Monetary Policy in a Low Inflation Environment

Monetair beleid in een omgeving van lage inflatie

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Preface

Since studying at the University of Groningen, I have always wanted to write a PhD thesis. I got the opportunity to combine writing this thesis with my regular job at De Nederlandsche Bank (DNB). Being involved in day-to-day policy issues inspired me to ask specific research questions. The other way round, doing research showed me new ways to tackle policy problems. In addition to DNB, the Economics Faculty of Erasmus University Rotterdam and OCFEB Research Centre for Economic Policy have facilitated my research activities in a generous way.

This thesis' broad macro-economic subject gives it a rather traditional flavour. At the same time, it has more modern features, in particular that it is not intended to be my magnum opus, but only intended to show proficiency in economic research on the basis of a couple of related articles.

This thesis is written using the first-person singular, thereby emphasizing that I take full responsibility for the final result. Nonetheless, many people have contributed directly or indirectly. First and foremost, I would like to pay tribute to my advisor Job Swank, who took over when Peter van Bergeijk left for Switzerland. It was both a privilege and a pleasure to work under Job's guard. As Doktorvater, he has been a major inspirator for my research. Behind his stern face he hides both deep economic intuition and warm humanity. Special thanks are due to my father. He helped me to crack a couple of mathematical nuts during long hours together, be it in his study or in the family's holiday-house in Langewiese. Jan Kakes, Gerben Hieminga and Jan Marc Berk & Bryan Chapple co-authored Chapters 4, 5 and 6, respectively. Martin Admiraal, René Bierdrager and Henk van Kerkhoff provided excellent statistical support. The contributions of co-authors and statisticians are gratefully acknowledged.

Combining writing a thesis and a regular job requires a supportive environment. I am indebted to my family, friends and colleagues, who have always encouraged me to proceed.

Amsterdam, October 2007

”I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.”
(Sir Isaac Newton)

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Chapter 1

Introduction

This thesis is on monetary policy issues that come to the fore in an environment with very low inflation.

Inflation has fallen world-wide since the 1980s. At the beginning of the 21st century, price stability prevails in most OECD countries, meaning that overall consumer price changes are anchored at a low level (ranging from around one half of a percent to 3 percent per annum). This is a positive accomplishment. High and volatile inflation during the 1970s and 1980s showed that aggregate price hikes blur relative price changes, and that transparency of relative price changes is indispensible for micro-economic efficiency. On the macro scale, the high inflation environment led to strong cyclical fluctuations and caused a redistribution of wealth from those who cannot insure against inflation to those who can.

After many years of inflation reduction, some countries reached very low inflation levels. A number of Asian countries have experienced deflation (negative inflation) in the last fifteen years, Japan being the most prominent example. The recent example of Japan, but also of the US in the 1930s, has shown that inflation can be too low: falling prices lift real debt burdens, they tend to undermine demand and drive prices even lower. Deflation or very low inflation may thwart the monetary policymaker's ability to pursue stabilization policies, since nominal interest rates cannot fall below zero. The zero floor exists because negative interest rates would mean that borrowers pay back less than they borrowed. For creditors, currency with a zero nominal return would offer a superior alternative. Therefore, the supply of private sector credit is zero at negative interest rates. The situation where interest rates cannot fall sufficiently to balance savings and investment at full employment, and where monetary stimuli are ineffective, was dubbed the 'liquidity trap' by John Maynard Keynes (1936). This phenomenon has long been regarded as a theoretical curiosity. But the reduction of Japanese monetary policy interest rates to the zero lower bound brought this issue to the forefront of the macroeconomic debate. In Western economies, the zero lower bound can no longer be put aside as a phenomenon of the remote past, since the US Federal reserve kept policy interest rates at just 1% for about a year during 2003-2004. In addition, there was some fear of deflation in the euro area in 1999.

Some observers have questioned whether the zero lower bound on nominal interest rates exists in reality. Institutional arrangements have been suggested to remove the floor to nominal interest rates. The most prominent example is the introduction of so-called Gesell money, as discussed in Chapter 2. The circulation of Gesell money implies that currency and its close substitutes (monetary liabilities on the central bank balance sheet) are taxed, thereby removing the zero return investment opportunity that currency offers. The practical obstacles to this solution are discussed in Chapter 2. An alternative way of removing the lower bound on nominal interest rates has been suggested by Eisler (1932), and more recently by Buiter (2007). The exchange function of money is separated from its unit of account function. The central bank calls in all banknotes and coins denominated in its currency (say euro), and introduces banknotes and coins in a new currency (say new guilder) as the medium of exchange. It continues to pursue price stability in terms of the euro and the central bank steers the exchange rate between the unit of account (euro) and the medium of exchange (new guilder). The monetary policy interest rate on euro bonds, which is no longer hindered by a lower bound since there is no zero interest rate alternative, can be used to stabilise the purchasing power of the euro. Implementing the dual currency proposal in practice seems to be difficult: people may start to use the medium of exchange as a unit of account, and inflation in the unit of exchange currency may fluctuate considerably. Taking these considerations into account, in this thesis the zero lower bound is regarded as a restriction to nominal interest rates.

The research presented in this thesis is carried out in a so-called New Keynesian framework, surveyed in Clarida et al. (1999) and Galí (2003). This strand of the literature adds Keynesian elements such as nominal rigidities to a dynamic general equilibrium model in the Real Business Cycle tradition. The equilibrium conditions are derived from optimizing behaviour by forward-looking economic agents with rational expectations. The New Keynesian framework is very useful for studying monetary policy issues, since it allows for short-run deviations of actual output from potential output and a role for stabilization policy, with the economy eventually moving towards the long-run classical equilibrium. It reflects modern practice in that the interest rate is treated as the instrument of monetary policy. The model accounts for the importance of expectations by incorporating many forward-looking elements. Because of its explicit theoretical foundations, New Keynesian models can be used for counterfactual policy experiments.

