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A Literature Survey

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Abstract in English

This document reviews the literature on the relationship between financial markets and the real economy. In the light of the recent financial crises, we focus on channels that are likely to be important in times of financial stress. Some of them are governed by balance sheet effects as the financial accelerator and the bank lending channel. We discuss the significance of these channels in the light of empirical evidence and try to extract their quantitative importance from the literature. Both channels seem to have played an important role in the aftermath of the crisis.Further, we discuss the role of trade finance in the collapse in world trade following the financial crisis 2007-2009. While finance is important for trade, the literature is not conclusive whether finance was also the reason for the observed collapse. Naturally, risk is important during a financial crisis. Taking a look at risk channels, we find risk also to play an important role in feedback loops between finance and the real economy. The theoretical and empirical evidence found in the literature appears to be useful in explaining the severe and long lasting effects of the recent financial crisis.

Key words: Financial crisis, finance and economic activity

JEL code: G01, E44, E37, F40

Abstract in Dutch

Dit document biedt een overzicht van de literatuur over de interactie tussen de financiële markten en de reële economie. Wij richten ons op transmissiekanalen die van belang zijn in het licht van de financiële crisis. Belangrijke kanalen, die samenhangen met de balansen van banken en bedrijven zijn de financiële accelerator en het ‘bank lending channel.’ Wij bespreken het belang van deze kanalen in het licht van de bestaande empirische kennis en we proberen het kwantitatieve belang van deze kanalen te destilleren uit de literatuur. Het blijkt dat beide kanalen een belangrijke rol hebben gespeeld in de nasleep van de financiële crisis. Hiernaast bespreken we de rol van handelskredieten bij de ineenstorting van de wereldhandel in 2008-2009 als gevolg van de crisis. Het blijkt dat weliswaar handelskredieten belangrijk zijn voor de internationale handel, maar dat het nog niet mogelijk is duidelijke conclusies te trekken over de rol die deze kredieten hebben gespeeld bij de teruggang van de wereldhandel. Rendementsrisico’s nemen sterk toe aan het begin van een financiële crisis. We bespreken de kanalen waarlangs deze risico’s de reële economie beïnvloeden. Het blijkt dat er zowel theoretische als empirische argumenten zijn waarom de toegenomen rendementsrisico’s het herstel vertragen.

Sleutelwoorden: Financiële crisis, financiële en economische activiteit

Contents

Preface

In 2009 CPB addressed the consequences of the financial crisis for the economy in the book *'De Grote Recessie'*. This book was intended for a broad readership applying the state of the art in economics in an accessible way to show how a shock on the U.S. housing market affected financial markets and the real economy around the globe. Now, one year later, the scientific community has learned from this crisis and gained further insights. We therefore want to address the question of the linkages between the economy's financial and real sector via a thorough survey of the scientific literature. We review what economists know about this relationship and focus in particular on mechanisms translating financial markets' shocks into real economic effects that are important in times of financial stress. In this document, we identify the key mechanisms, explain their theoretical concepts and discuss the empirical evidence. Whenever possible we try find quantitative estimates of the effects and we assess how the results might be used on the macro economic level to improve our analytical understanding of the economy.

The authors would like to thank the following people for valuable comments and suggestions: Michiel Bijlsma (CPB), Adam Elbourne (CPB), George Gelauff (CPB), Gabriele Galati (DNB), Ruud Okker (CPB), Bert Smid (CPB), Job Swank (DNB), Johan Verbruggen (CPB) and the participants in the project seminar at CPB.

Coen Teulings
Director

Summary

This document gives an overview of the now vast literature that deals with the relationship between financial markets and the real economy. Besides the traditional view, the literature has developed various new models that were proposed in order to get a better understanding of this interconnection. As this overview is written in response to the aftermath of the financial crisis 2007–2009, we put emphasis on economic mechanisms that are likely to be important in times of financial stress.

In a world with perfectly functioning capital markets we would rarely observe what has happened after 2007. GDP, employment and trade shrunk tremendously. This is true for major economies, the world in total and of course the Netherlands. We document the main reactions of the economy in response to the crisis in Chapter 1. However, financial markets do not function perfectly, indeed there are many market failures which might have led to what we observed. The economic literature took account of these failures and developed models that try to assess their importance for the economy. The way by which the economy is affected is termed the *transmission channel*. In Chapter 2 we introduce the channels which we investigate in this document: i. the financial accelerator, ii. the bank lending channel as well as iii. the risk channel and relate them to underlying market failures. We also stress the role of these channels for world trade.

Balance sheet effects stand at the core of two important mechanisms, the financial accelerator and the bank lending channel. This is because many financial decisions are simply based on balance sheet composition. The financial accelerator is concerned with the balance sheet of the borrower. The balance sheet reflects the worth of the borrower and an investor potentially bases her or his decision on it. This decision then influences the economic possibilities of the borrower in the future, e.g. through investments in housing, real estate or machinery. These decisions then form the balance sheet in the future. In short, a dynamic process emerges giving rise to positive and negative feedback loops. We find that the literature supports this theoretical idea. Given the empirical evidence in the literature, we can conclude that this mechanism is economically important and for certain aspects a quantification of the effect is possible. We also assess the potential for this mechanism to be implemented in CPB's macro economic models.

Not only the balance sheet of the borrower is important, but also the balance of the lender, e.g. a bank or other financial institution. It appears that bank balance sheet composition may affect bank lending activity. This can be due to either a duration mismatch effect, whereby banks experience a shortage of liquid assets, or to a capitalization effect, where bank capital falls short of bank liabilities in view of the return risk on bank assets. Monetary policy primarily affects bank liquidity. Empirical evidence based on changes in monetary policy shows that changes in bank liquidity do not have a large *independent* effect on real activity. Most of the effect of changes in liquidity supply on economic growth runs via the associated changes in interest rates.

Bank capitalization has a strong effect on bank lending and bank loan margins. As economy-wide shocks to bank capital are rare, the empirical evidence of the effects of bank capitalization on economic activity is mostly based on DSGE models. Results suggest that an economy-wide shock to bank capital has a substantial and long-lasting negative effect on economic growth.

International trade reacted extremely strong on the financial crisis. For a small open economy like the Netherlands, this effect is very important. Looking at the literature on the potential causes for this drop in trade, a mixed picture emerges. Finance plays an important role in trade and comes in many facets, i.e. letters of credit, factoring, lending and trade insurances to name the most important. Some studies come to the conclusion that finance was a considerable problem in the aftermath of the crisis, others conclude that the reasons were different. Demand effects concentrated on goods that are heavily traded, such as equipment, might also be important. Recent evidence points into the direction that trade insurances play a major role in times of financial stress. However, also the above balance sheet effects might be important. Given the results in the literature, we are not able to precisely judge the significance of finance for trade nor are we able to quantify its impact on a macro economic level. We think that further research has to be done here, especially given the importance of trade for the Netherlands.

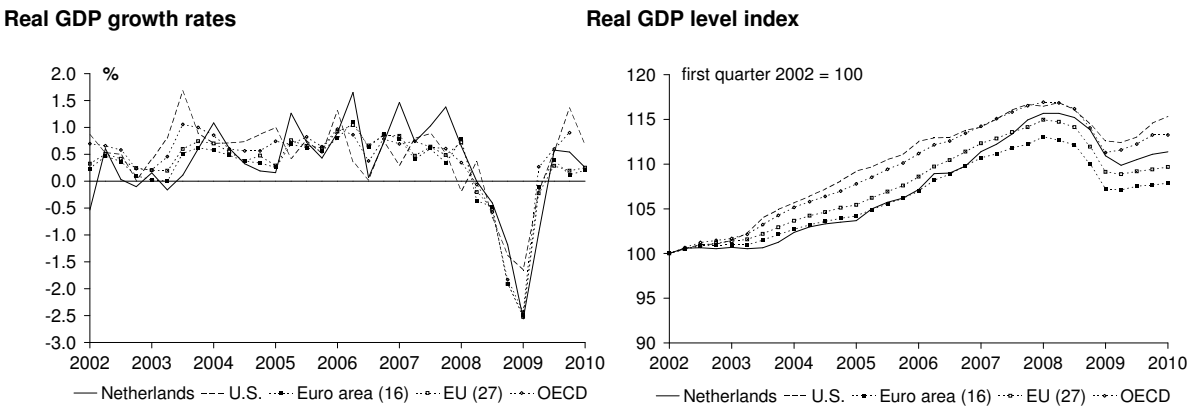
In times of crisis, risk is a major concern to actors on financial markets. Financial crises boost investment return risk and risk premia. Households and firms alike react to an increase in uncertainty by postponing expenditures. This creates a positive feedback loop that intensifies the downturn. The macroeconomic effects of a financial crisis therefore depend in part on the strength of the precautionary saving motive on the part of households and firms, and on the option value of investment on the part of firms. Existing empirical research indicates that both types of effects may be substantial. However, to take account of them considerable further empirical research would be necessary to quantify effects on the macro economic level.

We conclude the document by noting that the dynamic structure of the financial accelerator and the bank lending channel provide theoretically and empirically valuable insights. These insights are in accordance with empirical observations on the economic impact of the crisis and the long period of recovery. Feedback loops implied by the risk channel work in general in the same direction. Furthermore, we asses and discuss possible directions for future research and implementation possibilities regarding the above mechanisms in macro economic modelling strategies.

1 Introduction

The financial crisis that started in 2007 in the U.S. subprime market spread to the real side of the global economy in the second half of 2008. By early 2009, world production was down by 1%, and world trade by 13%. In comparison with 'normal' international business cycle fluctuations, this drop in real activity is both large and strongly synchronized. The natural question to ask is then what is so special about financial crises that causes these large disruptions in economic activity? In this paper, we survey the literature dealing with the transmission channels from the financial to the real sector of the economy in an attempt to find part of an answer to this question.

Figure 1.1 Gross domestic product (GDP)



Left panel: OECD.Stat quarterly national accounts. Quarterly growth rate of real GDP, seasonally adjusted.
Right panel: Real GDP level index computed from growth rates left panel.

From the literature,[1] a number of general characteristics emerge. First, economic slowdowns and recessions following a period of financial stress are more severe than normal ones and last longer, with a cumulative deficit in GDP till recovery of about 4½% as against 2%.

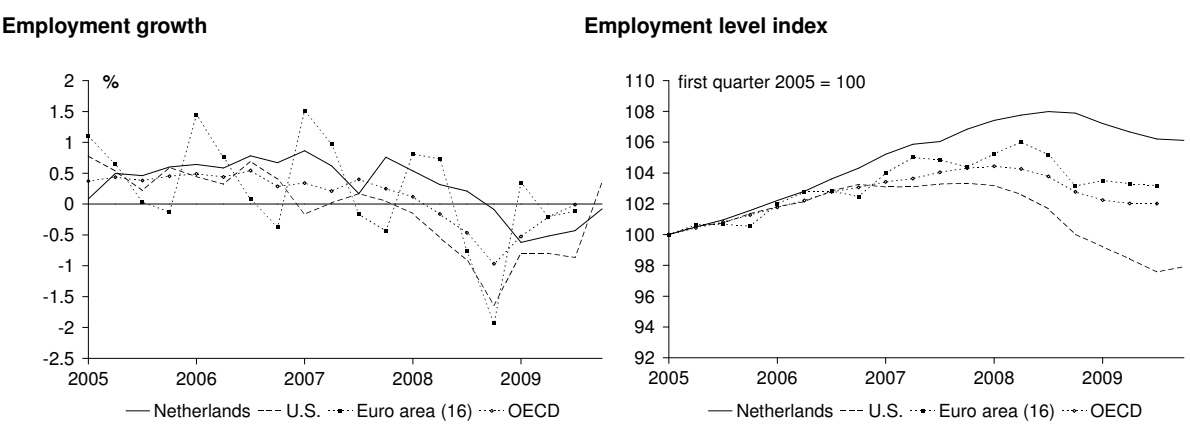
In addition, the recovery after a recession is often not complete, leading to a *permanent* output loss, compared to the original trend growth path. However, only about 50% of all episodes of financial stress are followed by a downturn. The risk of a downturn is larger after a banking crisis (as opposed to a currency crisis), following strong liquidity growth and in the presence of substantial debt in the private sector.

The response of key economic variables in the wake of a financial crisis differs. GDP growth start to recover after about two years, but unemployment stays above normal for about four years. Asset prices (common stock, house prices) show a peak-to-trough length of about 3½ years. Investment falls a lot more in response to a financial crisis than in other recessions, and

[1] See e.g. Cerra and Saxena (2008); Reinhart and Rogoff (2008); IMF (2008); Reinhart and Rogoff (2009); Van Ewijk and Teulings (2009); Allen et al. (2009); Laeven and Valencia (2010)

consumption growth also slows down more substantially. This stronger response of real expenditure coincides with a stronger fall in real interest rates.

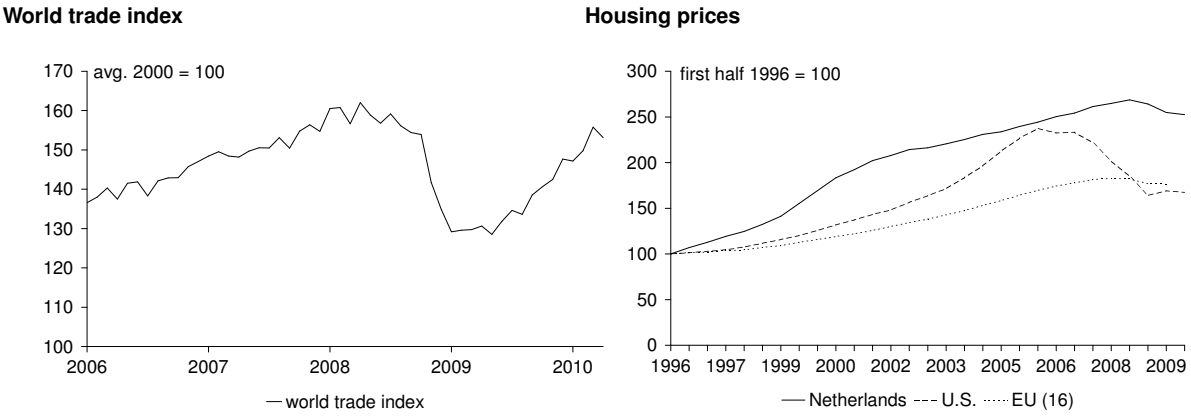
Figure 1.2 Employment



Left panel: OECD.Stat. Civilian employment including self employed. Quarterly growth rate of employment , seasonally adjusted.
Right panel: Employment level index computed from growth rates left panel.

To set the stage for this paper, it is interesting to take stock of the development of worldwide economic activity in the aftermath of the crisis of 2007/08, in an attempt to see whether the current crisis conforms to the characteristics of financial crises in general. The financial crisis started to have a serious impact on economic activity by mid 2008.

Figure 1.3 World trade and house prices



Left panel: CPB World trade merchandise goods volume index (2000=100).
Right panel: U.S.: Standard & Poor's/Case-Shiller Home Price Index U.S. national values. EU: European Central Bank, Euro-area (16 countries) residential property prices for new and existing dwellings, NL: Central Bureau voor de Statistiek, CBS Statline, price index existing dwellings.

The left panel in Figure 1.1 shows that on average the recession lasted five quarters, from Q2 2008 till Q2 2009. The impact on the level of GDP is obviously longer lasting as can be seen from the right panel in Figure 1.1. World trade started to fall a bit later than production, but the

decline was much steeper (left panel Figure 1.3). Still, the volume of world trade is (almost) back to the level before the start of the crisis, whereas the *level* of production is still substantially below pre-crisis levels in most countries surveyed here. The development of employment over the crisis is different yet again. The left panel in Figure 1.2 shows that employment started to decline one quarter later than production, in Q2 2008, but then stays negative at least until Q1 2010, about four quarter after the end of the recession. The impact on the level of employment is as in case of GDP longer lasting which can be seen in the right panel of Figure 1.2. What is striking here is that The Netherlands have not been hit as strong as other countries.

Both the size of the initial shock and the subsequent recovery appear to agree reasonably well with the stylised facts outlined above. The recession ended after about a year, a duration twice as long as a normal recession for the U.S., but nothing out of the ordinary for the EU (Artis et al., 2004). Employment is still going down in Q1 of 2010, but may reach its trough by the end of 2010, which would indeed match the average length of 3½years. Housing price decline in the U.S. appears to have stabilized, but housing prices in the EU are still under pressure (right panel in Figure 1.3). A special feature of the current crisis is the large fall in world trade, an issue that we shall come back to in Chapter 5 below.

2 Transmission Channels

In a world of perfect and complete financial markets, the channels through which financial shocks affect the real economy are interest rates and exchange rates, i.e. price channels. However, in such a (semi-) perfect world banks have no independent role and banking crises do not occur. In a financial crisis, non-price mechanisms play an important role. In the next few chapters, we review the theoretical structure of and empirical evidence on a number of non-price transmission channels of financial shocks.[2]

Financial transmission channels have been a subject of intense research at least since the Great Depression. According to Fisher (1933), the severity of the Great Depression was in large part caused by excessive leverage before the crash and deflation afterwards. The causal chain of events listed by Fisher contains many items that also appear in the current discussion, e.g. fire sales, bank runs, credit rationing, and precautionary saving.

Keynes (1936) took a different line to the analysis of the Great Depression by focusing on the money supply, rather than on credit channels, and the state of investor confidence. This view was elaborated on in Friedman and Schwartz (1963), who argued that the money supply had been a key determinant of output during the Great Depression. Monetary contraction led to deflation and high real interest rates at the same time when effective demand was low due to a lack of investor confidence.

The monetarist view of Friedman and others concentrates on the supply of money or, more generally, *loanable funds*. It holds that for the transmission of financial shocks, bank portfolio composition does not matter, because borrowers can easily issue bonds or commercial paper themselves. In this view, the only net role of banks is *money creation*, and monetary policy only affects the total amount of credit, or loanable funds, by means of its effect on the rate of interest.

2.1 The Monetarist Transmission Channel

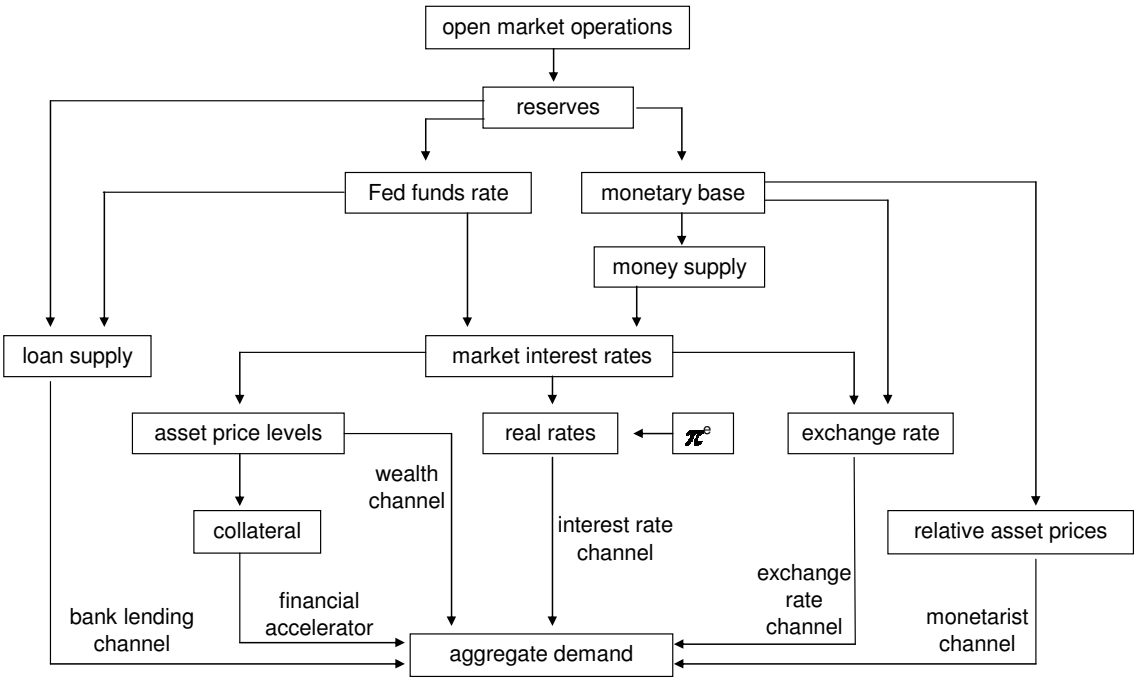
It will prove useful to first review the standard monetarist transmission channel. In any case, the most frequent type of financial shocks are monetary policy shocks, and most empirical information about financial transmission channels is based on the effects of changes in monetary policy. Figure 2.1[3] displays a flow diagram of the main transmission channels of monetary policy.

An open market operation by the central bank, e.g. monetary tightening by selling government securities, affects the reserves of the banking sector and the money supply. As banks have less liquidity, they may reduce bank loans (the bank lending channel). To induce the private

[2] Gertler (1988) surveys the literature up to 1987, Walsh (2003) and Freixas and Rochet (2008) offer a discussion of recent research.

[3] After Kuttner and Mosser (2002)

Figure 2.1 Monetary policy transmission channels



sector to hold the extra securities, interest rates rise.[4] This sets in motion the interest rate channel.[5] Private agents invest less since the opportunity costs for the invested capital increase. This applies first and foremost to firms that might lower investments into e.g. production facilities, which lowers their future output. However, consumer spending is affected too, notably regarding consumer durables and housing. The fall in private sector spending then boosts the saving rate, which acts as a stabilizing feedback towards further interest rate increases. In principle, shocks that affect long term real interest rates should have a larger impact, as these rates are the most relevant ones for large and long-lasting decisions. The real effects of such a financial shock are a reduction in current and future output and a lower demand for consumer durables.

