrepreneurs maximize, every period, the profits, F_t , given as

$$F_t \leq p^H Y_t - p^H \pi R_{Ft} L_t - p^H (1 - \pi) R_{F,t-1} L_{t-1} - (1 - p^H) \mu (1 - \delta) K_{t-1} \quad (1.4)$$

where δ is the constant physical depreciation rate of capital. Given that the firm chooses the project "good" (which will be the case as long as the incentive constraint stated below holds), with probability p^H the firm is able to make use of the loans it borrows from the FI to hire N_t amount of labor, which it can employ together with the capital stock it has, K_{t-1} , to produce Y_t amount of output. The entrepreneur makes

in this case an interest payment to the FI for the loans at the rate specified in the loan contract, R_{Ft} . In the case of failure, there is no output produced and the entrepreneur has to transfer a certain amount of its capital stock, which it used as collateral in order to be able to borrow from the FI, to the FI. Due to the fact that capital stock is employed in the production process and therefore subject to depreciation independent of the project outcome of the firm, it is the net-of-depreciation amount of capital stock, the fraction of which is to be handed over to the FI in the case of failure. The period t loans of the firm, L_t , and the period t wage payments, $W_t N_t$, cancel out above.

The production function of the firm is given by

$$Y_t = K_{t-1}^\alpha (A_t N_t)^{1-\alpha} \quad (1.5)$$

with A_t denoting technology, the shock process of which is a unit root with drift in the log of technology, given as

$$\ln A_t = \gamma + \ln A_{t-1} + \epsilon_{A,t}, \quad \epsilon_{A,t} \sim N(0, \sigma_A^2) \quad (1.6)$$

The capital accumulation equation is given as

$$K_t = p^H [\pi \mu (1-\delta) K_{t-1} + (1-\pi)(I_t + (1-\delta)K_{t-1})] + (1-p^H)(1-\mu)(1-\delta)K_{t-1}, \quad 0 < \delta < 1 \quad (1.7)$$

K_t represents the level of physical capital to be employed in the production process at time $t+1$, determined by the firm at time t . Equation (1.7) is the capital accumulation equation at the macro level in the sense that π represents here the mass, out of a group of entrepreneurs, that dies each period, rather than the probability of death of a single entrepreneur, as in the micro sense. Therefore, the first term in the paranthesis on the right-hand side of the equation, $\pi \mu (1-\delta) K_{t-1}$, stands for the capital stock held by the new entrants at the beginning of every period (recall the assumption that an equal mass, π , of new entrepreneurs enter the economy each period so that the total size of the population remains unchanged). The second term represents the amount of capital stock accumulated by the successful entrepreneurs continuing to live and produce; the net-of-depreciation amount of capital stock of the current period, $(1-\delta)K_{t-1}$, plus the amount of investment, I_t . Investment is equal to the real profits made by the successful entrepreneurs in the economy. The last term on the right-hand side of the equation gives the amount of the capital stock of the

unsuccessful entrepreneurs that cannot make positive real profits due to the fact that there is no output in the case of failure of the firms' projects.

For the capital accumulation process to become more clear, the profit and the capital accumulation functions can be rewritten from a micro perspective such that the profit made and the capital stock accumulated are captured separately for the cases of success and failure of the projects. Let F_t^s and K_t^s (F_t^f and K_t^f) denote the profit and the capital stock, respectively, accumulated by a single entrepreneur in the case of success (failure) of the projects. Then, the profit and the capital stock are given as

$$F_t = F_t^s p^H + F_t^f (1 - p^H) \quad (1.8)$$

and

$$K_t = K_t^s p^H (1 - \pi) + K_t^f (1 - p^H) \quad (1.9)$$

The profits made in the case of success of the projects, which are invested, and therefore transferred to the next period, by the entrepreneurs, are given by the following equation:

$$F_t^s = Y_t - \pi R_{F,t} L_t - (1 - \pi) R_{F,t-1} L_{t-1} \quad (1.10)$$

The corresponding capital stock in the case of success of the projects is, therefore, given as

$$K_t^s = F_t^s + (1 - \delta) K_{t-1} \quad (1.11)$$

In the case of failure of the firms' projects, there is no output produced; therefore, profits are

$$F_t^f = -\mu(1 - \delta) K_{t-1} \quad (1.12)$$

whereas the capital stock is given as

$$K_t^f = F_t^f + (1 - \delta) K_{t-1} = (1 - \mu)(1 - \delta) K_{t-1} \quad (1.13)$$

Plugging equations (1.11) and (1.13) into equation (1.9), the capital accumulation equation given in equation (1.7) is obtained at the micro level.

Entrepreneurs' maximization problem is subject to the constraint reflecting the fact that the firm finances its wage payments with the loans it borrows from the FI. Hence, it obeys

$$W_t N_t \leq L_t \quad (1.14)$$

Finally, there is an incentive constraint for the entrepreneur to choose the project "good":

$$Y_t - R_{Ft} L_t \geq \frac{PBK_t}{(p^H - p^L)} \quad (1.15)$$

As long as this constraint holds, the entrepreneur maximizes profits given in equation (1.4) that is written for the case of project "good". The incentive constraint also gives the borrowing constraint of the firm

$$R_{Ft} L_t \leq Y_t - \frac{PBK_t}{(p^H - p^L)} \quad (1.16)$$

from which the loan demand, L_t^d , is obtained:

$$L_t^d = \frac{Y_t - \frac{PBK_t}{(p^H - p^L)}}{R_{Ft}} \quad (1.17)$$

The loan supply, on the other hand, is determined according to the outside options of the financial intermediaries. More specifically, the financial intermediaries continue to supply loans to the firms as long as their return on the loans is greater than that on the alternative options available in the economy. Under the assumption that financial intermediaries can lend to and borrow from one another as well, this implies that their return on loans must be greater than the return from depositing at another financial intermediary; that is,

$$p^H R_{Ft} + (1 - p^H) \frac{\mu(1 - \delta)K_{t-1}}{L_t} \geq R_{Ht} \quad (1.18)$$

which constitutes the loan supply, L_t^s , equation. The loan market equilibrium condition is obtained through equating the loan supply and the loan demand equations.

1.2.3 Financial Intermediaries

The FI maximize the expected infinite horizon discounted stream of dividends they pay to households. They receive deposits from households, DD_t , and deposits from foreign investors, FD_t . FI then use these funds to give loans to firms. According to the loan contract between the FI and the firms, FI gain a net return of $R_{Ft} - 1$ in the case of success of the firms' projects and a certain fraction, μ , of the capital stock of the firms in the case of failure. They are allowed to hold no more than a certain fraction of their total deposits as foreign deposits. In other words, there is an upper limit on the fraction of foreign deposits over total deposits to be held by the FI, which represents the degree of financial openness in the economy.

The objective of the representative financial intermediary is to maximize the expected infinite horizon discounted stream of dividends it pays to households:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^{t+1} \frac{B_t}{C_{t+1}} \right\} \quad (1.19)$$

subject to first the budget constraint

$$B_t \leq [p^H \pi R_{Ft} L_t + p^H (1-\pi) R_{F,t-1} L_{t-1} + (1-p^H) \mu (1-\delta) K_{t-1}] - R_{H,t-1} DD_{t-1} - R^* FD_{t-1} \quad (1.20)$$

where $FD_t \geq 0$ is the foreign deposits collected by the FI. The net present value of future dividends is discounted by the marginal utility of consumption due to the fact that the FI are owned by households and that an extra unit of dividend is valued by households to the extent that it enables future consumption. Current period deposit holdings and loans cancel out in the budget constraint.

The second constraint the FI faces, namely the balance sheet constraint, requires that the liabilities of the FI are less than or equal to its assets, with deposits as the liabilities and loans as the assets

$$D_t \leq L_t \quad (1.21)$$

where $D_t = DD_t + FD_t$ and $FD_t = \psi D_t$, $DD_t = (1 - \psi) D_t$.

ψ represents the financial openness parameter assumed to be controlled by the financial regulator and varies between 0 and 1. Higher levels of ψ imply higher degrees of financial openness.

1.2.4 System of Equations

In a stochastic setting, the solution of the model is not a series of numbers that match a given set of equations, as in a deterministic setting. In a stochastic environment, the best thing agents can do is to specify a decision, policy or feedback rule for the future, in other words, their optimal actions contingent on each possible realization of shocks. Therefore, it is a function satisfying the model's equilibrium conditions that is being searched. The system of equations consists of the first-order conditions of the agents' optimization problems and the market-clearing conditions of the goods, labor and credit markets.

The first-order conditions of the household's optimization problem are:

$$\frac{(1 - \phi)}{C_t} = \frac{\phi}{W_t(1 - H_t)} \quad (1.22)$$

arising from the maximization of the household's utility function with respect to consumption, and

$$\frac{\beta R_{Ht}}{W_{t+1}(1 - H_{t+1})} = \frac{1}{W_t(1 - H_t)} \quad (1.23)$$

arising from the maximization with respect to deposits at the bank.

Combining (1.22) and (1.23) gives

$$\frac{1}{C_t} = \frac{\beta R_{Ht}}{C_{t+1}} \quad (1.24)$$

From the firm's optimization problem, there is the binding borrowing constraint

$$R_{Ft}L_t(p^H - p^L) = Y_t(p^H - p^L) - PBK_t \quad (1.25)$$

and the equilibrium condition that the marginal product of labor equals the real wage

$$K_{t-1}^\alpha (1 - \alpha) (A_t N_t)^{-\alpha} A_t = W_t \quad (1.26)$$

that are among the equations constituting the solution of the model.

Finally, the maximization problem of the FI yields

$$\frac{p^H \pi R_{Ft} C_{t+2}}{(1 - \psi)} = C_{t+1} \beta [R_{Ht} + \frac{\psi}{(1 - \psi)} R^* - \frac{p^H (1 - \pi) R_{Ft}}{(1 - \psi)}] \quad (1.27)$$

All markets clear at the equilibrium. The following equations represent equilibrium in the goods, labor and credit markets, respectively:

$$C_t + I_t + NX_t = Y_t \quad (1.28)$$

$$N_t = H_t \quad (1.29)$$

$$DD_t + FD_t = L_t \quad (1.30)$$

NX_t denotes net exports, the return on which is used for the net interest payment on foreign loans minus the amount of foreign borrowing in a given period. Therefore,

$$NX_t = \frac{\psi}{1 - \psi} [(R^* - 1) DD_{t-1} - DD_t] \quad (1.31)$$

Combining (1.14) and (1.22) with (1.29) gives

$$\left(\frac{\phi}{1 - \phi}\right) \frac{C_t}{1 - N_t} = \frac{L_t}{N_t} \quad (1.32)$$

which constitutes another equation of the system.

The model, however, needs to be made stationary first so that it can be linearized around the steady-state and that it returns to the steady-state after a shock.⁹ The problem of non-stationarity arises because of having stochastic trend in technology.

⁹In the case of linearization up to the first order, agents behave as if future shocks were equal to zero (since their expectation is null), due to certainty equivalence. In the linearization up to second order, agents make their decisions knowing that the future value of innovations are random but will have zero mean. This is not the same thing because of Jensen's inequality. For more detailed information, see DYNARE User Guide.

In the absence of shocks, real variables grow with A_t (except N_t which is stationary since there is no population growth). Detrending is carried out as follows (where hats above variables denote stationarity and $a_t = A_t/A_{t-1}$):

$$\hat{q}_t = q_t/A_t \text{ where } q_t = [Y_t, C_t, I_t, NX_t, K_t, L_t, W_t, DD_t].$$

The stationary system of equations is as follows:

$$(1 - \phi)(1 - N_t)W_t = \phi C_t \quad (1.33)$$

$$\beta R_{Ht}C_t = C_{t+1}a_{t+1} \quad (1.34)$$

$$R_{Ft}L_t(p^H - p^L) = Y_t(p^H - p^L) - PBK_t \quad (1.35)$$

$$K_{t-1}^\alpha(1 - \alpha)a_t^{-\alpha}N_t^{-\alpha} = W_t \quad (1.36)$$

$$p^H\pi R_{Ft}C_{t+2}a_{t+2} = C_{t+1}\beta[(1 - \psi)R_{Ht} + \psi R^* - p^H(1 - \pi)R_{Ft}] \quad (1.37)$$

$$C_t + I_t + NX_t = Y_t \quad (1.38)$$

$$W_tN_t = L_t \quad (1.39)$$

$$Y_t = K_{t-1}^\alpha a_t^{-\alpha} N_t^{1-\alpha} \quad (1.40)$$

$$K_t a_t = p^H[\pi\mu(1 - \delta)K_{t-1} + (1 - \pi)(I_t a_t + (1 - \delta)K_{t-1})] + (1 - p^H)(1 - \mu)(1 - \delta)K_{t-1} \quad (1.41)$$

$$NX_t a_t = \frac{\psi}{1 - \psi}[(R^* - 1)DD_{t-1} - DD_{t-1} + DD_t a_t] \quad (1.42)$$

$$DD_t = (1 - \psi)L_t \quad (1.43)$$

Given the equations (1.33)-(1.43) and the shock process (1.6), the expected future paths of the variables $[Y_t, C_t, I_t, NX_t, L_t, N_t, DD_t, K_t, W_t, R_{Ht}, R_{Ft}]$, namely, the impulse response functions, conditional on a temporary technology shock in period 1 are obtained next.

1.3 Results

1.3.1 Simulation

The procedure of making the model stationary is followed by linearization and simulation.¹⁰ The model is linearized up to first order. In the case of linearization up to the first order, agents behave as if future shocks were equal to zero (since their expectation is null), due to certainty equivalence. The second-order linearization of the model, on the other hand, leads to impulse response functions that are the results of actual Monte Carlo simulations of future shocks. This is due to the fact that there are cross terms involving the shocks in second-order linear equations, so that the effects of the shocks depend on the state of the system when the shocks hit. Therefore, it is not possible to get algebraic average values of all future shocks and their impact. What is instead done is to pull future shocks from their distribution and see how the system is affected by them, and to repeat this procedure several times in order to obtain an average response.

The perturbation method employed to solve and to simulate the model can be summarized as follows: The solution to the system of equations obtained in the previous section is a set of equations relating variables in the current period to the past state of the system and current shocks, that satisfy the original system. These are referred to as "the policy functions". In the linearization up to first order, future shocks enter the linearized system of equations only with their first moments (which are zero in expectations); therefore, they drop out when taking expectations of the equations. This is why certainty equivalence holds in the system linearized up to first order. The (approximate) policy functions are obtained by first rewriting the system in terms of past variables, current and future shocks, and then linearizing it around the steady states. Impulse response functions are then acquired simply through iterating the policy functions starting from some initial values (given by the steady states).¹¹

For simulations, the following values are assigned to the structural parameters of the

¹⁰The linearization and the simulation of the model are carried out using DYNARE, which is a pre-processor and a collection of MATLAB routines that have been developed to support modern macro modeling.

¹¹The impulse response functions presented in the next section depict the responses of the variables in terms of deviations from the steady states.

model: $\alpha=0.32$, $\beta=0.99$, $\phi=0.76$, $\delta=0.025$, $\gamma=0.003$.¹² Two parameters are of special interest, namely, ψ -the parameter measuring the degree of financial openness and R^* -the gross interest rate on foreign deposits. These parameters are interrelated through equation (1.37), which relates the interest rate on domestic deposits, the domestic loan rate and the interest rate on foreign deposits. Due to the fact that degree of financial openness, captured by ψ , is the main parameter of interest here, those parameters that are closely linked to ψ might also play crucial roles in the analyses of the implications of financial openness for the impact of shocks on the economy. Simulations are run using the following sets of values for those parameters: $\psi = [0.1, 0.5, 0.9]$ and $R^* = [1.01, 1.001, 1.0001]$. The fraction of the capital stock to be handed over to the financial intermediaries by the firms in the case of failure of the projects, μ , is set to 0.1. The probability of death of the entrepreneurs, π , is taken as 0.6. The probabilities of success of the "good" and the "bad" projects, p^H and p^L , are equal to 0.8 and 0.1, respectively. Finally, the parameter representing the private benefits of the entrepreneurs in the case of bad projects, PB, is assigned the value 0.1. In the next section, the impulse response functions are presented.

¹²For the parameter values, Mendoza (1991) and Dib (2003) are followed. Dib (2003) employs quarterly Canadian data for the calibration and the estimation in his small-open-economy DSGE model.

1.3.2 Impulse Response Functions

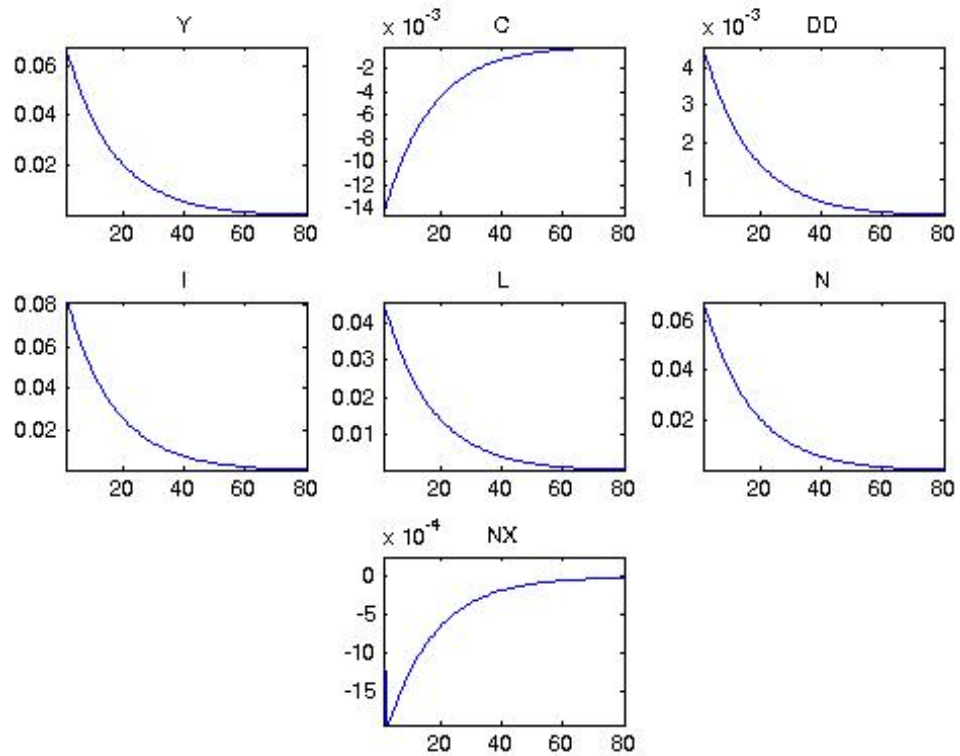


Figure 1.1: Temporary Technology Shock

Figure 1.1 presents the impulse responses of the variables in the model in the case of a one-time, positive, temporary technology shock in period 1. The model predicts an expansion in output, investment, labor supply and loans while there is contraction in consumption and net exports in response to the shock. The procyclical behavior of investment and labor supply, and the countercyclical behavior of trade balance are consistent with the findings of the real business cycle literature.¹³ Furthermore, it can be seen that households rather save than consume as a result of the shock; therefore, the positive correlation between savings and investment is in line with the empirical evidence pointed out by Mendoza (1991) for small open economies under imperfect capital mobility.

¹³See, among others, Mendoza (1991).

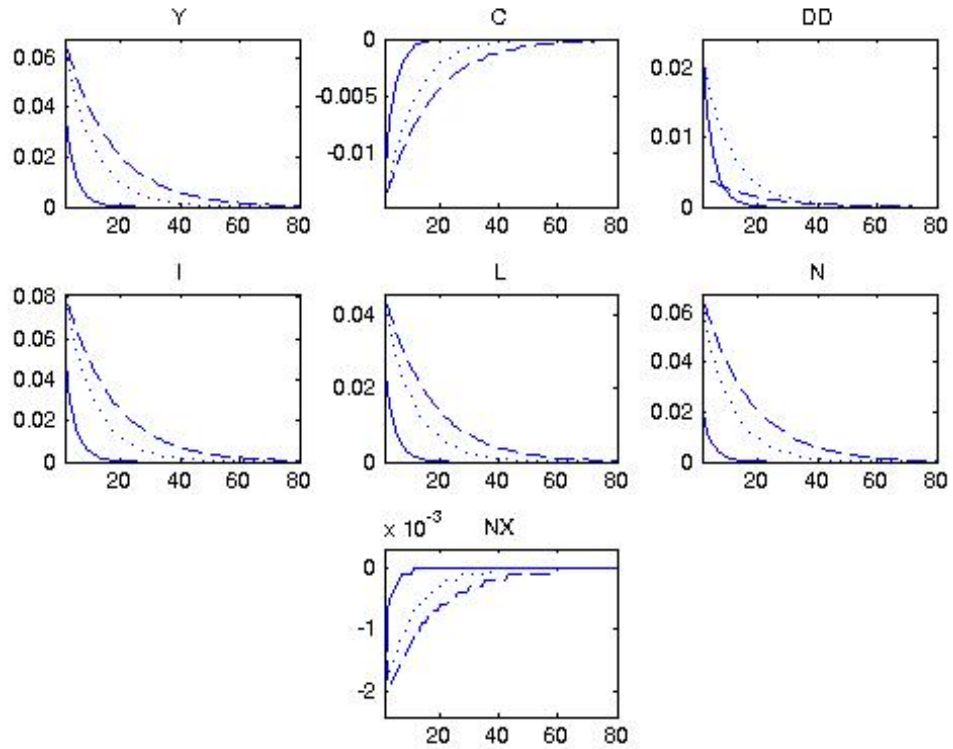


Figure 1.2: Temporary Technology Shock Under Varying Degrees of Financial Openness

Figure 1.2 displays the impulse response functions of the variables in the case of a positive, temporary technology shock under three different levels of financial openness.¹⁴ The straight line, the dotted line, and the dashed line represent the cases with ψ equal to 0.1, 0.5, and 0.9, respectively. It can be seen that increasing financial openness amplifies the impact of the positive technology shock on output, investment, consumption, labor supply, loans and net exports. This is due to the fact that the promoting effect of a positive technology shock on the economy is coupled with the improving impact of increasing financial openness on output led by increasing access to cheaper foreign funds.

¹⁴The value of the interest rate on foreign deposits used in the simulations that leads to the impulse responses presented here is $R^* = 1.01$.

1.3.3 Sensitivity Analyses

In this section, some robustness checks for the results presented in the previous section are undertaken. In addition to those parameters that are closely linked to the main parameter of interest; namely, the degree of financial openness, the other parameters in the model are analyzed in terms of their impact on the simulation results obtained above. It is done by running simulation experiments with varying values of those parameters. From equation (1.37), it can be seen that the success probability of project "good", p^H , the interest rate on foreign deposits, R^* , and the probability of death of entrepreneurs, π , are related to one another and to the degree of financial openness, ψ . Therefore, simulations are run with different values of those parameters as well as of the parameter measuring the fraction of the capital stock to be handed over to the FIs in the case of failure of the firms' projects, μ . Below are some of those simulation results that are similar to the results presented in the previous section.