As with all approaches, the New Keynesian framework is not without limitations. In particular, the assumption that firms face specific constraints on the frequency with which they can reset their prices lacks a firm micro-economic basis. So-called Calvo pricing is a simple way to introduce firms' price setting behaviour, providing a straight-forward way to model price stickiness. The Calvo parameter, which specifies the fraction of firms not allowed to adjust prices in a certain period of time, is determined exogenously. It seems likely that this parameter also depends on the inflation environment. In a climate with extreme price changes (hyper inflation or spiralling deflation), the costs of changing prices will be of less importance and firms will change prices more frequently (meaning a lower Calvo parameter). However, the reduction of average inflation from about 2% to about zero is unlikely to lead to strong changes in the Calvo parameter.

The standard New Keynesian setting also neglects financial frictions that may influence the effect of changes in monetary policy interest rates on market interest rates. This thesis accounts for financial frictions by focussing on the role of collateral. If economic prospects improve, asset prices rise, implying higher collateral values and lower risk premiums for collateralized loans. Chapter 3 discusses these issues in a theoretical framework, Chapter 4 from an empirical perspective. In addition, New Keynesian economists tend to pay little attention to the role of monetary aggregates. However, the money supply can have significant effects, depending on whether the economy is characterized by a high or low inflation regime (Bordo and Filardo, 2006). These aspects are elaborated upon in Chapters 2 and 6. Apart from the inclusion of financial frictions and monetary aggregates, it was a deliberate choice to use very stylized models for analyzing the issues at stake. These models are not intended for forecasting, but are used to add to the understanding of economic phenomena. This approach allows for a greater insight into the transmission channels in the economy than would the use of large-scale numerical models.

Chapter 2 defines the playing field. This survey chapter singles out the specific issues for further research, which are dealt with in the subsequent chapters. It appears that the issue of escaping from a binding zero lower bound has attracted much more attention than how an economy slips into such a situation in the first place. An initial exploration suggests that a collapse in macro-economic confidence plays a key role. Although it is difficult to model overall confidence, it shows up in several financial factors, in particular in macro-economic risk measures.

Chapter 3 developes a theoretical model to examine the key findings of Chapter 2. Transmission channels that drive monetary policy towards the zero interest rate bound, where further interest rate reductions are no longer possible, are investigated. The emphasis is on changes in market expectations of long-term potential growth that are reflected in asset prices, and on how these financial factors can exacerbate real economic shocks (the financial accelerator).

As is evident from Hubbard (1998), financial accelerator effects exist on a micro-economic scale. In particular, investment decisions by small- and medium-sized firms are influenced by their financial wealth. On the other hand, previous empirical research on the importance of the financial accelerator for macro-economic outcomes has come up with limited evidence. Against this background, Chapter 4 adds to the empirical literature on financial accelerator effects on a macro-economic scale by focussing on the large fluctuations in wealth that occur during asset price booms and busts. Using a probit model for a panel of 20 mature economies, the explanatory power of several financial variables is investigated.

Chapter 5 focuses on the relationship between the level of the inflation objective and the risk of reaching a binding zero lower bound. Before the central bank can strive for price stability, this concept must be operationalised. In particular, the level of the year-on-year increase of the consumer price level (inflation) must be determined. Under normal circumstances, actual inflation will hover around its target level. According to Friedman, the optimal level of the nominal interest rate is (close to) zero, to equalise the opportunity costs of holding money to the (negligible) costs of producing money. This implies an optimal inflation level equal to minus the real interest rate, i.e. deflation. Most New Keynesian economists have stressed the distortionary effects of (nominal) prices that only respond with lags to changes in economic conditions. In order to mitigate these distortions they have argued in favour of a stable general price level, i.e. zero inflation. However, if the zero lower bound poses a serious impedement to monetary policy by limiting the downward room for manoeuvre of real interest rates, the optimal average inflation level or inflation target is clearly above zero.

An increase in the money supply could still play a role in stimulating the economy when the policy interest rate has reached the zero floor. Chapter 6 reports on the role of money for monetary policy, and in particular on whether the monetary authority should take money explicitly into account when setting monetary policy. To this end, the standard New Keynesian model, with the interest rate as the monetary policy instrument instead of the money supply, is extended with a micro-founded role for money in determining aggregate demand and supply in order to better describe monetary policy transmission. Two different channels can be distinguished. The first is the real balance channel, since higher money stocks are associated with higher wealth, which will translate into higher spending. The second channel concerns the role of money as an information variable. Money captures information on the yields of other financial assets, since an increase in money reduces risk premiums on less liquid assets.

Chapter 7 brings together concluding observations on the above-mentioned issues. This thesis' main contribution to the literature is that it shows analytically how a situation can arise in which the monetary policy interest rate is zero, and can no longer be further reduced to boost economic activity. It appears that a deterioration in economic prospects not only reduces aggregate demand, but also hampers the loan market. This is because economic prospects determine the valuation of assets that serve as collateral. A downward shift in expectations and collateral value makes lending more risky, causing a rise in risk premiums, which, along with the risk free rate set by the central bank, determine market interest rates. In reaction, the central bank will have to reduce the policy interest rate sharply to engineer a market interest rate at which aggregate demand equals aggregate supply, restoring price stability. It is demonstrated that the patterns of monetary policy interest rates in OECD countries have been largely consistent with this story from the mid 1980s onwards, when financial markets were liberalized. Accordingly, there is a risk that the policy interest rate can hit the zero floor in a low inflation regime. Nevertheless, there may still be ways to relax monetary policy conditions when interest rates are zero, in particular by increasing the money supply. This thesis shows how monetary policy is set optimally when interest rate risk premiums depend on the money supply through wealth and financial market liquidity effects.