Exchange rates constitute an important supplementary price channel of monetary transmission. A rise in interest rates generally leads to capital inflows and an appreciation of the domestic currency. As a result, net exports fall, with a similar effect on real activity as that of the interest rate channel, as indicated in Figure 2.1. The exchange rate channel is mainly of *independent* importance in currency crises, which are outside the scope of this paper (see e.g. Sachs et al., 1996, for a survey). Other potentially important feedback loops, that are not displayed in Figure 2.1, may arise via policy intervention, e.g. policy measures to counteract the

[4] US monetary policy nowadays aims at maintaining a stable Federal Funds rate by means of open market operations, not at a target level of money supply.

[5] For a detailed overview of this channel see e.g. Taylor (1995).

destabilizing effects of some of the transmission channels (see e.g. Cecchetti et al., 2000; Bernanke and Gertler, 2001; Kannan et al., 2009). Policy issues are not dealt with in this paper.

The monetarist emphasis on the interest rate channel does not deny the existence of other channels. Indeed, interest rate changes affect desired portfolio holdings and the market value of assets, including equity. Changes in asset values act on the balance sheets of banks, non-financial firms and households. A fall in asset prices lowers the net worth of households and firms, and reduces the value of their collateral. This activates both the 'financial accelerator' and the wealth channel, to be discussed in Chapter 3 below.[6] Asset price changes also affect the net worth of banks. Chapter 4 discusses how this affects banks' loan supply and triggers the bank lending channel, or more specifically, the bank capital channel. However, within the monetarist view the financial accelerator and the bank capital channel are really only subchannels of the interest rate channel, triggered by interest rate movements.

2.2 Credit Channels

The monetarist view of real/financial interaction went on virtually unchallenged for about two decades, until Mishkin (1978) and Bernanke (1983) showed that monetary factors alone were insufficient to explain the depth and duration of the Great Depression and that financial factors, notably bank lending, had an independent effect in addition to the money supply.

Bernanke and Gertler (1995) identify three puzzles that the monetarist view cannot solve, and that point to the existence of other channels:

1. Following a monetary policy shock, the real side of the economy reacts substantially, while the size of interest rate effects is rather modest. To match these effects, interest rate elasticities for saving and investment should be much larger than what is empirically plausible.
2. The timing of the response paths of variables following a monetary policy shock shows that some real variables only start to move when interest rates are back to base value. This suggest the presence of substantial non-price effects.
3. The composition of the real expenditure response is also at odds with a purely monetarist interpretation. A policy shock mainly affects short-term rates, while on the expenditure side the main response is from real estate investment.

Bernanke and Gertler argue that these puzzles provide evidence for the existence of a credit channel of monetary policy besides the interest rate channel, to be subdivided into a bank lending channel and a financial accelerator (balance sheet channel in their terminology).

[6] Business cycle fluctuations are a common trigger of the financial accelerator: at the start of a recession asset prices fall, firm net worth drops and bank credit is curtailed.

The puzzles of Bernanke and Gertler indicate that the interest rate channel cannot provide the full story, but they do not deny the importance of the interest rate transmission channel. In fact, the monetarist view could remain dominant for so long because the interest rate channel is in any case a prominent channel of financial transmission, even if the presence of other channels can be demonstrated. In an extensive empirical study covering most EU countries, Angeloni et al. (2002) find that neither the Interest Rate Channel (IRC), nor a broader financial transmission channel appears to be dominant. However, the IRC is prominent throughout the EU, and *is* dominant in a subset of countries. Van Aarle et al. (2003) also find substantial diversity in the effects of monetary policy between EU countries.[7]

2.3 The Transmission of Asset Market Shocks

In a financial crisis, the relevant shocks are not open market operations, but (large) changes in asset prices. These shocks act directly on the balance sheet of private agents, bypassing the interest rate channel. In comparison with the effect of open market operations, asset price changes in a crisis are much larger. The annual standard deviation of stock market prices is about 15% (Campbell, 2003) and an economic crisis on average implies a fall in asset prices of 30% (Barro and Ursúa, 2008). In contrast, a typical policy intervention by the Central Bank changes interest rates by about 25 basis points and, if unexpected, causes a stock price change of 1.2%–1.7% (Rigobon and Sack, 2004; Bernanke and Kuttner, 2005). Still, the main wealth effect of monetary policy is via equity prices, not bond prices (Craine and Martin, 2003).

Compared to financial crises, monetary policy has only a second-order effect on asset prices and private agent's portfolios.[8] Hence, the relative importance of the interest rate channel and the credit channels changes substantially in a financial crisis. The types of shocks that we are concerned with in this paper primarily act through the balance sheets of agents, viz. the financial accelerator via the balance sheet of non-financial firms and households and the bank capital channel via the balance sheet of commercial banks. These channels are displayed in the lower left half of Figure 2.1. We shall also discuss the effects of relative asset price changes, notably risk premia, which are represented by the monetarist channel in the lower right of Figure 2.1.

[7] A related issue is whether the relative importance of different transmission channels has shifted over time. For the U.S., there is evidence that the effect of monetary policy shocks has declined in the last two decades (Kuttner and Mosser, 2002; Boivin and Giannoni, 2006; Boivin et al., 2010). Kuttner and Mosser distinguish three main reasons why monetary policy transmission channels may have changed, financial innovations (e.g. securitization), changes in monetary policy conduct, and structural changes in the non-financial sectors. Boivin et al. (2010) conclude that changes in the monetary transmission mechanism were mainly due to changes in policy rules and related changes in expectations of the private sector.

[8] Mishkin (2001) gives an overview of the effect of monetary policy via asset prices other than interest rates.

2.4 An Outline of the Document

In the next two chapters we discuss the *credit view* of financial transmission. This view focuses on the role played by financial assets and liabilities in the transmission of financial shocks. It expresses the idea that it is not just the total amount of loanable funds that matters for the supply of credit, but also the balance sheet composition of the agents involved. In this view, balance sheet composition matters because there is asymmetric information between borrowers and lenders, which creates a market incompleteness that is partly resolved through quantity adjustments. Knowledge of market prices alone is not sufficient to determine allocations. We distinguish between balance sheet effects for non-financial firms and households, which are discussed in Chapter 3, and balance sheet effects for banks in Chapter 4. Bank lending is also important to finance trade. In Chapter 5 we discuss the specifics of trade finance and the possible role of a credit channel in the collapse of world trade in the fall of 2008.

Not all effects of a financial crisis operate through the balance sheet of private agents, however. Chapter 6 discusses how a financial crisis affects expected asset return risk. This affects *relative* asset prices and interest rates, and activates the monetarist channel.

Table 2.1 gives a summary view of the relation between various market failures and the transmission channels to be discussed below.

Table 2.1 Market failures and finance

Type	Chapter
Moral hazard (borrowers), (partly) non-enforceable contracts, imperfect information	Financial accelerator (Chapter 3)
Moral hazard (lenders), monitoring, financial intermediation, customer markets	Bank lending (Chapter 4)
Moral hazard (borrowers), (partly) non-enforceable contracts, imperfect information, adverse selection, incomplete markets	Trade and finance (Chapter 5)
Volatility as a risk factor, incomplete markets, risk panics, precautionary behaviour	Risk channels (Chapter 6)

3 The Financial Accelerator

Since the financial crisis 2007-2009, the financial accelerator has gained increasing attention in the literature. Its basic mechanism builds on two influential contributions. First, there is the widely cited paper by Bernanke et al. (1996) which provided the term 'financial accelerator', and second and equally important, the model of Kiyotaki and Moore (1997) which develops the mechanism within a more complete model environment. Basically, both contributions stress the effects of credit constraints and credit collateral for the real economy propagated through an amplification mechanism in the sense of a feedback loop[9].

As the term 'accelerator' already suggests, the mechanism at work aims at explaining large effects that are caused by maybe minor shocks or events. The term 'financial' has been set in front of it since we are concerned with the balance sheet of investors. This has been emphasized by Bernanke (2007): '[t]his 'financial accelerator' effect applies in principle to any shock that affects borrower balance sheets or cash flows.' Thus, it is a mechanism that amplifies shocks through taking account of a borrower's financial situation determined by accounting and book keeping rules.

This chapter will first look at the theory behind the financial accelerator to provide its economic intuition. As we will see, the theory provides us with rather straightforward results. However, even though theory might be suggestive, it is only useful if the effects expected are economically significant and observable. The second section therefore looks at the available empirical evidence and at macroeconomic models that are guided empirically, i.e. DSGE models, and their success in explaining economic development. Finally, we discuss the findings and try to draw conclusions from the reviewed literature with respect to CPB macro economic models.

3.1 Theoretical Arguments

The key theoretical contributions that gave rise to the literature on the financial accelerator are briefly summarized in Bijlsma et al. (2010). However, at this point we would like to go a bit deeper into the details of the mechanism and elaborate more on its functioning. The necessary and most important ingredient for the mechanism of the financial accelerator to work is the prevalence of credit constraints tied to some underlying collateral asset's value. This is equivalent to a specific type of financial market imperfection. These are predominantly moral hazard on the side of the borrower, imperfect information on the side of the lender as well as non perfectly enforceable and incomplete credit contracts. The constraints can be strong or soft, depending on the assumptions that seem to be most appropriate in the particular setting. Strong

[9] It seems that also Fazzari et al. (1988) have suggested a comparable link between financial markets and the real economy but not within a fully formulated model.

credit constraints apply e.g. to a situation where lenders are only willing to provide credit against full collateralization, soft constraints might apply in a setting where credit is feasible beyond collateral but only against higher credit cost. Soft credit constraints might also be termed credit frictions. If there were no need for constraints or credit frictions, the mechanism would simply not apply and one would, of course, obtain a result in accordance with the well known Modigliani-Miller theorem stating that the real economy is not affected by the structure of finance. This means that the aforementioned market imperfections were not to exist and we were in principle back at a perfectly efficient Arrow and Debreu (1954) economy. There would be no need for collateral and the prerequisite of the financial accelerator would cease to exist.

In fact, this is what makes this channel distinct from the normal and standard interest rate channel which does not work via the structure of finance. It demands some form of market failure or market incompleteness. Arguments that are used in the literature to motivate this are e.g. principal-agent relationships in credit markets, where the lender (principal) can not perfectly enforce its rights against the borrower (agent) and has therefore to constrain the agent. Another example would be the case of information asymmetries where the borrower has no incentive to provide the lender with the full set of information. In such an environment there is a need for the lender to collateralize his lending with some assets owned by the borrower to provide sufficient incentives to the borrower to meet his obligations. This can have important dynamic effects which lead to amplifications.

The amplification effect comes into play by the following consideration. Consider that the collateral, a firm has to offer in order to obtain a credit for an investment, is in some way tied to the economic net worth of this investment. An example would be a new plant which is necessary for a firm to expand its business. If its value is hit by a shock, be it negative of positive by nature, the collateral's value changes and so does the volume of obtainable credit. The volume of credit then affects the economic activity of the firm e.g. as it influences investment possibilities as the size of the new plant in our example. This already causes a real effect. So far, this is only a direct effect of the credit constraint or friction. An amplification or accelerator effect sets in as soon as the economic activity of the borrower affects its net worth available as collateral. In our example this could be the case if the firm's total value declines if it is not able to build the new plant in the desired way. It would have to compromise on that new plant and might loose competitiveness. If this is to happen, the direct effect causes another revaluation of the collateral and a spiral mechanism emerges which might well be stronger than the direct effect of the mentioned shock. The amplification sets in because of the double role of the borrower's or firm's net worth. First, it is a collateral, and second, it is to some extent related to the borrower's real economic activity as in this case production in the new plant. Another quite good example for such a collateral is land which is a common used collateral value and is also in use as a factor of production. During e.g. a devaluation process both the land's value and the user's cost for land fall; the latter do simply reflect the opportunity cost of land holding. It should be noted that this mechanism does

not only affect bank lending but also all other forms of lending e.g. also external finance of firms directly over the capital market in case of commercial papers. Thus, the mechanism does not rely on the existence of a banking sector. The mechanism is visualized in Figure 3.1 which is taken from Kiyotaki and Moore (1997). In Appendix 8 at the end of this document we provide the basic mechanism of the financial accelerator through a simple model which is taken from Bernanke et al. (1996) based on the more elaborate model of Kiyotaki and Moore (1997).

Figure 3.1 Financial accelerator

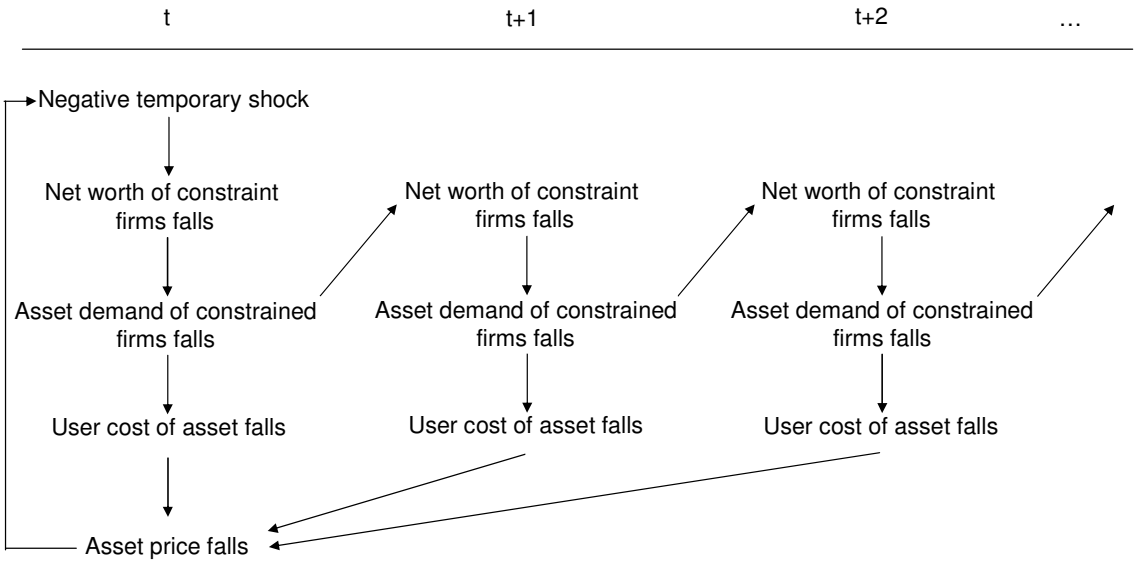


Figure following Kiyotaki and Moore (1997).

Building on these basic insights, a literature has developed which looks at the basic mechanism from different perspectives. Krishnamurthy (2010) gives an overview over the different classes of models developed in the literature. Brunnermeier and Pedersen (2009) and Vayanos (2004) analyse the effects of volatility shocks through this channel while He and Krishnamurthy (2008b) interpret a shock as an initial withdrawal of investor's equity. The interrelation between credit networks and the financial accelerator is modelled in Gatti et al. (2010). The basic mechanism in all of these models is identical, what varies is just the economic interpretation of the shock in the beginning of the acceleration.

The mechanism has found its way also into more elaborate models employing it as one aspect of the economy. In a series of papers, Aghion et al. (2001, 2004a,b) build theoretical models in which they try to explain currency crises through, among other things, balance sheet effects in the spirit of the financial accelerator. Also proceeding in this direction, Schneider and Tornell (2004) build a model of credit constraints and systemic bailout guarantees and show how currency and credit crises develop endogenously. Tornell and Westermann (2002) build a related

model focusing on middle-income countries during the financial crises in Asia and Mexico in 1990s.

Cooley and Quadrini (2006) employ a financial accelerator type mechanism in a heterogeneous firm model. Firms are heterogeneous with respect to size and equity with smaller firms more averse to high leverage. The authors find, not surprisingly, that financial shocks hit small firms harder and that a large number of small firms prolongs the output effect of monetary shocks through their investment decisions. The role of heterogeneous investment projects is analysed in Matsuyama (2007). The author shows that a corresponding extension of the Bernanke et al. (1996) and Kiyotaki and Moore (1997) models can give rise to a large number of effects in the credit market. Among them are credit cycles, credit collapses, traps and discontinuities. The reason for this is heterogeneity in productivity. Capital market shocks influencing credit possibilities thereby determine which productivities are able to refinance at the capital market. Due to this, capital market shocks influence technology through a selection process. This induces quite complex non-linearities with rather different outcomes.

Contagion is an important phenomenon in many financial crises. Essentially, contagion of a crisis means that a shock initially affecting a single firm, sector or economy later on spreads out to other firms, sectors or economies. The financial accelerator has found its way into this literature providing a theoretical appealing argument. The effect of a shock might spread to other firms, sectors or economies through collateral externalities. Theoretical work in this direction can be found in Kyle and Xiong (2001), Paasche (2001), Boissay (2006) and Fostel and Geanakoplos (2008), empirically Imbs (2010) finds some evidence for asset correlations during the crisis of 2007. The intuition behind this spill-over effect is simply that one borrower might suffer a negative shock; subsequently, the insetting devaluation of the collateral due to the accelerator mechanism carries over to another borrower because both use the same asset class as collateral.

Some authors have taken a deeper look at the specific role of the credit constraints in amplification mechanisms as the financial accelerator. This line of research goes a step further than the literature cited so far as they assess the role of credit constraints ex ante rather than ex post. In an ex post analysis, the credit constraints are simply exogenous rules which limit the possibilities of borrowing for an agent such as a firm or an economy. Ex ante, however, credit constraints are not exogenous but have to be endogenously explained in a model, i.e. have to be negotiated between the lender and the borrower. Lorenzoni (2008) points to an interesting dynamic source of inefficiencies if credit constraints are endogenous. If firms have a certain degree of freedom in offering collateral for obtaining finance, they might do this in an inefficient way. They tend to offer too much collateral in advance of a negative shock. After the accelerator mechanism has set in, they are even more constrained afterwards due the losses in their asset's value. Caballero and Krishnamurthy (2001) and Caballero and Krishnamurthy (2003) consider a

similar problem in an open economy setting. It is the problem of foreign currency denominated debt which is best applicable to less developed countries that is analysed here. Borrowers have the choice to obtain credit in the domestic or a foreign currency. However, negative shocks may lead to a devaluation of the domestic currency letting foreign denominated debt appreciate accordingly. The collateral they have to offer is the liquidation value of their firms. In case of foreign denominated debt, a domestic currency depreciation effectively increases the risk or extent of liquidation. As such the choice of foreign denominated debt results in an over supply of collateral in expected value and an endogenous choice of credit constraints. This replicates the result in Lorenzoni (2008) obtained for a closed economy. Following this argument, it is rather not surprising that Elekdağ and Tchakarov (2007) find in a similar setting welfare improving effects for exchange rate stabilizing policies in the presence of a financial accelerating mechanism.

The financial accelerator introduced by Kiyotaki and Moore (1997) and Bernanke et al. (1996) focuses on investment which is subject to constraints due to collateralization. However, some authors focus also on consumption. Before turning to the literature, we have to be aware that there is a fundamental difference between firms' investments and consumers' expenditures. The standard neoclassical firm would not constrain its investments through some natural limit if markets were to function perfectly. This is different with consumers. Consumers facing an intertemporal utility maximization problem have a budget constraint which sets a limit to their consumption expenditure. Consumers, if they act rationally, will voluntarily constrain themselves regarding their choice for consumption. Ludvigson (1999), Iacoviello (2004, 2005), Aoki et al. (2004) and also Goodhart and Hofmann (2008) follow this reasoning and make use of a life-cycle household consumption model. Not surprisingly, wealth is the important determinant of consumption and is influenced by asset values. This makes consumption subject to the accelerator mechanism. The just mentioned studies focus on house prices as the relevant collateral asset since housing is considered the most important investment by households. The result typically found in the literature is that high current house prices raise consumption while high (expected) future prices dampen it. The last effect is due to higher opportunity costs of current consumption. Investing in property would lead to higher returns in terms of household utility than contemporaneous consumption. This establishes a direct link between the financial accelerator and consumption. If house prices fall, ceteris paribus, today, consumption declines today but is to rise steeper in the future. This is only in accordance with consumption theory if the interest rate increase in the future which again negatively effect future house prices. Additionally, as is mentioned by some authors, credit constraints might also be important if wealth is represented by future income flows against which an individual might borrow in a constrained way in order to consume today.

There are, however, also opposing theoretical arguments in the literature that question the relevance and the justification for this amplification mechanism. Krishnamurthy (2003) shows that hedging strategies, e.g. through appropriate insurances or contingent credit contracts, can render the financial accelerator mechanism to loose its effects. However, on the aggregate level of the economy hedging counter parties might as well be constrained, which results in a shift of the accelerator mechanism from borrowers to e.g. insurances with almost identical effects as before. Bacchetta and Caminal (2000) build a deterministic general equilibrium model with credit constraints similar to the ideas in Bernanke et al. (1996). Their results show that acceleration or amplification only holds for unanticipated shocks. Cordoba and Ripoll (2004) criticize the theoretical literature on their tendency to allow for extreme modelling assumptions, i.e. linear preferences, that are the driving forces behind the amplification mechanism. In particular they construct a general equilibrium model along the lines in Kiyotaki and Moore (1997) and Bernanke et al. (1996) but with more standard assumptions on e.g. the utility function. With more realistic assumptions they find in simulations of their model that the amplification effect becomes much smaller. This critique, however, applies only to the rather stylised and partial models discussed so far. Below, we also review the literature that uses the financial accelerator mechanism in DSGE models which are robust with respect to this argument.

To sum up, the theoretical argument underlying the financial accelerator mechanism is appealing. It provides convincing intuition and a large literature with important theoretical contributions has emerged so far. In the light of the financial crisis 2007-2009 and the concerning literature, the mechanism has again gained the attention of many economists.

Some theoretical criticism exists, but it does not seem to be overwhelmingly strong. What however is important, is the empirical evidence on this theory. For the financial accelerator to be an important mechanism shaping and influencing economic development, it needs statistically as well as economically significant empirical results that underpin its role for the real economy.