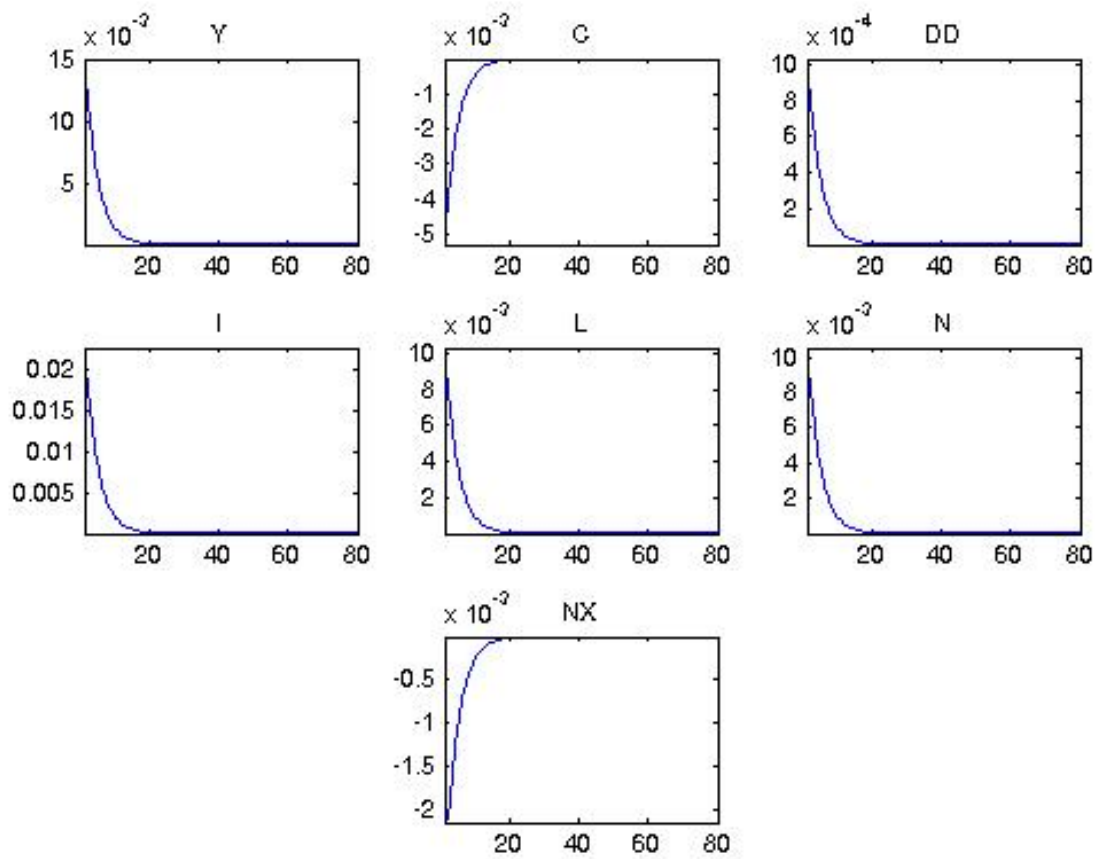


Figure 1.3: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.1$, $R^* = 1.01$, $\pi = 0.6$

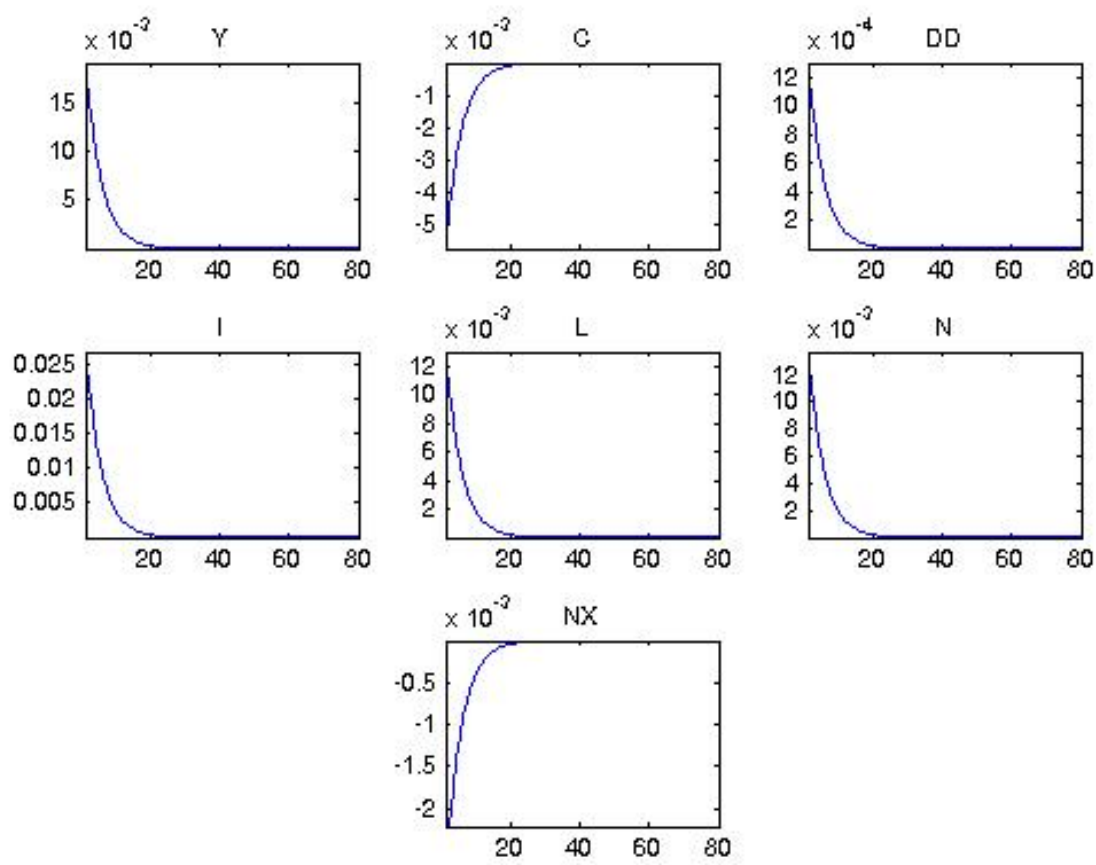


Figure 1.4: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.2$, $R^* = 1.01$, $\pi = 0.6$

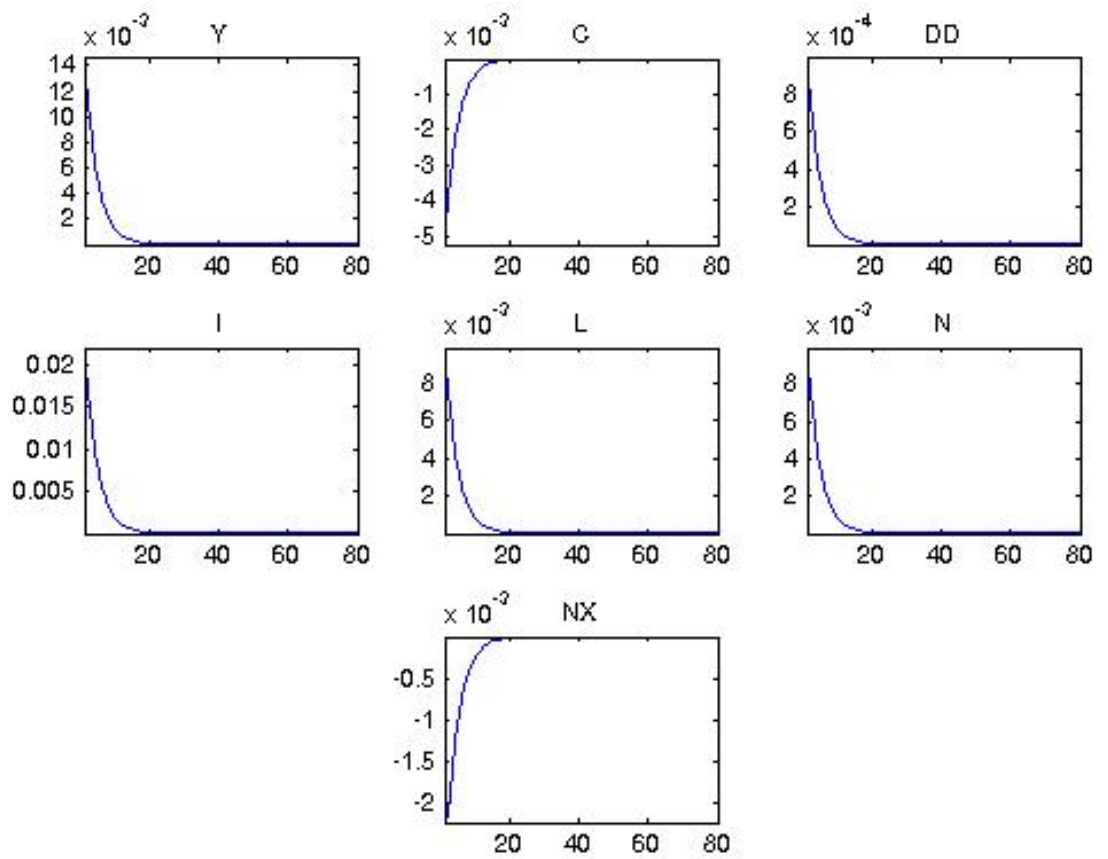


Figure 1.5: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.1$, $R^* = 1.001$, $\pi = 0.6$

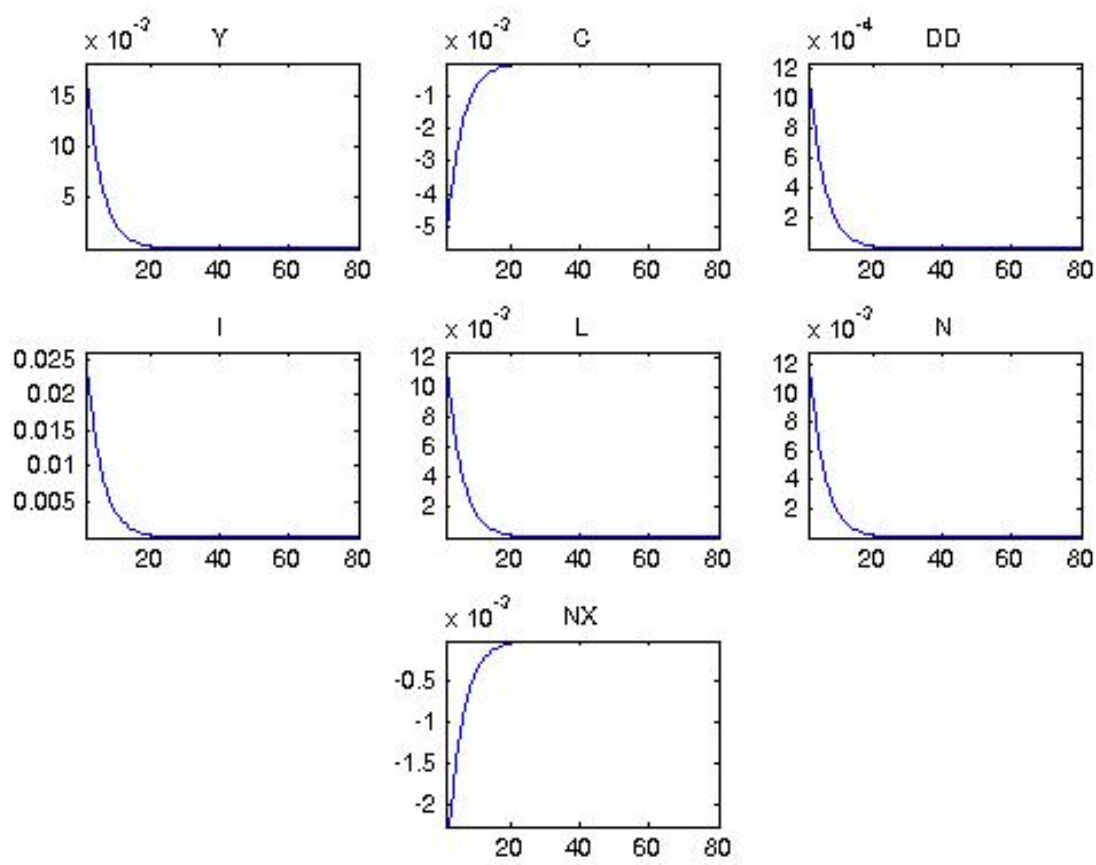


Figure 1.6: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.2$, $R^* = 1.001$, $\pi = 0.6$

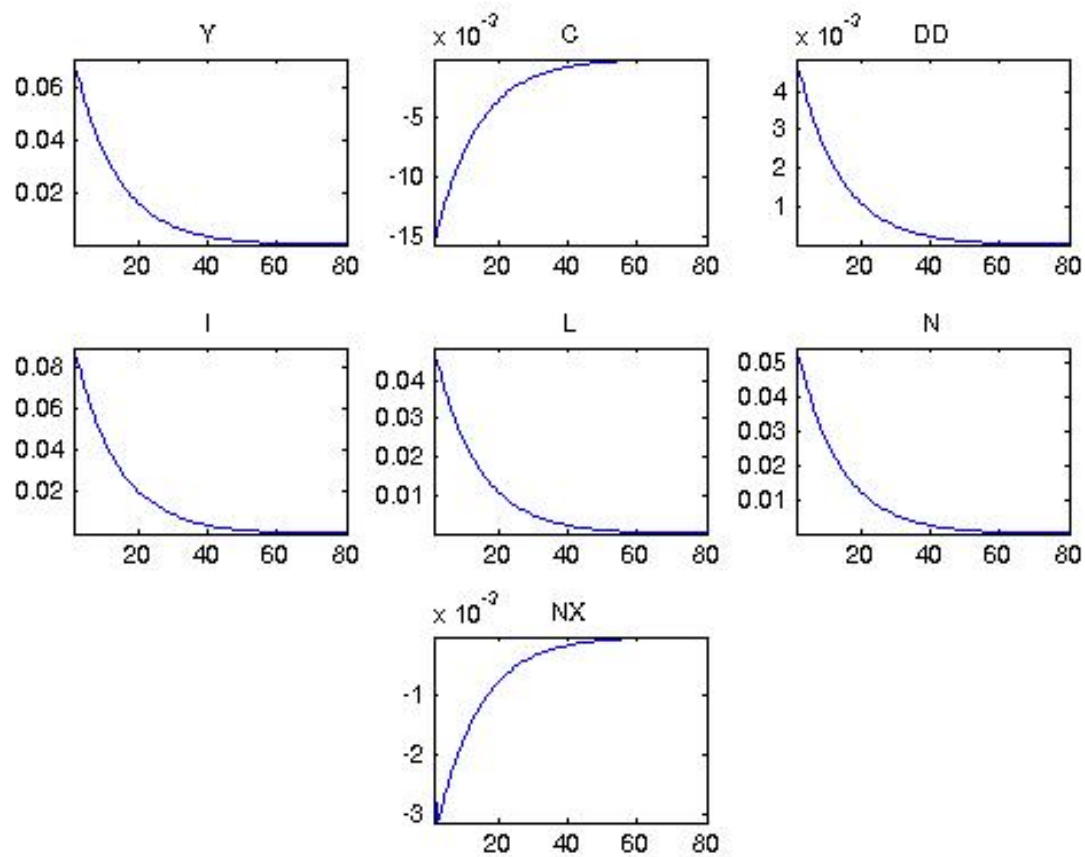


Figure 1.7: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.2$, $R^* = 1.001$, $\pi = 0.5$

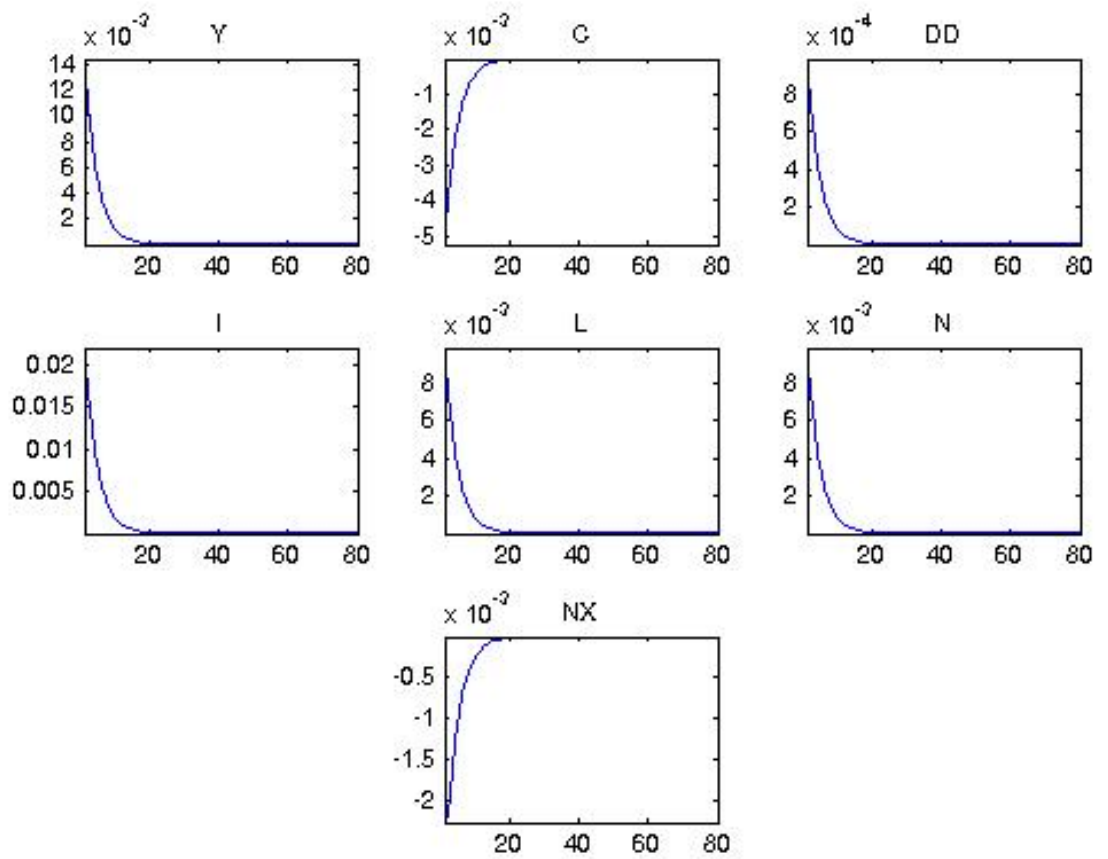


Figure 1.8: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.1$, $R^* = 1.0001$, $\pi = 0.6$

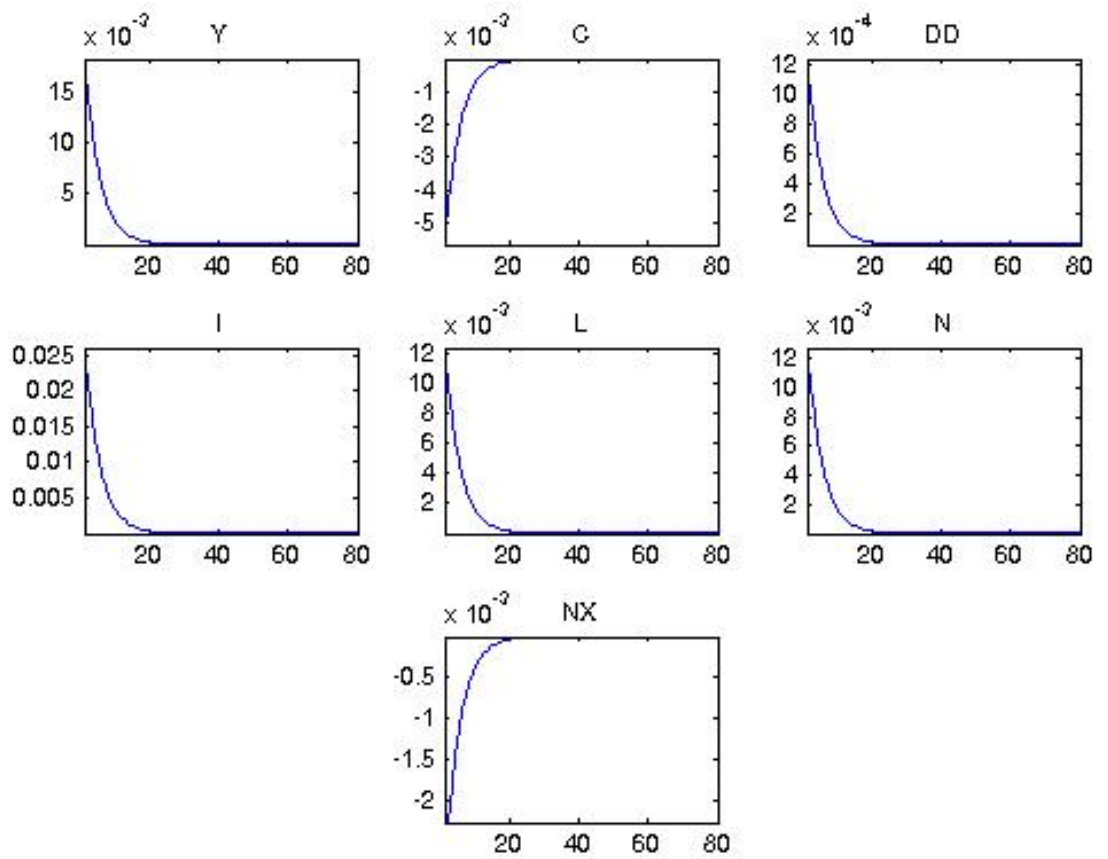


Figure 1.9: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.2$, $R^* = 1.0001$, $\pi = 0.6$

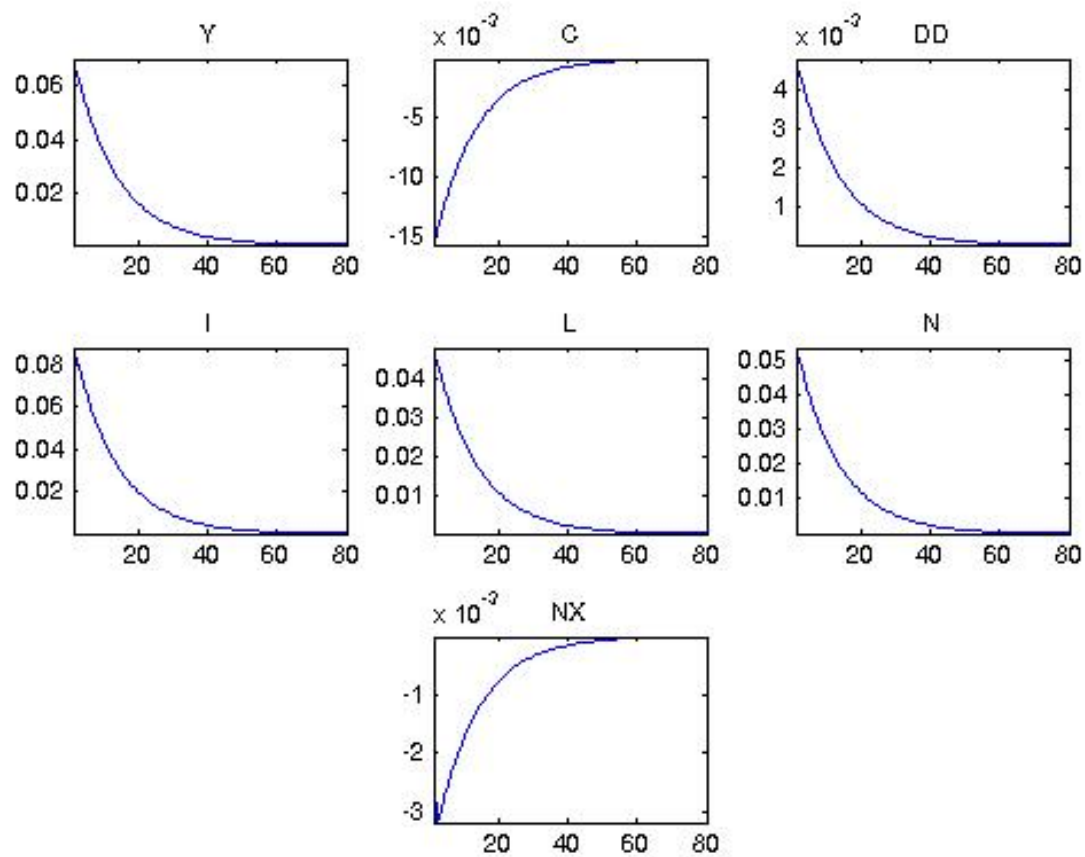


Figure 1.10: Temporary Technology Shock with $p^H = 0.9$, $p^L = 0.2$, $\mu = 0.2$, $R^* = 1.0001$, $\pi = 0.5$

1.4 Conclusion

In this chapter of the thesis, aggregate fluctuations and propagation mechanisms under varying degrees of financial openness are analyzed for a real, small open economy. Using a dynamic, stochastic, general equilibrium framework with financial intermediation and foreign borrowing, the implications of increasing financial openness for the impact of temporary technology shocks on the economy are investigated. This chapter contributes to the existing literature through proposing a new theoretical framework to examine financial openness, taking into account informational imperfections and uncertainty as well as financial frictions. Informational asymmetries among the agents in the economy and uncertainty in the production process necessitate financial intermediation in the economy. The Holmstrom-Tirole type of uncertainty in the production requires also collateralized borrowing by the firms, with the capital stock of the firms serving as the collateral as well as the factor of production. The abstraction from money in the setup of the framework makes it possible to be able to concentrate on the real implications of increasing financial openness for the impact of technology shocks, business cycle implications of which have long been discussed in the literature.