Finally, please note that symbols have slightly different meanings in different chapters.

Chapter 2

The zero lower bound issue: a survey

> Representative Brown: "...I think it would be interesting to Members of Congress, and particularly to this Committee, to know what your policy would be under present conditions..."
>
> Fed governor Eccles: "...Under present circumstances there is very little, if anything, that can be done."
>
> Representative Goldsborough: "You mean you cannot push a string."
>
> Fed governor Eccles: "That is a good way to put it, one cannot push a string. We are in the depths of a depression and, as I have said several times before this committee, beyond creating an easy money situation through reduction of discount rates and through the creation of excess reserves, there is litte, if anything that the reserve organization can do toward bringing about recovery...."
> (US Congress, 1935)

2.1 Introduction

In the 1980s and 1990s, inflation in the industrialised world fell from the high levels reached in the 1970s and early 1980s, when inflation waves occurred following the breakdown of the Bretton Woods system and two large oil price shocks.[1] According to IMF statistics, average year-on-year CPI inflation in OECD countries declined from 12% in 1980 to 5% in 1990, and 1.4% in 1999 (Figure 2.1). The variability of inflation in terms of standard

[1] This chapter is a slightly revised version of Ullersma (2002).

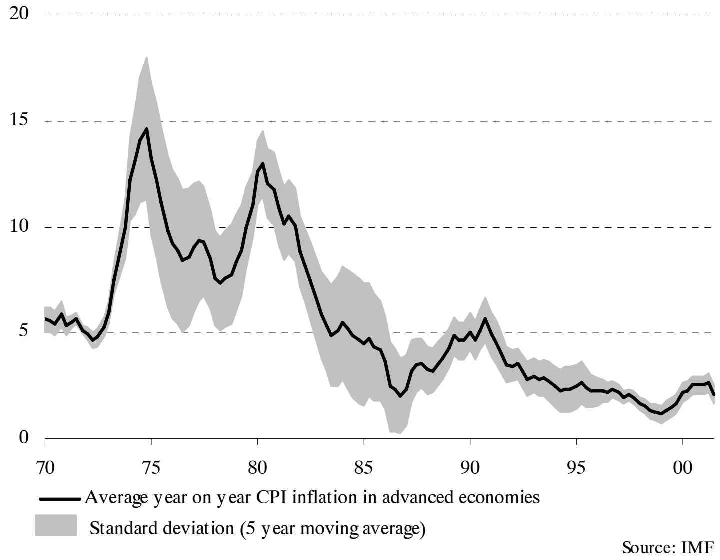

Figure 2.1: Consumer price inflation in advanced economies

deviations also decreased over these years. A new era seems to have emerged with low and more or less stable inflation rates in the major capitalist economies (Clarida et al., 1998; Viñals, 2001).[2] This situation is comfortable from the point of view of monetary policy, the overriding objective of which is price stability. In the words of Greenspan (1989), price stability is defined to mean 'that expected changes in the average price level are small enough and gradual enough that they do not materially enter business and household financial decisions.'

However, the achievement of price stability has not created a new Utopia for monetary policy. Instead, it has brought about new challenges (e.g. IMF, 1999). One of the main

[2]In 1995, the leading monetary authorities of the world also expressed this view. At a meeting of the Group of Seven in October 1995, the communiqué concluded: 'The ministers and central bank governors agreed that in most countries the conditions for continued growth and employment gains are in place and inflation is well under control.'

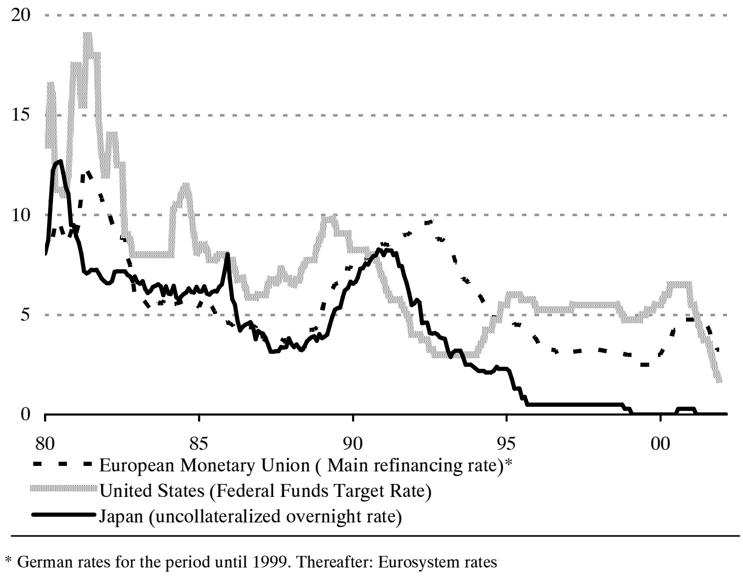

Figure 2.2: Monetary policy interest rates

challenges is the decrease in the room for manoeuvre for monetary policy.[3,4] The fall in the inflation rate in the advanced economies has coincided with a decline in the monetary policy interest rates (Figure 2.2).[5]

The point is that – assuming zero storing costs for cash and perfect substitutability between non-monetary assets – nominal interest rates cannot go negative. In that case, the rate of return on cash (zero) dominates that on assets yielding a negative nominal return. In practice, nominal interest rates on (short-term) financial claims can be slightly negative if the cost of storing currency exceeds that of storing other claims (McCallum, 2000), although exceptions to the lower zero bound have been rare.[6] Since for theoretical

[3]Vickrey (1954) argued against policies resulting in very low inflation or deflation. Deflation would prevent monetary policy from engineering negative *ex ante* real interest rates, which can be necessary for correcting downward tendencies in the economy.