3.2 Empirical Observations

In this section we take up the question that concluded the last section. We try to assess from the available literature whether the financial accelerator has economically significant implications for the economy. We, first, look at empirical and quantitative work and, second, we look at indirect evidence of the mechanism that is obtained in modern macroeconomic DSGE models. We regard this as indirect evidence as this literature looks at the question whether adding a financial accelerator to a standard DSGE models helps to improve its performance. As such this is not a direct test of the theory but is still very useful.

3.2.1 Quantitative Studies

Conceptually, there are two questions to be answered if we are to draw inference on the empirical relevance of the financial accelerator. The first is whether firms, sectors, consumers or the total economy are indeed credit constrained. The second question, which is only important if we can answer the first question with a 'yes,' asks then whether there are empirical findings supporting the amplification mechanism. Following this line of argument, there is one key variable that can be used to empirically track the economic importance of the financial accelerator mechanism. It is the existence of the spread[10] reflecting credit constraints. For the second question, it is its counter-cyclical behaviour[11] that fuels the accelerator effect.

It seems to be in order to elaborate a bit more on the implication of a counter-cyclical spread of the financial accelerator. It applies to the market for external finance and the rate of interest charged for financing an investment. The price for borrowing is higher than the costs to the lender for refinancing the borrower's debt on the capital market. The spread exists because firms are able to borrow less than they are willing to if there were no credit constraints; this is, of course, tautological. This drives the marginal product of investments inside a firm above the going rate of return on the capital market. Due to the credit constraints, this wedge can not be exploited by arbitrage. Indeed the wedge between the rates of return is needed to cover the cost associated with the credit constraint motivated by the above market failures (e.g. monitoring cost). If the economy or a part of the economy is hit by a negative shock, this wedge increases[12]. Through asset devaluation, the implied reduction in collateral value, firms are even less able to invest or even have to disinvest. This in turn drives up the marginal product of investments and increases the gap between the return on the capital market. The statistical test for the counter-cyclicality of the spread lies in a test of a significant relationship between the real economy and the credit constraints. This is precisely what induces the amplification mechanism as explained above.

Credit constraints

There are at least two ways to address the question on the relevance of credit constraints given the above theoretical arguments. One strand of the literature, predominantly from the 80s and 90s, looks at evidence for constraints from an aggregate point of view. These studies look at sector or even economy wide data. While we think that the constraints relevant to this chapter should be visible at this level of aggregation, we do not think that their existence is sufficient for the validity of the financial accelerator. The theory explained above has very sophisticated micro economic foundations. Therefore it seems necessary to search for empirical evidence on precise

[10] In the literature on the financial accelerator, the spread is often also refereed to as the 'price-cost margin.'

[11] E.g. an economic downturn should be accompanied by an increase in this spread on the financial market.

[12] This is due to the neo-classical assumption of a decreasing marginal product of capital. At lower values of the capital stock (i.e. if the credit constraint applies) the effects of shocks are larger than at higher values.

this level of aggregation what we will do below. We believe that this second way of addressing the question is preferable.

Reviewing the literature up to 1998, Hubbard (1998) points to the empirical relevance of credit constraints. The evidence cited in Hubbard (1998) is mostly micro econometric relying on firm level data and clearly show that a substantial part of companies is indeed credit constrained. Also, the credit constraints are economically significant in the sense of a sizable spread. Also Bernanke et al. (1996) give an overview over empirical work that seems to support the significance of credit constraints. Using data on U.S. commercial property finance contracts, Benmelech et al. (2005) find that collateralized properties which are less restricted in redeployability due to public regulation lead to more favourable finance contracts for the borrower. I.e. the borrower is able to negotiate a lower rate of interest and longer maturities among other things if e.g. a property used as collateral can be used for many purposes. Benmelech and Bergman (2009, 2010) find within the U.S. airline industry that decreasing collateral values increase the spread for external finance. Chaney et al. (2010) use U.S. firm level data on real estate property and firm's ability to obtain external finance. They authors find that an increase of the property value increases investments undertaken by the firm. There is also a considerable literature that tries to quantify the impact of Tobin's Q and q , i.e. the average and marginal ratio of a firm's market and book value, on investments decisions on the macro and micro level. Davis (2010) summarizes this literature. In general the findings are mixed and it is questionable whether these results can be taken as evidence against or in favour of credit constraints. The crucial question would be whether Tobin's Q or q is a valid proxy for collaterizable value which might not always be the case. A discussion on this point can be found e.g. in Hubbard (1998). At least on theoretical grounds this can well be questioned. Already in Hayashi (1982) it has been demonstrated that the role of Tobin's Q is theoretically caused by adjustment costs in the investment process which are not necessary equivalent to credit constraints or frictions. Also Chirinko (1993) discusses critically the role of Q in empirical investment studies.

The theoretical literature cited in the preceding section points also to the role of consumption in combination with a financial accelerator. Therefore one could also ask the question whether there is empirical evidence on credit constraints or comparable financial frictions for consumers. However, there are fundamental differences between consumption and investment as already outlined above. While a firm might potentially invest in an unlimited fashion[13], depending on its production technology, consumers will not act so regarding consumption. This is obvious when looking at life cycle models of consumption. Here consumers will rationally choose to limit

[13] This is the well known result from neoclassical economics stating that the size of the firms is undetermined in general equilibrium.

consumption to an extent determined by income and wealth[14]. Therefore one could never differentiate between voluntary choice or an exogenous constraint. However, a valid question would be whether there exist constraints that go beyond what consumers voluntarily would do. This question is important since the severity of constraints is an important determinant of the accelerator effect. We have already seen this in the stylised model regarding investment, presented in the Appendix of this document. A literature that could give indirect empirical evidence on such additional and more severe constraints is dealing with the effects of financial liberalization on consumption patterns. The underlying idea is that financial liberalization gives consumers more freedom to achieve their optimum consumption plans. If there were excessive constraints before, consumption should react to such a liberalization. Bacchetta and Gerlach (1997) find evidence for the relevance of additional constraints represented by aggregate credit market conditions for 5 large economies. Using rolling regression techniques, Byrne and Davis (2003) show for the G7 that financial wealth has an increasing explanatory content with respect to consumption. Interpreting this in the light of increasing financial liberalization, this points towards decreasing additional constraints. Barrell and Davis (2007) look at consumption patterns in the G7 countries taking account of a financial liberalization indicator provided by the OECD. They too find wealth to become more important for consumption as the indicator increases. The studies so far focus on a sample of countries. Barrell and Davis (2007) also review the literature that focuses on single countries where mixed evidence is to be found. The general tendency that can be found is that the results are in favour of the role of additional constraints for the U.S., UK and Canada but not so much for continental Europe. Using micro data, Ludvigson (1999) finds significant evidence for time varying credit constraints applying to U.S. consumers.

Accelerator

Probably the first study to deal empirically with the financial accelerator is Fazzari et al. (1988). In this study U.S. firm level data reveal that investments are quite more sensitive to variations in collateral for credit constrained firms than for unconstrained ones. Follow-up studies reviewed in Bernanke et al. (1996) come to comparable results. These results can at least be seen as indirect evidence in favour of the accelerator mechanism as it links credit constraints, activity and collateral value.

Indirect evidence has been found by Mendoza and Terrones (2008) who document for a large panel of countries the pro-cyclicality of credit volumes and asset prices at both the macro and the firm level for emerging and industrialized economies. While their contribution is a more descriptive threshold analysis, Goodhart and Hofmann (2008) employ more sophisticated panel VAR methods using data for industrialized economies. They find house prices to increase credit

[14] Theoretically this can be understood as a mechanism that rules out capital market inconsistencies as e.g. Ponzi schemes.

volume and credit volume to increase both house prices and GDP. Braun and Larrain (2005) use cross country sector data on output growth and the industry's reliance on external finance. They find that economic downturns hit that sectors hardest where dependence on external finance is highest. The effect is further amplified if a country's financial market is less developed. This finding is in line with results found in Rajan and Zingales (1998) who find less developed financial markets to be dampening growth if firms are increasingly dependent on external finance.

More direct evidence for the significance of the financial accelerator effect can be found in studies that focus on corporate bond interest rate spreads as they are closely linked to the above mentioned spread. This was first conducted in Gertler and Lown (1999) and more rigorously and more recently for the U.S. in Mody and Taylor (2003), where the authors find some evidence for the significance of the financial accelerator. The authors use a structural VAR approach to identify the responses of economic activity to shocks in yield spreads and find the spread to be a significant counter-cyclical predictor. Furthermore, they find evidence for non-linearities in the form of an increasing counter-cyclical relationship in the magnitude of the spread. This non-linearity has already been conjectured by Bernanke et al. (1996). There it is argued the response to a shock rises more than proportionate with the size of the shock. Significant evidence is also provided in Gilchrist et al. (2009b) where the authors follow essentially the same idea but build on an improved firm level data base for the U.S. with additional control variables.

Rather more pessimistic about the empirical content of the financial accelerator are Chari et al. (2007). In contrast to the just mentioned studies they do not rely on VAR methods but instead propose their method of 'Business Cycle Accounting.' They find that evidence that could be interpreted to support the financial accelerator is weak as it is not large in magnitude. However, Christiano and Davis (2006) criticize their finding by showing that their 'Business Cycle Accounting' is highly sensitive with respect to small parameter changes and that the method does not take account of externalities leading to an underestimation of the real effects.

A literature related to the cyclicality of spreads builds on asset pricing models. Gomes et al. (2006) using stock return data and Aliaga-Díaz and Olivero (2010) using U.S. bank data try to quantify the cyclicality of the spread for external finance. While the former find a pro cyclical pattern, the latter establish a significant negative relationship between the business cycle and the margin.

Considerably less work has been done on the consumption side. Iacoviello (2004) tries to test the role of the financial accelerator for consumption as laid out in the section on the theoretical arguments above. He estimates a structural econometric model based on an Euler-equation representing consumer optimisation under credit constraints and a financial accelerator. His conclusion is that the model behaves well in explaining consumption dynamics in the U.S.[15]

[15] Davis (2010) gives an overview over the literature on the relationship between (various) asset prices and consumption. This is, of course, relevant in this context, however, no systematic account is taken of the role of an acceleration

To sum up the evidence so far, we conclude that there seems to be convincing evidence in favour of economically relevant credit constraints, a necessary ingredient to the financial acceleration. A remaining problem is, however, how this micro economic evidence can be used for analysis at the macro level. Chaney et al. (2010) elaborate on this issue and point to their skepticism that macro inference based on purely micro economic evidence is valid. The authors do not further elaborate on this issue but it is not hard to join into this conclusion. Most of the cited literature focuses on rather specific data samples, i.e. only publicly listed companies or specific industries. Whether these firms are representative for the macro economy is more than questionable. Apart from this, aggregation from the micro to the macro level even with representative data is still an open issue in economics. For consumption, the question is differently as explained. There seems to be evidence on excessive credit constraint, however, due to the financial liberalization that took place in many industrialized countries, these additional constraints might have weakened. As constraints are present almost by economic definition, consumption is important in the light of the financial accelerator although the effects might be lower today than in the past.

With respect to the acceleration mechanism, one has to rely to some extent on indirect evidence that rests on one or the other assumption in order to draw inference. The results are largely in favour of an important role of the accelerator mechanism. Additionally some evidence is found on the important issue of non-linearity, i.e. the financial accelerator's power to increase in the size of an economic shock. The literature seems supportive for the presence of an accelerator mechanism both for firm investment and consumer behaviour. Taking together the findings, the evidence and the discussed problems, it seems reasonable to conclude that the literature supports the qualitative importance of the financial accelerator. However, it seems not possible, so far, to draw quantitative inference on the macro level from this literature.

3.2.2 DSGE Models

The financial accelerator was first introduced into DSGE models in Bernanke et al. (1999) although by deviating slightly from the original modelling in Bernanke et al. (1996) and Kiyotaki and Moore (1997) which use hard credit constraints. The basic mechanism operates through an entrepreneurial sector in the economy which is responsible for production and is subject to default risk due to shocks. Entrepreneurs have access to collateralized and not collateralized finance where the costs for the latter bear additional monitoring costs for the lender. Thus, this modelling strategy follows Townsend (1979) and the idea of costly credit monitoring. The constraint to collateralized finance is the worth of the entrepreneur's firm's assets. If asset value is pro-cyclical, the need for costly not collateralized debt is counter-cyclical and the financial accelerator emerges as argued already above. The key model variables in this

mechanism. The literature reviewed there does not focus on amplification effects but is more concerned with general consumption determinants.

type of modelling are the asset worth/capital ratio (a measure for the degree of financial leverage) and the spread in credit costs of not collateralized over collateralized debt. The parameter of interest is the elasticity of the former to the latter as it establishes the link between the margin and economic activity.

In their original work, Bernanke et al. (1999) calibrate their DSGE model to the U.S. economy and find that the model including the financial accelerator is better in explaining the dynamics in economic time series in response to e.g. monetary shocks. Employing the financial accelerator mechanism, they find the reaction of output and investment to be significantly higher when employing the financial accelerator mechanism as compared to a model without the financial accelerator. However, this is by no means a rigorous statistical test of significance since the model has been calibrated.

Meier and Müller (2006) go beyond this and estimate a DSGE model very similar to the one in Bernanke et al. (1999) through matching impulse-responses from a structural VAR for the U.S. economy. They focus their analysis on monetary shocks. The parameter estimates which they obtain for the model's part on the financial accelerator point in the direction predicted by theory, however, on statistical grounds they turn out to be insignificant both using standard and distant metric tests. Although not significant, it appears that the financial accelerator mechanism helps to replicate the empirical dynamics in the economy's investment behaviour. The results were not compared to a model without the financial accelerator mechanism.

Faia and Monacelli (2007) extend the DSGE model in Bernanke et al. (1999) by including a Taylor-rule for monetary policy and take account of asset prices in the presence of the financial accelerator. They also calibrate their model to the U.S. economy and find that monetary policy should in general react in response to asset price changes. With respect to the financial accelerator, they find the mechanism helpful in explaining the persistence in investment behaviour. Christensen and Dib (2008) go a step further in constructing a DSGE model which they estimate using U.S. data. Besides the financial accelerator mechanism, they include the Fisher (1933) debt-deflation effect and a stabilizing Taylor-rule for monetary policy. Regarding the estimation, they do not follow Meier and Müller (2006) and Faia and Monacelli (2007) but estimate the model with respect to the moments found in U.S. data. Especially the inclusion of a stabilizing Taylor-rule seems important as Bernanke et al. (1999) already argue that such a policy might counteract the financial accelerator mechanism. However, the authors still find a significant role of the financial accelerator mechanism as predicted by the theoretical literature. As in Meier and Müller (2006) and also Faia and Monacelli (2007) it seems that the financial accelerator affects the dynamic behaviour of investments strongest.

Table 3.1 Parameter Financial Accelerator

Study	Type	Value	Significance
Bernanke et al. (1999)	calibrated	–0.028854[a]	
Meier and Müller (2006)	estimated	–0.0672	no
Faia and Monacelli (2007)	calibrated	non constant[b]	
Christensen and Dib (2008)	estimated	–0.0420	yes
Gilchrist et al. (2009a)	estimated	–0.01	yes
Nolan and Thoenissen (2009)	calibrated	–0.0370	

Elasticity of interest spread with respect to net worth/capital ratio.

[a] Calculated from authors assumption that a net worth/capital ratio of 0.5 implies a spread of 200 basis points.

[b] Faia and Monacelli (2007) use a specification with a non constant (semi-)elasticity; the steady-state spread is identical to Bernanke et al. (1999).

Gilchrist et al. (2009a) estimate a DSGE model following rather closely the modelling framework in Bernanke et al. (1999) and use it to evaluate monetary and financial shocks. They find the financial accelerator to greatly amplify these in magnitude and duration. Nolan and Thoenissen (2009) build on Bernanke et al. (1999) and extend their model by including an additional shock. They refer to this shock as a stochastic component in the efficiency of financial markets. This shock has a direct influence on the worth of the entrepreneur's firm's assets which is in Bernanke et al. (1999) based on rational expectations. Through the shock, worth can deviate from its rational expectation's value and, thus, the shock represents ad hoc irrational behaviour in financial markets. It might be interpreted as to reflect other aspects in the decision making process of investors that are not modelled in detail. Adding this component to the model, the authors find an improved behaviour after calibration to U.S. data.

The models mentioned so far are the ones that aim at modelling the macro economy subject to the financial accelerator in general. As such they are to some extent comparable. The modelling strategies are basically clustered around the following relationship

$$s_i = \chi \left(\ln w_i - \ln k_i \right), \tag{3.1}$$

where s_i is the firm's excess cost of capital, i.e. over a risk free rate, w_i and k_i are the firm's net worth and capital stock. Net worth is to be seen as the sum of current assets and the present value of future net earnings. χ is the elasticity of the interest rate spread between un- vs. collateralized finance with respect to worth/capital ratio. Table 3.1 gives the values for this elasticities in the above mentioned studies.

Besides the just mentioned studies, there are also more specific DSGE models in the literature. Iacoviello (2005) and Iacoviello and Neri (2010) use a DSGE model to assess the role of house prices in the U.S. by employing the financial accelerator mechanism. They find that shocks to house prices improve the model's ability to replicate the properties of aggregate demand data. Boz and Mendoza (2010) go a step further in a similar environment by including time varying credit constraints based on risk perception. Bayesian learning about the true risk

leads to over borrowing and pricing in an up-swing followed by a credit crisis. Gertler et al. (2004) consider an open economy extension of the Bernanke et al. (1999) model to explore the role of exchange rate regimes in the Asian financial crisis at the end of the 90s. They find financial frictions to explain about half of the observed drop in economic activity. Also concerned with the open economy and the financial accelerator are Elekdağ et al. (2006) who estimate a DSGE model for emerging market economies with foreign currency denominated debt. They find this debt to be an important channel of shock transmission as it counteracts the stabilizing role of exchange rate adjustments. Brubakk et al. (2007) build a small open economy DSGE model to evaluate the implications of the financial accelerator for monetary policy. They find the inflation-output trade-off to become less favourable setting tighter restrictions on monetary policy. Gilchrist and Leahy (2002) introduce asset price shocks and try to assess whether monetary policy should implement asset pricing rules. They conclude asset prices to contain additional information besides that included through an interest rate type of rule. Gertler and Karadi (2010) build a DSGE model using a financial accelerator mechanism as in Bernanke et al. (1999) designed to evaluate the effects of the FED's recent monetary policy that intervenes directly in the commercial paper market. They conclude that such a policy can help to dampen the accelerating effect of credit constraint through the actions of an unconstrained central bank.

Besides the mentioned parameter values in Table 3.1 it seems in place to elaborate on the economic effects of the financial accelerator when integrated into a DSGE model. Again we refer here to the above 6 studies as they are most comparable and rather general. Unfortunately not all studies compare their results with a model without a financial accelerator. Bernanke et al. (1999) find output to react by some 50% and investment by some 100% stronger in response to monetary shocks. Christensen and Dib (2008) do not find this with respect to output but find a comparable number for investment. Examining the impulse response functions reported in the two articles, it is clear that the dynamics of the economy's reaction are prolonged due to a magnified impulse. For technology shocks, Bernanke et al. (1999) find the output response to be between 30 to 40% higher but do not report the investment's response. Christensen and Dib (2008) report both but find only a significant role for the financial accelerator for investment which react by some 50% less. Whether the speed of adjustment is also significantly affected can not be deduced as there are no numbers for this variable reported.

To round up this section it might be worthwhile looking back at the theoretical literature from where we departed from. Already Kiyotaki and Moore (1997) concluded in their article, that more work has to be done by future research to fully understand the implications of the financial accelerator for the real economy. One point that the authors made, and which gained tremendously in importance during the intensified use of DSGE models in macro economics, is the role of uncertainty. Both Bernanke et al. (1996) and Kiyotaki and Moore (1997) work with deterministic settings and unexpected shocks which are subsequently subject to acceleration. The growing number of DSGE models using the financial accelerator as one corner stone has

taken up this issue by incorporating the mechanism in a stochastic setting. The results seem supportive for the financial accelerator both on the firm and the consumer side of the economy. A final note should be on the modelling strategy taken by the literature. It seem nowadays common sense to use the DSGE setting due to Christiano et al. (2005) and Smets and Wouters (2007) as the workhorse model to be extended by additional frictions; in the present case through the financial accelerator.

3.3 Relation to CPB Models

Draper (1991) already included credit constraints in his study on investment in the Dutch economy. However, there was no acceleration mechanism and, thus, no financial accelerator. CPB's work is therefore well aware of the basic problem, but might need to take account of additional economic mechanisms. In this section we provide therefore an overview of the results found in the literature and their applicability to models currently in use by the CPB. We first focus on the SAFFIER model and, and second, on possible modelling strategies for CPB's DSGE modelling project.

3.3.1 SAFFIER

SAFFIER is the short and medium term macro economic model of the CPB. A detailed description of the most recent model's version can be found in Kranendonk and Verbruggen (2006). Here we will just shortly discuss the two model components which are relevant in the context of the financial accelerator. The first block that stands in direct relation to the financial accelerator mechanism is the demand for capital or put it differently, the investment decision in the economy. Secondly, it might be also worthwhile to take account of that mechanism in consumption.

To get an idea of how the financial accelerator could in principle be implemented it is important to remember that the literature considers it as a structural feature of various models. I.e. the implied credit constraints or financial frictions are not just transitory mechanisms but influence the economy in the long run. Furthermore, there are two ways of implementing the mechanism. The first one as in Bernanke et al. (1996) and Kiyotaki and Moore (1997) with a strong restriction that makes borrowing beyond a particular value of the capital stock impossible, and the second, where borrowing becomes increasingly costly given asset values. Certainly, the second option is to be preferred since it does not imply discontinuities.