The small-open-economy DSGE model developed here is solved and simulated in the case of one-time, positive, temporary technology shocks. The simulation experiments with different levels of financial openness reveal that increasing financial openness amplifies the impact of temporary, positive technology shocks on output, investment, consumption, labor supply and net exports. This is mainly due to the fact that the promoting effect of a positive technology shock on the economy is coupled with the improving impact of increasing financial openness on output led by increasing access to cheaper foreign funds. The model presented here confirms the findings of the real business cycle literature on small open economies and the empirical regularities typical of open economies in terms of the procyclicality of investment and labor supply and the countercyclicality of external trade. In addition, there is a positive correlation between savings and investment, which is in line with the empirical evidence pointed out in the business cycle literature for small open economies under imperfect capital mobility.

Sensitivity analyses carried out using varying values of the parameters in the model show that the simulation results obtained in the case of positive, temporary technology shocks are robust. Analyzing the impact of monetary shocks, as well as technology shocks, on an economy under varying degrees of financial openness might allow

one to gain insights into the design of optimal monetary policy in the case of varying levels of financial openness. This might have crucial implications especially for emerging economies, for most of which the process of financial liberalization has not yet been completed. Therefore, introducing money into the current framework and thereby analyzing the policy implications of increasing financial openness for small open economies might be interesting, and hence, constitutes the motivation of the next chapter of this thesis.

Chapter 2

Financial Integration and Business Cycles in a Small Open Economy

2.1 Introduction

The business cycle implications of financial frictions have long been investigated in the literature.¹ This study proposes a theoretical framework to examine aggregate fluctuations and propagation mechanisms under increasing financial integration (diminishing financial frictions) for a small open economy, contributing to the existing literature through taking into account financial and informational frictions and uncertainty.² Financial frictions in the model are in the form of restrictions on the composition of deposits held by the financial intermediaries in the economy. More specifically, financial intermediaries are assumed to be able to hold only a certain fraction of their total deposits as foreign deposits. An increase in this fraction is interpreted as increasing financial integration. Informational asymmetries among the agents in the economy and uncertainty in the production process necessitate financial intermediation and require special attention to the design of the loan contracts between borrowers (firms) and lenders (financial intermediaries).

In this chapter of the thesis, a dynamic, stochastic, general equilibrium (DSGE) framework that incorporates financial integration is developed in order to analyze the sen-

¹For a comprehensive survey on the interaction between financial structure and aggregate economic activity, see, among others, Gertler (1988).

²For more details on output dynamics and propagation mechanisms in real business cycle models, see Nason and Cogley (1995). Aggregate fluctuations in the case of financial frictions are analyzed by Fuerst (1995), Gertler (1995), and von Hagen and Zhang (2008b).

sitivity of the response of a small open economy to money growth and technology shocks under varying degrees of financial integration.³ The model developed here is one of cash in advance (CIA), similar in spirit to that by Nason and Cogley (1994), modified in such a way that it incorporates financial integration. The economy consists of households, firms, foreign lenders, financial intermediaries, the central bank and the financial regulator. It is shown that increasing financial integration amplifies the effect of a monetary shock on output, consumption, investment, labor demand and loans, while it has barely any implication for the impact of a technological shock on the economy.

The economy analyzed in this chapter features imperfections of the Holmstrom-Tirole (1997) type of uncertainty in the production process, financial frictions restricting the amount of foreign borrowing in the economy, and informational asymmetries among the agents in the economy. Entrepreneurs that run the firms can choose between two different projects for production, both of which are subject to idiosyncratic risk. The projects yield positive output in the case of success and no output in the case of failure. The projects differ according to their probabilities of success and the private benefits they provide to the entrepreneurs. It is those private benefits that create incentives for the managers of the firms, inducing them to act against the interest of their creditors. The project choices of the entrepreneurs are private information, whereas the project outcomes are verifiable by the financial intermediaries. Households and foreign investors are assumed to lack the ability to verify the project outcomes. Therefore, domestic and foreign investors prefer lending to firms indirectly, through financial intermediaries, rather than directly.

Financial integration has become an increasingly attractive topic in both theoretical and empirical literature over the last couple of decades. This is partly because of its interaction with macroeconomic fundamentals, and partly due to its contradictory consequences, especially for emerging economies. On the one hand, it provides emerging economies with the funds that might be used to realize investment opportunities. On the other hand, it exposes them to increasing financial vulnerability against external shocks since the financial infrastructure in such economies is not adequately developed. Financial integration can be interpreted as the process resulting from the reduction in financial frictions that prevent capital from freely flowing across inter-

³For analyses of transmission mechanisms in the case of monetary shocks in general equilibrium models, see, among others, Fuerst (1992) and Christiano and Eichenbaum (1992).

national borders. The impact of financial integration on economic growth, macroeconomic volatility, the effectiveness of government policy rules depends on many factors including the structure of the financial system, the quality of financial supervision and regulation, the soundness of financial institutions, and the rapidity of the integration process.

Financial integration is incorporated into the model through the introduction of a regulation in the economy that the financial intermediaries can hold only a certain fraction of their total deposits as foreign deposits. The parameter representing this fraction is assumed to be controlled by the financial regulator in the economy. This chapter aims to uncover the changes in the fluctuations in a small open economy in response to one-time, temporary technology and money growth shocks, if there are any, under varying degrees of financial integration. In other words, whether the degree of financial integration plays a role at all in the performance of the economy in response to technology and money growth shocks is investigated.

The empirical literature on the issue of financial liberalization has rather ambiguous findings regarding the impact of increasing financial openness on the economic performance of countries.⁴ Arteta et al. (2003) point out the high sensitivity of the issue of financial integration to the context, the framework in which it is analyzed, as far as its implications for countries are concerned. The authors find evidence for a positive association between financial liberalization and economic growth only under certain conditions; namely, OLS estimation with Quinn's (1997) measure of financial openness. In a more recent study, Kose et al. (2006) emphasize the fact that there is still little robust evidence for growth benefits of broad financial liberalization, but that equity market liberalizations are shown to significantly boost growth. Furthermore, it is argued that the indirect effects of financial globalization on financial sector development, institutions, governance and macroeconomic stability are likely to be more crucial than direct effects through capital accumulation or portfolio diversification. In a follow-up paper, Kose et al. (2009) argue that there are certain "threshold" levels of financial and institutional development that an economy needs to attain in order to be able to enjoy the benefits from financial liberalization.⁵ Alper

⁴See Henry (2007) for a general discussion regarding the effects of financial liberalization on the real economy and the robustness of these effects.

⁵Mishkin (2007) both examines the relationship between financial development and economic growth and analyses whether financial globalization can help encourage financial and economic development.

and Cakici (2009) analyze the impact of increasing financial liberalization on economic growth using a panel dataset of 75 countries covering the period 1980-2003. Authors show that financial liberalization has significantly positive effect on economic growth only when it is accompanied by fiscal prudence, which is proxied by overall budget balance. Sensitivity of financial integration as a topic to context and methodology creates room for research and contribution to the literature in the form of providing new frameworks to investigate it, which constitutes also the motivation of this chapter.

Among the theoretical studies on financial integration, Sutherland (1996), Senay (1998) and Buch et al. (2005) are similar to the study in this chapter in terms of their motivation to analyze financial integration; namely, to investigate the business cycle implications of financial integration in the presence of certain shocks. Sutherland (1996) models the process of financial integration in an intertemporal general equilibrium framework as the elimination of trading frictions between financial markets in different countries. Sutherland shows that increasing financial market integration increases the volatility of a number of variables when shocks originate from the money market, but decreases the volatility of most variables when shocks originate from real demand or supply. The author suggests that the results could change in response to relaxing the assumption of perfect goods market integration. Senay (1998) investigates how increasing financial and goods market integration changes the effectiveness of fiscal and monetary policy. Senay analyzes expansionary monetary and fiscal policies under different degrees of goods and financial market integration in a dynamic general equilibrium framework. Senay finds that increasing financial integration increases the effectiveness of monetary policy while it decreases that of fiscal policy. It is argued by the author that these effects arise through the interaction between relative asset returns and the exchange rate. Buch et al. (2005) develop a theoretical model based on that by Sutherland to derive empirically testable hypotheses on how financial market integration might influence the impact of macroeconomic shocks on business cycle volatility. They show that the link between financial openness and business cycle volatility depends on the nature of the underlying shock. More specifically, they find that increasing financial openness magnifies output volatility in the presence of monetary, productivity and risk premium shocks. The model economy employed in these studies consists of households, firms and government. Financial integration is captured through introduction of adjustment costs that households have to face while transferring funds from domestic bond market to foreign bond market. Reduction in these costs implies increasing financial integration. The novelty of this chapter of the thesis is the provision of a framework incorporating also financial intermediation for

the analysis of financial integration, which is then used to analyze the response of the economy to money growth and technology shocks under varying degrees of financial integration. Financial integration is captured here as the fraction of total deposits financial intermediaries hold as foreign deposits.

As far as models with financial intermediation are concerned, there is a literature following Kiyotaki and Moore (1997) designing the loan contracts between borrowers and lenders with some durable asset, like land, as collateral.⁶ In these models, lenders cannot force borrowers to repay debts unless those debts are secured. In such a context, borrowers' assets like land serve both as factors of production and as collateral for new loans. Kiyotaki and Moore (1997) employ such a framework in the dynamic equilibrium model they develop in order to analyze the transmission mechanism in the case of temporary shocks. Kiyotaki and Moore show that small, temporary shocks to technology or income distribution can generate large, persistent fluctuations in output and asset prices.⁷ Another study employing land as collateral by von Hagen and Zhang (2008a) investigates the welfare implications of financial liberalization in a real, small open economy and suggests that financial opening facilitates the inflow of cheap foreign funds and improves production efficiency.

The uncertainty involved in the production process requires also in the framework here special attention to the design of the loan contracts between the firms and the financial intermediaries. However, in the current framework, it is the capital stock of the firms that is suggested to be used as collateral by the firms in the case of failure of their projects. Therefore, the loan contracts specify the rate of interest on loans that is going to be valid in the case of success and the percentage of the capital stock of the firms to be handed over to the financial intermediaries in the case of failure. In this context, the output produced by the firms using capital and labor as inputs is the return of the projects in the case of success. It is assumed that there is no output in the case of failure. Due to this probability of zero output in the case of failure, firms have to use their capital stock as collateral in order to be able to borrow loans from financial intermediaries.

Discussions regarding the contribution of technology shocks to business cycles have

⁶For more information on models with financial intermediation, see Freixas and Rochet (1997).

⁷For an analysis on the propagation of aggregate fluctuations in general, see Bernanke et al. (1996).

been controversial since the pioneering work by Kydland and Prescott (1982). It has been argued that the contribution of technology shocks to aggregate fluctuations depends on several factors including the extent of imperfect competition, external economies of scale, overtime wage premiums and measurement errors in labor input and output, as also pointed out by Aiyagari (1994). Consequently, in order to be able to determine the exact contribution of technology shocks to business cycles, precise quantitative measures of these factors would be required. In this chapter, it is aimed to examine the implications of both technology shocks and monetary shocks for aggregate fluctuations taking into account the potential impact of degree of financial integration.

The rest of the chapter is structured as follows: Section 2.2 describes the model and presents the solution of the model that consists of the system of equations including the first-order conditions and the market-clearing conditions. The simulation of the model, summary statistics, the impulse response functions and the sensitivity analyses are given in section 2.3. Finally, section 2.4 comprises the concluding remarks.

2.2 The Model

The model developed here is one of cash in advance (CIA), similar to the model employed by Nason and Cogley (1994), modified in a way so as to incorporate financial integration. All decisions are made after, and therefore completely reflect, the current period surprise change in money growth and technology. For the timing of the stock variables, like money and capital stock, "stock as of the end of the period" convention is used. For instance, M_t denotes the money stock as of the end of period t , that is to be transferred to period $t+1$, and K_t is the capital stock at the end of period t . The economy consists of households, firms, foreign lenders, financial intermediaries, the central bank and the financial regulator.

Infinitely lived households, that are assumed to be the owners of the financial intermediaries, maximize their utility functions that depend on consumption, C_t , and hours worked, H_t . They decide how much money to deposit at the financial intermediaries, DD_t , in order to earn $R_{Ht} - 1$ of net interest, how much to spend on consumption, and how much labor to supply to the firms. At the beginning of each period, households receive their previous period deposits plus the interest payment, and make current period deposits at the financial intermediaries. They also supply labor, earn wage income and decide how much consumption to make and how much money to transfer to the next period. There is no bond market in the economy, therefore there are no bond holdings of households.

Firms are owned by entrepreneurs, who have a finite but stochastic lifetime. Every period, a certain mass of entrepreneurs receives a signal of death and leaves the economy, whereas new entrepreneurs of equal mass enter the economy next period. In the aggregate, the share of entrepreneurs in the society is constant. Entrepreneurs maximize profits, F_t , by choosing next period's capital stock, K_t , labor demand, N_t , and loans, L_t , they borrow from financial intermediaries. At the beginning of every period, the existing entrepreneurs in the economy pay back the loans they borrowed in the previous period from the financial intermediaries including the interest and borrow new loans for the current period. Entrepreneurs then use these loans to hire labor for production. The new entrants, on the other hand, are assumed to bring along some initial wealth with which they can buy the capital stock they need for production from the financial intermediaries.

There is Holmstrom-Tirole (1997) type of uncertainty in the production process. Firms have two available project choices to produce the single consumption good⁸, both of which are subject to idiosyncratic risk; namely, they yield positive return in the case of success and zero return in the case of failure. The projects differ according to their probabilities of success, with p^H in the case of project "good" and p^L in the case of project "bad". The reason why the entrepreneur might have incentives to choose project "bad" is that it yields some private benefits, PB , to the entrepreneur. Project "good" yields no private benefits. It is assumed, as in von Hagen and Zhang (2008a), that the project outcomes can be perfectly verified by the financial intermediaries while the project choices of the entrepreneurs are unobservable.

Foreign lenders are assumed to supply funds, FD_t , infinitely elastically at a constant interest rate, R^* , that is lower than the domestic loan rate.

Finally, financial intermediaries (FI henceforth) maximize the expected infinite horizon discounted stream of dividends, B_t , they pay to households. They receive cash deposits from households, DD_t , cash deposits from foreign investors, FD_t , and cash injections, X_t , from the central bank (which equal the net change in nominal money balances, $M_t - M_{t-1}$). The FI then use these funds to give loans to firms. According to the loan contract between the FI and the firms, the FI gain a net return of $R_{Ft} - 1$ in the case of success of the firms' projects and a certain fraction, μ , of the capital stock of the firms in the case of failure. The FI are allowed to hold no more than a certain fraction of their total deposits as foreign deposits. At the beginning of each period, financial intermediaries receive the loans they lent to firms in the previous period inclusive of the interest payments, sell the capital stock they have acquired from firms whose projects failed, and pay back the domestic and foreign deposits they collected in the previous period together with the interest. Additionally, they accept current period deposits from households and foreign lenders and give current period loans to firms.

Financial integration is captured in this model by the fraction of foreign deposits over total deposits the FI collect. Higher levels of this fraction imply higher degrees of financial integration.

⁸The consumption good and the capital good are assumed to be identical for analytical purposes.

2.2.1 Households

A typical household maximizes an expected utility function of the form

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t [(1 - \phi) \ln C_t + \phi \ln(1 - H_t)] \right\}, 0 < \beta, \phi < 1, \quad (2.1)$$

where β is the discount factor, subject to the CIA constraint

$$P_t C_t \leq M_{t-1} + W_t H_t - DD_t + R_{H,t-1} DD_{t-1} \quad (2.2)$$

where it is assumed that the money stock transferred from the previous period, labour income and interest income on previous period deposits net of current period deposits are available for consumption purchases of households. The household budget constraint is given as

$$M_t = M_{t-1} + W_t H_t - P_t C_t + R_{H,t-1} DD_{t-1} - DD_t + B_t \quad (2.3)$$

Households' maximization problem is also subject to the nonnegativity constraint on domestic deposits

$$0 \leq DD_t \quad (2.4)$$

where P_t and W_t denote the price level of the single consumption good and the nominal wage rate, respectively. B_t refers to the dividends paid to households by financial intermediaries. R_{Ht} is the gross nominal interest rate on household deposits. DD_t is denominated in domestic currency.

2.2.2 Firms

As in the framework in Chapter 1, there is a certain mass of entrepreneurs in the population that runs the firms in the economy. Each period, π percent of them dies and new entrants of an equal mass are added to the population such that the size of the population remains the same. At the micro level, this means that, with probability π , each entrepreneur receives a signal every period that he will die at the end of the period. Entrepreneurs receiving this signal consume everything that is left of their wealth at the end of the period after paying back their debts. The new entrants bring along some initial wealth with which they can obtain the capital

stock they need to start production. They buy this capital stock from the financial intermediaries, which receive capital stock as repayment of loans in the case of failure of the firms' projects. Entrepreneurs, therefore, maximize profits taking into account this probability of death. There is uncertainty involved in the production process of the firm, resulting from the fact that the entrepreneur has two available projects to produce goods, both of which are subject to idiosyncratic risk. More specifically, the entrepreneur has two project choices that differ according to their probabilities of success and the private benefits they provide to the entrepreneur, and there is positive output in the case of success of the projects while there is no output in the case of failure. p^H and p^L denote the probabilities of success of the "good" and the "bad" project, respectively, where $0 < p^L < p^H < 1$. The entrepreneur gets PB amount of private benefits per capital stock if he chooses the project "bad" whereas there is no private benefit obtained from the project "good". The entrepreneur's payoffs from the projects can be summarized as follows:

In the case of "good project":

$$p^H[P_t Y_t - R_{F_t} L_t] + (1 - p^H)[0 - \mu(1 - \delta)K_{t-1}P_t]$$

In the case of "bad project":

$$p^L[P_t Y_t - R_{F_t} L_t] + (1 - p^L)[0 - \mu(1 - \delta)K_{t-1}P_t] + PBK_t P_t$$

Entrepreneurs' profits, F_t , are given as

$$F_t \leq p^H P_t Y_t - p^H \pi R_{F_t} L_t - p^H (1 - \pi) R_{F_t, t-1} L_{t-1} - (1 - p^H) \mu (1 - \delta) K_{t-1} P_t \quad (2.5)$$

where δ is the constant physical depreciation rate of capital. Given that the entrepreneur chooses the project "good" (which will be the case as long as the incentive constraint stated below holds), with probability p^H the firm is able to make use of the loans it borrows from the FI to hire N_t amount of labor, which it can employ together with the capital stock it has, K_{t-1} , to produce Y_t amount of output. The entrepreneur makes in this case an interest payment to the FI for the loans at the rate specified in the loan contract, R_{F_t} . In the case of failure, there is no output produced and the entrepreneur has to transfer a certain amount of its capital stock, which it used as collateral in order to be able to borrow from the FI, to the FI. μ

represents the fraction of the capital stock of the firm guaranteed in the loan contract to be handed over to the FI in the case of failure. Due to the fact that capital stock is employed in the production process and therefore subject to depreciation independent of the project outcome of the firm, it is the net-of-depreciation amount of capital stock, the fraction of which is to be handed over to the FI in the case of failure. The period t loans of the firm, L_t , and the period t wage payments, $W_t N_t$, cancel out above.

The production function of the firm is given by

$$Y_t = K_{t-1}^\alpha (A_t N_t)^{1-\alpha} \quad (2.6)$$

where A_t denotes technology, the shock process of which is a unit root with drift in the log of technology, given as

$$\ln A_t = \gamma + \ln A_{t-1} + \epsilon_{A,t}, \quad \epsilon_{A,t} \sim N(0, \sigma_A^2) \quad (2.7)$$

The capital accumulation equation is given as

$$K_t = p^H [\pi \mu (1-\delta) K_{t-1} + (1-\pi)(I_t + (1-\delta)K_{t-1})] + (1-p^H)(1-\mu)(1-\delta)K_{t-1}, \quad 0 < \delta < 1 \quad (2.8)$$

K_t is the level of physical capital to be employed in the production process at time $t+1$, determined by the entrepreneur at time t . Equation (2.8) is the capital accumulation equation at the macro level in the sense that π represents here the mass, out of a group of entrepreneurs, that dies each period, rather than the probability of death of a single entrepreneur, as in the micro sense. Therefore, the first term in the parenthesis on the right-hand side of the equation, $\pi \mu (1-\delta) K_{t-1}$, stands for the capital stock held by the new entrants at the beginning of every period (recall the assumption that an equal mass, π , of new entrepreneurs enter the economy each period so that the total size of the population remains unchanged). The second term represents the amount of capital stock accumulated by the successful entrepreneurs continuing to live and produce; the net-of-depreciation amount of capital stock of the current period, $(1-\delta)K_{t-1}$, plus the amount of investment, I_t . Investment is equal to the real profits made by the successful entrepreneurs in the economy. The last term on the right-hand side of the equation gives the amount of the capital stock of the unsuccessful entrepreneurs that cannot make positive real profits due to the fact that there is no output in the case of failure of the firms' projects.