[4]Another challenge is analysed by Akerlof et al. (1996). They have focussed on the existence of downward rigidities that would favour the central bank having a small but positive inflation rate objective.

[5]For a historic account of (the volatility of) inflation and interest rates, see McFarlane and Mortimer-Lee (1994) and Homer (1977), respectively.

[6]One recent example is the occurrence of slightly negative interest rates on Japanese short-term

discussions the exact level of the floor to nominal interest rates does not matter, I assume for simplicity that nominal interest rates cannot go negative. In this context, the so-called problem of the zero lower bound on nominal interest rates is that the monetary authority is no longer in a position to pursue a policy of monetary easing by lowering nominal interest rates.[7] Under these circumstances, monetary policy may still be effective via other transmission channels than nominal interest rates. For instance, inflationary expectations can be fuelled via higher money growth. I follow Buiter and Panigirtzoglou (2001) in their definition of a liquidity trap.[8] An economy is said to be in a liquidity trap if all channels of monetary transmission are blocked. Only in one case, the liquidity trap and the zero bound on nominal interest rates are identical concepts. This applies if the nominal interest is the only monetary transmission channel. In other cases, a binding zero lower bound is a necessary but not a sufficient condition for the liquidity trap to prevail.

The zero lower bound on nominal interest rates has long been regarded as a phenomenon of the past. It has been related mainly to the Great Depression in the US (1929-1930s). The main monetary policy rate in the US by then, the three months 'T-bill' rate, was close to zero from 1932 onwards; it did not exceed 1% until 1948. The long-term interest rate was also very low in this period. It has been suggested that monetary policy was completely ineffective by then, i.e. that a liquidity trap prevailed.[9] The only example of a binding zero lower bound in the period between the Great Depression

government bonds and some interbank lending in late 1998. Longer ago, in 1978, the Swiss authorities imposed negative interest rates on foreign deposits in order to fight speculative buying of the Swiss franc. During the Great Depression US T-bills occasionally gave a small negative yield in the context of exemption from personal property taxes in some States (Cecchetti, 1988).

[7] In such circumstances, monetary easing is said to be like 'pushing on a string', see this chapter's motto.

[8] In between these extreme positions on the interpretation of a liquidity trap, there exists a large range of slightly different interpretations of the liquidity trap. Since they all share common features, these differences are of limited importance to our discussion of the liquidity trap. For a detailed discussion of different interpretations, see Patinkin (1965, 1974) and Beranek and Timberlake (1987).

[9] In the 1960s and 1970s, there was an intensive, but inconclusive, debate on whether the US economy was in a liquidity trap during the years of the Great Depression. This debate focussed on the interest elasticity of the money demand function. Some authors found that the interest elasticity was without limit when the short-term nominal interest rate approached zero. Therefore, they concluded that the economy was in a liquidity trap (Eisner, 1963, 1971; Spitzer, 1976); others found a fixed interest elasticity and came to the opposite conclusion (Bronfenbrenner and Mayer, 1960, 1963; Meltzer, 1963).

and the 1990s is Switzerland. In the late 1970s, Switzerland went through periods with nominal interest rates at or close to the zero lower bound. However, in contrast to the US during the Depression years, the Swiss economy was buoyant in the late 1970s. The very low Swiss rates have been associated with the liberalisation of global exchange rates in the early 1970s, although the introduction by the Swiss authorities of capital controls also played a role (Mauro, 1995). The new exchange rate regime implied appreciation and expectations of further appreciation of the Swiss franc.

Developments in Japan in the late 1990s have revived interest in the zero lower bound phenomenon. From February 1999 to January 2002 completion of this paper , the uncollateralized overnight call rate was virtually zero.[10] Like the US economy during the Depression years, Japan has been characterised by a substantial output gap since the early 1990s.[11] The level of potential real economic growth is estimated to be around 1% (OECD, 2000). Given that potential growth in other large economies is generally estimated to be considerably higher,[12] it follows that even in steady state (i.e. output gap closed) the Japanese real longterm interest rate will be relatively low. Assuming identical risk and term premiums across countries, this will go hand in hand with relatively low short-term nominal interest rates. The Japanese example illustrates that a zero lower bound can emerge in a modern capitalist economy. Krugman (1998, 1999b) and Svensson (2000) have warned explicitly that such a situation might also prevail in the US and the euro area, given the structural decline in nominal interest rates over the last two decades.

This chapter surveys the literature on the zero lower bound on nominal interest rates and the related phenomenon of the liquidity trap. Section 2 sketches the main issues in the framework of a New-Keynesian model, which is a dynamic stochastic real business cycle model with nominal rigidities. Section 3 offers an appraisal of the four main strands in the literature. As it turns out, these theories are incomplete. In the concluding Section 4, I argue that certain crucial insights got lost in the literature. This pertains in partic-

[10] Until March 19, 2001, the uncollateralized overnight call rate was the direct operational target of the Bank of Japan. From then onward, the operational target has been the outstanding balance of the current accounts at the Bank of Japan, with the uncollateralized overnight call rate determined in the market.

[11] According to the OECD (2000), Japan's output gap in 1999 is 4.0% of GDP. Applying Okun's law, Krugman (1998) concludes that Japan's output gap is even higher, in the order of 10%.

[12] The OECD (2000) projects potential real growth in 2000 at 1.2% in Japan, 3.7% in the US, and 2.4% in the euro area.

ular to expectations, which were totally left out in the static ISLM representation of a macroeconomy by Hicks (1937) to return only partly in later work. It appears that supply factors that undermine confidence are depressing total demand in a situation with a binding zero lower bound. Hence, a lack of confidence is the main force driving the emergence of a liquidity trap; similarly, restoring confidence is the main challenge in escaping from it.