For the capital decision of the firm sector, the modelling strategy that would be most simple to implement is one that is also applied in most of the cited DSGE models. It rests on a linkage of the spread for firm borrowings and the net worth/capital ratio implied by equation (3.1). Values for the elasticity χ are given in table 3.1 for relevant models in the literature.

As such the only missing gap is the determination of w_i inside SAFFIER in a pro-cyclical way as demanded by the accelerator mechanism. Implementing the spread should in principle be feasible since user cost of capital are already a determinant of the capital stock in SAFFIER. The inclusion of an equation along (3.1) would of course be ad hoc and based on economic considerations not explicitly modelled.

The authors of the literature cited above have also turned their attention to consumer behaviour. This is often done by considering housing as an investment object for consumers and taking account of the development of its prices in their decision making process. Housing would in this case be the relevant collateral influencing consumer behaviour in case of credit constraints. A possible implementation would follow the idea of a reduced form consumption function as in Iacoviello (2004). This consumption function is essentially based on a linearized Euler-equation describing optimal consumption in the presence of housing as an intertemporal asset reflecting wealth. As explained, in such a consumption function both present and future house prices enter as determinants of consumption. The price multipliers implicitly set the severity of consumer's additional borrowing constraints. Such considerations could be used to complement the existing consumption function in SAFFIER. This would also imply to introduce forward looking behaviour into SAFFIER. Concerning the severity of consumer credit constraints one might recall that empirical evidence for continental Europe is weak.

What remains a critical issue in the context of SAFFIER is uncertainty. As argued above, uncertainty is judged by the literature as being important for the relevance of a model's predictions. To deal with this type of criticism, one has no choice but to use DSGE models. This is what we discuss in the following section.

3.3.2 CPB's DSGE Model

The construction of a DSGE model for the Dutch economy is under way at CPB. The steps towards such a model can be found in Elbourne et al. (2008) and Elbourne et al. (2009). One conclusion from these contributions is that it is important to model capital market imperfections. The financial accelerator is a natural candidate for such a consideration.

In the basic DSGE models as Bernanke et al. (1999) and Meier and Müller (2006), the financial accelerator is implemented through an equation such as 3.1. Depending on the complexity of the CPB's DSGE model, of course, the other cited articles could give valuable hints on how to proceed further with the financial accelerator mechanism. A caveat that one has to bear in mind when doing so is that the mechanism has some requirements for the underlying DSGE model to be logically consistent. As it is explained in Bernanke et al. (1999) the model requires a three sector structure in the form of households, entrepreneurs and retailers. Households and entrepreneurs are needed to motivate lending and borrowing. The retail sector is needed to open up the possibility of sticky prices which are a standard ingredient to DSGE

models. The technical implementation of the financial accelerator would take the form of equation (3.1), as said before.

Going further, there would also be the possibility of introducing a financial accelerator mechanism applying to consumption of households through effects on consumer's wealth which is at least partly determined by house prices (e.g. Iacoviello (2005) or Iacoviello and Neri (2010)). This, however, would demand considerably new aspects of modelling introduced to the existing DSGE models at the CPB. What would be needed in any event is a modification of the consumers' intertemporal problem to take account of houses as an intertemporal asset. In turn this demands a housing market to be modelled as well.

3.4 Assessment

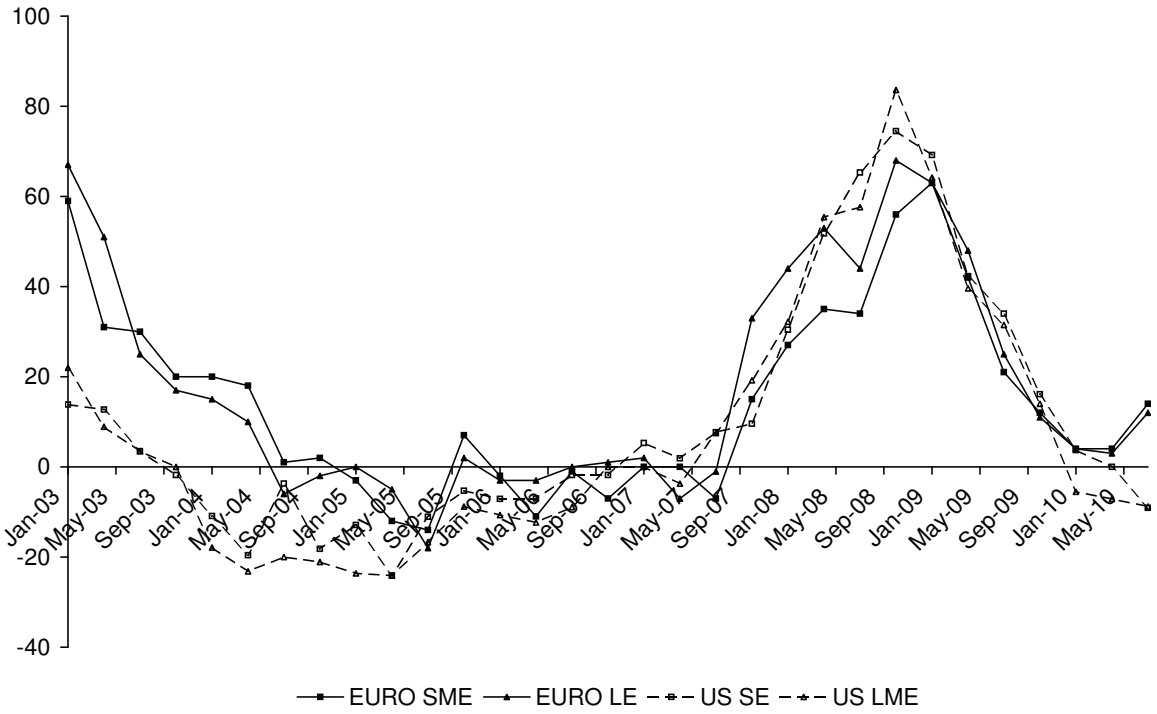
In general, it seems that the inclusion of the financial accelerator mechanism in SAFFIER and the CPB's DSGE models should be possible. The empirical evidence above suggest that the mechanism is important. Even more important, the recent events on the capital markets strongly suggest to take care about the financial sector in macro models. The effects of the financial crisis were much stronger than expected, possibly due to amplification mechanisms as the financial accelerator. To keep such a project tractable, it should be started with the firm's investment modelling strategy as integration in existing models is more straightforward. This view is supported by Smets et al. (2010) who compare the two quite complex DSGE models currently employed by the ECB of which just one explicitly models the financial sector using the financial accelerator. It should also be noted that the financial accelerator is not only important as an amplifier of financial or monetary shocks. Bernanke et al. (1999) and Christensen and Dib (2008) find that it has also a significant impact on the effects of e.g. technology shocks.

The introduction of the financial accelerator to SAFFIER should imply less practical problems since the model is deterministic. Calibration of an equation comparable to (3.1) could be done in accordance with the values in table 3.1. Integration of the financial accelerator in CPB's DSGE models might be more demanding especially if the model is to be estimated. However, it is also possible to work in a partly estimated setting where an existing estimated DSGE model is extended by a calibrated financial sector subject to the financial accelerator. This is expected to reduce the complexity of such a project considerably. In general the implementation should begin with the firm's investment behaviour since the integration strategy seems to be more straightforward and empirically founded than for the consumption side of the economy.

4 The Bank Lending Channel

Bank credit fluctuates strongly over the business cycle. Dell'Ariccia and Garibaldi (2005) show that the volatility of gross credit flows in the US is an order of magnitude larger than that of GDP. In addition, the volatility of credit contraction is substantially larger than that of credit expansion (28% vs. 18%). At the onset of a recession, bank credit is sharply reduced and at the end of a recession it expands again more gradually. The reduction in bank credit may be due both to reduced credit supply, to reduced demand, or both. Figure 4.1 compares reported credit conditions in the Euro area and the US over the last two cycles. During the latest recession, over

Figure 4.1 Tightening of credit conditions over the latest two cycles



Note: Net percentage increase in banks reporting a tightening of credit conditions for small and medium sized enterprises (SME), large enterprises (LE), small enterprises (SE), large and medium enterprises (LME) in the Euro area and the U.S. Source: Bank Lending Survey, Eurosystem for the Euro area, Senior Loan Officer Opinion Survey on Bank Lending Practices, Federal Reserve for the U.S.

two-thirds of banks reported a tightening of credit conditions. For the Euro area, a comparable tightening is also reported for the 2002-03 recession, but in the U.S. conditions were not raised as much. Figure 4.1 suggests that during recessions the credit supply curve shifts inward. The question that will occupy us in the next few sections is whether a shift in the credit supply curve matters for the depth or the length of a recession.

The findings of Mishkin (1978) and Bernanke (1983), that bank lending did matter during the Great Depression, did not easily fit into the then available theoretical framework, which regarded portfolios as instantaneously adjustable and did not distinguish between financial markets and financial intermediation. This led Bernanke and Blinder (1988) to present a simple extension of the IS-LM model with a separate credit market to analyse the effect of a bank lending channel on monetary policy. In their model, the effects of the bank lending channel arise from the imperfect substitutability of money and credit for both banks and non-financial agents. More generally, for the bank lending channel to be operative, two conditions have to be satisfied:

1. banks react to a liquidity shortage by cutting back loans, instead of issuing more certificates of deposit;
2. bank loans and market finance are imperfect substitutes, so that borrowers cannot easily turn to alternatively sources of funds if bank lending is curtailed.

The next sections discuss each of these conditions. Section 4.1 discusses the conditions under which bank loans and market finance are imperfectly substitutable. Section 4.2 discusses reasons why banks may respond to changes in their balance sheet composition by adjusting their credit supply. Section 4.3 presents empirical evidence on the bank lending channel.

4.1 Financial Intermediation and Credit Supply

What is the value added of a financial intermediary? Why is any difference between borrowing and lending rates not arbitraged away? The fundamental insight of Jaffee and Russell (1976) and Stiglitz and Weiss (1981) was that information needed by the lender to assess the risk involved in the loan is often in substantial measure private to the borrower: the borrower's earning potential, the risk characteristics of the investment project, etc. In these circumstances, lenders will want to screen potential borrowers before granting the loan, and to monitor the borrower for the duration of the loan. Jaffee and Russell and Stiglitz and Weiss discuss a setting where the interest rate charged selects the borrowers in high- and low-risk types. In this situation a lender may prefer to ration credit rather than to raise interest rates and attract a higher proportion of high-risk types.

Another consequence of asymmetric information is that the loan contract is incomplete. This creates a moral hazard problem, that may be partly resolved through monitoring. However, As monitoring is costly, it will not fully resolve the asymmetry in information (Townsend, 1979). The optimal loan contract is a standard debt contract with a fixed interest rate, and an audit upon default. Because of the monitoring costs, projects with a relatively low return may be rationed (Williamson, 1986). The general consequence of incomplete information in financial markets is therefore that differences between borrowing and lending rates are not arbitraged away: borrowers may be rationed and a loan contract, if available, carries a surcharge to compensate the lender for the expected cost of monitoring.

The essential role of banks as financial intermediaries is then to mitigate the effects of market incompleteness by engaging in risk and information pooling (see e.g. Gorton and Winton, 2003; Freixas and Rochet, 2008, chapter 2). There are a number of reasons why banks are better able to provide financial services than individual depositors

1. commitment: a bank acts as a commitment device against renegotiation of the terms of the loan contract (as this might lead to a bank run), something an individual lender cannot credibly do (Diamond and Rajan, 2001).
2. economies of scope: a bank can offer loans of various duration and risk, if the depositors are heterogeneous. Thus a bank acts as a risk diversification unit (Pyle, 1971). In particular, a bank offers liquidity insurance to households and firms (Diamond and Dybvig, 1983).
3. economies of scale (Williamson, 1986): the bank can monitor the borrowers' creditworthiness more efficiently than private investors can, because the bank pools the monitoring efforts of individual depositors.
4. Banks typically enter into a long-term relationship with their borrowers, as a consequence of the information that the bank accumulates during its monitoring activities (Sharpe, 1990; Rajan, 1992). This inside information leads to a monitoring cost advantage of the bank, the rents of which are shared between the bank and the firm.
5. As monitoring is costly, and monitoring costs are non-verifiable, banks too face a moral hazard problem (Holmström and Tirole, 1997). Banks must earn a positive return on their monitoring activity. To avoid that banks gain a net profit from monitoring, which would not be incentive-compatible, it is necessary that banks take part of the risk of a firm's investment projects. Hence part of the capital supplied by the bank is illiquid, which restricts the options of the bank to terminate the partnership with a customer firm. This is an advantage for the owners of the firm, as it lowers liquidity risk. It also implies that the net worth of the bank affects the amount of credit supplied.

The comparative advantage of banks as intermediaries between uninformed private investors and lenders thus gives rise to a number of theoretical predictions concerning the degree to which bank loans and market credit are substitutable. Bank credit is more expensive than internal funds for borrowers as internal funds escape the need for monitoring. However, the liquidity insurance offered by banks obviates the need to hold large cash reserves as a buffer to finance volatile expenditure categories like inventories or durable consumption goods. Hence even firms and households with sufficient cash flow will need bank credit to stay liquid. Bank credit is generally less expensive than direct access to the capital market, provided that the firm has sufficient collateral, because of the monitoring cost advantage of banks. On this account, bank lending is especially important as a source of funds for small firms and households. For large firms, this monitoring cost disadvantage is less important and they can more easily substitute commercial paper for bank loans. Finally, banks and firms are involved in a strategic partnership, in which it

is costly for either side to terminate the relationship and find another customer, or switch to another bank. This also implies that bank assets are for a substantial part tied up in existing loans, and as a result illiquid.

4.2 Bank Liquidity and Balance Sheet Effects

The second condition for the existence of a bank lending channel is that banks cannot easily adjust their balance sheets if they face a liquidity shortage by attracting new funds. This condition may be put in a bit broader perspective by distinguishing two aspect of the bank's balance sheet that may affect its supply behaviour:

- Banks may face a *liquidity shortage*, i.e. there exists a severe maturity mismatch between their assets and liabilities;
- Banks may be *undercapitalised*. This occurs e.g. if they have lower capital than allowed for under the Basel accords.[16] More generally, the amount of bank capital affects their risk-bearing capacity and their preferred portfolio composition, so that there exists an optimal capitalization rate, that may not be achieved.

We discuss both points in turn.

4.2.1 Bank Liquidity Shortage

If banks face a liquidity shortage, why cannot they simply restore liquidity by attracting new funds, either by issuing new equity, by issuing new deposit certificates, or by selling insured loans? In a world of asymmetric information, issuing new equity in times of financial stress is expensive for existing shareholders, because the bank must offer a substantial discount to overcome the informational disadvantage of new shareholders (Calomiris and Wilson, 2004).

The second possibility for banks to improve their balance sheet in the face of a liquidity shortage is to issue additional certificates of deposits (CD's). Romer and Romer (1990) hypothesize that this is precisely what banks do under these circumstances, because they find no evidence of a curtailment of bank lending during episodes of restrictive monetary policy. However, Kashyap and Stein (1993) argue that bank lending is bound to react slower than measures of the money stock to a tightening of monetary policy, because of contractual constraints, and the need to finance increased inventory holdings of customer firms at the start of a slowdown. As a result, the effects of monetary policy on bank lending may realize themselves mostly after the initial episode of restrictive policy. In addition, Kashyap and Stein (2000) use

[16] We do not go into the issue of *regulation* of banks, except to note that regulation is motivated by another type of market imperfection, the lack of contracts that are contingent on macro risks, e.g. liquidity risk (Diamond and Dybvig, 1983). Without contingent contracts the probability of a bank default is always positive, and the issue is whether regulation can improve the equilibrium. See Bijlsma et al. (2010), section 5, for a literature survey.

micro panel data to demonstrate that less liquid banks do reduce their loan supply more in periods of restrictive monetary policy. Ludvigson (1998) also finds direct evidence of an effect of monetary policy on loan supply.

To explain the apparent reduction in bank lending following tight monetary episodes, Stein (1998) constructs a model of adverse selection between banks. Banks limit their use of CD's to signal their financial soundness. A 'sound' bank will react to a withdrawal of insured demand deposits by cutting back loans, a 'bad' bank will resort to using more uninsured external finance. A different explanation is offered by Diamond and Rajan (2006), who argue that banks themselves do not like to issue new demand deposits to lend out as illiquid assets in times of restrictive monetary policy, because the withdrawal risk of these deposits is higher as well.

The third possibility, selling uninsured loans to third parties, in itself is not attractive either, as banks have a special relation with their debtors (James, 1987). Selling of the loans would weaken or terminate this relationship. In addition, as banks have inside information about their debtors, (Sharpe, 1990; Rajan, 1992, cf.. Section 4.1 above), selling of debtor claims faces the lemons problem. The lemons problem can be overcome by securitization, however.

Securitization is a relatively recent financial innovation that offers a solution to the problem of converting illiquid loans to liquid assets. In the U.S., securitization of mortgage loans started in the seventies. By late 2000, 46% of all mortgage loans was securitized. In the EU, securitization started only after the introduction of the Euro, and the size of the market is still considerably smaller than in the US. The basic idea is that the default risk in a loan is to a large extent idiosyncratic, and can therefore be diversified away by repackaging a sufficiently large number of these loans in a security with a given risk characteristic of the associated cash flow (Cowley and Cummins, 2005). The security can be sold on the market, as the asymmetric information problem has been solved through diversification.[17] The risk of the newly created security is of a macroeconomic nature, not unlike the risk of a (sectoral) stock market index fund. As a result of securitization, banks can remove illiquid loans from their balance sheet. The role of banks as a transformation unit of liquidity (Diamond and Dybvig, 1983) is thus substantially reduced. It follows that monetary policy that uses the bank lending channel by targeting the liquidity of banks is less effective. This holds in particular for loans related to mortgages or credit cards. Securitization of firms' loans does not occur, as it would sever the special client-bank relationship, see Section 4.1.[18]

4.2.2 The Bank Capital Channel

Next to liquidity, another balance sheet item deemed important in the credit view of monetary transmission is the net worth of banks. The importance of bank net worth is already pointed out

[17] Of course, this creates a new moral hazard problem, by reducing the bank's monitoring incentives.

[18] However, securitization of single complete firms is not uncommon (Cowley and Cummins, 2005).

in the analysis of Holmström and Tirole (1997), where banks have to participate in the risk taking of firms to resolve an incentive compatibility problem. Van den Heuvel (2006) discusses a separate 'bank capital channel,' as distinct from the bank lending channel (i.e. liquidity), in which the capitalization of banks plays an important role. Because of a maturity mismatch between assets and liabilities, an interest rate change has an effect on bank's profits, hence on its net worth. In case of an increase in interest rates profits go down and, as a result of regulatory constraints, banks will either need to issue new equity or cut back on their loans. The effect is similar to a financial accelerator effect for real firms, caused by a collateral requirement (see Bernanke and Gertler, 1995), in that the required rate of return goes up, while the market value of the bank goes down.

Bank capitalization is also important because it is subject to regulatory constraints. Blum and Hellwig (1995) were the first to study the macroeconomic implications of the original Basel agreement. They pointed out the existence of a positive feedback loop, whereby a recession leads to lower bank capital, which reduces bank lending and reinforces the recession. Under the Basel accords, a bank's assets are weighted with a measure of credit risk, so that a risky portfolio is valued less and lowers the capitalization ratio of a bank. If a bank's credit risk increases, the imputed portfolio value decreases, and the bank's capitalization may fall below the imposed threshold value. This drives up the cost of capital for the bank and forces it to cut back its risky loans (Thakor, 1996). In times of recession, all banks are hit simultaneously by increased credit risk, so that credit supply peters out. The net effect of Basel is therefore procyclical (Kashyap and Stein, 2004; Gordy and Howells, 2006; Drumond, 2009).[19]

A paper along these lines is Bolton and Freixas (2006), who analyse the transmission effects of monetary policy in a general equilibrium model of the financial sector, with bank lending and securities markets. Bank lending is constrained by capital adequacy requirements, and asymmetric information adds a cost to outside bank equity capital. As a result, the cost of capital for banks is endogenous, and the cost of bank lending as well. Bolton and Freixas show that multiple equilibria may arise, including a 'credit crunch' equilibrium with low bank capital and high costs of lending.

4.3 Empirical Support for the Bank Lending Channel

There is wide empirical support for a limited substitutability between bank loans and financial market access, in particular for small firms. Hoshi et al. (1991) show that Japanese firms that are part of an industrial group (a 'keiretsu,' with a city bank at its core) display a lower sensitivity of investment to cash flow than firms that are not part of an industrial group. Petersen and Rajan

[19] Basel III strives to repair the negative side effects of Basel II by imposing higher capital ratios and by imposing flexible leverage constraints.

(1994, 1995) find that for small firms a close relationship between the firm and one or a few banks increases the availability of credit to the firm, compared to firms who borrow from a large number of creditors. Gertler and Gilchrist (1994) analyse the response of small versus large manufacturing firms to monetary policy. They find that small firms account for a significantly disproportionate share of the manufacturing decline that follows tightening of monetary policy. Khwaja and Mian (2008) show that, while banks pass their liquidity shocks on to firms, large firms – particularly those with strong business or political ties – completely compensate this loss by additional borrowing through the credit market. Small firms are unable to do so and face large drops in overall borrowing and increased financial distress.