In order to make the capital accumulation process more clear, the profit and the capital accumulation functions are rewritten below from a micro perspective such that the profit made and the capital stock accumulated are captured separately for the cases of success and failure of the projects. Let F_t^s and K_t^s (F_t^f and K_t^f) denote the profit and the capital stock, respectively, accumulated by a single entrepreneur in the case of success (failure) of the projects. Then, the profit made and the capital stock accumulated are given as

$$F_t = F_t^s p^H + F_t^f (1 - p^H) \quad (2.9)$$

and

$$K_t = K_t^s p^H (1 - \pi) + K_t^f (1 - p^H) \quad (2.10)$$

The profits made in the case of success of the projects, which are invested, and therefore transferred to the next period, by the entrepreneurs, are given by the following equation:

$$F_t^s = P_t Y_t - \pi R_{F,t} L_t - (1 - \pi) R_{F,t-1} L_{t-1} \quad (2.11)$$

The corresponding capital stock in the case of success of the projects is, therefore, given as

$$K_t^s = F_t^s / P_t + (1 - \delta) K_{t-1} \quad (2.12)$$

In the case of failure of the firms' projects, there is no output produced; therefore, profits are

$$F_t^f = -\mu(1 - \delta) K_{t-1} P_t \quad (2.13)$$

whereas the capital stock is given as

$$K_t^f = F_t^f / P_t + (1 - \delta) K_{t-1} = (1 - \mu)(1 - \delta) K_{t-1} \quad (2.14)$$

Plugging equations (2.17) and (2.14) into equation (2.15), the capital accumulation equation given in equation (2.8) is obtained at the micro level.

Entrepreneurs' maximization problem is subject to the constraint reflecting the fact that the firm finances its wage payments with the loans it borrows from the FI. Hence,

it obeys

$$W_t N_t \leq L_t \quad (2.15)$$

Finally, there is an incentive constraint for the entrepreneur to choose the project "good":

$$P_t Y_t - R_{Ft} L_t \geq \frac{PBK_t P_t}{(p^H - p^L)} \quad (2.16)$$

As long as this constraint holds, the entrepreneur maximizes profits given in equation (2.5) that is written for the case of project "good". The incentive constraint also gives the borrowing constraint of the firm

$$R_{Ft} L_t \leq P_t Y_t - \frac{PBK_t P_t}{(p^H - p^L)} \quad (2.17)$$

from which the loan demand, L_t^d , is obtained:

$$L_t^d = \frac{P_t Y_t - \frac{PBK_t P_t}{(p^H - p^L)}}{R_{Ft}} \quad (2.18)$$

In the standard collateralized borrowing literature, the maximum amount of loans supplied to the firms by the FIs is determined according to the value of the collateral firms have. More precisely, the value of the loans the FIs supply does not exceed the value of the collateral of the firms, which is exactly what the collateral constraints imply. However, in those frameworks, the total supply of loans is often fixed (limited). Therefore, it is an optimal allocation problem of loans and assets (that are used as collateral) among agents with differing productivities. In the current framework, the total amount of loans available is determined in part stochastically, due to the fact that it is the sum of total deposits and the monetary injection the FIs hold and that the monetary injection is an exogenous stochastic process. As a result, the optimization problem here has to do with the allocation of the incoming (injected) new loans available to the FIs. In the standard CIA literature, where the total supply of loans is subject to uncertainty similar to our framework here, the allocation problem of the new loans is solved through the adjustment of the loan rate. To be more specific, as the total supply of loans increase, the loan rate falls so that the firms continue to demand the extra loans available, and the FIs continue to supply the extra loans to the firms as long as their return (the loan rate) is positive. However, in those frameworks, there is no uncertainty in the production process; therefore, there is no need for collateralized borrowing. The major novelty of the model in this chapter is

to reconcile these two strands of literature with the motivation of analyzing aggregate fluctuations and propagation mechanisms under increasing financial integration for an economy with uncertainty and frictions.

For the FI to continue lending the new resources available as loans to firms, the return on the loans must be positive and greater than the return on any outside option of the FI; that is,

$$p^H R_{Ft} + (1 - p^H) \frac{\mu(1 - \delta)K_{t-1}P_{t+1}}{L_t} \geq R_{Ht} > 0 \quad (2.19)$$

where R_{Ht} represents the return on the outside option of the FI, namely, lending to other FIs.⁹ The parameters of the model are calibrated in such a way that the inequality holds.

The inequality also gives the loan supply, L_t^s :

$$L_t^s = \frac{(1 - p^H)\mu(1 - \delta)K_{t-1}P_{t+1}}{(R_{Ht} - p^H R_{Ft})} \quad (2.20)$$

The loan market equilibrium condition is obtained through equating the loan supply and the loan demand equations.

2.2.3 Financial Intermediaries

The objective of the FI is to maximize the expected infinite horizon discounted stream of dividends it pays to households:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^{t+1} \frac{B_t}{C_{t+1}P_{t+1}} \right\} \quad (2.21)$$

subject to first the budget constraint

$$B_t \leq [p^H \pi R_{Ft} L_t + p^H (1 - \pi) R_{F,t-1} L_{t-1}] + [(1 - p^H) \mu (1 - \delta) K_{t-2} P_t] - R_{H,t-1} D D_{t-1} - R^* F D_{t-1} E_{t-1} \quad (2.22)$$

⁹The return on loans just has to be positive, once the assumption that FIs can lend to and borrow from one another is relaxed.

where $FD_t \geq 0$ is denominated in foreign currency and E_t is the nominal exchange rate (the domestic currency value of one unit of the foreign currency). Purchasing power parity (PPP) holds so that $P_t = E_t P_t^*$, with P_t^* denoting the foreign price level. P_t^* is normalized to 1; therefore, the fluctuations in the exchange rate due to the monetary and technology shocks are captured by the movements in the domestic price level. The net present value of future dividends is discounted by the marginal utility of consumption due to the fact that financial intermediaries are owned by households and that an extra unit of dividend is valued by households to the extent that it enables future consumption. The monetary injection, X_t , and the total deposits at the FI in period t , D_t , are used by the FI for the period t loans, L_t ; therefore, they cancel out in the budget constraint of the FI.

X_t is the monetary injection during date t , $X_t = M_t - M_{t-1}$, defined similarly to Nason and Cogley (1994).¹⁰

The exogenous stochastic process for the growth rate of the monetary injection is given as

$$\ln m_t = (1 - \rho)\ln m^* + \rho \ln m_{t-1} + \epsilon_{M,t}, \quad \epsilon_{M,t} \sim N(0, \sigma_M^2) \quad (2.23)$$

where $m_t = \frac{M_t}{M_{t-1}}$.

It is therefore an autoregressive stationary process in the growth rate of money, but an AR(2) with a unit root in the log of the level of money. This can be seen from the definition of m_t which can be rewritten as $\ln M_t = \ln M_{t-1} + \ln m_t$.

The second constraint the FI faces, namely the balance sheet constraint, requires that the liabilities of the FI are less than or equal to its assets

$$D_t + X_t \leq L_t \quad (2.24)$$

where $D_t = DD_t + FD_t E_t$ and $FD_t E_t = \psi D_t$, $DD_t = (1 - \psi)D_t$.

¹⁰It can be seen from the households' budget constraint that X_t equals the total income of households (labor income+interest on deposits+dividends from the financial intermediaries) minus consumption, which cannot be negative since households are assumed to transfer some cash to the next period.

ψ represents the financial openness parameter assumed to be controlled by the financial regulator and varies between 0 and 1. Higher levels of ψ imply higher degrees of financial integration.

2.2.4 System of Equations

In a stochastic setting, the solution of the model is not a series of numbers that match a given set of equations, as in a deterministic setting. In a stochastic environment, the best thing agents can do is to specify a decision, policy or feedback rule for the future, in other words, their optimal actions contingent on each possible realization of shocks. Therefore, it is a function satisfying the model's equilibrium conditions that is being searched. The system of equations consists of the first-order conditions of the agents' optimization problems and the market-clearing conditions of the goods, labor, money and credit markets.

The following first-order conditions are obtained from the household's optimization problem:

$$\frac{(1 - \phi)}{C_t} = \frac{\phi P_t}{W_t(1 - H_t)} \quad (2.25)$$

from the maximization of the household's utility function with respect to consumption, and

$$\frac{\beta R_{Ht}}{W_{t+1}(1 - H_{t+1})} = \frac{1}{W_t(1 - H_t)} \quad (2.26)$$

from the maximization with respect to deposits.

Combining (2.25) and (2.26) gives

$$\frac{1}{C_t P_t} = \frac{\beta R_{Ht}}{C_{t+1} P_{t+1}} \quad (2.27)$$

From the firm's optimization problem, the binding borrowing constraint

$$R_{Ft} L_t (p^H - p^L) = P_t Y_t (p^H - p^L) - P B K_t P_t \quad (2.28)$$

and the equilibrium condition that the marginal product of labor equals the real wage

$$K_{t-1}^\alpha (1 - \alpha) (A_t N_t)^{-\alpha} A_t = \frac{W_t}{P_t} \quad (2.29)$$

are among the system of equations constituting the solution of the model.

Finally, the FI maximizes its dividends with respect to deposits, which leads to the following first order condition:

$$p^H \pi R_{Ft} P_{t+2} C_{t+2} = \beta P_{t+1} C_{t+1} [(1 - \psi) R_{Ht} + \psi R^* - p^H (1 - \pi) R_{Ft}] \quad (2.30)$$

As stated above, all markets clear in equilibrium. The following equations represent equilibrium in the goods, labor, money, and credit markets, respectively:

$$C_t + I_t + NX_t = Y_t \quad (2.31)$$

$$N_t = H_t \quad (2.32)$$

$$P_t C_t = M_{t-1} + X_t \quad (2.33)$$

$$D_t + X_t = L_t \quad (2.34)$$

NX_t denotes net exports, which is equal to the net interest payment on foreign borrowing minus the change in the amount of foreign borrowing in a given period. Therefore,

$$P_t NX_t = (R^* - 1) F D_{t-1} E_{t-1} - [F D_{t-1} E_{t-1} - F D_t E_t] \quad (2.35)$$

Combining (2.15), (2.25) and (2.32) gives

$$\left(\frac{\phi}{1 - \phi} \right) \frac{P_t C_t}{1 - N_t} = \frac{L_t}{N_t} \quad (2.36)$$

which constitutes another equation of the solution.

Finally, there is the purchasing power parity (PPP) condition

$$P_t = E_t P_t^* \quad (2.37)$$

with $P_t^* = 1$, which is used to convert the foreign currency denominated foreign deposits into domestic currency in the system of equations.

The model, however, needs to be made stationary first so that it can be linearized around the steady-state and that it returns to the steady-state after a shock. The problem of non-stationarity arises because of having stochastic trends in money and technology. In the absence of shocks, real variables grow with A_t (except N_t which is stationary since there is no population growth), nominal variables grow with M_t and prices grow with M_t/A_t . Detrending is carried out as follows (where hats above variables denote stationarity):

For real variables, $\hat{q}_t = q_t/A_t$ where $q_t = [Y_t, C_t, K_t]$. For nominal variables, $\hat{z}_t = z_t/M_t$ where $z_t = [W_t, D_t, L_t]$. For prices, $\hat{P}_t = P_t A_t / M_t$.

The stationary system of equations is as follows:

$$(1 - \phi)(1 - N_t)L_t m_t = \phi P_t C_t N_t \quad (2.38)$$

$$m_t C_{t+1} P_{t+1} = \beta R_{Ht} C_t P_t \quad (2.39)$$

$$R_{Ft} L_t (p^H - p^L) m_t = P_t Y_t (p^H - p^L) - P B K_t P_t \quad (2.40)$$

$$K_{t-1}^\alpha (1 - \alpha) a_t^{-\alpha} N_t^{-\alpha} = W_t m_t \quad (2.41)$$

$$p^H \pi R_{Ft} P_{t+2} C_{t+2} m_{t+1} = \beta P_{t+1} C_{t+1} [(1 - \psi) R_{Ht} + \psi R^* - p^H (1 - \pi) R_{Ft}] \quad (2.42)$$

$$C_t + I_t + N X_t = Y_t \quad (2.43)$$

$$P_t C_t = m_t \quad (2.44)$$

$$\frac{D D_t}{(1 - \psi)} + 1 - \frac{1}{m_t} = L_t \quad (2.45)$$

$$W_t N_t = L_t \quad (2.46)$$

$$Y_t = K_{t-1}^\alpha a_t^{-\alpha} N_t^{1-\alpha} \quad (2.47)$$

$$K_t a_t = p^H [\pi \mu (1 - \delta) K_{t-1} + (1 - \pi)(I_t a_t + (1 - \delta) K_{t-1})] + (1 - p^H)(1 - \mu)(1 - \delta) K_{t-1} \quad (2.48)$$

$$NX_t = \psi [(R^* - 1) DD_{t-1} - DD_{t-1} + DD_t m_t] / (1 - \psi) P_t \quad (2.49)$$

Given the equations (2.38)-(2.49) and the shock processes (2.7) and (2.23), the expected future paths of the variables $[Y_t, C_t, I_t, NX_t, P_t, DD_t, L_t, N_t, K_t, W_t, R_{Ft}, R_{Ht}]$, namely, the impulse response functions, conditional on temporary money growth and technology shocks in period 1 are obtained next.

2.3 Results

2.3.1 Simulation

The procedure of making the model stationary is followed by linearization and simulation.¹¹ The model is linearized up to first order.¹² The perturbation method employed to solve and to simulate the model can be summarized as follows: The solution to the system of equations obtained in the previous section is a set of equations relating variables in the current period to the past state of the system and current shocks, that satisfy the original system. These are referred to as "the policy functions". In the linearization up to first order, future shocks enter the linearized system of equations only with their first moments (which are zero in expectations); therefore, they drop out when taking expectations of the equations. This is why certainty equivalence holds in the system linearized up to first order. The (approximate) policy functions are obtained by first rewriting the system in terms of past variables, current and future shocks, and then linearizing it around the steady states. Impulse response functions are then acquired simply through iterating the policy functions starting from some initial values (given by the steady states).¹³

For simulations, the following values are assigned to the structural parameters of the model: $\alpha=0.32$, $\beta=0.99$, $\phi=0.76$, $\delta=0.025$, $\gamma=0.003$, $\rho=0.7$.¹⁴ For the success probability of project "bad" and the unconditional mean of monetary injection growth, $p^L=0.1$ and $m^*=1.01$, respectively, are used. The fraction of the capital stock to be used as collateral by firms, μ , is taken to be equal to 0.1, whereas the probability of death of firm managers, π , is set to 0.9. The parameter measuring the private benefits

¹¹The linearization and the simulation of the model are carried out using DYNARE, which is a pre-processor and a collection of MATLAB routines that have been developed to support modern macro modeling.

¹²In the case of linearization up to the first order, agents behave as if future shocks were equal to zero (since their expectation is null), due to certainty equivalence. In the linearization up to second order, agents make their decisions knowing that the future value of innovations are random but will have zero mean. This is not the same thing because of Jensen's inequality. For more detailed information, see DYNARE User Guide.

¹³The impulse response functions presented in the next section depict the responses of the variables in terms of deviations from the steady states.

¹⁴For the parameter values, Mendoza (1991), Nason and Cogley (1994) and Dib (2003) are followed. Dib (2003) employs quarterly Canadian data for the calibration and the estimation in his small-open-economy DSGE model.

of entrepreneurs from project "bad", PB , is taken as 0.5.

Three parameters are of special interest, namely, ψ -the parameter measuring the degree of financial integration, p^H -the success probability of project "good", and R^* -the gross interest rate on foreign deposits. These parameters are interrelated through equation (2.42), which relates the loan rate, the interest rate on domestic deposits and the interest rate on foreign deposits. Due to the fact that degree of financial integration, captured by ψ , is the main parameter of interest here, those parameters that are closely linked to ψ should be analyzed carefully in the simulations as well, since they might also play crucial roles in the analysis of the implications of financial integration for the impact of shocks on the economy. Simulations are run using the following sets of values for those parameters: $\psi = [0.5, 0.75, 0.99]$, $R^* = [1.01, 1.001, 1.0001]$, and $p^H = [0.7, 0.8, 0.9]$. In the next sections, the summary statistics and the impulse response functions are presented.¹⁵

¹⁵In a stochastic setup, DYNARE computes impulse response functions, by default, for one positive standard deviation of each of the shocks.

2.3.2 Summary Statistics

Solving a rational expectations model means finding an unknown function that could be inserted into the original model and satisfy the implied restrictions, i.e., the first order conditions. A first order approximation of such a function can be written in terms of the steady-state values of the variables, the deviations of the variables from the steady states, the partial derivatives of the function with respect to the variables and the stochastic error terms. In other words, the function is a time recursive representation of the model that can generate time series which will approximately satisfy the rational expectations hypothesis in the original model. The policy and transition functions given below in Table 2.1 contain the partial derivatives mentioned above. In Table 2.2, the moments of the simulated variables are presented; whereas the correlations and the autocorrelations of the simulated variables are given in Table 2.3 and 2.4, respectively.

Table 2.1: Policy and Transition Functions

Var.	I	L	N	NX	Rf	W	Y	DD	K	C	P
Const.	-0.22	-0.29	-0.09	-0.001	1.01	2.87	-0.07	-0.03	-0.03	0.15	6.6
K_{t-1}	2.4	2.25	0.86	0.32	0	2.25	1.18	0.23	0.47	-1.57	67.2
m_{t-1}	0.08	0.4	0.16	-0.07	-0.28	0.4	0.07	-0.03	0.01	0.05	2.2
$\epsilon_{A,t}$	0.06	0.06	0.02	0.01	0	0.06	0.03	0.01	0.01	-0.04	1.8
$\epsilon_{M,t}$	0.12	0.59	0.23	-0.1	-0.41	0.59	0.1	-0.04	0.01	0.08	3.2

Table 2.2: Moments of Simulated Variables

Variables	Mean	Std.Dev.	Variance	Skewness	Kurtosis
DD	-0.03	0.005	0.00002	0.02	0.17
I	-0.21	0.01	0.0002	-0.02	-0.14
L	-0.29	0.06	0.004	-0.01	0.05
NX	-0.0005	0.01	0.0001	0.04	-0.13
Y	-0.07	0.01	0.0001	-0.01	0.004
C	0.15	0.01	0.0001	-0.01	0.11
N	-0.1	0.02	0.001	-0.01	0.05
W	2.87	0.06	0.004	-0.01	0.05
P	6.55	0.48	0.23	0.01	0.02
Rh	1.01	0.08	0.006	-0.02	0.11
Rf	1.11	0.04	0.002	0.02	0.11

Table 2.3: Correlations of Simulated Variables

Variables	C	DD	I	K	L	N	NX	P	Rf	W	Y
C	1	-0.86	0.51	0.24	0.8	0.8	-0.87	0.55	-0.83	0.8	0.67
DD	-0.87	1	-0.77	-0.61	-0.96	-0.96	0.8	-0.88	0.99	-0.96	-0.92
I	0.51	-0.77	1	0.95	0.9	0.9	-0.78	0.93	-0.85	0.9	0.95
K	0.24	-0.6	0.95	1	0.77	0.77	-0.54	0.89	-0.7	0.77	0.87
L	0.8	-0.96	0.9	0.77	1	1	-0.86	0.94	-0.99	1	0.98
N	0.8	-0.96	0.9	0.77	1	1	-0.86	0.94	-0.99	1	0.98
NX	-0.87	0.8	-0.78	-0.54	-0.86	-0.86	1	-0.65	0.84	-0.86	-0.79
P	0.55	-0.88	0.93	0.89	0.94	0.94	-0.65	1	-0.92	0.94	0.98
Rf	-0.83	0.99	-0.85	-0.7	-0.99	-0.99	0.84	-0.92	1	-0.99	-0.96
W	0.8	-0.96	0.9	0.77	1	1	-0.86	0.94	-0.99	1	0.98
Y	0.67	-0.92	0.95	0.87	0.98	0.98	-0.79	0.98	-0.96	0.98	1

Table 2.4: Autocorrelations of Simulated Variables

Variables	1	2	3	4	5
DD	0.73	0.48	0.3	0.17	0.09
I	0.55	0.33	0.21	0.11	0.06
L	0.63	0.41	0.26	0.14	0.07
Y	0.67	0.44	0.28	0.16	0.08
C	0.44	0.26	0.15	0.07	0.04
N	0.63	0.41	0.26	0.14	0.07
W	0.63	0.41	0.26	0.14	0.07
P	0.76	0.5	0.32	0.18	0.09
Rh	0.68	0.44	0.28	0.16	0.08
Rf	0.68	0.44	0.28	0.16	0.08

In order to have an idea about the cyclical variability of the variables, one can take a look at Table 2.2, where the moments of the simulated variables are presented. Investment exhibits a slightly higher degree of variability than output. The correlations of the simulated variables presented in Table 2.3 are the contemporaneous correlations. It can be seen that output is positively correlated with investment, consumption and labor demand, whereas it is negatively correlated with net exports. The impulse response functions given in the next section exhibit the countercyclical behavior of net exports, which is one of the key empirical regularities typical of open economies.¹⁶ Moreover, labor demand and stock of capital have high positive correlations with output. Loans and labor demand are perfectly and positively correlated with each other, which makes sense due to the fact that firms borrow loans from financial intermediaries which they then use to hire labor. Finally, autocorrelations of simulated variables, given in Table 2.4, are up to the fifth lag, with correlations decreasing for higher lags.

¹⁶See, among others, Backus et al. (1994).