2.2 The consensus model

The zero lower bound on nominal rates was recognised as early as 1896 by Irving Fisher (1896). However, Keynes (1936) was the first to elaborate on the problem of the liquidity trap[13] in Chapters 15 and 17 of *The General Theory* (see also Lerner, 1952, and Ono, 1994). He emphasises the *liquidity preference* of economic agents, implying that the utility of holding money is always positive, even if more money is held than required by the transactions or precautionary motive (compare Modigliani, 1944). Keynes shows that a liquidity trap can emerge in an environment with liquidity preference and sluggish price adjustment. The basic idea is that an economic agent allocates his income to consumption, money holdings and bonds, assuming that all assets other than money are perfect substitutes for each other. Under normal circumstances, optimising behaviour will equalise the marginal rate of substitution between present and future consumption ((intertemporal) time preference rate), the marginal rate between present consumption and present money holdings (liquidity premium), and the nominal market interest rate. However, if the nominal market interest rate is below the liquidity premium, economic agents will keep consumption below the market clearing level. Persistent stagnation will occur, because economic agents will not be satiated with money, no matter how much they have accumulated. Liquidity preference prevails because of the speculative motive, based on uncertainty about future economic developments in general, and more specifically,

[13] The liquidity trap as described by Keynes differs from the usual textbook description. The latter is based on Hicks' (1937) representation of a Keynesian economy in the famous ISLM framework. Hicks left out the intertemporal choice completely and put the economy in a static framework, thereby focussing on intratemporal choices that are key in Keynes (1936). In a one-period model, there is no role to play for a change in expectations. Hicks was well aware of the limitations of his simplification. He himself noted that the assumption of given expectations is not realistic.

about future nominal interest rates. If the long-term nominal interest rate is perceived to be very low (in the order of 2% according to Keynes, 1936), economic agents will expect this rate to rise and will hold liquid assets (money) in an attempt to benefit from it. In Keynes' (1936) view, the role of money as a store of wealth is the reason that 'changing views about the future are capable of influencing the present situation.' With the market interest rate below the liquidity premium, consumption remains insufficient to restore market equilibrium, and money becomes a 'bottomless sink for purchasing power.' The economy is then said to be in a liquidity trap. In Keynes' (1936, page 207) own words:

> 'There is the possibility [...] that, after the rate of interest has fallen to a certain level, liquidity preference may become virtually absolute in the sense that almost everyone prefers cash to holding a debt which yields so low a rate of interest. In this event the monetary authority would have lost effective control over the rate of interest.'

The classical economist Pigou (1943, 1947) disagreed with Keynes on this conclusion. In his view, the utility of money is satiable, meaning that ultimately the liquidity premium will decline sufficiently to reach the time preference rate when liquidity holdings increase.[14] In this view, rational economic agents will ultimately spend their cash holdings. The basic idea behind the mechanism that will restore equilibrium is the following. Economic agents realise that monetary growth will ultimately imply higher inflation (Fisher identity) and that future inflation will reduce their spending capacity. Hence, they have a strong incentive – at least in the long run – to spend before others do. If the time preference rate at the market clearing level is lower than the liquidity premium, economic agents will reduce consumption. This will imply disequilibrium in the goods market, and therefore generate deflation. As a result, real balances will rise over time, which will raise consumption until equilibrium is restored. This is the so-called Pigou effect.

Now, a consensus model has emerged to study the zero lower bound. In the long run, market clearing and the Pigou effect are generally believed to restore full employment equilibrium. Ultimately, there are no nominal rigidities and money is neutral. Hence, monetary policy has no real economic effects in the long run, and a liquidity trap is inconceivable as a persistent phenomenon. As regards the short-run analysis of the zero

[14] Compare McCallum (1983) for a formal analysis.

lower bound, different approaches have culminated in the New-Keynesian synthesis,[15] which can be regarded as a symbiosis of neo-classical and Keynesian thoughts. New-Keynesian models introduce nominal price and/or wage rigidities in a dynamic stochastic real business cycle framework. It took a long time until serious consideration was given to the zero lower bound for nominal interest rates in this framework. Summers (1991) and Fischer (1994) have revived this old concern. Since then, Fuhrer and Madigan (1997), Krugman (1998), Orphanides and Wieland (1998), Svensson (2000, 2001), Buiter and Panigirtzoglou (2001), and Wolman (1998) have studied the zero lower bound and the liquidity trap in a New-Keynesian framework. Although this framework has important limitations when analysing the zero lower bound, it has proven to be a helpful workhorse to study certain aspects of this issue. I take it as a starting point and discuss its limitations and possible extensions along the way. Following Smets (2003) and Viñals (2001), a highly stylised New-Keynesian macroeconomic model can be specified as follows (equations 2.1-2.4):

$$y_t = \rho_y y_{t-1} + \left(1 - \rho_y\right) E_t y_{t+1} - \sigma r_t + \varepsilon_t^y, \tag{2.1}$$

$$\pi_t = \omega \pi_{t-1} + (1 - \omega) E_t \pi_{t+1} + \lambda y_t + \varepsilon_t^\pi, \tag{2.2}$$

$$r_t = i_t - E_t \pi_{t+1}, \tag{2.3}$$

$$i_t = \rho_r i_{t-1} + \beta_\pi \pi_t + \beta_y y_t. \tag{2.4}$$

y_t (in logs) is the percentage deviation of output from its steady state trend level in period t, i_t the nominal interest rate, t_t the *ex ante* real interest rate, and π_t the inflation rate. ε_t^y and ε_t^π are the (serially uncorrelated zero-mean) stochastic components of equations 2.1 and 2.2, representing demand and inflation disturbances, respectively. $E_t x_{t+1}$ is the expected value at period t of variable x in period $t+1$; ρ_y, σ, ω and λ are parameters. Equation 2.1 is a representation of the demand side of the economy. Equation 2.2 is a Phillips curve, representing the supply side. With ρ_y and ω equal to zero, Goodfriend and King (1997) have demonstrated that these equations can be derived from micro foundations. However, equations 2.1 and 2.2 consist of both forward and backward looking components in order to describe the inflation dynamics in industrialised economies better (Smets, 2003). Equation 2.3 describes the Fisher relation between (*ex ante*) real and