4.3.1 Bank Liquidity

The empirical support for an effect of monetary policy on bank credit supply is mixed. A fundamental problem is how to distinguish supply shifts from demand shifts. Kashyap and Stein (1993) use the dating method employed by Romer and Romer (1990) to identify periods of tight monetary policy. They find that tighter monetary policy leads to a shift in firms' mix of external financing: commercial paper issuance rises while bank loans fall. They take this to imply that contractionary policy can indeed reduce loan supply. Moreover, these shifts in loan supply appear to affect real activity through investment expenditures, although the effect is not very large. Oliner and Rudebusch (1996) argue that the effect of monetary policy on the financing mix is mainly a composition effect. It is due to the larger exposure of small firms to business cycles, (see Gertler and Gilchrist, 1994). For small firms the bank/non-bank credit mix does not change over the cycle. They interpret their result as indicating that small firms face a more severely restricted *overall* access to credit during the downward phase of the cycle, rather than just restricted access to bank credit. In reply, Kashyap et al. (1996) point out that also in the subsample of large firms the ratio of commercial paper to bank credit increases following a monetary contraction. Indeed, Kashyap et al. (1993) show that the spread between the federal funds rate and the rate on commercial paper widens during periods of tight monetary policy, which also suggests a *relative* shift from bank loans to commercial paper for all agents combined.

More micro-econometric evidence is given by Ludvigson (1998) and Kashyap and Stein (2000). Ludvigson estimates the change in the composition of consumer loans in response to a change in monetary policy. She finds that unanticipated changes in monetary policy have an effect on the *composition* of consumer credit. However, the effects of this shift in debt composition on the *level* of consumption are found to be rather small. Kashyap and Stein use a panel data set of individual banks to show that less liquid banks do reduce their loan supply in response to tighter monetary policy. This behaviour is stronger for smaller banks. The size of the effect on macroeconomic activity is left open, however. Gambacorta and Mistrulli (2004) also find that well-capitalized banks can better shield their lending from monetary policy shocks,

which agrees with the bank lending channel hypothesis. The existence of non-price channels may be demonstrated more easily in markets that are financially less developed. Khwaja and Mian (2008) use unexpected shocks from nuclear tests in Pakistan to show that for the same firm borrowing from two different banks, its loan from the bank experiencing a 1 percent larger decline in liquidity drops by an additional 0.6 percent. This agrees well with Paravisini (2008), who tests for financial constraints and underinvestment by local banks. Banks are found to expand lending by $0.66 in response to an additional dollar of external financing.

Den Haan et al. (2007) distinguish between a number of components of bank loans, viz. commercial and industrial loans, real estate loans, and consumer credit. Using U.S. data, they find that these components behave quite differently during a monetary tightening episode, so that the results of standard VAR analyses suffer from aggregation bias. In particular, real estate and consumer loans fall significantly, while commercial loans go up (in agreement with the argument of Kashyap and Stein (1993)). During non-monetary downturns on the other hand, commercial loans fall, while real estate and consumer credit do not show any marked response. Black et al. (2010) look specifically at the effect of monetary policy on mortgage loan supply. They find that only loan supply of banks who finance subprime mortgages at the margin from unsecured deposits is affected, in that the interest rate spread of these banks increases in times of tight money. The implication is that over the sample period, 1995–2006, the larger part of mortgage loan supply was not affected by monetary policy (possibly as a result of ongoing securitization).

For the Netherlands, Van Ees et al. (1999) test the adjustment of Dutch banks' balance sheets in times of monetary policy changes during the period 1957–1991. In case of changes in the official interest rate, the volume of bank loans is not affected and banks display a kind of buffer-stock behaviour by diminishing their publicly traded assets. In situations with quantity restrictions on the growth of net money creation, however, the volume of loans is affected significantly when the quantity restriction is withdrawn, thereby fulfilling a necessary condition for the bank lending channel to be effective. Garretsen and Swank (2003), using a series of VAR models, estimate the effect of monetary policy on bank lending, production, and inflation. They do not find any evidence that a bank lending channel affects real activity. Bank loans do not start to decrease until twenty months after the monetary contraction, and private spending is hardly affected at all. As a possible explanation, the authors suggest that firms and households adjust their portfolio holdings in response to monetary tightening. De Haan (2003), using micro data, finds a bank lending channel for unsecured lending, i.e. loans not backed by a government guarantee. In agreement with the results of Kashyap and Stein (2000), the channel is stronger for small banks. However, De Haan does not look at the effect of the reduction in loan supply on private spending, so that the quantitative impact of the bank lending channel on real activity is unclear.

Altunbaş et al. (2009) claim that the changing role of credit intermediaries due to securitization has modified the effectiveness of the bank lending channel and banks' ability to

grant loans. Using a novel database of securitization activity and a large sample of European banks, the paper finds that the use of securitization shelters banks' loan supply from the effects of monetary policy. Securitization activity has also strengthened banks' capacity to supply new loans. This capacity, however, depends on business cycle conditions and, notably, on banks' risks positions.

4.3.2 Bank Capital

The evidence for an effect of bank capitalization on bank lending is fairly strong. Bernanke and Lown (1991) discuss the effects of a curtailment of bank lending on the recession of 1990-91 in the US (the 'credit crunch'). Bank capitalization had dropped on the eve of the recession as a result of the burst of a real estate bubble in New England and a tightening of monetary policy. Bernanke and Lown find a clear relation between the capitalization of banks and the growth of credit supply. However, the relation between bank capitalization and real economic activity is less clear. In particular, they do not find any relation between capitalization and employment growth. Hancock and Wilcox (1993) use the credit crunch episode to estimate the impact on bank credit flows of such real and financial factors as weak loan demand, banks' revised estimates of the risks of and returns on lending, and banks' capital conditions. Some banks apparently reduced their lending to satisfy regulators' capital requirements. Peek and Rosengren (1995) also find that the reduction in bank capital in 1990 caused New England banks to contract, *independent* of demand conditions. Kishan and Opiela (2000) provide evidence of a bank capital channel of monetary policy in the United States over the period 1980 to 1995. They test for bank loan supply shifts by segregating banks according to asset size and capital leverage ratio. They find that the loan growth of both small and undercapitalized banks is significantly affected by policy.

Altunbaş et al. (2002) examine evidence for a bank lending channel in Europe. Following the approach suggested by Kishan and Opiela (2000), they use bank balance sheet data to estimate the response of bank lending to changes in monetary policy stance between 1991 and 1999. Using a panel data approach they find that across the EMU systems, undercapitalised banks (of any size) tend to respond more to a change in policy. Gambacorta and Mistrulli (2004) use the excess capital-to-asset ratio to better control for the riskiness of banks' portfolios, and to disentangle the effects of the 'bank lending channel' from those of the 'bank capital channel.' Using Italian data, they find evidence of both a bank lending channel and a bank capital channel, in which the effect of a financial shock on credit supply is larger, the larger is the maturity mismatch between assets and liabilities.

The evidence for an effect of bank capitalization on real activity is mixed. Hancock and Wilcox (1998) present estimates of the effects of the 1990 capital crunch on bank loans and real activity. They find that small banks shrank their loan portfolios considerably more than large banks and that real economic activity was reduced more by capital declines and loan declines at

small banks than at large banks. Hubbard et al. (2002) find that banks with less capital charge higher loan rates, in particular to firms for which information costs are important and that cannot easily switch banks. This creates an empirically observed incentive for these firms to hold higher cash reserves, which affects their cost of capital. Ashcraft (2006) finds little effect of the share of financially constrained banks on output, which leads him to conclude that the bank lending channel is not important for output fluctuations.

Japan constitutes an important natural experiment in the effects of bank capitalization on the real economy. Japanese banks held considerable amounts of domestic stock at the time of the collapse of the Nikkei in 1990-91. In addition, they had substantial positions in Japanese real estate in the form of collateral. The value of all these assets was reduced by two thirds and more in just two years, leaving Japanese banks severely undercapitalized by 1992. This problem was for a long time not addressed by policy, so that the undercapitalization persisted for several years. Woo (2003) shows that this led to a contraction of credit supply in Japan and Peek and Rosengren (2000) that it affected mortgage loan supply of Japanese banks in the US. The undercapitalization of banks is often used to explain the stagnation of the Japanese economy in the nineties (e.g. Bayoumi, 2001; Kuttner and Posen, 2001). However, Hayashi and Prescott (2002) argue that the main cause of the stagnation is a productivity slowdown, and not a lack of funds for investment. In fact, Japanese investment fell most of all expenditure categories during the nineties (Horioka, 2006), so that a link with credit supply is plausible. Indeed, Goyal and Yamada (2004) and Hori et al. (2006) explain the investment decline partly from a lack of bank credit, but mostly as a consequence of a fall in the value of firms' assets, i.e. a financial accelerator effect.[20]

4.3.3 Bank Lending in DSGE Models

The empirical evidence on the bank lending channel cited in Section 4.3 shows that both the capitalization ratio and the liquidity position of a bank have a clear effect on its lending. Illiquid and undercapitalized banks reduce their lending and charge higher rates for loans. On the basis of this evidence, the macroeconomic impact of this mechanism is difficult to assess, however. If banks succeed in rapidly adjusting their balance sheets, the effect may be short-lived. In this case, the impact of bank balance sheet composition on capital costs for borrowers is small. On the other hand, in the presence of destabilizing feedback loops, economy-wide cuts in bank lending due to undercapitalization lending will further reduce the value of bank capital and delay adjustment. Therefore, as in the case of the financial accelerator, the full effect of this transmission channel can only be assessed in a general equilibrium framework.

[20] Neither study tries to distinguish between the effects of changes in firm collateral value, and changes in bank capital. As the two were heavily correlated over the sample period, the estimates may have picked up a bank lending channel effect.

Recently, a number of papers have appeared that include an effect of bank balance sheet composition on economic activity in a general equilibrium setting.[21] These models all use the bank capital channel, in which the capitalisation ratio of banks affects their lending behaviour.[22]

Angeloni and Faia (2009) introduce banks into a standard DSGE model. As in Diamond and Rajan (2000, 2001), the intermediation role of banks is based on the disciplinary threat of bank runs: if the entrepreneur offers too low a return on its loan, the bank defaults, a bank run occurs, and the investment project has to be liquidated (point 1 in Section 4.1). The threat of a bank run determines an optimal deposit/capital ratio that balances the desire of the bank to attract more deposits with the risk of a bank run. A higher level of bank capital lowers the risk of a bank run, but also reduces profits. Low capitalization ratios and high interest rates therefore reduce bank loan supply. Conversely, high entrepreneurial profits boost loan supply, as they reduce the probability of a default of the entrepreneur and therefore the risk of a bank run. Angeloni and Faia use this framework to study the role of banks in the transmission of shocks, the effects of monetary policy when banks are exposed to runs, and the interplay between monetary policy and Basel-like capital ratios. They find that procyclical capital requirements are destabilizing and can only be partly offset by monetary policy. The welfare loss of introducing procyclical capital regulation can be substantial at a few percent of consumption.

De Walque et al. (2010) specify a DSGE model with a heterogeneous banking sector. Banks are subdivided into merchant banks and deposit banks. Merchant banks invest in securities and firm loans and obtain their funds from the interbank market or shareholder capital. They face a quadratic cost of default on their interbank borrowing, so that an optimal capitalization rate exists. Deposit banks use own funds and household deposits to invest in loans to the interbank market and securities (securities are exogenous). Both types of banks are subject to regulation by the Central Bank. The model contains two balance sheet feedback mechanisms: a financial accelerator along the lines expounded in Chapter 3.1 and a bank capital channel that affects the interbank loan market. If merchant banks have low capital, their default rate is higher so that deposit banks will charge higher interest rates in the interbank loan market. As a result, merchant banks have a problem attracting sufficient funds, which lowers their profits and slows down their recovery. In addition, the problems in the interbank market trigger a financial accelerator feedback loop in the real sector of the economy, further delaying recovery. The Central Bank can stabilize interest rates through liquidity injections in the interbank market.[23]

Meh and Moran (2010) develop a DSGE model in which banks act as intermediaries between investors and entrepreneurs. Bank capital invested in a firm mitigates an agency problem

[21] The larger part of DSGE models that incorporate a non-price credit channel uses feedback mechanisms based on the balance sheet of firms and households (the financial accelerator), see Chapter 3.

[22] Gertler and Kiyotaki (2010) develop a canonical framework to think about credit market frictions and aggregate economic activity in the context of the current crisis.

[23] The liquidity injection is in the form of commodities, as the model is of the RBC type, without money.

between banks and their creditors (see point 5 in Section 4.1). Banks with low capital must reduce their supply of profitable loans and therefore attract fewer deposits as well. As a result, these banks cannot expand at the same rate as well-capitalized banks with the same book value. This negative feedback loop characterizes the bank capital channel. The model is calibrated using parameter estimates from other authors and matches the U.S. economy in a number of respects. The authors find that negative shocks in bank capital create sizeable declines in output and investment. Technology shocks are also amplified through this channel, as they affect the market value of firms, and therefore the capitalization of banks.

In Gerali et al. (2010) the bank capital channel is generated by an exogenous regulatory constraint, as in Van den Heuvel (2006). The authors introduce an imperfectly competitive banking sector into a DSGE model with financial frictions. Banks have some degree of monopoly power, which enables them to offer different lending and borrowing rates to households and firms. The margins charged on loans depend on the capitalization ratio of the bank and on the degree of interest rate stickiness. In addition, the loans supplied are collateralized, so that households and firms face a credit constraint that depends on their net worth. The model thus contains both a bank capital channel and a financial accelerator. The model is estimated with Bayesian techniques using data for the Euro area. The authors find that the banking sector partially attenuates the effects of demand shocks, while it boosts supply shocks. Second, shocks originating in the banking sector explain the larger share of the fall of output in 2008 in the euro area. Third, an unexpected destruction of bank capital has a substantial impact on the real economy and particularly on investment.

The papers discussed do not provide direct information about the macroeconomic impact of raising capital requirements, as in the Basel III proposal. However, the papers of Gerali et al., Meh and Moran, and De Walque et al. do offer information about the macroeconomic adjustment path following a fall in bank capital. Estimated adjustment periods vary, but are long in all cases. In de model of De Walque et al., it takes about seven years for output to recover after a shock to bank capital, although the adjustment period can be shortened substantially if the central bank resorts to liquidity injections. In the model of Meh and Moran the adjustment period for the bank capitalization ratio is about ten years, whereas output is still not back on track at that time. Gerali et al. do not show the full length of the adjustment path, but after 5 years none of the key macroeconomic variables is close to the benchmark path. [24]

[24] These adjustment periods are longer than those reported in Macroeconomic Assessment Group (2010), where the average adjustment period over all models used is about three years for a two-year implementation period. Moreover, the short-term effects of raising the target capital ratio in the Macroeconomic Assessment Group study are substantially smaller than those in the DSGE models discussed here. It is difficult to assess the causes for this difference in outcomes without detailed knowledge of the models involved, in particular with respect to the presence of the balance sheet transmission channels discussed in the present paper.

4.4 Relation to CPB Analyses

Once, macroeconometric models used at CPB contained a monetary sector (Hasselman et al., 1983; Van Erp et al., 1989) with a separate market for bank credit. In Hasselman et al. rationing of short-term bank credit may occur. Supply and demand of bank credit are modelled as standard portfolio equations, with interest rates and lagged portfolio holdings as their main arguments.[25] In addition, the actual amount of bank credit affects portfolio decisions. The interest rate on bank credit is pegged to the discount rate of the central bank. The actual amount of bank credit equals the minimum of supply and demand. Bank credit affects inventory investment, so that the model does contain a bank lending channel.[26] In Van Erp et al. rationing of bank credit does not occur, and the interest rate channel is the only channel of monetary transmission.

Bijlsma et al. (2010), section 4, briefly discuss the bank lending channel in relation to capital adequacy requirements and the Basel accords.

4.5 Assessment

The existence of a separate bank lending channel is theoretically founded in the asymmetric information between borrowers and lenders. Banks enjoy economies of scale and scope in the acquisition of credit that households and (small) firms lack. The empirical evidence on the quantitative importance of the bank lending channel is however inconclusive. There is substantial empirical evidence that monetary policy affects bank lending. It appears that especially small banks are affected by a tightening of monetary policy. Large, well-capitalized, banks are better able to shield their borrowers from changes in monetary tightness.

The effect of changes in loan supply on private sector spending is more ambiguous. Many studies do not find a substantial effect of monetary policy on real activity via the bank lending channel. It appears that at least part of the disruption of bank loan supply can be offset by firms and households by changing their portfolios. In addition, securitization has blunted the use of monetary policy to restrict bank loan supply, especially with respect to the mortgage market. However, there is evidence that the activity of small firms is affected.

There is substantial microeconometric evidence that shocks to bank capital do affect bank loan supply.[27] The conclusion also applies to large banks, even if to a lesser degree than to small banks. In addition, under-capitalized banks appear to charge higher interest rates, which raises capital costs for firms and households alike. Empirical evidence as to the macroeconomic effects

[25] Bank capital does not play a role in the portfolio equations, so that the bank capital channel is not present.

[26] A peculiar element of the inventory equation is that inventory formation depends on bank credit even if firms are not credit-constrained.

[27] The finding that the bank lending channel is quantitatively unimportant as a transmission channel of monetary policy therefore applies specifically to the bank liquidity channel.

of the bank capital channel is mixed. If the capital shock is limited to a subset of banks, macro effects do not appear to be present. Evidence from DSGE models *suggests* that an economy-wide shock to bank capital has substantial and long-lasting effects on economic activity.

5 Trade and Finance

World trade has dropped tremendously during the financial crisis. In pure numbers it did so even stronger than production. Levchenko et al. (2009) analyse U.S. monthly and quarterly data on exports and imports. As seen in world trade, the drop in imports- and exports is quite more dramatic than in GDP. Most strongly did trade in consumer durables and industry supply as well as intermediates fall. It did so evenly across trading partners. Both, quantities and prices of traded goods fell, however, the reduction in quantity was economically more important. The exceptionality can also be seen in the contribution of Grossman and Meissner (2010) who put this crisis in historical perspective especially with respect to the great depression of the 1930s.

The relative movement between trade and production is an interesting occurrence, since it displays a pattern that we do not expect looking at standard economic models. A widely and commonly used model to explain trade patterns is the well known gravity model[28]. To put it in simple words, the model explains trade between two partner countries to be a function of the relevant distance between the countries and the size of their economies usually measured by GDP. If economic size, i.e. GDP, is the important economic figure during a crisis, the gravity model should at least to some extent be able to replicate the size of the drop in trade and relate it to the drop in production or GDP. However, recent evidence points in a different direction. The drop in trade is by far larger than predicted by a typical gravity model, see e.g. Amiti and Weinstein (2009) and the references therein.

Following this, we are left with a puzzle or at least with a situation which is not adequately explained by typical models motivated by past observations. The question that remains to be answered is why did indeed trade drop so much in excess of production as it did. This question already suggests to look for something as an amplification mechanism analogous to the financial accelerator which we were looking at above.

Below, we will look at the literature in order to come closer to an answer. As the focus of this document is on the relationship between financial markets and the real economy, we will focus on finance related arguments. Other arguments are e.g. greater trade barriers during crises, direct demand and supply effect or demand composition effects as well as arguments related to the supply chain architecture of world production. Demand composition and supply chain effects are likely to interact. In general, the drop in demand was most drastic in the automotive and durable investment goods industry, see e.g. Eaton et al. (2010). Comparing the composition of trade and general production reveals that trade is biased towards such goods. Therefore trade should be more heavily affected than production in general, the bias is however not strong enough to explain the drastic drop in trade relative to production. The production of such goods

[28] The model was introduced by Tinbergen (1962) and Pöyhönen (1963). It owes its name due to the formal similarity to Newton's universal law of gravity.

is heavily spread across countries through the global supply chain. The drop in demand for such goods therefore immediately spreads out among many countries. During a crisis, a country might be tempted to protect its own economy by limiting competition by firms from abroad. However, free trade agreements are designed and aimed at prohibiting such behaviour. Nevertheless countries can invoke informal trade barriers by introducing safety or health related product standards 'tailored' to the home country industry. However, this was not happening to a great extent during this crisis (see e.g. OECD (2010)). In general it seems that these arguments do not deliver sufficient satisfying answers to our question. For a recent discussion of these arguments see e.g. chapter 3 in Van Ewijk and Teulings (2009) or Bricongne et al. (2009a,b).

Since there seems to be a lack of a standard theory that is able to explain such a relationship between financial markets and trade, we discuss mostly empirical observations in the following subsections. However, there are also some theoretical results which we report that point towards the possibility of an amplifying mechanism related to trade and finance. Looking at the existing literature provides us further with the impression that the question about financial effects on trade has mostly concerned researchers in the recent past due to the developments during the crisis 2007-2009. Many contributions we review are therefore working or discussion papers and not peer reviewed journal articles.

To judge upon the contribution of the literature on the topic, we first give a brief introduction about financial practices in international trade. This is helpful because it shows us the numerous problems that exist in trade and which are all relevant when shocks on the capital market occur. After this, we turn to the theoretical and empirical literature. Finally, we conclude this chapter with a summary of the findings and how they might relate to CPB's macro economic models.

5.1 Practices in Trade Related Finance

Trade brings about at least two major problems in connection with finance. Typically, the exporter and the importer of a good or service are located in different countries with possibly substantial differences in institutional, cultural and legal settings. Enforceability of contracts is a particular cross border problem. Second, a substantial fraction of trade in goods take place via shipment methods that consume time, time during which a good is unproductive or can not be sold further by the importer in case of a missing future market.

Both problems give rise to a deviation from the assumption of perfect and complete markets underlying many main stream economic models. They introduce the problems of uncertainty and missing markets and are, as such, the source of inefficiencies. In trying to overcome these problems, actors on financial markets have developed instruments that aim at reducing these sources of inefficiencies. The main constructs related to trade are letters of credit, international factoring, trade lending and credit insurances. The letter of credit seems to be the most frequently used instrument with a market share in developed countries of about 40%. All of the

instruments introduce their own problems that link this section to the remainder of the document. Below we give a brief overview about how these instruments work. Trade finance goes well beyond pure credit lending. The most important additional aspect is uncertainty that is involved in business with trading partners in other countries.