2.3.3 Impulse Response Functions

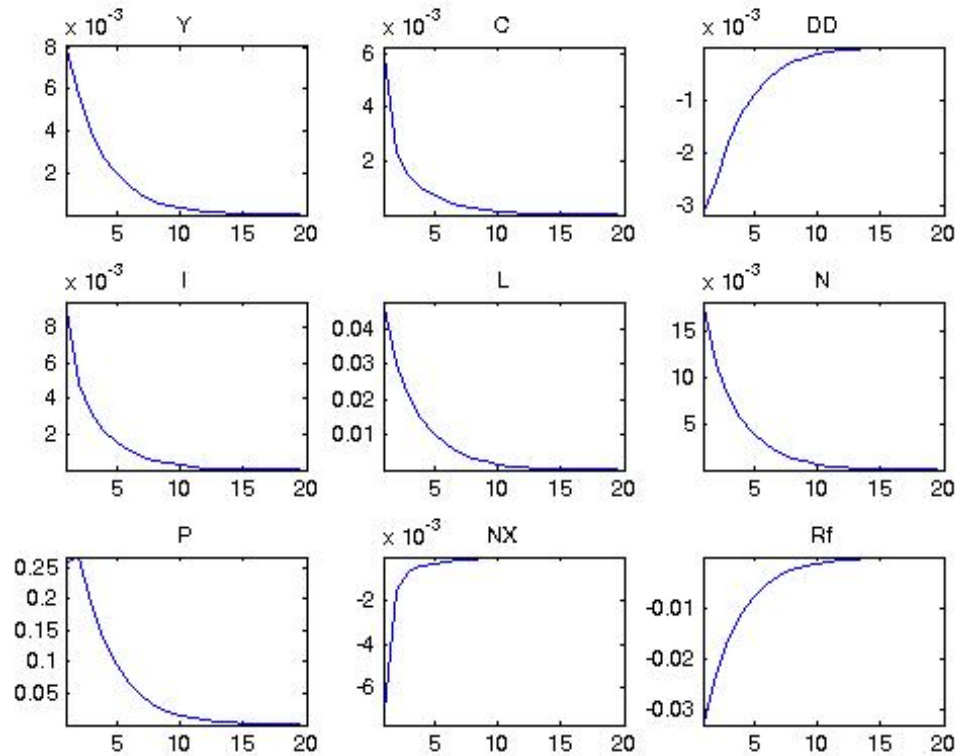


Figure 2.1: Temporary Monetary Shock

Figure 2.1 displays the impulse response functions of the variables in the model in the case of a positive, one-time, temporary money growth shock in period 1.¹⁷ The model predicts an expansion in output, consumption, investment, labor demand and loans, and a contraction in domestic deposits, net exports and domestic loan rate in response to the monetary shock. Considering the fact that the FIs use the deposits they collect plus the monetary injection to give loans to the firms and that the firms use these loans to hire labor for production, an increase in the monetary injection is expected to lead to the above-mentioned expansions in loans, labor demand and production. It can also be seen that the loan rate falls in response to the positive monetary shock, which actually constitutes the mechanism through which the loans given to the firms increase. As a result of the monetary injection, the FIs have more funds available to give loans to the firms and since they do not have any other alternative to evaluate

¹⁷The values used in the simulations that lead to the impulse responses presented here are $\psi = 0.9$, $R^* = 1.01$ and $p^H = 0.9$.

their funds, they continue supplying loans to the firms at lower rates. These results regarding the impact of increasing monetary injection on an economy with financial intermediation are consistent with those in the CIA literature.¹⁸ Moreover, higher money growth resulting in higher output is consistent with the empirical literature that shows the positive correlation between output growth and money growth.¹⁹ Last but not least, net exports exhibit countercyclical behavior as a result of the monetary shock, which might be explained by a strong income effect on imports, as in the traditional models of the current account.

¹⁸For standard CIA modelling, see, among others, Fuerst (1992) and Schorfheide (2000).

¹⁹For a more detailed analysis, see, among others, McCandless (2008).

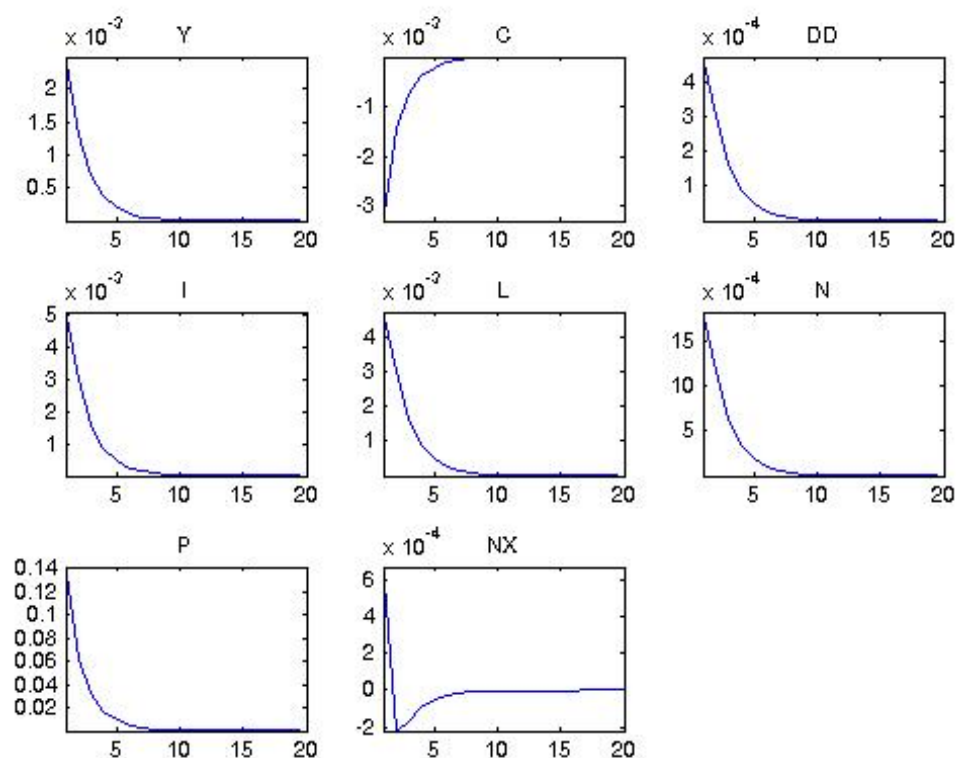


Figure 2.2: Temporary Technology Shock

The responses of the variables to a one-time, positive, temporary technology shock in period 1 are depicted in figure 2.2. It can be seen that output, investment, domestic deposits, loans, labor demand and net exports increase as a reaction to the shock while consumption exhibits contraction. The increase in investment and net exports outweighing the decrease in consumption, thereby leading to an expansion in output makes sense considering that the shock is positive. The positive correlation between savings and investment is in line with the evidence pointed out by Mendoza (1991) as one of the stylized facts for open economies under imperfect capital mobility, constituting therefore a confirmation of this argument in a monetary setting.²⁰

²⁰Mendoza (1991) also provides support for the argument presented by Obstfeld (1986) and Finn (1990) that the intensity of the comovement between savings and investment in economies with perfect capital mobility depends on the degree of persistence of the underlying technological disturbances.

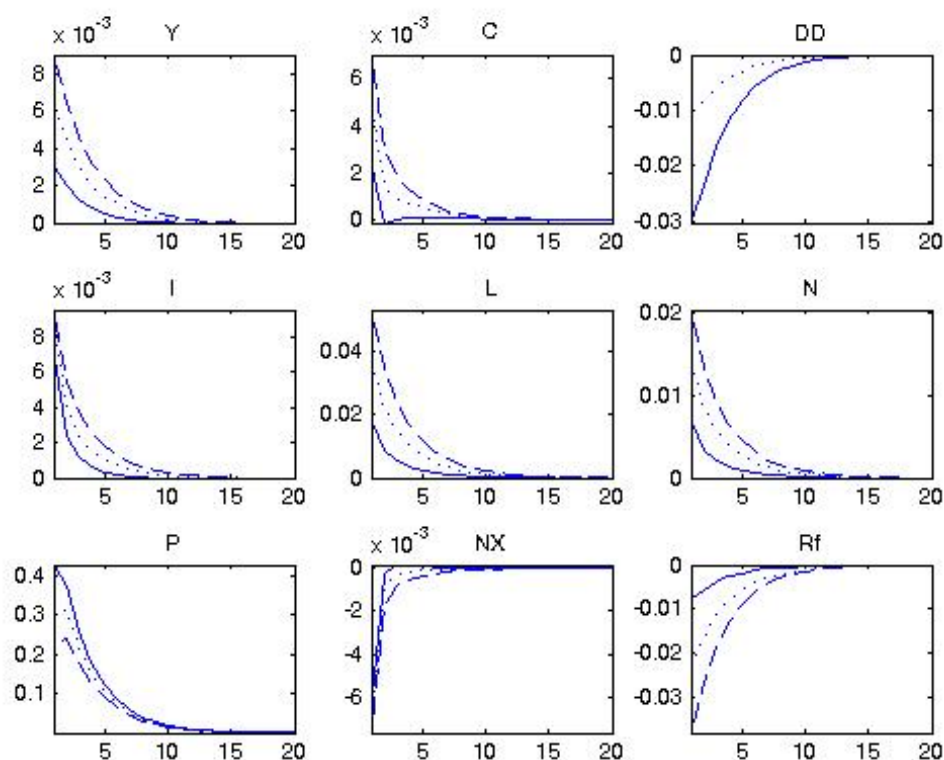


Figure 2.3: Temporary Monetary Shock with Varying Degrees of Financial Integration

Figure 2.3 shows the responses of the economy to a one-time, temporary money growth shock, under three different levels of financial integration. The straight line, the dotted line, and the dashed line represent the cases with ψ equal to 0.5, 0.75, and 0.99, respectively. It can be seen that increasing financial integration amplifies the impact of the monetary shock on output, consumption, investment, labor demand and loans whereas it diminishes that on domestic deposits and price level. The amplification effect of increasing financial integration is mainly due to the fact that the output-promoting impact of positive monetary growth is coupled with increasing access to cheaper foreign funds that enhance production through leading to a rise in loanable funds available for firms. As presented above in Figure 2.1, the loan rate falls in response to a positive monetary shock due to the increase in the amount of funds FIs have to give loans to the firms. As can be seen in Figure 2.3, increasing financial integration leads to a further decrease in the loan rate through increasing the amount of cheaper foreign funds the FIs hold.²¹

²¹Simulations with different levels of financial integration were carried out also for temporary technology shock and it was found that varying the degree of financial integration has negligible im-

2.3.4 Sensitivity Analyses

Some robustness checks regarding the results presented in the previous section are undertaken in this section. Simulations are run using varying values of several parameters in the model including those that are closely linked to the basic parameter of interest, the degree of financial integration. Equation (2.42) shows that the success probability of project "good", p^H , the interest rate on foreign deposits, R^* , and the probability of death of entrepreneurs, π , are related to one another and to the degree of financial integration, ψ . Therefore, the impulse response functions are analyzed under varying values of these parameters as well as of the parameter measuring the fraction of the capital stock to be handed over to the FIs in the case of failure of the firms' projects, μ , and of the parameter representing the private benefits of entrepreneurs from "bad" projects, PB. Below are some of the simulation experiments that yield similar results to those presented in the previous section.

plications for the impact of a temporary technology shock on the economy. Therefore, the simulation results are not presented here.