[15] The New-Keynesian literature is surveyed in Goodfriend and King (1997) and Clarida et al. (1999).

nominal interest rates. By definition, the zero lower bound is binding when the sum of the real rate of interest and the rate of expected inflation is zero. Nominal interest rates cannot go negative. For in that case, the zero rate of return on cash would dominate the rate of return on other assets, which is ruled out *a priori*. The model does not distinguish between short- and long-term interest rates.[16] Perfect substitutability is assumed between non-monetary assets. Finally, equation 2.4 is the Taylor type rule that describes the interest rate reaction function. The nominal interest rate is increased when current inflation exceeds its target (assumed to be zero) or when the output gap is positive. Equation 2.4 may require that the monetary authority set a negative real interest rate, which may be impeded by low or even negative expected rates of inflation. Then, the zero lower bound will be binding, and the economy will be in a liquidity trap in the absence of other transmission mechanisms than the nominal interest rate.

An economy with a low average real interest rate over the business cycle is in a more vulnerable position concerning the risk of drifting into a situation with a binding zero lower bound than an economy with a higher average real interest rate. Usually, however, an economic shock is necessary to trigger a sudden decline in the steady state real interest rates and/or the rate of expected inflation (e.g. Orphanides and Wieland, 1998). I discuss several kinds of shocks that can hit the economy.

First, a *downward cost-push shock* can trigger a binding zero lower bound. Examples are a downward shock in oil prices or increased competition. Such a shock implies a significant negative value of ε_t^π in equation 2.2. The direct effect is lower inflation in period t. As a result, the nominal interest rate will be decreased (equation 2.4), moving in the direction of the zero lower bound. The *ex ante* real interest rate will decrease too, causing some counterbalancing upward pressure on inflation through y_t. In general, a downward cost-push shock is favourable, supporting output but reducing inflationary pressures.[17] Only if there is very strong initial downward pressure on inflation, there is a

[16] For ease of exposition, the model ignores term and risk premiums. The incorporation of risk premiums would add a spread to the interest rate in equation 2.1, and would lift the lower bound to the nominal interest rate. In general, risk premiums are increasing with the level of interest rates. If there would still be a risk premium with the riskless nominal interest rate at its lower bound – which seems likely – the incorporation of risk premiums in the model would make a binding lower bound more likely.

[17] E.g. continued price cuts in the computer industry in the 1980s and 1990s associated with technical progress have not undermined investment in this sector, because productivity gains have more than offset

severe risk that the zero lower bound will be hit.

Second, a *downward demand shock*, $\varepsilon_t^y < 0$ in equation 2.1, putting downward pressure on both output and inflation, can cause a binding zero lower bound. The output gap will fall first (equation 2.1), resulting in lower inflation in the same period (equation 2.2). Both effects are translated into a lower nominal interest rate (equation 2.4), bringing closer a binding zero lower bound. A demand shock may originate from a collapse in aggregate demand, e.g. following a sudden lack of confidence. Contrary to the situation after a downward supply shock, both the output gap and inflation pressure have similar effects on the nominal interest rate. Therefore, this is potentially a more severe situation. Budgetary contraction offers an example of a negative demand shock that lowers real interest rates and can fuel deflationary expectations, as was the case in the US in the late 1920s/early 1930s.

Third, in an open economy, a sudden large *expected appreciation* can cause a binding zero lower bound (McKinnon and Ohno, 2000). To illustrate this, the model can be extended to include interactions with the outside world. I assume Uncovered Interest Parity (UIP), which can be stated as:

$$i_t = i_t^* + (E_t s_{t+1} - s_t)\,, \tag{2.5}$$

where i_t^* is the foreign nominal rate of interest. $E_t s_{t+1}$ is the expected nominal exchange rate of the foreign currency expressed in units of the domestic currency for period $t+1$. So, an increase in s means a nominal depreciation of the domestic currency. In real terms, UIP can be written as:

$$r_t = r_t^* + (E_t q_{t+1} - q_t)\,, \tag{2.6}$$

where q is the real exchange rate $(s_t P_t^*/P_t)$, the domestic price level P is assumed to be temporarily fixed; the foreign price level P^* is treated as given, because it is beyond the influence of the domestic monetary authority. The central bank can influence q via foreign currency interventions that alter s. I restate the model (equations 2.1-2.4) in an open economy context as follows (equations 2.7-2.10):

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the price effect. Other sectors of the economy have clearly benefited from lower computer prices.