Letter of credit

The letter of credit is typically issued by the bank of the importer to give the exporter the needed certainty to ship the product. The bank therein guarantees to pay a specified amount to the exporter's bank if conditions of the letter are fulfilled. Usually, these conditions contain the documents related to the trade for shipment, insurance and landing but can be freely negotiated. Thus, this instrument is aimed at reducing the risk and uncertainty to some degree. However, the approval of trade is only by inspection of documents and not the physical good. Therefore, some degree of uncertainty remains. Note also, the bank of the importer issues a guarantee which is to some extent equivalent to a credit and might therefore be subject to collateral to be provided by the importer. The instrument is not resolving the illiquidity problem of the good during shipment directly but is sold in practice at a discount.

International factoring

To provide a solution to the illiquidity problem, international factoring agencies offer their service. The exporter who has a financial claim on the importer which he only will fulfil after he obtained the good or service can sell his claim at a discount rate to the agency. Thus, the exporter is instantaneously provided with liquidity for which he has to incur the costs of the discount. If agreed so, this arrangement leaves the factoring agency with the solvency risks of the importer which might be manifold. To cover that risk, factoring agencies typically make use of trade insurances. They refinance their operations usually on the capital market.

Trade lending

This also works at reducing the problems arising from illiquidity. It is however a traditional credit provided by the exporter's bank which is subject to the usual credit restrictions such as collateral and additionally is affected by potentially higher risks do to trade as compared with domestic sales.

Trade insurances

Trade insurances are typically not the business of banks but that of more traditional insurance companies or public institutions. Within freely negotiable contracts the insurer can guarantee the payment of a specific amount in case of a particular event. This might be insolvency of the importer but can also cover e.g. political risks which might be relevant to specific countries. Typical clients are international factoring agencies but in principle also the exporter can directly

buy insurances. Also banks can invoke specific insurances for letters of credit instead of collateral provided by the importer. There is nothing like a standard as in case of the letters of credit. Therefore these are just examples which are by far not exhausting. Insurances can be offered by private insurances where the usual problems of insurance markets come into play, but can also be provided by public institutions or a state as means or part of trade policy.

5.2 Theoretical arguments

The recent theoretical literature in trade emerging after the publication of Melitz (2003) stresses extensively the role of heterogeneous firms. As this approach seems to be the new paradigm in trade theory we focus our overview over theoretical arguments on the relation between trade and finance on this class of models.

In Melitz (2003), firms differ with respect to their total factor productivity drawn from a random distribution. In its very basic formulation, the model predicts that only firms with high productivity choose to export to another market besides their domestic. The reason for this is that firms have to incur a fixed entry cost if they decide to supply a foreign market. Only for high productivity firms it is possible to sell a quantity high enough to recover these fixed cost. Since its publication, many extensions of the model have been proposed in the literature. Also it seems that the model when confronted with data does well in explaining trade patterns. Important for this subsection are the contributions that deal with the role of credit constraints in the decision making process for firms regarding their export behaviour.

In the model of Chaney (2005), firms have heterogeneous productivity and are faced with the decision whether to export or not as in the original Melitz (2003) model. Additionally, they are confronted with credit constraints that apply to the financing possibilities of the fixed cost that have to be incurred before entering a market abroad. In a world without financial frictions, any firm that finds it profitable to export could finance these fixed cost. In the presence of credit constraints this however, is not the case. In the model, firms can only borrow against their domestic cash flow and an exogenous liquidity supply which is supplied to the firm in a stochastic manner. The predictions of the model are twofold, first, some firms are excluded from exporting due to credit constraints although they would export in a first best world. Second, an increase in the exogenous liquidity supply generally boosts trade. A special focus of the paper is on real exchange rate movements. It is shown that an appreciation of the domestic currency has both positive and negative effects on trade: First, it increases the value of domestic cash flow, and second, it decreases profits from exporting. Thus, the effect of exchange rate movements is ambiguous. More suggestive is a conjecture of the author for future research of a possible amplification mechanism through credit constraints. If a firm is able to export to one country, this might give rise in an extended model to additional cash flows making it possible to conquer

another market and so forth. The mechanism could run if true, of course, also the other way around.

Manova (2008) employs in principle also a Melitz (2003) type of model but in the more stylised and less elaborate version of Helpman et al. (2008). The model aims at explaining certain empirical trade patterns through credit constraints. Looking at trade data often reveals that countries tend to concentrate trade among only a few other countries. A typical trade matrix contains numerous zero entries[29]. As in Manova (2008), heterogeneous firms endogenously choose whether to export or not; exporting demands incurring a fixed cost. Finance of these fixed cost is subject to credit constraints given by the value of collateral determined by a fraction of the fixed costs which is meant to represent a tangible asset. Thus, contrary to Manova (2008), the non-domestic activity serves as collateral.

The interesting result both models have in common is the occurrence of sudden stops in trade at the firm level. Once the credit constraints passes by a certain threshold, a firm or even a sector chooses not to trade at all. If however the firm is active in trade, its trading volume is identical to the one that would be obtained in a world without trade frictions.

Raddatz (2010) proposes an interesting theoretical argument related to the financial accelerator. Trade partners might be seen as an extraordinary risk by lenders devaluing a firms assets used as collateral. This might first give rise to an amplification mechanism as explained in the chapter on the financial accelerator. Second, firms have an extra incentive to cut back in trade to forgo such a negative effect which might be a reason for a drastic drop in trade. This argument gives way to consider further consequences when recalling the literature on endogenous credit constraints in Chapter 3.1. Given the validity of this argument, trade insurances gain in importance due to their nature of counteracting the potential of foreign trading partners in devaluating collateral values.

In brief, theoretical models related to trade finance, especially with respect to heterogeneity, come from recent contributions. It seems that the models are mostly applicable to trade lending or normal credit lending, thus, insurance problems are not touched upon. However, the cited papers give some interesting arguments. These are the two arguments related to a possible feedback loop in trade in Chaney (2005) and Raddatz (2010) both of which give a direct connection to the financial accelerator.

[29] A similar motivation drives the work in Muûls (2009) with a comparable model and comparable results.

5.3 Empirical observations

Anecdotal evidence

This type of evidence is as its name suggests not scientific approved evidence. Rather it is based on expert's opinions, informal surveys or other information. Typically no sophisticated quantitative methods are applied to form conclusions.

The International Chamber of Commerce (ICC (2009)) conducted a survey among exporting firms in several countries on trade finance conditions. According to their results there seems to be on the one hand an increasing demand of trade finance during the crisis since less firms are willing to trade on open account. On the other hand firms experience tighter conditions by financial institutions, higher costs and less finance volume. It seems not in order to report the precise numbers as there is no information on the representativeness of the survey. The survey is partly also less clear about how different instruments in trade finance were affected.

Dorsey (2009) and IMF (2009) report on a bank survey conducted by the IMF and the Bankers Associations for Finance and Trade (BAFT) in 2008 in response to the drop in trade. Increased cost for letters of credit since 2007 were reported by 70% and of trade lending by 90% of respondents. The vast majority of responding banks sees the cause in increased refinancing cost and increased capital requirements. No information was given regarding the representativeness of the survey respondents.

Auboin (2009a,b,c) stresses the role of trade finance since at least 80% of world trade relies on some type of underlying finance agreement (number provided without source) and that in the peak during the crisis the letter of credit spread (with respect to LIBOR) increased up to 500 basis points for some counter parties. According to the author, the trade finance shortage might be responsible for up to 15% of trade drop (number according to World Bank calculations without precise source).

Directly related to trade insurances, Jones (2010) gives an overview on their gained importance during the recent past. Trade insurance is now an essential part in the course of world trade. During the crisis, losses to insurers increased dramatically. The loss-ratio, i.e. the ratio of losses to gross insurance premia raised from roughly 40% before 2008 to about 85% in 2008 and 2009. Total exposure to risk to all insurers was 1.8 trillion USD in 2008 and trade volume insured was 2.6 trillion USD.

However, there is also anecdotal skepticism. Humphrey (2009) reports on a telephone survey among horticulture and garments firms in sub-Saharan Africa. No evidence on trade finance shortage was reported from the respondents. Almunia et al. (2010) are sceptic for a large role to play by trade finance friction. They argue that programs involving public banks and institutions providing different means of trade finance during and in the aftermath of the crisis render the argument useless.

Econometric evidence

Going beyond the just mentioned anecdotes, there are also quite a view more scientific studies on the role trade finance. Studies at various levels of aggregation can be found in the literature and we review them starting with the most aggregate ones.

Cheung and Guichard (2009) use time series data on world trade in an error correction model. To account for trade finance the authors proxy by using three different measures. First, the difference between the fraction of U.S. banks reporting a tightening and a loosening in credit conditions, second, the spread of U.S. T-bills and third a 'financial stress' indicator reflecting both aforementioned aspects. The results are mixed, in some cases a significant negative impact of adverse financial conditions is found. However, when controlling for things as vertical integration of world production and recession synchronization effects, this significance vanishes. It should be noted that the measures of financial conditions are quite general and rather non-specific to trade. In a simulation, the authors calculate that the adverse financial conditions contribute to about 10 to 20% of the observed trade collapse.

Ronci (2005) looks at the problem from the country's point of view by using panel data. The measure or proxy for trade finance is short term outstanding U.S. Dollar debt associated with trade as reported by the Bank of International Settlement. The panel comprises just 10 countries over a period of 10 years. The results indicate that growth in the trade finance measure has a significant positive impact on the country's export and import growth.

There are also several studies at the industry level which allow the authors to make use of data with better quality. Raddatz (2010) uses sector data for 28 manufacturing industries in 44 countries from input-output tables from 1980 to 2004. He looks at sector pairs across and within countries and in particular at their correlation in growth of value added and production. Through the input-output construction each pair has one downstream sector which is the input sector. Drawing on U.S. industry data, the author uses the downstream sector's dependence on trade finance and weights it by the input-output relationship to the upstream sector. He obtains in this way a measure of 'credit chain closeness' between sectors. In numerous regressions this measure turns out to be positively associated with the correlation of both industries growth in value added and production. This study can provide us with indirect evidence on the importance of trade finance for the synchronization of real sector activity. However, due to the intense data manipulation in the study it is hard to quantify effects.

Levchenko et al. (2009) use import and export growth data for 450 U.S. sectors between mid 2008 and mid 2009. To account for trade finance the authors use two measures working as proxies. Through aggregating firm level data from Compustat, they obtain two measures of trade finance volume in each sector. In a simple OLS regression none of them turns out to be statistical significant. It seems obvious that the results might be subject to endogeneity problems and reverse causality. Trade finance volume is the result of supply and demand and estimation is subject to the well known problems of endogeneity of market outcomes. Iacovone and Zavacka

(2009) also conduct an industry study but for export growth alone. They use an industry panel for 81 industries in 21 countries over the period 1980-2006. Key variable is an interaction variable of a country specific industry wide crisis dummy and an industry specific dependence measure on external finance and tangible assets for the U.S. The idea behind the latter is to assume that the U.S. variable is representative across countries. This assumption might also derive from the fact that no comparable data are available across a large enough sample of countries. By interacting these variables one obtains by construction a new variable that does not suffer from reduced variation. The results indicate that the interaction term is a significant variable with a negative coefficient. The authors conclude from this that the effect of a crisis on export growth is amplified by the dependence on finance volume. This seems however questionable since such a conclusion would demand the crisis dummy to be included in a regression also separately. This is however not possible due to the low variation problem as the crisis dummy is defined as indicating industry wide crises. It seems therefore questionable in how far the results are reliable. In a similar vain Manova (2008) analyses also a panel of 27 industries in 107 countries over the period 1985-1995. He also uses the dependence on external finance measures for the U.S. industries and interact them with a country specific measure of financial development which is given by the ratio of private debt to GDP. A significant positive effect of financial development on trade is found. Chor and Manova (2010) examine a cross country industry panel for 2006 to 2009 of exports to the U.S. Finance conditions for exporters is proxied by the applicable interbank rate in the respective country and is common for all sectors in that country. Sector exposure to financial conditions is as in Manova (2008) measured by U.S. industry data. The explanatory variable which is used in the regression is then the interaction between the two measures. The main results indicate that tougher credit conditions and higher financial exposure is affecting U.S. import negatively. However, the same caveats apply as before. Exposure is measured by U.S. data alone, additionally finance conditions are proxied by a country's interbank rate which is clearly not representing trade finance conditions but is more general. Eaton et al. (2010) use the approach of business cycle accounting of Chari et al. (2007) and combine it with a general equilibrium trade model. The authors aim at a decomposition of the trade effects during the crisis 2007-2009 for U.S. imports and exports. Their main findings is not supportive for finance as the primary source of the drop in trade. Rather the results indicate that a combination of trade composition and demand effects is largely responsible.

At an even lower level of aggregation, we find quite some firm level studies that deal with our general question. Amiti and Weinstein (2009) use matched Japanese firm-bank data for the firm's trade behaviour and the 'health' of their banks during the crisis in the 1990s. Their sample covers about 700 manufacturing firms responsible for 80% of good exports. Their main argument relies on the necessity of exporters to finance their shipments. The key variable in the study is the measure of 'bank health' which is the yearly change in the bank's market-to-book value reflecting the market's judgement on the bank. Aggregating over firms in the sample, the

authors first find that there is significant positive correlation between banks' health and the amount of trade finance supplied by them. Second, they find exports to be positively correlated with the volume of trade finance. Going beyond pure correlations, their estimates reveal that firms' export growth is affected by one year lagged change in their bank's health. Through robustness checks with additional variables and different estimation techniques, the authors conclude that they uncovered a causal relationship which is able to explain about 30% of the decline in trade during the crisis.

Muûls (2009) tries to test the hypothesis obtained from a Melitz (2003) type of model using a firm data set for Belgium. As a measure for external finance the author uses a firm's credit worthiness score which is not necessarily trade related. In different regression exercises the following results are obtained. First, a favourable credit score in the past increases the firm's probability to be an exporter to date, second, a favourable credit score increases the number of export destinations. Furthermore, it is empirically shown that exporter first serve large and easy to access markets and with increasing access to external finance, i.e. a favourable credit score, go further in serving smaller markets.

Finally, Greenaway et al. (2007) use panel data on UK manufacturing firms for the time period of 1993 to 2003. Evidence for the role of credit constraints in exporting is indirect. The authors show that the decision to export is positively influenced by the firm's ratio of assets to liabilities and negatively by short term debt to assets. Looking at the way the financial accelerator has found its way into DSGE models, we remember a similarity as the firms net worth to capital ratio was an important variable there.

There are a limited number of studies on the particular instrument of trade insurances which gained considerably in importance during the recent past. Egger and Url (2006) and Moser et al. (2008) estimate the effect of public trade insurances on exports for Austrian and German exporters respectively. They find a statistical and economical significant relationship with a (local) multiplier based on a constant elasticity in the order of 2.8 and 1.7. These numbers are to be interpreted in unit levels, i.e. an increase of publicly insured exports of 1 Euro increases total exports by 2.8 and 1.7 Euro respectively. A recent and important study by Van der Veer (2010) is concerned with quantifying the impact of private trade insurances on total exports. This study is even more important than the two aforementioned since public trade insurances where considerably reduced in most developed countries in order to foster the private insurance market. In a panel of 25 mostly OECD countries, the author finds a multiplier of the order 2.3 in the short run. The rather high multipliers might be suspicious, however, they fit quite well into the theory developed in the above cited Melitz (2003) models. These models have a threshold effect in common, i.e. a certain level of financing ability has to surpassed for a foreign market to be served. This gives rise to a non-linearity which can be seen to reflected by the above multipliers. As mentioned above, insurances might help in reducing risks through foreign trading partners that might negatively influence the firm's collateral values.

5.4 Relation to CPB models

In Chapter 3 on the financial accelerator we were able to formulate ideas on how to implement the mechanism in a quite concrete manner into CPB's macro models. This was due to at least some common agreement in the literature on how the amplification mechanism is to be implemented in macro economic models. Regarding trade and finance, this seems to be not as straightforward. Particular ideas have sound economic intuition or foundation but are not formally developed. Empirical effects are observable but to quite some extent based on proxy measures and additionally might apply only to micro economic settings. An exception might be the recent evidence for trade insurances, however, this is only one aspect of trade finance. By drawing on the existing literature alone, a clear picture for an application in macro economic models does not emerge. There is need for further research in order to develop a formal structure that could be implemented in CPB's models. The importance of trade for The Netherlands strongly encourages this.

5.5 Assessment

At first sight, the empirical literature seems to be a little bit disappointing given the question we post at the outset. There seems to be no clear answer why we have observed such a dramatic fall in trade during the crisis 2007-2009. What can be read off from the literature is that there is likely to be a relation between finance and trade. However, it seems less clear how to draw inference about the precise pattern of this relationship. Also the literature does not look in detail into the different trade finance instruments explained above. The measures used are more or less proxies that can be associated with trade finance in general but not a specific instrument. As such we are not able to distinguish between bank or insurance related problems that led to the observed pattern.

Aggregate studies suffer most from the possibility of biased estimates. These can be due to endogeneity of the independent variables or reverse causality. The exception might be the study of Raddatz (2010) which is done in a sophisticated manner but gives us just indirect evidence on financial effects on trade. Although also not distinguishing between the various aspects of trade finance, the literature using firm level data seems to be more promising. First, such studies can usually draw on higher quality data. Second, they also seem to be on a track closely related to our initial question. It is the sudden stop of trade or a non-linear behaviour of firms in reaction to changes in financial constraints which seems to be supported by the data. However, we have also to be aware of the fact that they provide micro economic evidence and whether the effects carry over to the aggregate remains an open question.

Another aspect concerns the use of proxies or measures for trade finance in the above cited studies. It limits the possibilities of quantifying effects. It might well be possible to calculate

effects from the reported estimates, e.g. the effect of a decrease in credit scores as in Muûls (2009). It is however unclear how a specific shock to the economy and its financial system affects this credit score. We are therefore not in the same position as with quantifying the magnitude of the financial accelerator where the literature has developed a more common specification. These critics apply to a lesser extent to the empirical findings for the effect of trade insurances. But, as said before, this is just one aspect of trade finance.

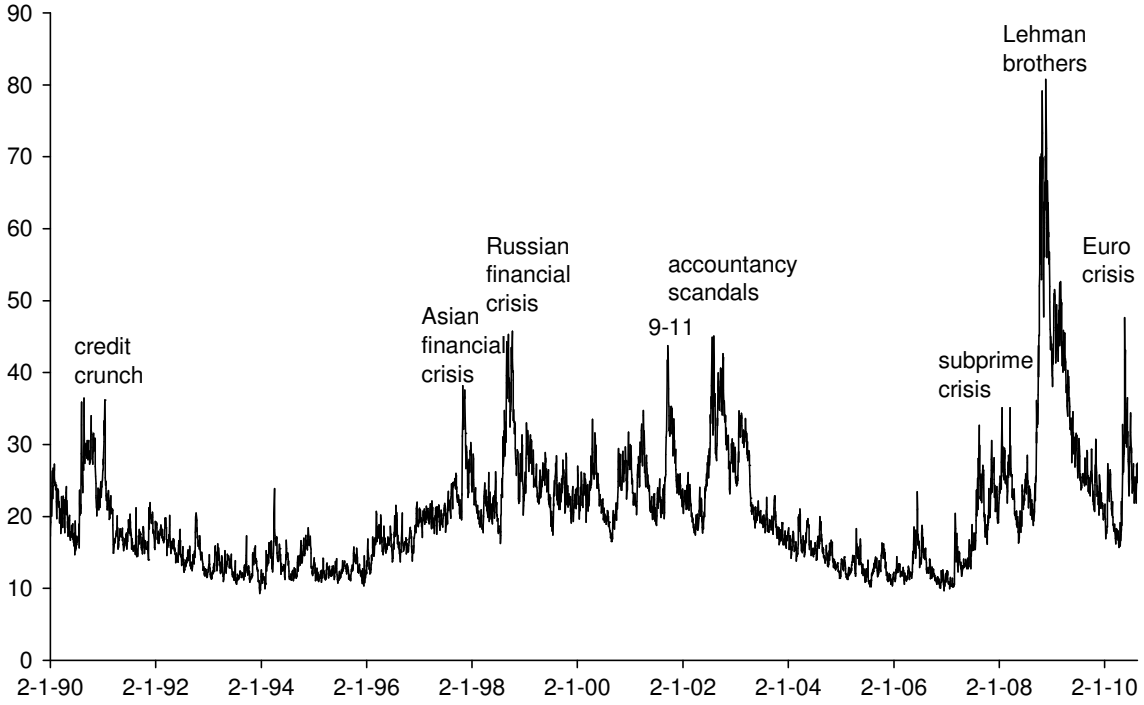
If we were to draw a clear conclusion form the empirical literature, it would read as follows. There seems to be an influence of a real effect of finance on trade and there is some evidence for possible non-linearities. Future research has, however, to be done to quantify them. Also possible feedback loops proposed in the theoretical literature should be investigated. There has to be additional research on the quantitative effects of particular trade finance instruments.

As already mentioned, the importance of trade for The Netherlands strongly suggests to devote more effort on this issue. What the preceding literature review made clear is that there does not exist something as a standard approach for relation between trade and finance. Given this, the opportunity could be taken to work on this in a way that is suitable to produce results that are compatible with CPB's macro models. Another route for further research could be the issue of financial flows, financial markets and the real economy. Modern production methods imply highly diversified supply chains with corresponding investments in different countries. Also these investments are influenced by financial shocks and influence real economic activity.

6 Risk Channels

Financial crises boost asset return risk. Figure 6.1 presents the Chicago Board Options Exchange Volatility Index (VIX) over the period 2/1/1990–17/8/2010. The VIX is a measure of the *expected* volatility of the S&P 500 index as derived from the Black-Scholes formula. The financial crises of the past two decades correspond well with the spikes in the VIX (see González-Hermosillo and Hesse (2009) for a dating method that distinguishes periods of high ex ante risk).[30] The figure also shows that expected volatility is skewed to the right, with strong positive peaks occurring mainly at times of negative shocks and few, if any, negative peaks.