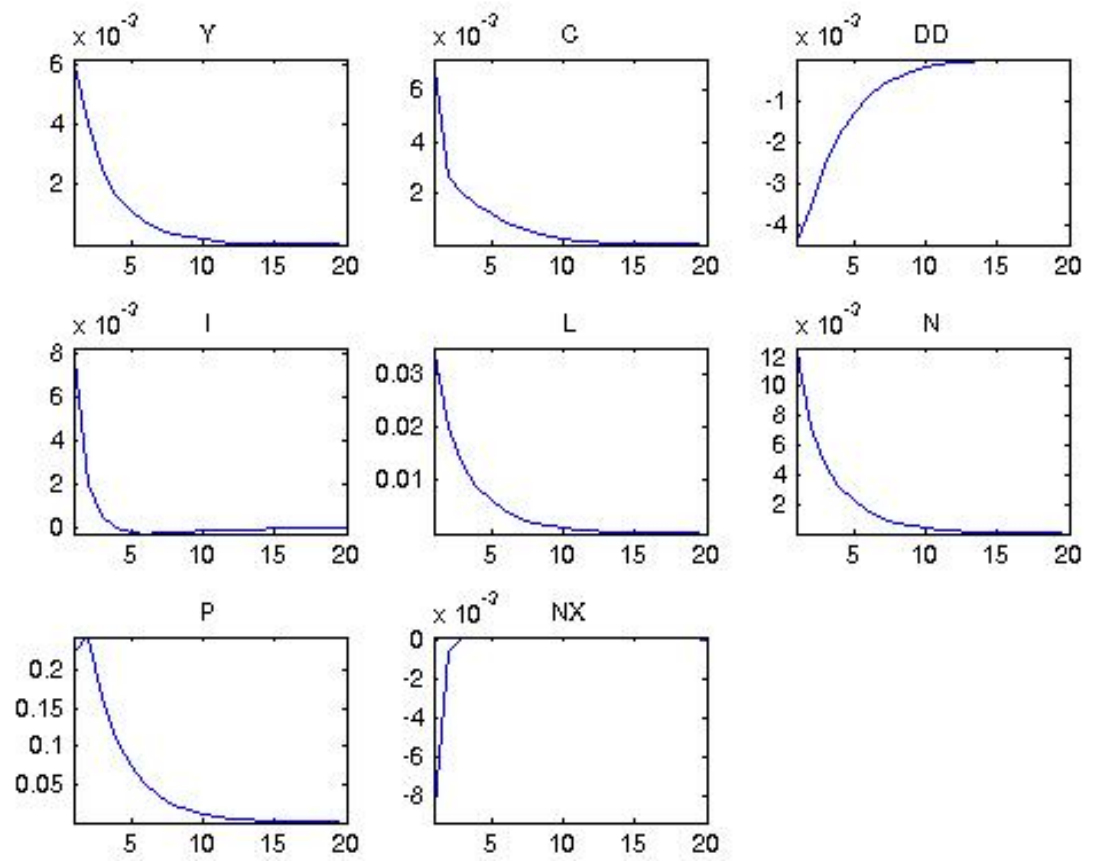


Figure 2.4: Temporary Monetary Shock with $PB = 0.4$

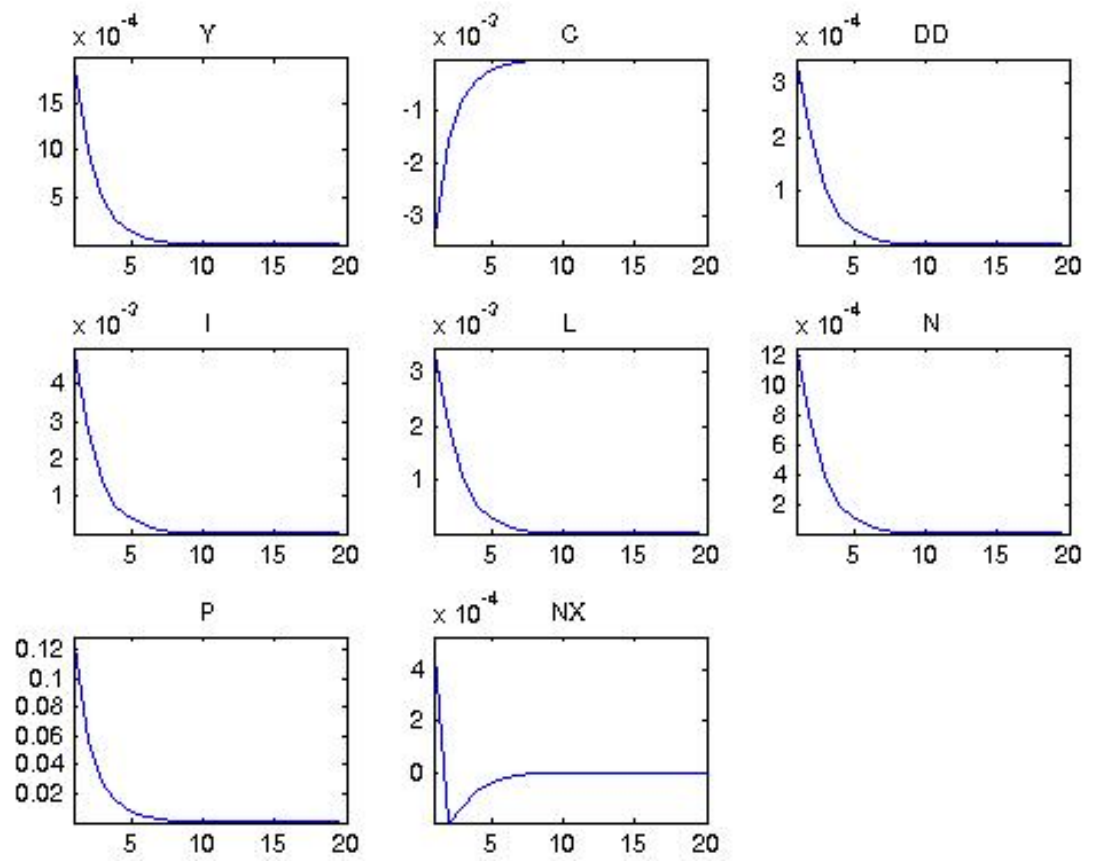


Figure 2.5: Temporary Technology Shock with $PB = 0.4$

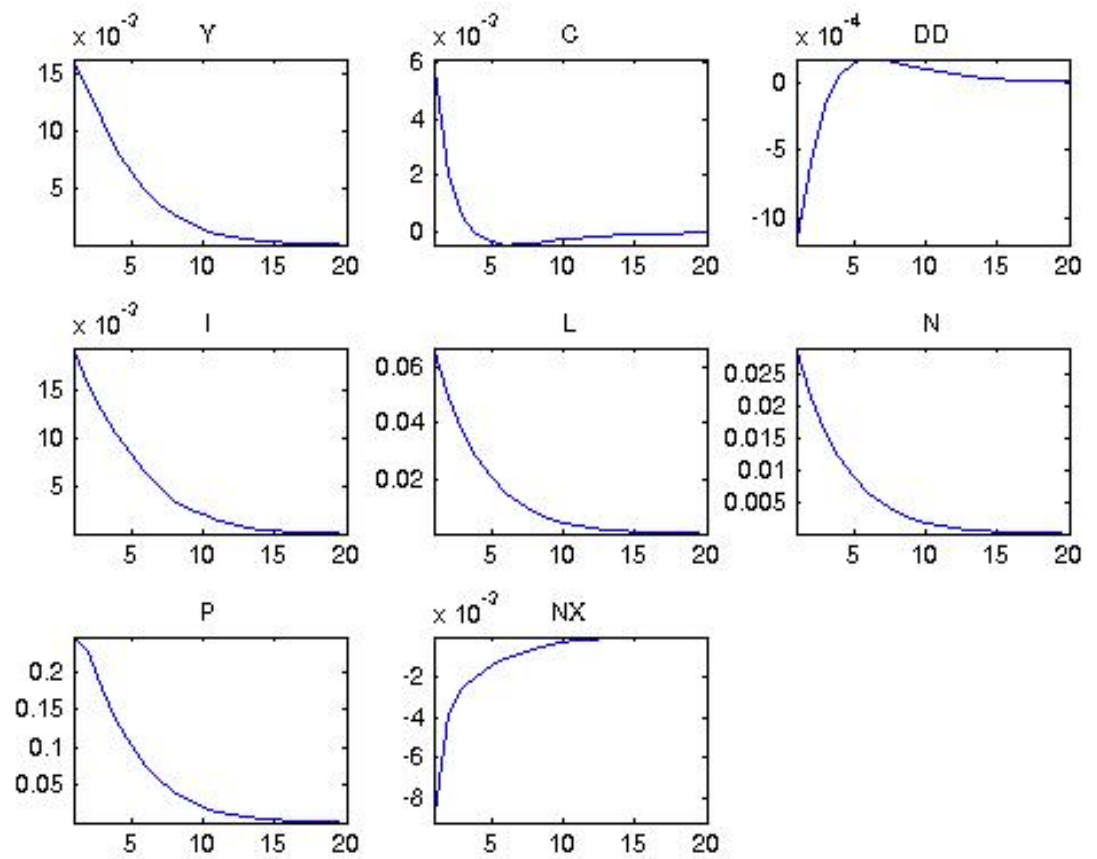


Figure 2.6: Temporary Monetary Shock with $PB = 0.3$, $\pi = 0.8$

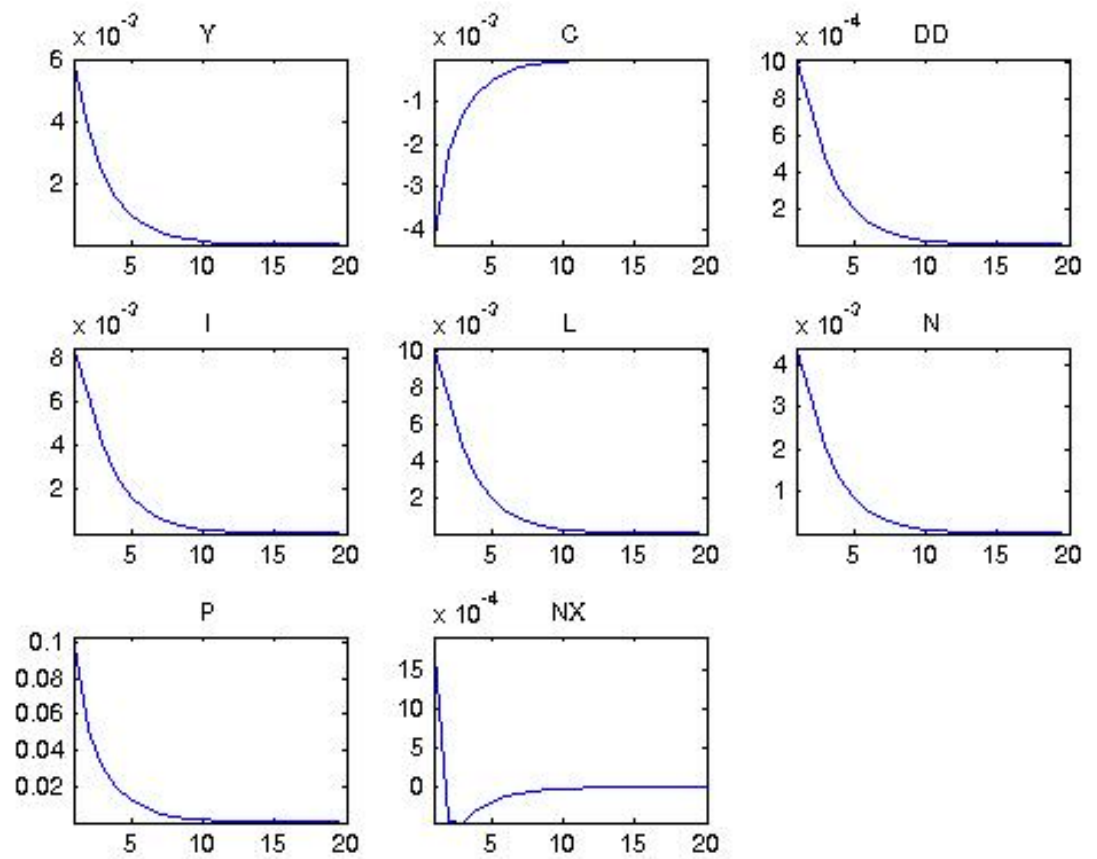


Figure 2.7: Temporary Technology Shock with $PB = 0.3$, $\pi = 0.8$

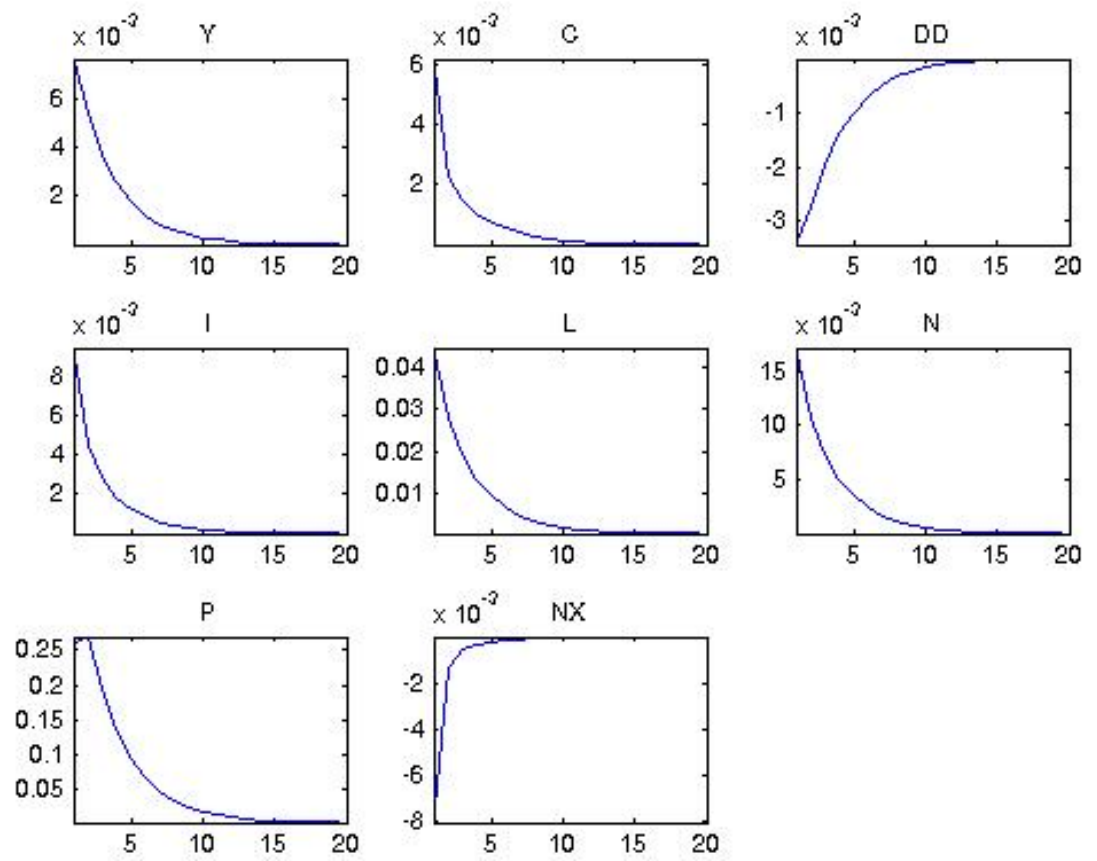


Figure 2.8: Temporary Monetary Shock with $R^* = 1.001$

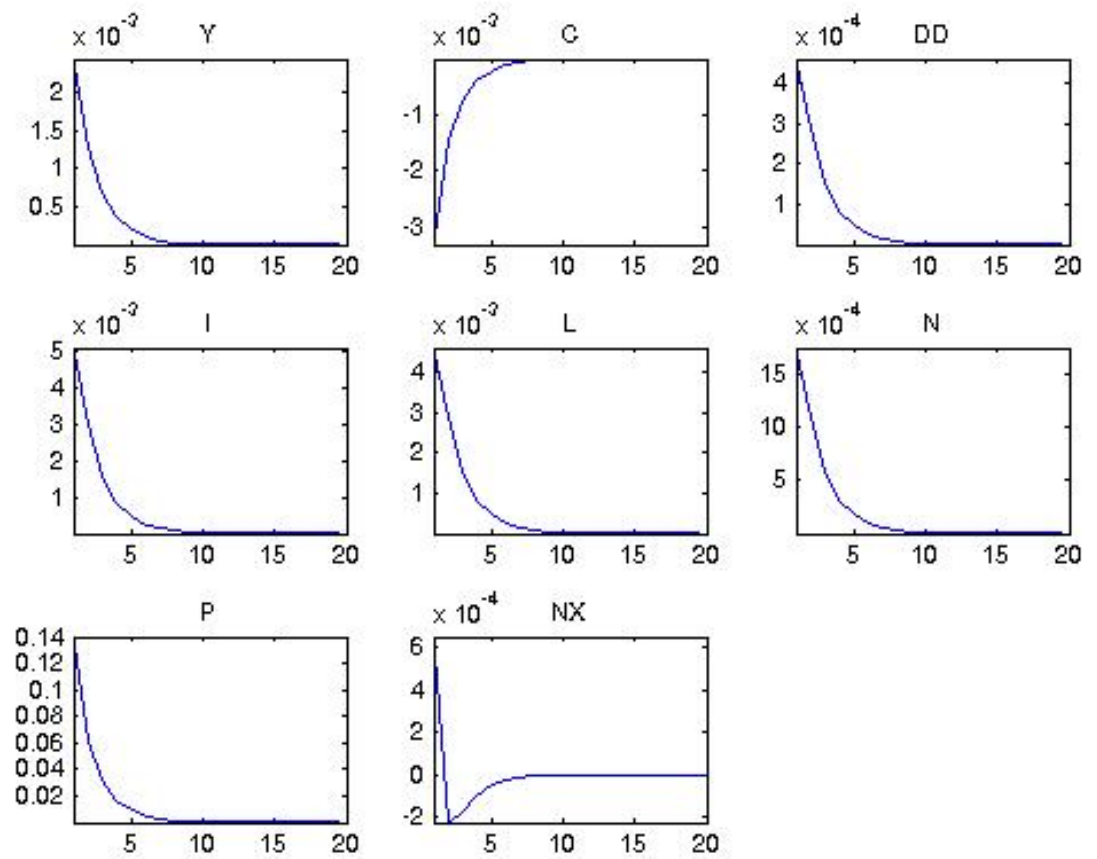


Figure 2.9: Temporary Technology Shock with $R^* = 1.001$

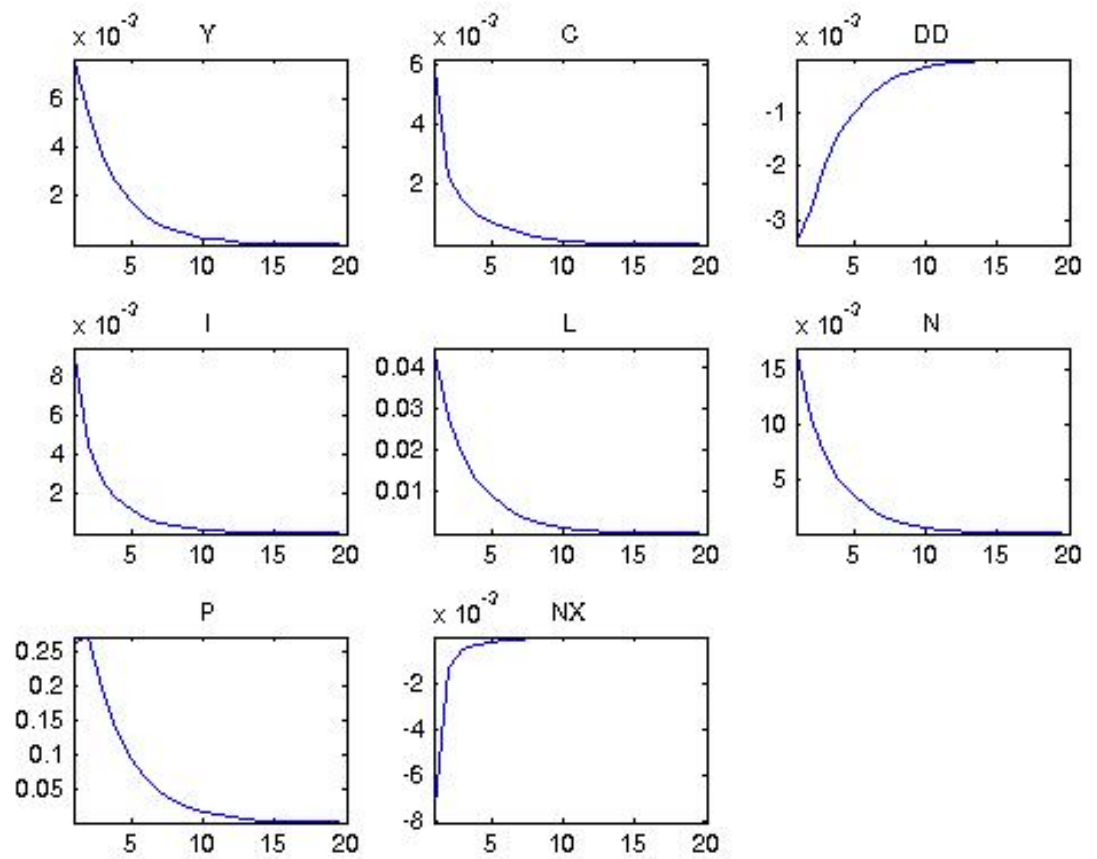


Figure 2.10: Temporary Monetary Shock with $R^* = 1.0001$

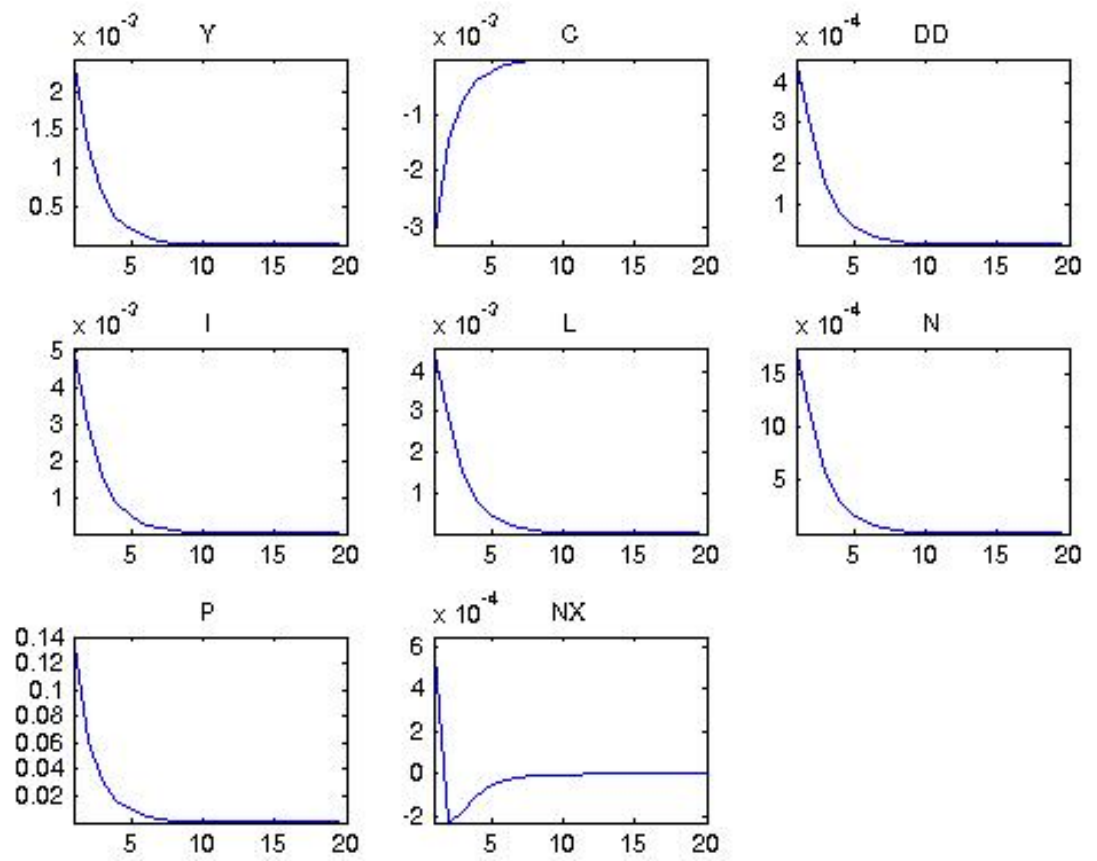


Figure 2.11: Temporary Technology Shock with $R^* = 1.0001$

2.4 Conclusion

In this chapter of the thesis, aggregate fluctuations and propagation mechanisms are analyzed under varying degrees of financial integration for a small open economy. Using a dynamic, stochastic, general equilibrium framework with financial and informational frictions and uncertainty, the implications of increasing financial integration for the impact of money growth and technology shocks on the economy are investigated. Financial frictions in the model are in the form of restrictions on the composition of deposits held by the financial intermediaries in the economy. More specifically, financial intermediaries are assumed to be able to hold no more than a certain fraction of their total deposits as foreign deposits. An increase in this fraction is interpreted as increasing financial integration. Informational asymmetries among the agents in the economy and uncertainty in the production process necessitate financial intermediation and require special attention to the design of the loan contracts between the firms and the financial intermediaries. The Holmstrom-Tirole type of uncertainty in the production process leads to collateralized borrowing by the firms, where the capital stock of the firms serves as the collateral as well as the factor of production.

Financial frictions have long been investigated in the literature in terms of their business cycle implications. Especially over the last two decades, theoretical progress as a result of the developments in economics of information and incentives made it possible to analyze asymmetries and imperfections in financial markets. The literature has focused on a wide array of issues related to financial frictions such as the way financial frictions are captured, the financial infrastructure of the economies featuring those frictions and the interaction between those frictions and other imperfections in an economy. This chapter contributes to the existing literature by proposing a new theoretical framework to examine aggregate economic activity and amplification mechanisms in the case of decreasing financial frictions (defined here as increasing financial integration), taking into account informational asymmetries and uncertainty in production.

The small-open-economy DSGE model developed here is solved and simulated in the case of one-time, temporary, positive money growth and technology shocks. The model predicts an expansion in output, consumption, investment, labor demand and loans in response to a monetary shock; whereas a technology shock leads to an increase in output, investment, domestic deposits, loans, labor demand and net exports, and a decrease in consumption. The simulation experiments with different levels of financial

integration reveal that increasing financial integration amplifies the impact of temporary monetary shocks on output, consumption, investment, labor demand and loans. The amplification effect of increasing financial integration is due to the mechanism in which the output-promoting impact of positive monetary injection is coupled with increasing access to cheaper foreign funds that enhance production through leading to a rise in loanable funds available for firms. The increase in the amount of funds available for firms due to a positive monetary injection leads to a rise in the amount of loans actually given to the firms through a fall in the loan rate, which is stimulated further by increasing financial integration that raises the volume of cheaper foreign funds held by financial intermediaries. The effect of increasing financial integration in the case of temporary technology shocks is found to be rather negligible. The sensitivity analyses undertaken for varying values of parameters of interest reveal that the results regarding the impact of temporary monetary and technology shocks on a small open economy are robust.

The model presented here confirms, in a monetary framework, the findings of the real business cycle literature on small open economies and the empirical regularities typical of open economies in terms of the procyclicality of investment and consumption, and the countercyclicality of external trade. In addition, a positive correlation between savings and investment is found in the case of technology shocks under imperfect capital mobility, which is also consistent with the results of the benchmark framework in the business cycle literature for small open economies. Analyzing the impact of monetary shocks on the economy under varying degrees of financial integration allows one to gain insights into the design of optimal monetary policy in the case of varying levels of financial integration. Moreover, the current framework might be extended further to include business cycle implications of other shocks as well as fiscal policy analyses. The following chapter of this thesis takes the first step towards that through providing a framework that includes also a government sector to analyze risk premium shocks.

Chapter 3

Risk Premium Shocks and Aggregate Fluctuations in a Small Open Economy

3.1 Introduction

The implications of default risk premiums for the business cycles in emerging economies have been investigated extensively over the last decade.¹ One strand of literature focuses on the effects of movements in domestic variables on country risk premiums and documents that risk premiums respond systematically and countercyclically to the business cycles in emerging economies.² Another line of research assumes that risk premiums are exogenous to the domestic conditions in emerging countries. Authors advocating this argument relate the risk premium and the world interest rate through some exogenous, stochastic process and attempt to partially explain aggregate volatility in small open economies with interest rate fluctuations.³ This chapter of the thesis proposes a theoretical framework incorporating financial and informational frictions as well as uncertainty to examine aggregate fluctuations in response to risk premium shocks in a small open economy.⁴ Financial frictions in the model are in the form

¹See, among others, Arellano (2008).

²See, among others, Edwards (1984), Cline (1995), Cline and Barnes (1997) and Eichengreen and Mody (2000).

³Neumeier and Perri (2001) provide evidence for the fact that interest rate shocks constitute an important factor for explaining business cycles in emerging economies.

⁴For a detailed analysis on the relationships between country risk premiums, business cycles and emerging market fundamentals, see Uribe and Yue (2006).

of restrictions on the composition of deposits held by the domestic financial intermediaries in the economy. More specifically, financial intermediaries are assumed to be able to hold no more than a certain fraction of their total deposits as foreign deposits. Informational asymmetries among the agents in the economy and uncertainty in the production process necessitate financial intermediation and require special attention to the design of the loan contracts between the lenders (financial intermediaries) and the borrowers (firms) in the economy.

In this chapter, a dynamic, stochastic, general equilibrium framework with financial and informational frictions is developed in order to analyze the impact of risk premium shocks on a small open economy. In other words, aggregate fluctuations in response to risk premium shocks are investigated. It is shown that positive, temporary risk premium shocks lead to an increase in domestic deposits, loans, nominal exchange rate, tax rate and government spending, and a decrease in consumption, output, labor supply, investment and government borrowing. There is a cash-in-advance (CIA) framework, similar to that in Nason and Cogley (1994), modified in such a way that it includes financial and informational frictions. The economy consists of households, firms, foreign lenders, financial intermediaries, the government, the central bank and the financial regulator. The government in the economy is assumed to borrow domestically from the households with an endogenous partial default risk. In order to compensate the households, that also have the options of depositing at the financial intermediaries or holding foreign bonds, for the risk involved in the government bonds, the government offers households some risk premium in addition to the international interest rate prevailing for the foreign bond holdings.

Risk premium is, by definition, relevant for emerging economies that are exposed to risks of default on debt due to their lack of adequately developed financial and macroeconomic infrastructure. Therefore, the implications of risk premium shocks for aggregate fluctuations are of special importance for emerging economies, that are also facing financial frictions. These two crucial aspects of emerging markets; namely, exposure to default risk and financial frictions, are combined in this chapter in a DSGE framework with financial intermediation.

The default risk has been modeled both exogenously and endogenously in several different frameworks in the literature. Mendoza and Yue (2008) explain output dynamics around defaults, countercyclical spreads, high debt ratios and key business cycle moments in a model with simultaneous default on public and private foreign

obligations. They attempt to propose a model that reconciles the business cycle models treating default risk exogenously and the sovereign default models treating output fluctuations exogenously. They develop a model of strategic sovereign default with endogenous output dynamics and examine its quantitative predictions.⁵ Bi and Leeper (2010) criticize the strategic default literature due to its inability to match the data. More precisely, they argue that the default frequency is predicted by this literature to be far too high and the level of debt at which default occurs far too low. They propose a dynamic stochastic general equilibrium model, where the perceived riskiness of government debt depends partly on the fiscal environment, to study the tradeoffs between short-run fiscal stimulus and long-run sustainability.

The economy analyzed in this chapter features financial frictions restricting the amount of foreign borrowing in the economy, informational asymmetries among the agents in the economy, and imperfections of the Holmstrom-Tirole (1997) type of uncertainty in the production process. Entrepreneurs that run the firms have two different project choices for production, both of which are subject to idiosyncratic risk. The projects yield positive output in the case of success and no output in the case of failure. The projects differ according to their probabilities of success and the private benefits they provide to the entrepreneurs. It is those private benefits that create incentives for the managers of the firms, inducing them to act against the interest of their creditors. The project choices of the entrepreneurs are private information, whereas the project outcomes are verifiable by the financial intermediaries. Households and foreign investors are assumed to lack the ability to verify the project outcomes. Therefore, domestic and foreign investors prefer lending to firms indirectly, through financial intermediaries, rather than directly.

Exploring the potential impact of financial frictions on aggregate fluctuations has long been a topic of interest in the literature.⁶ Financial markets and institutions have been considered to have significant effects on aggregate economic activity. Financial frictions are incorporated into the model here through the introduction of a regulation in the economy that the financial intermediaries can hold no more than a

⁵The strategic default literature has grown out of the papers by Eaton and Gersovitz (1981) and Eaton et al. (1986). This strand of literature models default on external debt as an optimal and strategic decision made by the government. See, among others, Aguiar and Gopinath (2006) for a recent study following this literature.

⁶See von Heideken (2009) for an analysis of the implications of financial frictions for business cycles in the US and the Euro Area.

certain fraction of their total deposits as foreign deposits. The parameter representing this fraction is assumed to be controlled by the financial regulator in the economy. The implications of financial frictions for the impact of risk premium shocks on a small open economy are investigated in this chapter of the thesis.

As mentioned above, a DSGE framework with financial intermediation and a government sector is developed in this chapter of the thesis in order to analyze aggregate fluctuations in the case of risk premium shocks. As far as models with financial intermediation are concerned, there is a literature following Kiyotaki and Moore (1997) designing the loan contracts between borrowers and lenders with some durable asset, like land, as collateral.⁷ In these models, lenders cannot force borrowers to repay debts unless those debts are secured. In such a context, borrowers' assets like land serve both as factors of production and as collateral for new loans. Kiyotaki and Moore (1997) employ such a framework in the dynamic equilibrium model they develop in order to analyze the transmission mechanism in the case of temporary shocks. Kiyotaki and Moore show that small, temporary shocks to technology or income distribution can generate large, persistent fluctuations in output and asset prices.⁸ Employing land as collateral, von Hagen and Zhang (2008a) investigate the welfare implications of financial liberalization in a real, small open economy and suggest that financial opening facilitates the inflow of cheap foreign funds and improves production efficiency.

The loan contracts between the firms and the financial intermediaries in the current framework must be designed in such a way that the uncertainty involved in the production process is taken into account. At this point, collateralized borrowing becomes relevant here. However, in the current framework, it is the capital stock of the firms that is offered to be used as collateral by the firms in the case of failure of their production projects. Therefore, the loan contract specifies the rate of interest on loans that is going to be valid in the case of success and the fraction of the capital stock of the firms to be handed over to the financial intermediaries in the case of failure. In this context, the output produced by the firms using capital and labor as inputs is the return of the projects in the case of success. It is assumed that there is no output in the case of failure. Due to this probability of zero output in the case of failure, firms have to use their capital stock as collateral in order to be able to borrow loans from financial intermediaries.

⁷For more information on models with financial intermediation, see Freixas and Rochet (1997).

⁸For a detailed analysis on the propagation of aggregate fluctuations, see Bernanke et al. (1996).

The structure of the rest of the chapter is as follows: Section 3.2 describes the model and presents the solution of the model that consists of the system of equations including the first-order conditions and the market-clearing conditions. The simulation of the model and the impulse response functions are given in section 3.3. Finally, concluding remarks are presented in section 3.4.