$$y_t = \rho_y y_{t-1} + \rho_y^* y_t^* + \left(1-\rho_y\right) E_t y_{t+1} - \sigma r_t + \alpha_1 \left(E_t q_{t+1} - q_t\right) + \varepsilon_t^y, \tag{2.7}$$

$$\pi_t = \omega \pi_{t-1} + (1-\omega) E_t \pi_{t+1} + \lambda y_t + \alpha_2 \left(E_t q_{t+1} - q_t\right) + \varepsilon_t^\pi, \tag{2.8}$$

$$r_t = i_t - E_t \pi_{t+1} = r_t^* \left(E_t q_{t+1} - q_t\right), \tag{2.9}$$

$$i_t = \rho_r i_{t-1} + \beta_\pi \pi_t + \beta_y y_t. \tag{2.10}$$

ρ_y^*, α_1 and α_2 are parameters. In equation 2.7, $\rho_y^* y_t^*$ represents foreign export demand[18]; $\alpha_1 \left(E_t q_{t+1} - q_t\right)$ is an expression for changes in competitiveness. In equation 2.8 the term $\alpha_2 \left(E_t q_{t+1} - q_t\right)$ is added to include the effects of expected costs of imported intermediaries. Equation 2.9 follows from equation 2.6. With a large expected real appreciation, the direct effect on the inflation rate will be downward (equation 2.8),[19] bringing closer a binding zero lower bound (equation 2.10). There is also an indirect downward effect on inflation via a lower output gap (equation 2.7). Exchange rate arrangements that cause substantial real appreciation can turn out to be problematic in this respect. Keynes (1923) was well aware of the international propagation of deflationary pressures through the fixed nominal exchange rates of the gold standard, which limited the scope for domestic policy actions in an international environment with free capital movement (incompatible triangle). In the 1980s, the Plaza and Louvre agreements set similar mechanisms in motion, with negative effects on Japan (Siebert, 2000). The international movement towards stable and low inflation rates (Section 1) has reduced the risk of the emergence of a sudden large expected appreciation in today's advanced economies.

Economic shocks are most devastating when they lead to persistent deflationary expectations, lifting real interest rates, and set in motion a chain of events that lead to stagnation, i.e. a *deflationary spiral* (Krugman, 1999a). Persistent deflationary expectations can stem from prevailing adaptive expectations (high value of ω in the model). They can also stem from price and/or wage stickiness (e.g. DeLong and Summers, 1986). The implied slowness of price reductions can fuel (rational) expectations of still further

[18] In an open economy, net additional demand via net exports reduces the risk of very low *ex ante* real interest rates.

[19] In the Exchange Rate Mechanism (ERM) of the EMS (fixed but adjustable exchange rates), higher inflation of an ERM country relative to inflation in Germany (the anchor country) caused a loss of competitiveness (real appreciation), mitigating inflationary pressures.

price reductions ($E_t\pi_{t+1}$ lower). Fisher[20] (1933), Tobin (1975, 1980), Minsky (1982), King (1994), and Bernanke (1995) have emphasised that high nominal indebtedness will make a deflationary spiral more likely to occur due to the heterogeneous nature of economic agents. More specifically, debtors, who spend a higher proportion of their income than creditors, get into trouble by deflation since their real income declines substantially. So, even if net debt is modest (with debtors and creditors offsetting each other), debt distribution is relevant. High nominal indebtedness can arise during an asset price bubble (Minsky, 1982; Wolfson, 1996). When the bubble collapses, the debt may turn out to be unbearable, especially in a deflationary climate. An alternative propagation mechanism concerns the collateral value associated with the debt. Deflation will erode the collateral value. As a result the cost of capital will increase, subsequently decreasing investment demand (Bernanke and Gertler, 1989). A vicious circle can develop, with falling asset prices, rising real debt levels, lower aggregate demand, consumer price deflation, and downward spiralling expectations. Note that a deflationary spiral is not the mirror image of an inflationary spiral. In the latter case, the monetary authority can stabilise the economy by raising the real rate of interest via an increase in nominal rates (assuming nominal price and/or wage rigidities). However, in a deflationary environment, the monetary authority will not be able to lower real rates below a certain level, due to the lower bound on nominal interest rates.

Usually, the risk of a binding zero lower bound is regarded as limited. According to Orphanides and Wieland (1998), the risk of hitting the zero bound would be negligible for the US with an average nominal interest rate over the cycle of 3%. To get this result, they use stochastic simulations of a small structural rational expectations model. They suppose stochastic shocks similar in magnitude to those over the 1980s and 1990s. Only with a lower level of the average nominal interest rate, they found a significant risk of a binding zero bound. Using a similar model, Viñals (2001) has compared the US and the euro area chance of hitting the zero lower bound. His findings for the US are more or less in line with those of Orphanides and Wieland (1998). For the euro area, his results suggest an even smaller chance than for the US of hitting the zero lower bound due to the structural characteristics of the euro area. However, finding that shocks that cause a binding zero lower bound are unlikely, does not rule them out altogether. The

[20] Fisher's debt-deflation theory is clearly analysed in Dimand (1999).

probability of a binding zero lower bound depends on the likelihood of a combination of extreme shocks. Since the frequency of such shocks is limited, they are hard to assess econometrically (King, 1999).[21] Typically, in a financial crisis, several different shocks can reinforce themselves. Mishkin (1991, 1996) defines a financial crisis as 'a disruption to financial markets that sharply and severely increases asymmetric information [...] so that financial markets are no longer able to efficiently channel funds to those who have the most productive investment opportunities.' He has found that most financial crises in the US started with a combination of shocks, including a sharp increase in interest rates, a stock market crash, and a sharp increase in uncertainty due to economic recession. In addition, the terrorist attacks on New York and Washington on 11 September 2001 offer an example of a rare combination of shocks. Lower demand as a result of the virtual stand-still of the US economy for several days, falling asset prices, together with strong negative confidence effects, can potentially trigger a binding zero lower bound.