Figure 6.1 VIX volatility index of SP 500 stock



Financial crises affect not just asset return risk, but also other macroeconomic risks, like GDP risk and productivity risk. These risks are related. The output loss associated with crises must be reflected in equity prices. In the absence of a separate return risk, asset price shocks should still occur, depending on the shocks in productivity, labour supply, etc. However, it turns out that asset price volatility cannot be explained from other risk factors such as productivity risk. E.g., it appears that most of the volatility spikes in Figure 6.1 do not relate to other macroeconomic risk factors (see Section 6.3 below).

[30] Not all financial crises generate increased volatility, however. E.g. the 1992-93 EMS crisis cannot be read back from the VIX volatility index.

Return risk is an important determinant of investment decisions for firms and saving decisions for households. The question that will occupy us in this chapter is how changes in expected risk affect real economic activity, including the 'procyclicality' of risk. If higher return risk boosts risk premia, higher risk premia depress real activity, and a recession boosts risk premia, a positive feedback channel arises that amplifies the initial shock to return risk.

A positive relation between asset return risk and risk premia is not evident from the data on realized returns. Black (1976) showed that changes in volatility are *negatively* correlated with excess returns, so that low returns coincide with high volatility and vice versa. The same conclusion holds for returns and expected volatility, as measured by the VIX index (Fleming et al., 1995). This finding raises two questions: what causes volatility changes, and how do volatility changes affect the price of risk?

6.1 Volatility

It is well known that the volatility of asset returns is highly persistent (Cont, 2001). This implies that volatility is predictable. Most volatility forecast methods use the autocorrelation properties of (nonlinear transformations of) the returns (see Poon and Granger, 2003; Andersen et al., 2006, for surveys of volatility forecasting models).[31] The literature on the *determinants* of volatility is much thinner on the ground and not very conclusive. Christie (1982) finds a strong effect of leverage and interest rates on volatility, which supports Black's 'leverage' hypothesis: a fall in stock prices boosts the leverage of the firm, which increases the volatility of the firm's market value. However, Schwert (1989) finds that a recession dummy is the only variable which is consistently significant. Financial leverage is significant only if no other variables are included in the regression. Schwert concludes that there exists a 'volatility puzzle.' Like Christie, Glosten et al. (1993) find that the nominal risk-free rate has a significant positive effect on volatility. Instead of interest rates, Whitelaw (1994) uses the spread between the treasure bill rate and the commercial paper rate as a determinant of expected volatility, which also appears to be significant. Hamilton and Lin (1996) formulate a joint time series model for industrial production and volatility in which a recession is a hidden state variable that follows a Markov transition process. The results confirm the conclusions of Schwert with respect to the importance of recessions for equity return volatility. The recession state explains over 60% of the variance of stock returns.

Flannery and Protopapakakis (2002) use an extensive data set of announcements ('news') to find determinants of equity returns and volatility. They find that monetary expansion (M1), trade balance, employment, and housing starts affect volatility in a GARCH(1,1) specification.

[31] The return on good volatility forecasts is non-negligible. Fleming et al. (2001, 2003) analyse the economic value of volatility timing in portfolio allocation. They find that the annual return value of taking daily volatility into account is up to 200 basis points.

However, the effects of macroeconomic news on volatility are short-lived, with a mean lag of 9 days. For Europe, Errunza and Hogan (1998) also report that macroeconomic factors do affect stock volatility, in particular money supply boosts volatility in Germany and France, and industrial production volatility Granger causes volatility in Italy and the Netherlands. Konrad (2009) also finds a significant effect of monetary policy on asset return volatility in Germany. Ludvigson and Ng (2007) use a dynamic factor analysis to construct determinants of volatility and excess returns from a wide range of variables. They obtain two factors from financial indicators, a 'volatility factor' that explains the larger part of volatility, and a 'risk premium' factor, used to predict risk premia (in conjunction with the consumption-wealth ratio, cf. Lettau and Ludvigson (2001)). A third 'real' factor from macroeconomic indicators correlated with output and employment also helps explaining volatility.

Asymmetry in the effect of excess return shocks on expected volatility has been investigated in a number of papers. The general finding is that negative return shocks create considerably more volatility than positive shocks. see e.g. Nelson (1991); Glosten et al. (1993); Bollerslev et al. (1994), and the survey in Table 1 of Bekaert and Wu (2000).

6.2 Volatility and Risk Premia

The observation of Black (1976) that volatility and excess returns are negatively correlated generated a fair amount of debate. Black suggested that the causal relation runs from excess returns to volatility. French et al. (1987) point out that the observed correlation between volatility and return consists of two components, a positive relation between the expected excess return and *expected* volatility, and a negative relation between the actual excess return and *realised* volatility. An unexpected, persistent, increase in volatility will initially lower excess returns, due to the effect of a higher risk premium on asset prices, and afterwards, on average, lead to an increase in excess returns. French et al. (1987) and Bollerslev et al. (1988) model this relation in terms of a GARCH-m process, in which the conditional expected return is a function of volatility. They find a positive relation between predicted volatility and expected excess returns. Generally, the relative size of the effect depends on the persistence in volatility. French et al. obtain a mean lag in volatility of about 12 months and Bollerslev et al. of about 2 quarters.

The positive relation between expected returns and expected volatility is not found in all studies, however. E.g. Nelson (1991); Glosten et al. (1993) obtain a negative effect of expected volatility on excess returns in their GARCH-m specification.[32] The diversity of results obtained from GARCH-m models suggests that the relation between expected returns and volatility may be more complicated than what can be captured in a single coefficient. E.g. Whitelaw (1994)

[32] Backus and Gregory (1993) provide numerical examples that show that, theoretically, a positive relation between expected volatility and expected returns need not exist.

finds that while the impact effect of expected volatility on expected returns is negative, this effect changes sign after three months and peaks after eight months. That is, the structure of the CAPM, with its invariant relation between risk premia and risk, appears to be too restrictive.

Parametric specifications of volatility condition volatility in terms of a small number of observable variables, and the particular assumptions used appear to affect the results. A more general approach is to model the variance as a latent stochastic process (Andersen et al., 2006, section 4). Brandt and Kang (2004) model both conditional returns and conditional volatility as latent state variables. They find a positive effect of volatility innovations on expected returns, as well as a negative effect of returns innovations on expected volatility. The general shape of the response functions corresponds well with those in Whitelaw, including the peak in expected returns eight months after a volatility shock (0.5% for a volatility shock of 5%). Ghysels et al. (2005) improve on the standard GARCH-m model by using daily stock returns to measure volatility and by estimating the optimal data window length along with the return process. They too obtain a positive relation between expected excess returns and expected volatility. Ludvigson and Ng (2007) use factor analysis to circumvent the restrictions of parametric models. They find a positive relation between the conditional mean return and the *change* in conditional volatility, with a coefficient of about 1.4 for quarterly returns and volatility, so that a one percentage point increase in volatility boosts expected returns by about 1.4%

The behaviour of risk premia during banking crises may deviate from the general pattern over the standard business cycle on account of the different role of financial intermediaries. He and Krishnamurthy (2008a) discuss a model in which the marginal investor is a financial intermediary. Intermediaries face a constraint on raising equity capital. When the constraint binds, so that intermediaries' equity capital is scarce, risk premia rise to reflect the capital scarcity. Adrian and Shin (2010) also explore the hypothesis that financial intermediaries drive the business cycle by way of their role in determining the price of risk. In this 'risk-taking channel' of monetary policy, balance sheet quantities emerge as a key indicator of risk bearing capacity. Adrian and Shin present evidence that the balance sheets of financial intermediaries reflect the transmission of monetary policy through capital market conditions. It points to the importance of short-term interest rates in influencing the size of financial intermediary balance sheets.

6.2.1 The Price of Risk

A useful summary measure of the relation between volatility and risk premia is the *price of risk* defined as the ex ante, or conditional, Sharpe ratio, which is defined as the expected excess return of an asset over the safe return, divided by the expected standard deviation of this excess return.[33] Part of the appeal of the Sharpe ratio is that in the standard CAPM the price of risk is a

[33] With multiple risk factors, the price of risk is also a vector.

constant. Going beyond the CAPM, asset pricing theory gives the following expression for the price of asset return risk, χ,

$$\chi_t \equiv \frac{\mathrm{E}[R_{t+1}] - R^f_{t+1}}{\sigma_t(R_{t+1})} = -R^f_{t+1}\,\sigma_t(m_{t+1})\,\rho_t(m_{t+1}, R_{t+1}) \tag{6.1}$$

where R denotes the asset return, R^f the risk-free return, $\sigma_t(R_{t+1})$ the expected volatility of the return, m is the stochastic discount rate of the investor, and $\rho(m,R)$ denotes the correlation between the stochastic discount rate and the return to the asset. The price of risk is high if consumption risk is high ($\sigma(m)$, R^f), or if low asset returns coincide with bad times ($\rho(m,R)$). For a given price of risk, the expected excess asset return varies in proportion to the expected return risk on the asset. A boost in expected volatility should therefore result in a corresponding increase in the risk premium of the asset, unless the price of risk falls. This cannot be excluded a priori, e.g. a substantial fall in the safe rate may occur due to a 'flight to safety.'

The price of risk can be estimated parametrically from (6.1) by modelling the stochastic discount rate m. Campbell and Cochrane (1999) use a consumption-based asset pricing model with habit formation to explain excess stock returns. They find that the price of risk is strongly countercyclical, as stocks do poorly at times where consumption is low. The Campbell and Cochrane model is rather restrictive in the number of risk factors, as it uses only consumption risk. However, Bansal and Yaron (2004) obtain similar conclusions, using dividend growth as an additional risk factor. Wachter (2006) extends the Campbell-Cochrane model by introducing inflation risk and modelling the bond term structure. This does not affect the conclusions with respect to the countercyclical price of risk either.

Alternatively, stochastic volatility models may be used to estimate the price of risk with less restrictions imposed. Brandt and Kang (2004), using a latent variable approach, find that the conditional Sharpe ratio falls on impact in response to an innovation in volatility and becomes positive after seven months. Whitelaw (1997), Ludvigson and Ng (2007) and Lettau and Ludvigson (2009) estimate the price of risk for equity by using *predicted* excess returns and *predicted* volatility to construct a conditional Sharpe ratio, based on a number of risk factors. Whitelaw obtains a strongly time-dependent conditional Sharpe ratio, that varies between -0.4 and 1.1.[34] The estimates presented by Ludvigson and Ng (2007) and Lettau and Ludvigson (2009) also indicate a volatile price of risk, that is strongly countercyclical, and varies between -0.8 and 2. The price of risk rises substantially during most recessions, and on average falls again during expansions, although the pattern during expansions is less clear than during recessions.

[34] Negative conditional Sharpe ratios are an artifact of the linear estimators of expected returns and expected volatility

6.3 Risk Panics

Utility-based structural models like that of Campbell and Cochrane cannot match the volatility of the price of risk. The empirically oriented risk pricing models of Ludvigson and Ng (2007) and others *are* able to explain risk premia in terms of fundamentals plus a 'volatility risk' factor. However, the nature of this factor remains obscure. Section 6.1 above pointed out that volatility can be partly explained from fundamentals, but that a large part of volatility variation remains unexplained. In particular, it is difficult to explain the volatility spikes associated with financial crises from fundamentals. E.g., figure 6 in Ludvigson and Ng (2007) shows that all of the spikes associated with financial crises in the nineties (cf. Figure 6.1) are missed by the predicted series. It appears that financial crises are a separate risk factor, that cannot be traced back to underlying causes. A possible explanation for this phenomenon is a coordination failure of expectations of market participants. Indeed, several papers analyse spikes in market risk in terms of a coordination failure, or 'risk panic.'

Townsend (1983) analyses the consequences of an environment were agents have to forecast other agents' forecasts. Agents therefore need to infer other agents' beliefs via Bayesian learning. He finds that forecast errors are serially correlated across agents, and also serially correlated over time. Bikhchandani et al. (1992) use Bayesian learning in a context where individual agents' information signals are noisy. In this case, observed behaviour of a sufficiently large number of agents may lead agents to discard their own private information in their decisions. The consequence is that in an information cascade new market signals no longer affect agents' decisions, which may lead to multiple equilibria. Bikhchandani and Sharma (2001) survey the implications of this idea for financial markets. They conclude that in developed, *transparent*, financial markets the probability of an informational cascade is not very high.

Information coordination failures may easily arise in a situation where there is true Knightian uncertainty. Caballero and Krishnamurthy (2008) present a model of crises and central bank policy that incorporates Knightian uncertainty. Severe flight-to-quality episodes involve uncertainty about the environment, not just risk about asset payoffs. The uncertainty is triggered by unusual events and untested financial innovations that lead agents to question their world view. The model explains crisis regularities such as market-wide capital immobility, agents' disengagement from risk, and liquidity hoarding. Krishnamurthy (2010) describes two amplifications mechanisms that operate during crises and discuss the benefits of policy, conditional on either mechanism. The first mechanism involves asset prices and balance sheets. A negative shock to agents' balance sheets causes them to liquidate assets, lowering prices, further deteriorating balance sheets and amplifying the shock. The second mechanism involves investors' Knightian uncertainty. Unusual shocks to untested financial innovations increase agents' uncertainty about their investments, causing them to disengage from markets and amplifying the crisis. Liquidity provision by the central bank alleviates the crisis in both

mechanisms. Bacchetta et al. (2010) propose an explanation for spikes in asset price risk based on self-fulfilling shifts in risk perception, made possible by a negative link between the current asset price and risk about the future asset price.

6.4 Households

How do consumption and investment of risk-averse agents respond to an increase in risk? Economic theory does not put any firm restrictions on behaviour in this respect. First, risk aversion does not have any implications for optimal behaviour. If agents have quadratic utility, risk doesn't affect their behaviour at all. Second, in a setting of complete markets, consumption/saving decisions and investment decisions are the same. All households use the same discount rates of future uncertain income, so the ownership of firms is not an issue. In a world of incomplete markets, there is no shareholder unanimity and investment decisions of firms do not in general derive from the same objective function as saving decisions of households (Magill and Quinzii, 1996, Chapter 6). Below, we discuss the effects of risk on household behaviour. The effects of risk on investment in productive assets is discussed in Section 6.5.

Leland (1968) pointed out that the degree to which households' behaviour responds to changes in risk depends on the slope of *marginal* utility of consumption. Precautionary behaviour, in which an increase in risk boosts household saving, occurs only if marginal utility is convex in consumption. In analogy to the Arrow-Pratt measures of risk aversion (Pratt, 1964), Kimball (1990) defines the degree of *prudence* as a measure of the sensitivity of the agents decision (saving) with respect to the risk factor involved (per unit of variance). The *precautionary premium* then gives the absolute or relative reduction in the risk factor (e.g. income) that would induce the agent to take the same decision as in the absence of risk.[35] In the CRRA case, prudence and risk aversion are directly related, the coefficient of relative prudence equals one plus the coefficient of relative risk aversion.

Zeldes (1989) shows numerically for a life cycle model with CRRA utility that income uncertainty leads to a strongly nonlinear relation between consumption and financial wealth: at low wealth levels consumption is low, but the marginal propensity to consume out of wealth is high, and vice versa at high levels of wealth. In combination with a positive time preference, Carroll (1997) shows that this implies that at low wealth, consumption grows relatively fast, while at high levels of wealth consumption grows slowly. The wealth level at which expected wealth growth is zero, is the 'buffer stock.' Thus household saving may be characterised as buffer stock saving: households try to maintain a target level of wealth, and near the buffer stock of wealth consumption corresponds closely to income. The level of the buffer stock depends a.o.

[35] A prudent household therefore reacts to income uncertainty by choosing a consumption level that corresponds to an income level under certainty that is lowered by the precautionary premium.

on income uncertainty. With higher income uncertainty, next period's expected marginal utility rises, and consumption falls until a new, higher, buffer stock level is attained.

It appears that, empirically, saving of young to middle-aged households can be characterised as buffer stock saving. Gourinchas and Parker (2002) and Cagetti (2003) estimate life cycle models with relatively high time preference rates and moderate rates of risk aversion. The buffer stock saving motive is active primarily over the first half of households' working life, at a stage when the households has a rising wage profile and would therefore, without income uncertainty, have liked to borrow against future income. Instead, they hold a few months of income as precautionary wealth. From their late forties on, households accumulate more wealth and as a result start to behave like a 'standard' life cycle household, with a constant, low, propensity to consume out of wealth and transitory income.

Using the Panel Study of Income Dynamics (PSID), Carroll and Samwick (1997) show that income uncertainty has a strongly significant positive effect on household wealth for households under 50, in agreement with the buffer stock model. Carroll and Samwick (1998) compute the relative importance of precautionary wealth in total wealth. First they provide numerical evidence that the theoretical relation between saving and income uncertainty is well approximated by a linear relationship between the wealth-income ratio and the variance of the log of income. Next, they estimate the relation between income variance and the wealth-income ratio from the PSID and obtain a coefficient of around 0.5, implying that a doubling of the standard deviation of log income approximately doubles the target buffer stock as well, i.e. adds several months of wages to target wealth. Carroll and Samwick estimate that a reduction of income uncertainty of all household groups to match the uncertainty of the group with the lowest uncertainty would reduce asset holding by between 45%.

For young households, income risk is to a large extent labour income risk. Carroll et al. (2003) use unemployment risk as a measure of uncertainty. They find a relation between precautionary wealth and unemployment risk for medium- and high-income households. Low-income households show no saving response to variations in unemployment risk.[36] In addition, precautionary wealth holding is not observed if housing wealth is excluded, which is surprising in view of the low liquidity of housing wealth.

Kennickell and Lusardi (2004) use responses to direct questions about desired precautionary wealth from the Survey of Consumer Finances to assess the importance of precautionary motives. They find that most households save partly for precautionary reasons. On average, desired precautionary wealth is about 20% of total financial wealth in the US. Stated precautionary motives are especially strong for older households and business owners. This

[36] This may be related to the observation that high-income households in the U.S. face far greater income risk than low-income households, see Parker and Vissing-Jørgensen (2009)

indicates that other risks besides income risk (e.g. health care) should be taken into account when investigating saving motives.

The theoretical link between the consumption-wealth ratio and risk premia is confirmed by Lettau and Ludvigson (2001), who show that the consumption-wealth ratio forecasts both stock returns and dividend growth at horizons as short as one quarter.[37,38] The consumption-wealth ratio therefore contains information about discount that is independent of the price-dividend ratio. In addition, the consumption-wealth ratio outperforms the price-dividend ratio at periods of up to four years.

6.5 Firms

Firms are owned by households. A fully general treatment of the effects of risk on economic agents would not therefore make any distinction between households and firms.[39] For prudent investors, the expected stochastic discount rate rises in times of greater income risk. The issue is what happens to the covariance with the expected return to investment. The discussion in Section 6.2 indicates that empirically the probable effect of an increase in return volatility for an investor is to raise the discount rate of future investment returns. In addition, the price of risk may also rise, further boosting discount rates. This leads to a hike in the cost of capital and a fall of the desired capital stock.[40]

Still, it is useful to discuss the impact of risk on firms separately. First, with incomplete markets it is difficult to link the discount rate of the firm to a representative investor. This is particularly relevant in the case of risks that cannot be traded (like the risk of a financial crisis), but the problem is more general, as most households do not trade in the stock market, so that the representative household is different from the representative investor (cf. Mankiw and Zeldes, 1991). In particular, the representative investor is both a lot richer than the representative consumer, and therefore less susceptible to precautionary motives. Also, investors are less risk-averse than the average household and have more 'confidence' in future economic conditions. Second, decisions taken in a production environment often face different constraints from those of a portfolio investor. E.g., productive investments are often irreversible, hiring and

[37] Lettau and Ludvigson construct a proxy for human wealth based on current labour income, *assuming* that the return on human wealth is a stationary process.

[38] The estimates suggest that a 1% increase in the consumption-wealth ratio boosts predicted excess returns by 5% over a 1-year horizon, or 7% over a two-year interval.

[39] Write the arbitrage equation for the market value V of a firm as $1+r_{t+1}=V_{t+1}/(V_t-D_t)$, where r is the rate of return, and D are the net dividend payments. The optimal investment equation is equivalent to the portfolio equation $\mathrm{E}[(1+r_{t+1})m_{t+1}]=1$, where m is the stochastic discount rate of the investor, e.g. $m_{t+1}=\left(\frac{c_{t+1}}{c_t}\right)^{-1/\gamma}/(1+\rho)$ in the CRRA case.

[40] *Theoretically*, this conclusion is not unavoidable because of the potential offsetting effects of portfolio adjustments, cf. Backus and Gregory (1993).

firing of workers is subject to frictions, etc. In these cases risk has an effect on investment even if the investor is risk-neutral.

In the next two sections, we discuss the effect of risk on investment and employment decisions for a risk-neutral investor.

6.5.1 Investment in Productive Assets

An early survey of the effects of risk on the decisions of firms is Rothschild and Stiglitz (1971). Hartman (1972) and Abel (1983, 1984) were the first to apply the concepts expounded by Rothschild and Stiglitz to the dynamic problem of investment. They both examine the effect of price uncertainty on the investment decision of a risk-neutral competitive firm. Hartman showed that with a linearly homogeneous production function, increased output price uncertainty leads the competitive firm to *increase* its investment. Abel demonstrated that Hartman's results continue to hold in a continuous-time setting with a mean-reverting price process and in the presence of adjustment costs. The basic intuition for this result is that because of short-run decreasing returns to scale, the revenue function is a convex function of price: at lower output prices the firm contracts and profits don't fall much, whereas at high prices the firm expands and profits go up more than proportionally.