3.2 The Model

The model developed here is one of cash in advance (CIA), similar to the model employed by Nason and Cogley (1994), modified in a way so as to incorporate financial integration. All decisions are made after, and therefore completely reflect, the current period surprise change in money growth and technology. For the timing of the stock variables, like money and capital stock, "stock as of the end of the period" convention is used. For instance, M_t denotes the money stock as of the end of period t , that is to be transferred to period $t+1$, and K_t is the capital stock at the end of period t . The economy consists of households, firms, foreign lenders and financial intermediaries as the agents, and of the government, the central bank and the financial regulator as the authorities.

Infinitely lived households, that are assumed to be the owners of the financial intermediaries, maximize their utility functions that depend on consumption, C_t , and hours worked, H_t . They decide how much money to deposit at the bank, DD_t , in order to earn $R_{Ht} - 1$ of net interest, how much government bonds, GB_t , to hold at a gross interest rate of R_t^{GB} and how much foreign bonds, FB_t , to hold in return for a gross interest rate of R^* , how much to spend on consumption, and how much labor to supply to the firms. At the beginning of each period, households receive their deposits from the previous period plus the interest payment and make current-period deposits at the financial intermediary. Additionally, they receive payments from the government and the foreign bond issuers for their bond holdings from the previous period inclusive of the interest payments and decide on bond holdings for the current period. They also supply labor, earn wage income and decide how much consumption to make and how much money to transfer to the next period.

Firms are owned by entrepreneurs, who have a finite but stochastic lifetime. Every period, a certain mass of entrepreneurs receives the signal of death and leaves the economy, whereas new entrepreneurs of equal mass enter the economy next period. In the aggregate, the share of entrepreneurs in the society is constant. Entrepreneurs maximize profits, F_t , by choosing next period's capital stock, K_t , labor demand, N_t , and loans, L_t , they borrow from financial intermediaries. At the beginning of every period, the existing entrepreneurs in the economy pay back the loans they borrowed in the previous period from the financial intermediaries including the interest and borrow new loans for the current period. Entrepreneurs then use these loans to hire

labor for production. The new entrants, on the other hand, are assumed to bring along some initial wealth with which they can buy the capital stock they need for production from the financial intermediaries. There is Holmstrom-Tirole (1997) type of uncertainty in the production process. Firms have two available project choices to produce the single consumption good⁹, both of which are subject to idiosyncratic risk; namely, they yield positive return in the case of success and zero return in the case of failure. The projects differ according to their probabilities of success, with p^H in the case of project "good" and p^L in the case of project "bad". The reason why the entrepreneurs might have incentives to choose project "bad" is that it yields some private benefits, PB , to the entrepreneurs. Project "good" yields no private benefits. It is assumed that the project outcomes can be perfectly verified by the financial intermediaries, which have the exclusive technology to do so, while the project choices of the entrepreneurs are unobservable. It is this uncertainty that rationalizes the existence of financial intermediation in the economy.

Foreign lenders prefer lending through the financial intermediaries instead of directly to the firms also due to their limited familiarity with the domestic economy. They are assumed to supply funds, FD_t , infinitely elastically at a constant interest rate, R^* , that is lower than the domestic loan rate.

Financial intermediaries (FI henceforth) maximize the expected infinite horizon discounted stream of dividends, B_t , they pay to households. They receive cash deposits from households, DD_t , cash deposits from foreign investors, FD_t , and cash injection, X_t , from the central bank (which equals the net change in nominal money balances, $M_t - M_{t-1}$). The FI then use these funds to give loans to firms. According to the loan contract between the FI and the firms, the FI gain a net return of $R_{Ft} - 1$ in the case of success of the firms' projects and a certain fraction, μ , of the capital stock of the firms in the case of failure. The FI are allowed to hold no more than a certain fraction of their total deposits as foreign deposits. In other words, there is an upper limit on the fraction of the foreign deposits over total deposits to be held by the FI. At the beginning of each period, financial intermediaries receive the loans they lent to firms in the previous period inclusive of the interest payments, sell out the capital stock they hold due to the probability of failure of firms' projects, and pay back the domestic and foreign deposits they collected in the previous period together with the interest. Additionally, they accept current period deposits from households and for-

⁹The consumption good and the capital good are assumed to be identical for analytical purposes.

eign lenders and give current period loans to firms.

Finally, the government finances unproductive government purchases, G_t , through collecting taxes and issuing one-period government bonds, GB_t . It raises tax revenue through a time-varying income tax, τ_t . The government debt is denominated in foreign currency and is subject to partial default risk. More specifically, only with probability p_t^R , the government is able to repay its debt totally and with probability $1 - p_t^R$, it can pay only a certain fraction of its debt, determined by the parameter χ , back to the households. In order to compensate the households for the default risk they take, the government has to offer some risk premium in addition to the world interest rate prevailing for the foreign bond holdings of the households.

3.2.1 Households

A typical infinitely lived household maximizes an expected utility function of the form

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t [(1-\phi) \ln C_t + \phi \ln(1-H_t)] \right\}, 0 < \beta, \phi < 1 \quad (3.1)$$

where β is the discount factor, subject to the CIA constraint

$$P_t C_t \leq M_{t-1} + (1-\tau_t) W_t H_t - DD_t + R_{H,t-1} DD_{t-1} - GB_t E_t + Z_t - FB_t E_t + FB_{t-1} E_{t-1} R^* \quad (3.2)$$

where $Z_t = [p_t^R GB_{t-1} E_t R_{t-1}^{GB} + (1-p_t^R) \chi GB_{t-1} E_t R_{t-1}^{GB}]$. It is assumed that the money stock transferred from previous period, labour income, interest income on previous-period deposits net of current-period deposits, and interest income on previous-period bond holdings net of current-period bond holdings are available for consumption purchases of households. The maximization problem of households is also subject to the budget constraint

$$M_t = M_{t-1} + (1-\tau_t) W_t H_t - P_t C_t + R_{H,t-1} DD_{t-1} - DD_t + Z_t - GB_t E_t + FB_{t-1} E_{t-1} R^* - FB_t E_t + B_t \quad (3.3)$$

and to the nonnegativity constraint

$$0 \leq DD_t \quad (3.4)$$

where P_t and W_t denote the price level of the single consumption good and the nominal wage rate, respectively. B_t refers to the dividends paid to households by financial intermediaries. R_{Ht} is the gross nominal interest rate on household deposits. DD_t is denominated in domestic currency whereas GB_t is denominated in foreign currency.

3.2.2 Firms

There is a certain mass of entrepreneurs in the population that runs the firms in the economy. Each period, π percent of them dies and new entrants of an equal mass are added to the population such that the size of the population remains the same. At the micro level, this means that, with probability π , each entrepreneur receives a signal every period that he will die at the end of the period. Entrepreneurs receiving this signal consume everything that is left at the end of the period after paying back the

debt. The new entrants bring along some initial wealth with which they can obtain the capital stock they need to start production. They buy this capital stock from the financial intermediaries, which receive capital stock as repayment of loans in the case of failure of the firms' projects. Entrepreneurs, therefore, maximize profits taking into account this probability of death. There is uncertainty involved in the production process of the firm, resulting from the fact that the entrepreneur has two available projects to produce goods, both of which are subject to idiosyncratic risk. More specifically, the entrepreneur has two project choices that differ according to their probabilities of success and the private benefits they provide to the entrepreneur, and there is positive output in the case of success of the projects while there is no output in the case of failure. p^H and p^L denote the probabilities of success of the "good" and the "bad" project, respectively, where $0 < p^L < p^H < 1$. The entrepreneur gets PB amount of private benefits per capital stock if he chooses the project "bad" whereas there is no private benefit obtained from the project "good". The entrepreneur's payoffs from the projects can be summarized as follows:

In the case of "good project":

$$p^H[P_t Y_t - R_{Ft} L_t] + (1 - p^H)[0 - \mu(1 - \delta)K_{t-1}P_t]$$

In the case of "bad project":

$$p^L[P_t Y_t - R_{Ft} L_t] + (1 - p^L)[0 - \mu(1 - \delta)K_{t-1}P_t] + PBK_t P_t$$

Entrepreneurs' profits, F_t , are given as

$$F_t \leq p^H P_t Y_t - p^H \pi R_{Ft} L_t - p^H (1 - \pi) R_{F,t-1} L_{t-1} - (1 - p^H) \mu (1 - \delta) K_{t-1} P_t \quad (3.5)$$

where δ is the constant physical depreciation rate of capital. Given that the entrepreneur chooses the project "good" (which will be the case as long as the incentive constraint stated below holds), with probability p^H the firm is able to make use of the loans it borrows from the FI to hire N_t amount of labor, which it can employ together with the capital stock it has, K_{t-1} , to produce Y_t amount of output. The entrepreneur makes in this case an interest payment to the FI for the loans at the rate specified in the loan contract, R_{Ft} . In the case of failure, there is no output produced and the entrepreneur has to transfer a certain amount of its capital stock,

which it used as collateral in order to be able to borrow from the FI, to the FI. μ represents the fraction of the capital stock of the firm guaranteed in the loan contract to be handed over to the FI in the case of failure. Due to the fact that capital stock is employed in the production process and therefore subject to depreciation independent of the project outcome of the firm, it is the net-of-depreciation amount of capital stock, the fraction of which is to be handed over to the FI in the case of failure. The period t loans of the firm, L_t , and the period t wage payments, $W_t N_t$, cancel out above.

The production function of the firm is given by

$$Y_t = K_{t-1}^\alpha (A_t N_t)^{1-\alpha} \quad (3.6)$$

where A_t denotes technology, the shock process of which is a unit root with drift in the log of technology, given as

$$\ln A_t = \gamma + \ln A_{t-1} + \epsilon_{A,t}, \quad \epsilon_{A,t} \sim N(0, \sigma_A^2) \quad (3.7)$$

The capital accumulation equation is given as

$$K_t = p^H [\pi \mu (1-\delta) K_{t-1} + (1-\pi)(I_t + (1-\delta)K_{t-1})] + (1-p^H)(1-\mu)(1-\delta)K_{t-1}, \quad 0 < \delta < 1 \quad (3.8)$$

K_t is the level of physical capital to be employed in the production process at time $t+1$, determined by the entrepreneur at time t . Equation (3.8) is the capital accumulation equation at the macro level in the sense that π represents here the mass, out of a group of entrepreneurs, that dies each period, rather than the probability of death of a single entrepreneur, as in the micro sense. Therefore, the first term in the parenthesis on the right-hand side of the equation, $\pi \mu (1-\delta) K_{t-1}$, stands for the capital stock held by the new entrants at the beginning of every period (recall the assumption that an equal mass, π , of new entrepreneurs enter the economy each period so that the total size of the population remains unchanged). The second term represents the amount of capital stock accumulated by the successful entrepreneurs continuing to live and produce; the net-of-depreciation amount of capital stock of the current period, $(1-\delta)K_{t-1}$, plus the amount of investment, I_t . Investment is equal to the real profits made by the successful entrepreneurs in the economy. The last term on the right-hand side of the equation gives the amount of the capital stock of the unsuccessful entrepreneurs that cannot make positive real profits due to the fact that

there is no output in the case of failure of the firms' projects.

It might help to make the capital accumulation process more clear to rewrite the profit and the capital accumulation functions from a micro perspective such that the profit made and the capital stock accumulated are captured separately for the cases of success and failure of the projects. Let F_t^s and K_t^s (F_t^f and K_t^f) denote the profit and the capital stock, respectively, accumulated by a single entrepreneur in the case of success (failure) of the projects. Then, the profit made and the capital stock accumulated are given as

$$F_t = F_t^s p^H + F_t^f (1 - p^H) \quad (3.9)$$

and

$$K_t = K_t^s p^H (1 - \pi) + K_t^f (1 - p^H) \quad (3.10)$$

The profits made in the case of success of the projects, which are invested, and therefore transferred to the next period, by the entrepreneurs, are given by the following equation:

$$F_t^s = P_t Y_t - \pi R_{F_t} L_t - (1 - \pi) R_{F_{t-1}} L_{t-1} \quad (3.11)$$

The corresponding capital stock in the case of success of the projects is, therefore, given as

$$K_t^s = F_t^s / P_t + (1 - \delta) K_{t-1} \quad (3.12)$$

In the case of failure of the firms' projects, there is no output produced; therefore, profits are

$$F_t^f = -\mu(1 - \delta) K_{t-1} P_t \quad (3.13)$$

whereas the capital stock is given as

$$K_t^f = F_t^f / P_t + (1 - \delta) K_{t-1} = (1 - \mu)(1 - \delta) K_{t-1} \quad (3.14)$$

Plugging equations (3.12) and (3.14) into equation (3.10), the capital accumulation equation given in equation (3.8) is obtained at the micro level.

Entrepreneurs' maximization problem is subject to the constraint reflecting the fact that the firm finances its wage payments with the loans it borrows from the FI. Hence, it obeys

$$W_t N_t \leq L_t \quad (3.15)$$

Finally, there is an incentive constraint for the firm to choose the project "good":

$$P_t Y_t - R_{Ft} L_t \geq \frac{PBK_t P_t}{(p^H - p^L)} \quad (3.16)$$

As long as this constraint holds, the entrepreneur maximizes profits given in equation (3.5) that is written for the case of project "good". The incentive constraint also gives the borrowing constraint of the firm

$$R_{Ft} L_t \leq P_t Y_t - \frac{PBK_t P_t}{(p^H - p^L)} \quad (3.17)$$

from which the loan demand, L_t^d , is obtained:

$$L_t^d = \frac{P_t Y_t - \frac{PBK_t P_t}{(p^H - p^L)}}{R_{Ft}} \quad (3.18)$$

In the standard collateralized borrowing literature, the maximum amount of loans supplied to the firms by the FIs is determined according to the value of the collateral firms have. More precisely, the value of the loans the FIs supply does not exceed the value of the collateral of the firms, which is exactly what the collateral constraints imply. However, in those frameworks, the total supply of loans is often fixed (limited). Therefore, it is an optimal allocation problem of loans and assets (that are used as collateral) among agents with differing productivities. In the current framework, the total amount of loans available is determined in part stochastically, due to the fact that it is the sum of total deposits and the monetary injection the FIs hold and that the monetary injection is an exogenous stochastic process. As a result, the optimization problem here has to do with the allocation of the incoming (injected) new loans available to the FIs. In the standard CIA literature, where the total supply of loans is subject to uncertainty similar to our framework here, the allocation problem of the new loans is solved through the adjustment of the loan rate. To be more specific, as the total supply of loans increase, the loan rate falls so that the firms continue to demand the extra loans available, and the FIs continue to supply the extra loans to the firms as long as their return (the loan rate) is positive. However, in those frameworks, there is no uncertainty in the production process; therefore, there is no need

for collateralized borrowing. The major novelty of the framework in this chapter is to reconcile these two strands of literature with the motivation of analyzing aggregate fluctuations in the case of risk premium shocks for an economy with uncertainty and frictions.

For the FI to continue lending the new resources available as loans to firms, the return on the loans must be positive and greater than the return on any outside option of the FI; that is,

$$p^H R_{Ft} + (1 - p^H) \frac{\mu(1 - \delta)K_{t-1}P_{t+1}}{L_t} \geq R_{Ht} > 0 \quad (3.19)$$

where R_{Ht} represents the return on the outside option of the FI, namely, lending to other FIs.¹⁰ The parameters of the model are calibrated in such a way that the inequality holds.

The inequality also gives the loan supply, L_t^s :

$$L_t^s = \frac{(1 - p^H)\mu(1 - \delta)K_{t-1}P_{t+1}}{(R_{Ht} - p^H R_{Ft})} \quad (3.20)$$

The loan market equilibrium condition is obtained through equating the loan supply and the loan demand equations.

3.2.3 Financial Intermediaries

The objective of the FI is to maximize the expected infinite horizon discounted stream of dividends it pays to households:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^{t+1} \frac{B_t}{C_{t+1}P_{t+1}} \right\} \quad (3.21)$$

¹⁰The return on loans just has to be positive, once the assumption that FIs can lend to and borrow from one another is relaxed.

subject to first the budget constraint

$$B_t \leq [p^H \pi R_{Ft} L_t + p^H (1-\pi) R_{F,t-1} L_{t-1}] + [(1-p^H) \mu (1-\delta) K_{t-1} P_t] - R_{H,t-1} D D_{t-1} - R^* F D_{t-1} E_{t-1} \quad (3.22)$$

where $F D_t \geq 0$ is denominated in foreign currency and E_t is the nominal exchange rate (the domestic currency value of one unit of the foreign currency). Purchasing power parity (PPP) holds so that $P_t = E_t P_t^*$, with P_t^* denoting the foreign price level. P_t^* is normalized to 1; therefore, the fluctuations in the exchange rate in response to the shocks are captured by the movements in the domestic price level. The net present value of future dividends is discounted by the marginal utility of consumption due to the fact that financial intermediaries are owned by households and that an extra unit of dividend is valued by households to the extent that it enables future consumption. The monetary injection, X_t , and the total deposits at the FI in period t , D_t , are used by the FI for the period t loans, L_t ; therefore, they cancel out in the budget constraint of the FI.

X_t is the monetary injection during date t , $X_t = M_t - M_{t-1}$, defined similarly to Nason and Cogley (1994).¹¹

The exogenous stochastic process for the growth rate of the monetary injection is given as

$$\ln m_t = (1 - \rho) \ln m^* + \rho \ln m_{t-1} + \epsilon_{M,t}, \quad \epsilon_{M,t} \sim N(0, \sigma_M^2) \quad (3.23)$$

where $m_t = \frac{M_t}{M_{t-1}}$.

It is therefore an autoregressive stationary process in the growth rate of money, but an AR(2) with a unit root in the log of the level of money. This can be seen from the definition of m_t which can be rewritten as $\ln M_t = \ln M_{t-1} + \ln m_t$.

The second constraint the FI faces, namely the balance sheet constraint, requires that the liabilities of the FI are less than or equal to its assets

$$D_t + X_t \leq L_t \quad (3.24)$$

¹¹It can be seen from the households' budget constraint that X_t equals the total income of households (labor income+interest on deposits+dividends from the financial intermediaries) minus consumption, which cannot be negative since households are assumed to transfer some cash to the next period.

where $D_t = DD_t + FD_tE_t$ and $FD_tE_t = \psi D_t$, $DD_t = (1 - \psi)D_t$.

ψ represents the financial openness parameter assumed to be controlled by the financial regulator and varies between 0 and 1. Higher levels of ψ imply higher degrees of financial integration.

3.2.4 Government

The government in the economy finances unproductive government purchases denominated in the consumption good, G_t , through raising tax revenues and issuing one-period government bonds, GB_t . Tax revenues are obtained by a time-varying flat rate tax, τ_t , on labor income. Government bonds are denominated in foreign currency and government debt is subject to a partial default risk, with an endogenous default probability $1 - p_t^R$. To be more precise, probabilistically, the government might not be able to repay its debt totally. The government budget constraint is then given as

$$\tau_t W_t N_t + GB_t E_t = [p_t^R GB_{t-1} E_t R_{t-1}^{GB} + (1 - p_t^R) \chi GB_{t-1} E_t R_{t-1}^{GB}] + G_t P_t \quad (3.25)$$

where p_t^R is the probability with which the government will be able to repay its debt totally and χ denotes the percentage of the government debt to be repaid in the case of default. R_t^{GB} represents the gross nominal interest rate on government bonds, which is determined by the following equation:

$$R_t^{GB} = R^* + RP_t \quad (3.26)$$

RP_t stands for the "risk premium" that the government has to pay in addition to the world interest rate, R^* , in order to compensate the households, that also have the option of holding foreign bonds, for the risk of default on the government debt. Risk premium is determined partly by the probability of default by the government, $1 - p_t^R$, and partly by a shock to the risk premium:

$$RP_t = \frac{(1 - p_t^R)}{p_t^R} + \epsilon_{RP,t} \quad (3.27)$$

where $\epsilon_{RP,t}$ denotes the risk premium shock.

The probability of default, $1 - p_t^R$, is a function of the value of the government debt¹²:

$$(1 - p_{t+1}^R) = \frac{e^{GB_t E_t} - 1}{e^{GB_t E_t} + 1} \quad (3.28)$$

The government also follows a simple tax rule, adjusting the tax rate in response to a change in the level of government debt:

$$\frac{\tau_t}{\tau_{t-1}} = \lambda \frac{GB_t E_t}{GB_{t-1} E_{t-1}}, \quad 0 < \lambda < 1 \quad (3.29)$$

where λ might be interpreted as the tax adjustment parameter.

3.2.5 System of Equations

In a stochastic setting, the solution of the model is not a series of numbers that match a given set of equations, as in a deterministic setting. In a stochastic environment, the best thing agents can do is to specify a decision, policy or feedback rule for the future, in other words, their optimal actions contingent on each possible realization of shocks. Therefore, it is a function satisfying the model's equilibrium conditions that is being searched. The system of equations consists of the first-order conditions of the agents' optimization problems and the market-clearing conditions of the goods, labor, money and credit markets.

The first-order conditions of the household's optimization problem are given as:

$$\frac{(1 - \phi)}{C_t} = \frac{\phi P_t}{W_t(1 - H_t)} \quad (3.30)$$

from the maximization of the household's utility function with respect to consumption,

$$\frac{\beta R_{Ht}}{W_{t+1}(1 - H_{t+1})} = \frac{1}{W_t(1 - H_t)} \quad (3.31)$$

from the maximization with respect to deposits and

¹²Alternative ways have been proposed in the literature to endogenize default rates. Uribe (2006b), for instance, suggests a framework where future default rates are predicted by current and past fiscal deficits.

$$\frac{1}{W_t(1-H_t)(1-\tau_t)} = \frac{\beta[R_t^{GB} E_{t+1}(p_t^R - \frac{2e^{GB_t E_t} GB_t E_t}{(e^{GB_t E_{t+1}})^2}) + \chi R_t^{GB} E_{t+1}(1-p_t^R + \frac{2e^{GB_t E_t} GB_t E_t}{(e^{GB_t E_{t+1}})^2})]}{W_{t+1}(1-H_{t+1})(1-\tau_{t+1})} \quad (3.32)$$

from the maximization with respect to government bonds.

Combining (3.30) and (3.31) we have

$$\frac{1}{C_t P_t} = \frac{\beta R_{Ht}}{C_{t+1} P_{t+1}} \quad (3.33)$$

From the firm's optimization problem, there is the binding borrowing constraint

$$R_{Ft} L_t (p^H - p^L) = P_t Y_t (p^H - p^L) - P B K_t P_t \quad (3.34)$$

and the equilibrium condition that the marginal product of labor equals the real wage

$$K_{t-1}^\alpha (1-\alpha)(A_t N_t)^{-\alpha} A_t = \frac{W_t}{P_t} \quad (3.35)$$

that are among the equations constituting the solution of the model.

Finally, the FI maximizes its dividends with respect to deposits, which leads to the following first order condition:

$$p^H \pi R_{Ft} P_{t+2} C_{t+2} = \beta P_{t+1} C_{t+1} [(1-\psi)R_{Ht} + \psi R^* - p^H(1-\pi)R_{Ft}] \quad (3.36)$$

As stated above, all markets clear at the equilibrium. The following equations represent equilibrium in the goods, labor, money, and credit markets, respectively:

$$C_t + I_t + G_t + N X_t = Y_t \quad (3.37)$$

$$N_t = H_t \quad (3.38)$$

$$P_t C_t = M_{t-1} + X_t \quad (3.39)$$

$$D_t + X_t = L_t \quad (3.40)$$

NX_t denotes net exports, which is equal to the net interest payment on foreign borrowing minus the change in the amount of foreign borrowing in a given period. Therefore,

$$P_t NX_t = (R^* - 1)FD_{t-1}E_{t-1} - [FD_{t-1}E_{t-1} - FD_t E_t] \quad (3.41)$$

Combining (3.15), (3.30) and (3.38) gives

$$\left(\frac{\phi}{1-\phi}\right)\frac{P_t C_t}{1-N_t} = \frac{L_t}{N_t} \quad (3.42)$$

which constitutes another equation of the solution.

Finally, there is the purchasing power parity (PPP) condition

$$P_t = E_t P_t^* \quad (3.43)$$

with $P_t^* = 1$, which is used to convert the foreign currency denominated foreign deposits, foreign bond holdings and government bond holdings into domestic currency in the system of equations.

The model, however, needs to be made stationary first so that it can be linearized around the steady-state and that it returns to the steady-state after a shock. The problem of non-stationarity arises because of having stochastic trends in money and technology. In the absence of shocks, real variables grow with A_t (except N_t which is stationary since there is no population growth), nominal variables grow with M_t and prices grow with M_t/A_t . Detrending is carried out as follows (where hats above variables denote stationarity):

For real variables, $\hat{q}_t = q_t/A_t$ where $q_t = [Y_t, C_t, K_t, I_t, NX_t, G_t]$. For nominal variables, $\hat{z}_t = z_t/M_t$ where $z_t = [W_t, D_t, L_t]$. For prices, $\hat{P}_t = P_t A_t/M_{t-1}$.

The stationary system of equations is as follows:

$$(1-\phi)(1-N_t)L_t m_t = \phi P_t C_t N_t \quad (3.44)$$

$$m_t C_{t+1} P_{t+1} = \beta R_{Ht} C_t P_t \quad (3.45)$$

$$\frac{1}{W_t(1-H_t)(1-\tau_t)} = \frac{\beta[R_t^{GB}E_{t+1}(p_t^R - \frac{2e^{GB_tE_t}GB_tE_t}{(e^{GB_tE_{t+1}})^2}) + \chi R_t^{GB}E_{t+1}(1-p_t^R + \frac{2e^{GB_tE_t}GB_tE_t}{(e^{GB_tE_{t+1}})^2})]}{W_{t+1}(1-H_{t+1})(1-\tau_{t+1})m_{t+1}} \quad (3.46)$$

$$R_{Ft}L_t(p^H - p^L)m_t = P_tY_t(p^H - p^L) - PBK_tP_t \quad (3.47)$$

$$K_{t-1}^\alpha(1-\alpha)a_t^{-\alpha}N_t^{-\alpha} = W_t m_t \quad (3.48)$$

$$p^H \pi R_{Ft}P_{t+2}C_{t+2}m_{t+1} = \beta P_{t+1}C_{t+1}[(1-\psi)R_{Ht} + \psi R^* - p^H(1-\pi)R_{Ft}] \quad (3.49)$$

$$C_t + I_t + G_t + NX_t = Y_t \quad (3.50)$$

$$P_t C_t = m_t \quad (3.51)$$

$$\frac{DD_t}{(1-\psi)} + 1 - \frac{1}{m_t} = L_t \quad (3.52)$$

$$W_t N_t = L_t \quad (3.53)$$

$$Y_t = K_{t-1}^\alpha a_t^{-\alpha} N_t^{1-\alpha} \quad (3.54)$$

$$K_t a_t = p^H [\pi \mu (1-\delta) K_{t-1} + (1-\pi)(I_t a_t + (1-\delta)K_{t-1})] + (1-p^H)(1-\mu)(1-\delta)K_{t-1} \quad (3.55)$$

$$NX_t = \psi[(R^* - 1)DD_{t-1} - DD_{t-1} + DD_t m_t]/(1-\psi)P_t \quad (3.56)$$

$$\tau_t W_t N_t m_t + GB_t E_t m_t = [p_t^R GB_{t-1} E_t R_{t-1}^{GB} + (1-p_t^R)\chi GB_{t-1} E_t R_{t-1}^{GB}] + G_t P_t \quad (3.57)$$

$$\frac{\tau_t}{\tau_{t-1}} = \lambda \left(\frac{GB_t E_t}{GB_{t-1} E_{t-1}} \right) m_t \quad (3.58)$$

$$R_t^{GB} - R^* = \frac{(1 - p_t^R)}{p_t^R} + \epsilon_{RP,t} \quad (3.59)$$

$$(1 - p_{t+1}^R) = \frac{e^{GB_t E_t} - 1}{e^{GB_t E_t} + 1} \quad (3.60)$$

$$P_t = E_t \quad (3.61)$$

Given the equations (3.44)-(3.61) and the risk premium shock given in (3.27), the expected future paths of the variables $[Y_t, C_t, I_t, NX_t, P_t, DD_t, L_t, N_t, K_t, W_t, GB_t, G_t, \tau_t, p_t^R, E_t, R_{Ft}, R_{Ht}, R_t^{GB}]$, namely, the impulse response functions, conditional on temporary risk premium shocks in period 1 are obtained next.

3.3 Results

3.3.1 Simulation

The procedure of making the model stationary is followed by linearization and simulation.¹³ The model is linearized up to first order.¹⁴ The perturbation method employed to solve and to simulate the model can be summarized as follows: The solution to the system of equations obtained in the previous section is a set of equations relating variables in the current period to the past state of the system and current shocks, that satisfy the original system. These are referred to as "the policy functions". In the linearization up to first order, future shocks enter the linearized system of equations only with their first moments (which are zero in expectations); therefore, they drop out when taking expectations of the equations. This is why certainty equivalence holds in the system linearized up to first order. The (approximate) policy functions are obtained by first rewriting the system in terms of past variables, current and future shocks, and then linearizing it around the steady states. Impulse response functions are then acquired simply through iterating the policy functions starting from some initial values (given by the steady states).¹⁵

For simulations, the following values are assigned to the structural parameters of the model: $\alpha=0.32$, $\beta=0.99$, $\phi=0.76$, $\delta=0.025$, $\gamma=0.003$, $\rho=0.7$.¹⁶ The success probability of project "bad", p^L , is set equal to 0.1. The fraction of the capital stock to be used as collateral by firms, μ , is taken to be equal to 0.1, whereas the probability of death of firm managers, π , is set to 0.6. The parameter measuring the private benefits of entrepreneurs from project "bad", PB , is taken as 0.5. The fraction of the debt on

¹³The linearization and the simulation of the model are carried out using DYNARE, which is a pre-processor and a collection of MATLAB routines that have been developed to support modern macro modeling.

¹⁴In the case of linearization up to the first order, agents behave as if future shocks were equal to zero (since their expectation is null), due to certainty equivalence. In the linearization up to second order, agents make their decisions knowing that the future value of innovations are random but will have zero mean. This is not the same thing because of Jensen's inequality. For more detailed information, see DYNARE User Guide.

¹⁵The impulse response functions presented in the next section depict the responses of the variables in terms of deviations from the steady states.

¹⁶For the parameter values, Mendoza (1991), Nason and Cogley (1994) and Dib (2003) are followed. Dib (2003) employs quarterly Canadian data for the calibration and the estimation in his small-open-economy DSGE model.

which the government defaults, χ , is assigned the value 0.7. The tax adjustment parameter, λ , is calibrated to 0.99.

Three parameters are of special interest, namely, ψ -the parameter measuring the degree of financial frictions, p^H -the success probability of project "good", and R^* -the gross interest rate on foreign deposits. These parameters are interrelated through equation (3.49), which relates the loan rate, the interest rate on domestic deposits and the interest rate on foreign deposits. Simulations are run using the following sets of values for those parameters: $\psi = [0.5, 0.7, 0.9]$, $R^* = [1.01, 1.001, 1.0001]$, and $p^H = [0.7, 0.8, 0.9]$. In the next section, the impulse response functions are presented.¹⁷

¹⁷In a stochastic setup, DYNARE computes impulse response functions, by default, for one positive standard deviation of each of the shocks.

3.3.2 Impulse Response Functions

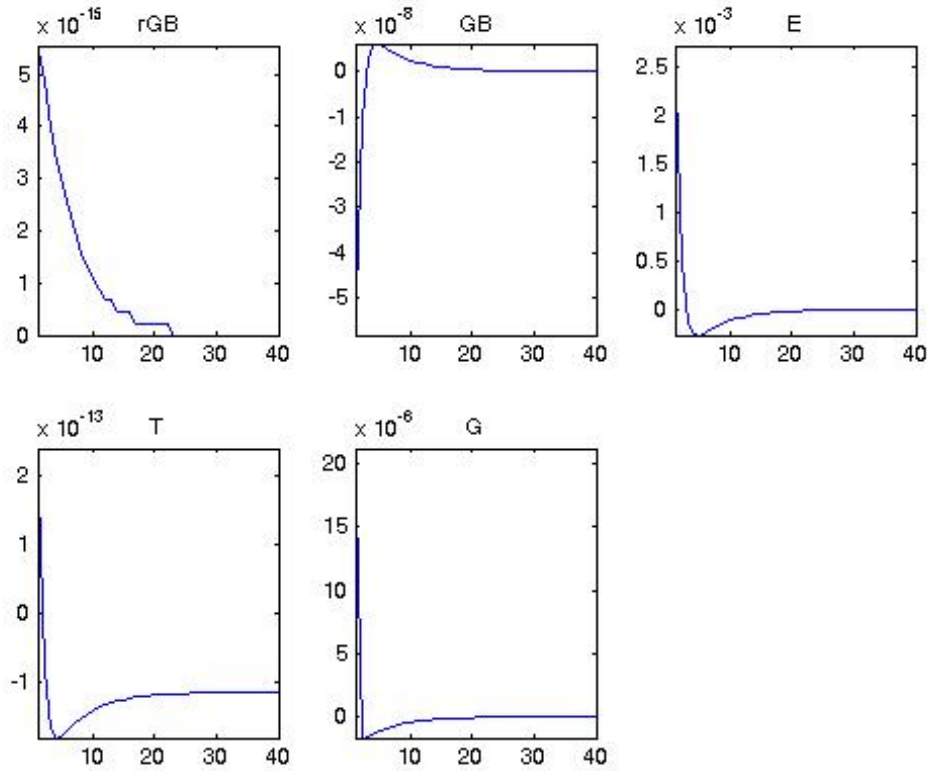


Figure 3.1: Temporary Risk Premium Shock (1/2)

Figure 3.1 displays the impulse response functions of the variables in the model in the case of a positive, one-time, temporary risk premium shock in period 1.¹⁸ The positive risk premium shock leads directly to an increase in the interest rate on government bonds, which leads to a contraction in the amount of government bonds supplied by the government. The risk premium shock also causes an increase in the nominal exchange rate; that is, a depreciation in the exchange rate. Due to the fact that the tax rate growth is proportional to the growth of the total value of the government debt, according to the simple tax rule followed by the government, the tax rate increases in response to the risk premium shock. Determined partly by the size of the exchange rate depreciation and partly by the tax adjustment parameter, the increase in the government revenue leads consequently to an expansion in government spending.

¹⁸The values used in the simulations that lead to the impulse responses presented here are $\psi = 0.9$, $R^* = 1.01$, $p^H = 0.9$ and $\lambda = 0.99$.

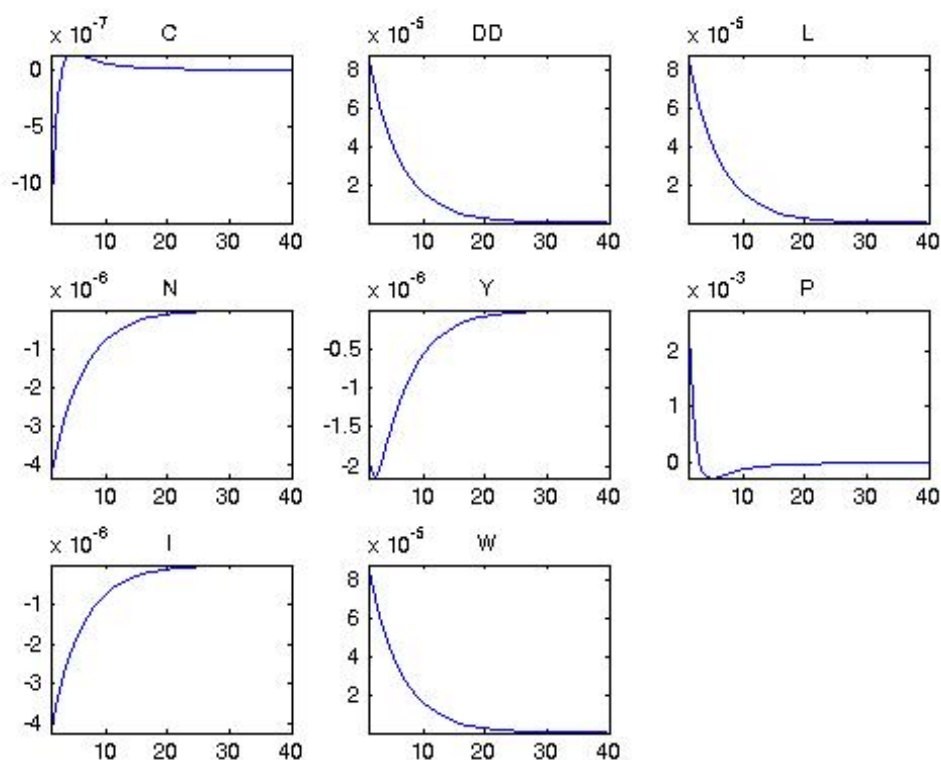


Figure 3.2: Temporary Risk Premium Shock (2/2)

In response to the rise in the price level, households reduce their consumption. Domestic deposit holdings by households, on the other hand, increase since the supply of government bonds is lower due to the higher costs of borrowing for the government. As deposits rise, so do total loans available for firms. However, the increase in the amount of loans does not consequently lead to an increase in employment, and subsequently in production, as a result of the rise in the distorting tax rate creating disincentives to work and thereby causing a fall in the labor supply. Therefore, output also falls in response to the positive risk premium shock. The fall in output and investment in the case of a positive risk premium shock confirms in a monetary framework the findings of the RBC literature for open economies.¹⁹

¹⁹See, among others, Uribe (2006a).

3.4 Conclusion

Aggregate fluctuations in the case of risk premium shocks are analyzed in this chapter of the thesis for a small open economy. The business cycle in a dynamic, stochastic, general equilibrium framework with financial and informational frictions is investigated in response to positive, temporary risk premium shocks. The risk premium arises in the model due to the existence of a government sector that borrows domestically with a partial default risk. More specifically, in order to be able to compensate the domestic households, that also have the option of holding foreign securities, for the default risk involved in the government bonds, the government offers some risk premium in addition to the international interest rate prevailing for the foreign bonds. A risk premium shock, therefore, affects the investment decisions of households in terms of relative asset holdings. It also has implications for government spending, which is supposed to be financed through domestic borrowing and taxation.

Risk premium is, by definition, an issue of relevance for emerging economies that are exposed to risks of default on debt due to their lack of adequately developed financial and macroeconomic infrastructure. Therefore, the implications of risk premium shocks for aggregate fluctuations are of special importance for emerging economies, that are also facing financial frictions. These two crucial aspects of emerging markets; namely, exposure to default risk and financial frictions, are combined in this chapter in a DSGE framework with informational frictions and uncertainty in the production process. Informational asymmetries among the agents in the economy and uncertainty in the production process necessitate financial intermediation in the economy. The Holmstrom-Tirole type of uncertainty in the production process also leads to collateralized borrowing by firms, which requires special attention to the design of the loan contracts between the firms and the financial intermediaries.

The small open economy DSGE model developed in this chapter is solved and simulated in the case of positive, one-time, temporary risk premium shocks. The model predicts an increase in the interest rate on government bonds and in the nominal exchange rate in response to the shock. The depreciation in the exchange rate increases the value of the government bonds in terms of the domestic currency, which leads to a rise in the tax rate due to the simple tax rule followed by the government. Determined partly by the size of the exchange rate depreciation and partly by the tax adjustment parameter, the increase in the amount of the tax revenue of the government, accompanied by a decrease in the government borrowing due to higher costs of repayment

for the government, leads to an increase in the government spending. In response to the rise in the price level, households reduce their consumption. Domestic deposit holdings by households, on the other hand, increase since the supply of government bonds is lower due to the higher costs of borrowing for the government. As deposits rise, so do total loans available for firms. However, the increase in the amount of loans does not consequently lead to an increase in employment, and subsequently in production, because of the fact that the rise in the distorting tax rate creates disincentives to work and thereby causes a fall in the labor supply. Therefore, output also falls in response to the positive risk premium shock.

Conclusion

Financial frictions have long been investigated in the literature in terms of their business cycle implications. Especially over the last two decades, theoretical progress as a result of the developments in economics of information and incentives made it possible to analyze asymmetries and imperfections in financial markets. The literature has focused on a wide array of issues related to financial frictions such as the way financial frictions are captured, the financial infrastructure of the economies featuring those frictions and the interaction between those frictions and other imperfections in an economy. This thesis contributes to the existing literature by proposing new theoretical frameworks to examine aggregate fluctuations in the case of technology, money growth and risk premium shocks and amplification mechanisms under decreasing financial frictions, taking into account informational asymmetries and uncertainty in the production processes.

In the first chapter of this thesis, aggregate fluctuations and propagation mechanisms under varying degrees of financial openness are analyzed for a real, small open economy. Using a dynamic, stochastic, general equilibrium framework with financial intermediation and foreign borrowing, the implications of increasing financial openness for the impact of temporary technology shocks on the economy are investigated. The chapter contributes to the literature through examining the business cycle in a small open economy with financial frictions, taking into account informational imperfections and uncertainty. Informational asymmetries among the agents in the economy and uncertainty in the production process necessitate financial intermediation and collateralized borrowing in the economy. Abstraction from money in the setup of the framework enables to concentrate on the real implications of increasing financial openness for the impact of technology shocks, business cycle implications of which have long been discussed in the literature.

The simulation experiments with different levels of financial openness reveal that increasing financial openness amplifies the impact of positive, temporary technology shocks on output, investment, consumption, labor supply and net exports. This is mainly due to the fact that the promoting effect of a positive technology shock on the economy is coupled with the improving impact of increasing financial openness on output led by increasing access to cheaper foreign funds. The model confirms the findings of the real business cycle literature on small open economies and the empirical regularities typical of open economies in terms of the procyclicality of investment and

labor supply and the countercyclicality of external trade. In addition, there is a positive correlation between savings and investment, which is in line with the empirical evidence pointed out in the business cycle literature for small open economies under imperfect capital mobility.

Sensitivity analyses carried out show that the simulation results obtained in the case of positive, temporary technology shocks are robust. Analyzing the impact of monetary shocks, as well as technology shocks, on an economy under varying degrees of financial openness might allow one to gain insights into the design of optimal monetary policy in the case of varying levels of financial openness. This might have crucial implications especially for emerging economies, for most of which the process of financial liberalization has not yet been completed. Therefore, introducing money into the real framework in Chapter 1 and thereby analyzing the policy implications of increasing financial openness for small open economies might be interesting, and hence, constitutes the motivation of Chapter 2.

The second chapter of the thesis examines the business cycle implications of increasing financial integration for a small open economy. Extending the dynamic, stochastic, general equilibrium framework with financial and informational frictions in Chapter 1 in such a way as to incorporate money into the economy, the impact of money growth and technology shocks on the aggregate economic activity is investigated under varying degrees of financial integration. Financial frictions in the model are in the form of restrictions on the composition of deposits held by the financial intermediaries in the economy. More specifically, financial intermediaries are assumed to be able to hold no more than a certain fraction of their total deposits as foreign deposits. An increase in this fraction implies decreasing financial frictions that is interpreted as increasing financial integration here. Informational frictions among the agents in the model necessitate financial intermediation in the economy. Finally, Holmstrom-Tirole type of uncertainty in the production process leads to collateralized borrowing by the firms, where the capital stock of the firms serves as the collateral as well as the factor of production.

The small open economy DSGE model developed in the second chapter of this thesis predicts an expansion in output, consumption, investment, labor demand and loans in response to a positive, temporary monetary shock; whereas a positive, temporary technology shock leads to an increase in output, investment, domestic deposits, loans, labor demand and net exports, and a decrease in consumption. The simula-

tion experiments with different levels of financial integration reveal that increasing financial integration amplifies the impact of temporary monetary shocks on output, consumption, investment, labor demand and loans. The amplification effect of increasing financial integration is due to the mechanism in which the output-promoting impact of positive monetary injection is coupled with increasing access to cheaper foreign funds that enhance production through leading to a rise in the loanable funds available for firms. The increase in the amount of funds available for firms due to a positive monetary injection leads to a rise in the amount of loans actually given to the firms through a fall in the loan rate, which is stimulated further by increasing financial integration that raises the volume of cheaper foreign funds held by financial intermediaries. The effect of increasing financial integration in the case of temporary technology shocks is found to be rather negligible. The sensitivity analyses undertaken reveal that our results regarding the impact of temporary monetary and technology shocks on a small open economy are robust.

Finally, in the third chapter of this thesis, risk premium shocks are investigated in terms of their implications for aggregate fluctuations in a small open economy. A government sector that borrows domestically with an endogenous partial default risk is incorporated into the dynamic, stochastic, general equilibrium framework in Chapter 2. The risk premium arises in the model due to the default risk, for which the domestic lenders, that also have the option of holding foreign securities, must be compensated by the government. A risk premium shock, therefore, affects the investment decisions of households in terms of relative asset holdings. It also has implications for government spending, which is supposed to be financed through domestic borrowing and taxation.

In response to a positive, temporary risk premium shock, the model developed in Chapter 3 predicts an increase in the interest rate on government bonds and in the nominal exchange rate. The depreciation in the exchange rate increases the value of the government bonds in terms of the domestic currency, which leads to a rise in the tax rate due to the simple tax rule followed by the government. Determined partly by the size of the exchange rate depreciation and partly by the tax adjustment parameter, the increase in the amount of the tax revenue of the government, accompanied by a decrease in the government borrowing due to higher costs of repayment for the government, leads to an increase in the government spending. In response to the rise in the price level, households reduce their consumption. Domestic deposit holdings by households, on the other hand, increase since the supply of government bonds is

lower. As deposits rise, so do total loans available for firms. However, the increase in the amount of loans does not consequently lead to an increase in employment, and subsequently in production, due to the rise in the distorting tax rate creating disincentives to work and thereby causing a fall in the labor supply. Therefore, output also falls in response to the positive risk premium shock.

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