The result that increased risk boosts investment for a risk-neutral firm depends on a number of assumption. First, for risk-averse investors there are two counteracting forces at work, and Zeira (1990) shows that the net outcome may go either way. Second, the assumptions of perfect competition and long-run constant returns to scale are essential. Pindyck (1988) investigates the consequences of irreversibility of investment for a firm that is subject to price uncertainty and is subject to a decreasing returns production technology and a demand schedule. In this case the investment decision has an option value that increases with price uncertainty. As a result the firm postpones investment and invests only if the price exceeds a threshold value. The net effect of demand uncertainty is that it leads to a lower optimal capital stock.

Caballero (1991) shows that the difference in results between Hartman/Abel and Pindyck derives not only from the nature of the adjustment cost function, but also from the assumptions of perfect competition and constant returns versus imperfect competition and decreasing returns. Irreversibility does not alter Hartman and Abel's conclusions if markets are perfectly competitive and free entry prevails, as there is no option value of waiting. In reply, Pindyck (1993) argues that the problem setting of Caballero is not useful to study industry equilibrium, and that if industry faces a downward sloping demand curve, the conclusions of Pindyck (1988) still hold.

The model of asymmetric (downward) adjustment costs and decreasing returns generates lumpy investment at the level of the individual firm, a feature that is not observed in aggregate investment. Bertola and Caballero (1994) characterize the aggregate implications of microeconomic irreversibility and idiosyncratic uncertainty. It appears that with sufficient idiosyncratic uncertainty, the dynamics of aggregate investment can be matched to U.S. data

without assuming convex adjustment costs. The idiosyncratic shocks generate a capacity *distribution* and at any given time only the subset of firms with capacity below the threshold will invest. At the macro level, the implication is that aggregate level investment adjusts more sluggishly to e.g. demand shocks the larger idiosyncratic uncertainty. Compared to the reversible investment case, the capital stock is smaller at the points in time at which the firm invests.[41]

In terms of a general volatility spike, this model predicts an increase in the gap between the actual and desired capital stock for most firms, and a consequent fall in investment. As long as the high risk persists, investment will be smoother in response to variations in business conditions. However, the capital stock will gradually recover, and eventually exceed its original level, as a larger percentage of firms faces excess capacity (that is, with risk-neutral investors).

Bloom et al. (2007) show that with (partial) irreversibility higher uncertainty reduces the responsiveness of investment to demand shocks. Uncertainty increases real option values making firms more cautious when investing or disinvesting. This is confirmed both numerically for a model with a mix of adjustment costs, time-varying uncertainty, and aggregation over investment decisions and time and also empirically for a panel of manufacturing firms.

Miao and Wang (2007) analyse the consequences of undiversifiable idiosyncratic risk of the investment project for the investment timing decision. In this case, the standard real options approach fails, and if the agent is not risk-neutral, precautionary motives enter that may induce the entrepreneur to invest early. This effect is strongest if the entrepreneur can sell her project once the investment is in place, because it allows the investor to exit the incomplete market of project development. If the idiosyncratic risk of the revenue stream from the project cannot be sold, the value of the project diminishes, which works the other way, so that the net effect is ambiguous. Gryglewicz et al. (2008) investigate the effects of the expected useful life of an investment. If a project is short-lived, increased uncertainty may speed up the implementation date of the project.

6.5.2 Empirics of Investment and Risk

The empirical literature on the effects of uncertainty on investment is extensive.[42] Uncertainty measures include exchange rate risk (Goldberg, 1993; Campa and Goldberg, 1995; Bell and Campa, 1997), price volatility and inflation (Driver and Moreton, 1991; Huizinga, 1993; Ghosal and Loungani, 1996; Bell and Campa, 1997; Beaudry et al., 2001), the term structure of interest rates (Ferderer, 1993), demand uncertainty (Bell and Campa, 1997; Guiso and Parigi, 1999), and stock market volatility (Leahy and Whited, 1996; Baum et al., 2009). Some studies simply take

[41] Abel and Eberly (1999) discuss the effects of idiosyncratic uncertainty on the *expected* size of the capital stock in the presence of irreversible investment. Two forces are at work on the capital stock: the option value of waiting lowers the investment incentive, while the 'hangover' effect prevents the firm from selling off capital in case of excess capacity. There will therefore always be a fraction of firms with excess capacity. It appears that in the long run, an increase in uncertainty will lead to a higher average capital stock due to the hangover effect.

[42] Carruth et al. (2000) present a survey of the literature of the effects of uncertainty on investment up to 1996.

realized volatility as a measure of risk, but most use forecasted volatility (see Section 6.1). Guiso and Parigi use survey data to measure demand uncertainty, while Baum et al. use high-frequency stock market data.

Lettau and Ludvigson (2002) find indirect confirmation of the effect of risk on investment. If there is a term structure in the equity premium, investment in long-lived fixed assets should depend more on future equity premia than the current expected excess returns. Lettau and Ludvigson show that the consumption-wealth ratio predicts both future excess returns and *future* investment. The interpretation of this finding is that if the current consumption-wealth ratio is above normal, wealth holdings of most households must be below their target buffer stock wealth. Most households therefore have a high discount rate, so the equity premium must be high. Because the equity premium is mean-reverting, a high equity premium now implies a lower equity premium in the future and hence a higher marginal value of capital (q), i.e. higher investment in the future.

Most studies find a significant negative effect of uncertainty on investment. However, Huizinga finds a positive effect of profit uncertainty on investment, while Goldberg (1993) and Campa and Goldberg (1995) find no effect of exchange rate risk. Bell and Campa report that for a sample of American and European chemical companies only exchange rate variability mattered and this only for European firms.[43] Baum et al. find that market uncertainty has a negative effect on investment, but own cash flow uncertainty has a positive effect.

The number of empirical studies that explicitly use irreversibility and option value to model investment decisions is limited. Caballero et al. (1995) apply the model of irreversible lumpy micro-level investment to aggregate data of the U.S. manufacturing sector. The main conclusions are that the long-run elasticity of capital with respect to capital costs is much larger than the short-run elasticity, and centres around -1, and that adjustment at the macro level is asymmetric: capital surpluses above the desired value can persists for much longer than capital shortages. Caballero and Engel (1999) generalize the model by including stochastic adjustment costs that lead to a probability of adjustment of the capital stock instead of a fixed (S,s) adjustment band. The model empirically outperforms standard accelerator models.

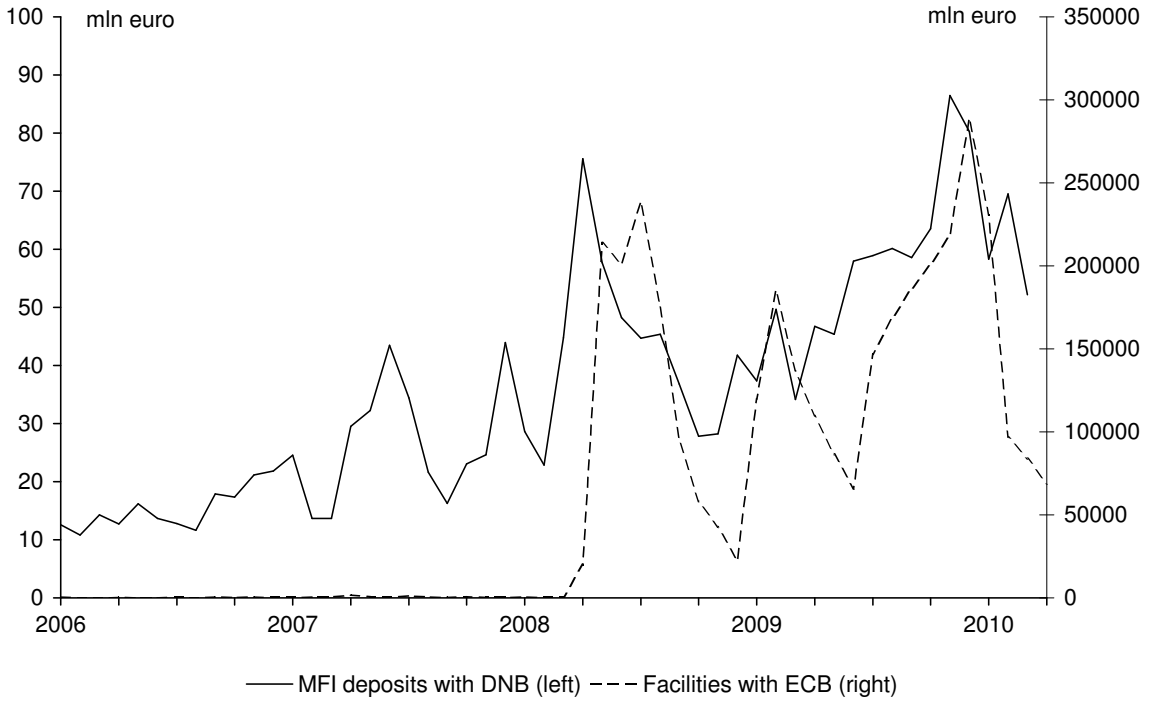
Bloom et al. (2007) applies the lumpy investment model with demand shocks to a panel of U.K. firms over the period 197–91. They find that the precautionary effects of uncertainty are large – going from the lower quartile to the upper quartile of the uncertainty distribution typically halves the first year investment response to demand shocks. This implies the responsiveness of firms to any given policy stimulus may be much weaker in periods of high uncertainty, such as after the 1973 oil crisis and September 11, 2001

[43] A potential measurement problem is that the paper uses *realized* volatility.

6.5.3 Trust and Risk

An important topic in the recent financial crisis was the role and the drying up of the interbank lending market. Heider et al. (2009) are giving a very comprehensive exposition of this issue. In short, shocks from the capital market, the onset of the crisis in late summer 2007 and the bankruptcy of Lehman Brothers Holding Inc., first, gave rise to an increase in interbanking spreads and finally a halt in lending. An impression about the last issue can be obtained from Figure 6.2 from which we can infer the volume of deposits of the Euro area financial sector at the DNB and the deposit facilities at the ECB.

Figure 6.2 Deposits at central banks



Source: ECB's statistical data warehouse and monthly balance sheet of the DNB.

Especially the deposit facilities at the ECB show a tremendous increase after the collapse of Lehman Brothers but also an increase in deposits with the DNB can be identified. Heider et al. (2009), and the literature referred therein, see the reason for this in an increase in asymmetric information among banks. The participants in the interbank market simply did not know about the true counter party risk in lending and were stopping operations in this market. Instead banks deposited their excess liquidity at national central banks and the ECB. Interpreted in terms of trust, banks did not compensate the asymmetric information by simply trusting borrowing banks, they distrusted and stopped lending. Stinespring and Kench (2009) present in a pedagogical note a game theoretical model with one equilibrium being a prisoner's dilemma with exactly this property.

In this context, a recent quote of Jean-Claude Trichet is quite enlightening[44]

> *'It remains for others - national governments, regulators and supervisors, and the private sector and financial industry - to proceed with the difficult, but vital, measures required to re-establish the trust on which a well-functioning market economy relies.'*

He sees the key function of trust as in overcoming market failures that lead to non-functioning markets. It was not the increased risk in interbank lending, which in principle could be priced, but the lack of information about the amount of risk in the market that caused the problem. If an institution as Lehman Brothers can go bankrupt, eventually any bank can do so as well. Trust as bridging the gap over market failures is also recognized by the scientific literature. If we look at a fully competitive economy as assumed in Arrow and Debreu (1954), we do not see any need for trust; the economy is functioning perfectly efficient without a need of trust. As has been put perfectly correct by Williamson (1993) who postulates that in a world with full contractibility and information, there is neither room nor need for something like trust. It is the assumption of complete and enforceable contracts as well as full information that renders trust unnecessary. However, in reality contracts are hardly complete nor can contracts be written over all possible goods; information is by far not perfect. Karlan (2005) therefore gives the very good explanation that the main role for trust in economics is to overcome market imperfections. Since market imperfections are so frequent, trust is so important. Indeed, all the preceding chapters of this document share a common feature. Problems arise within the financial system and affect the real economy due to market imperfections. A statement that seems to be quite applicable can be found in Alesina and La Ferrara (2002):

> *'When people trust each other transaction costs in economic activities are reduced, large organizations function better, governments are more efficient, financial development is faster: more trust may spur economic success'.*

We conclude this paragraph by noting that trust needs to return into markets as the one for interbank lending in order to fully overcome the recent financial crisis.

6.6 Relation to CPB Analyses

CPB models do not pay much attention to the effects of risk on economic behaviour. In the SAFFIER model and its precursor, the SAFE model (Kranendonk and Verbruggen, 2006; CPB, 2003), risk enters only implicitly. In the consumption equation the interest rate used in the present value of future income is adjusted by a constant risk correction. The same type of correction is applied in the expression for the capital costs of firms. The Overlapping

[44] Speech by Jean-Claude Trichet, President of the ECB, at the 38th Economic Conference of the Oesterreichische Nationalbank, Vienna, 31 May 2010.

Generations model GAMMA (Draper et al., 2005) employs a constant exogenous equity premium to correct for average return differences between stock and bonds.

A number of research projects do explicitly deal with risk. Draper and Westerhout (2009) study the effects of privatising pensions in an OLG setting with equity risk. Bonenkamp and Westerhout (2010) use a 2-period OLG model with equity return risk to study intergeneration risk sharing. Elbourne et al. (2009) present a DSGE model for the Netherlands. However, households are assumed to behave as certainty-equivalent utility maximisers, so that precautionary motives are not present.

6.7 Assessment

Financial crises induce a volatility spike in asset returns. The effects of the increase in return risk are reinforced by a boost in the price of risk. Judged by the effects of standard business cycle recessions on risk premia, the price of risk about doubles, so that risk premia should far more than double during a financial crisis. In normal business cycles, the peak in risk premia and the price of risk occurs about eight months after the start of the recession. Volatility reverts to normal after twelve months, and risk premia are back to normal after about two years. It is plausible that during (severe) financial crises risk premia are boosted more, due to the effect of Knightian uncertainty, and lags are longer, but empirical information is lacking.

The effect of a hike in income risk on consumers is to boost precautionary saving. Young households have a buffer stock of a few months salary, and this buffer stock moves proportionally with income risk. In the US, a severe recession may double income risk, so that US households may want to save several months of salary in a relatively short time interval. Households above approximately age fifty are not buffer stock consumers, but life cycle consumers. The consumption of these households is affected more by movements in remaining lifetime wealth than in current income. In a financial crisis, these households therefore also cut back their consumption substantially.

Theoretically, the effect of risk on investment is ambiguous, but empirically there is strong evidence that an increase in return risk lowers investment. Two main reasons may be identified: risk-aversion of investors, and an increase in the option value of waiting. The second effect follows from the fact that investment is to a large extent irreversible: once installed, capital can only be sold at a loss, especially in recessions. The downside risk is therefore higher than the upside risk, and firms prefer to wait and see, even if they are risk-neutral. The initial effect on investment of a boost in return risk is postponement, but investment also reacts more sluggishly to changes in business conditions for as long as the high-risk period continues. However, the long-run effect of uncertainty on the capital stock is again ambiguous.

7 Conclusion

Credit constraints do limit the activities of borrowers considerably. This issue becomes an important dynamic component if constraints are determined by pro cyclical collateral values. During a downturn, this value drops, credit constraints tighten and activity shrinks further. This is the financial accelerator. This mechanism is part of many important economic models published in excellent scientific journals. Empirical evidence is in favour of the underlying theory and institutions as the ECB make use of it when evaluating the impact of their policies. The theory has been applied to firms' investment and households' consumption. The literature on the former is, however, better developed and more reliable than the latter. For firms' investment, there is a common sense in the literature on how to implement the mechanism in macro models. In general, it is therefore possible to include it in CPB's models as well. This holds both for DSGE models as well as SAFFIER. An alternative to the explicit modelling of the mechanism would be to take account of this mechanism through an adjustment in course of the models' simulations. This could be done through a proper adjustment in the size of shocks that are used in order to compute the effects of shocks. These adjustments have in turn to be based on the insights that we gained from the cited literature.

Bank lending is an important determinant of credit supply. It appears that bank balance sheet composition may affect bank lending activity. This can be due to either a duration mismatch effect, whereby banks experience a shortage of liquid assets, or to a capitalization effect, where bank capital falls short of bank liabilities in view of the return risk on bank assets. Monetary policy primarily affects bank liquidity. Empirical evidence based on changes in monetary policy shows that changes in bank liquidity do not have a large *independent* effect on real activity. Most of the effect of changes in liquidity supply on economic growth run via the associated changes in interest rates. Bank capitalization has a strong effect on bank lending and bank loan margins. As economy-wide shocks to bank capital are rare, the empirical evidence of the effects of bank capitalization on economic activity is mostly based on DSGE models. Results suggest that an economy-wide shock to bank capital has a substantial and long-lasting negative effect on economic growth.

International trade and finance is a hot topic in economics caused by the tremendous effects of the recent financial crisis on world trade. However, trade finance is complex and comes in many variants. Most studies assess the impact of finance from a very broad perspective, heavily using proxy variables and in a not differentiated way. In addition evidence seems to be mixed; some authors find finance important while others do not. Given the state of the art, we find no common sense approach that could directly be applied in a macro setting aiming at policy analysis. Given the importance of trade for the Dutch economy, there is however the need for further research. This should be done by taking account of available data for the various trade

finance instruments for The Netherlands in a pilot study. After an assessment of these data, a more detailed future research strategy could be developed.

Financial crises boost investment return risk and risk premia. Households and firms alike react to an increase in uncertainty by postponing expenditures. This creates a positive feedback loop that intensifies the downturn. The macroeconomic effects of a financial crisis therefore depend in part on the strength of the precautionary saving motive on the part of households and firms, and on the option value of investment on the part of firms. Existing empirical research indicates that both types of effects may be substantial.

To integrate these mechanisms in CPB analyses, it would be useful to start a project to develop measures of return risk and income risk that can be empirically linked to real expenditures. Relevant measures of risk would be *expected* volatility of asset returns and household income, as measured e.g. by stock volatility indices, bond spreads, credit default swaps, etc. The project should result in empirical estimates of the effect of uncertainty on investment expenditures and on consumption and saving. A possible spin-off of the project is the integration of the effects of risk on behaviour in CPB's macroeconomic analyses.

To sum up, it appears that balance sheet mechanisms such as the financial accelerator and the bank lending channel significantly amplify financial market shocks and their impact on the real economy. This seems to be especially true when shocks are large. These mechanisms provide a dynamic theoretical underpinning for adjustments that take place in the aftermath of a crisis. This dynamic structure causes the effects to last longer which is very well in accordance with the empirical finding that recovery after a financial crisis takes longer. While not working over balance sheets, the risk channel also gives rise to feedback loops that point in the same direction with respect to the size and the duration of the impact on the real economy. It seems that these mechanism become extremely important in times of financial crises while they are not that visible during normal times.

8 Appendix A

This appendix provides the stylised model explaining the working mechanism of the financial accelerator and is taken from Bernanke et al. (1996). The model uses due to reasons of simplification the assumption of a hard credit constraint where the borrower is able to borrow only up to the value of its collateral asset and not beyond.

The model is a two period model, $t = 0, 1$. An entrepreneur has to finance variable production inputs x_1 in period 0 in order to produce output in period 1. An additional input to production is a fixed factor K with end of period value q_t which is owned by the entrepreneur. The entrepreneurs debt beginning of period is b_t and the gross interest rate is denoted by r_t. Production takes place according to

$$y_t = a_t f(x_t), \tag{8.1}$$

where a_t is a productivity parameter and $f(\cdot)$ is the production function.

The entrepreneur has to finance purchase of x_1 which is in units of output and its price is normalized to one. Therefore

$$x_1 = a_0 f(x_0) + b_1 - r_0 b_0 \tag{8.2}$$

which is just a book keeping identity.

If there were no credit constraint, the entrepreneur is simply faced with an unconstrained optimization problem with the solution

$$a_1 f'(x_1^*) = r_1, \tag{8.3}$$

where $f'(z) = \frac{\partial f(z)}{\partial z}$ which is a standard first order marginal product condition. However, in case of a hard credit constraint given by the present value of the fixed factor K

$$b_1 \leq \frac{q_1 K}{r_1} \tag{8.4}$$

or equivalently using (8.2)

$$x_1^c \leq a_0 f(x_0) + \frac{q_1 K}{r_1} - r_0 b_0 \tag{8.5}$$

with equality if the credit constraint binds exactly and the production function is well behaved. If now $x_1^* > x_1^c$, which is true whenever the constraint binds, the marginal product at x_1^c is naturally higher than at x_1^* due to decreasing marginal returns. Thus, the constraint drives a wedge between the marginal product of x_1 inside the entrepreneur's firm and the market interest rate r_1. (8.5) also reveals that a decrease of the collateral value q_1 automatically reduces x_1^c and with this also economic activity $a_1 f(x_1^c)$.

Although this is the most simple model containing a financial accelerator, it still does not allow for a closed form solution that allows us to show the dynamic amplifying mechanism.

However, we can show them at least partially by linearizing the model. Consider the immediate impact in a decrease in the collateral value q_1 of the amount dq_1. Using (8.5) we can easily obtain the induced change in x_1^c, ceteris paribus, as

$$dx_1^c = \frac{K}{r_1} dq_1 \tag{8.6}$$

and the induced change in production as

$$df(x_1^c) = a_1 f'(x_1^c) dx_1^c = \frac{a_1 f'(x_1^c)}{r_1} K dq_1. \tag{8.7}$$

We see immediately that the spread between $f'(x_1^c)$ and r_1 amplifies the effect. This highlights the importance of the credit constraint. First, it gives rise to a real economy effect via (8.6) and then amplifies is via (8.7). However, in reality the effects proceed to materialize in the more distant future which can not be inferred in this model since it covers just 2 periods.

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