2.3 Different views on the zero lower bound: an appraisal

Four main strands of literature can be distinguished to discuss the zero lower bound. First, Krugman and his followers have emphasised the importance of lifting expected inflation to lower the market real interest rate at the zero lower bound. Second, Meltzer and other monetarist authors have argued that transmission mechanisms other than the nominal interest rate will be effective at the zero lower bound. Third, Buiter and Panigirtzoglou as well as Goodfriend have proposed to introduced so-called *Gesell money*. As explained by Goodfriend (2000), Gesell money is a carry tax on money (both currency and bank reserves) to circumvent the interest rate floor. Fourth, Svensson has tried to combine several other approaches, and claims to have found a 'foolproof' way to escape from the liquidity trap. These different approaches are discussed below in the context of the consensus model. Meanwhile, it is important to keep in mind that Japan has been

[21] Amirault and O'Reilly (2001) warn that relying on historical data to determine the risk of hitting the zero lower bound may underestimate this risk due to the recent world-wide tendency towards regimes with low average levels of inflation.

struggling for many years with a binding zero lower bound. This may indicate that the theories put forward are incomplete, although it is fair to say that this proposition does not follow from the Japanese example *per se*, as a referee has correctly pointed out. From the perspective that the available theories seem incomplete, this section also evaluates the limitations of the main strands in the literature.

2.3.1 Krugman's view

Several years before Krugman (1998), Summers (1991) had emphasised that a (very) low level of average inflation and low inflationary expectations will imply (very) low average short-term nominal interest rates. If the monetary strategy leads to inflationary expectations close to or below zero, this will make the emergence of a binding zero lower bound more likely. Krugman (1998) has triggered a discussion on Japanese monetary policies. In his analysis, *lifting expected inflation* is the way forward for Japan and other economies struggling with a binding zero lower bound. He makes a strong case for the announcement of an *inflation target* in a deflationary environment in order to guard inflationary expectations. Then, lifting expected inflation (equation 2.3) can reduce the *ex ante* real interest rate, which is the interest rate decisive for economic performance (equation 2.1).

According to, among others, Svensson (2000) and Smets (2003), *price level targeting* might be a better way to anchor expectations than an inflation target. This is because, in contrast to an inflation targeting regime, undershooting of the price level target in period t leads to inflationary expectations in period $t+1$. Berg and Jonung (1999) describe how Sweden dropped the gold standard in 1931 and adopted an explicit price level target. It turned out that price level targeting was a successful way for Sweden to stop deflationary expectations and mitigate the output decline. The potentially better performance of price level targeting as compared to inflation targeting is subject to the confidence of the general public and financial markets in the monetary authority's ability to reflate the economy.[22] In this respect, the public can be expected to be more confident if the central bank has at its disposal instruments with which it can create future inflation directly.

In addition to the long turn orientation of monetary policy, monetary tactics (i.e.

[22] Batani and Yates (2003) have shown that the probability of hitting the zero lower bound under the alternative regimes is model specific.

the way in which monetary policy is executed on a short-term basis) may also matter. Reifschneider and Williams (2000) have argued that if the central bank follows a Taylor-type rule and targets a (close to) zero inflation rate, the rule can be modified slightly to reduce dramatically the detrimental effects of the zero lower bound. In their paper, one possible modification with promising results is to lower the nominal monetary policy rate pre-emptively if a binding zero bound is expected. This would involve a higher value for β_π in equation 2.4 if there were a serious threat of a binding zero bound in the near future. The suggested policy reaction is in line with what several authors (e.g. Mundell, 2000) have concluded on Fed policies in the late 1920s. With hindsight, they have stated that the Fed should have lowered nominal interest rates sooner and more forcefully and should have injected reserves via its lender-of-last-resort function. Then, the Fed might have been in a position to prevent the rapid decline in broad money and the collapse of the banking sector. The deflation of the Great Depression would probably have been more modest, or even avoided.

Krugman launched his ideas in order to influence Japanese policies at the end of the 1990s. The Japanese authorities and others have been very sceptical about his recipes. In their view, the Bank of Japan cannot explicitly show how to achieve the desired inflation level. They fear following Krugman's advice would result in a loss of credibility (Okina, 1999). Whereas Krugman acknowledges that creating inflationary expectations might be difficult, especially when the public is convinced of the central bank's commitment to price stability, Buiter and Panigirtzoglou (2001) regard this virtually impossible. In their words 'targeting a higher rate of inflation after you are caught in the trap would be like pushing toothpaste back into the tube.' The problem is that Krugman's recipe is conditional on the central bank's ability to increase expected inflation.[23] In reality, the central bank has no instruments available to force higher expected inflation. It might also be difficult to raise inflationary expectations because price stickiness can make the expected future price also sticky (Fuhrer and Madigan, 1997; Orphanides and Wieland, 1998). Krugman's ideas fit in the literature on time inconsistency and credibility by Kydland and Prescott (1977), Barro and Gordon (1983) and their followers that credible

[23] Wolman (1998) models an economy in which the monetary authority can always create inflationary expectations. Not surprisingly, in this case a policy regime where nominal interest rates are occasionally bounded by the interest rate floor generates higher welfare than a regime that always avoids nominal rates at zero.

central bank commitment to price stability can anchor expected inflation at a low and stable level. If his recipe works, it is important to avoid that creating higher inflationary expectations paves the way for a future inflationary spiral, which would be suboptimal from a microeconomic perspective. Therefore, it is crucial to base monetary policies on a nominal anchor provided by the medium term monetary policy strategy (Taylor, 2001). In so doing, the monetary policy strategy helps in reducing uncertainty about the future. Similarly, Svensson (2000) argues that the mere announcement of an inflation target is not likely to be enough to fuel inflationary expectations. Instead, it would be necessary to set up an inflation-targeting framework, including transparent inflation reports and published inflation forecasts among other things. In the words of Blinder (1998), it is about 'words matching deeds.' All in all, it seems unlikely that the exact set-up of the monetary policy strategy is essential for its success in solving the zero lower bound problem. What matters, is that it helps anchoring medium term inflationary expectations. But if a central bank is initially lacking credibility, it is unlikely that it is able to commit credibly to higher inflation.

2.3.2 Meltzer's monetarist view

Monetarists argue that the monetary transmission channel[24] is much more complicated than is incorporated in equation 2.1. The monetarist view differs from the consensus model in so far that monetary easing will still be successful with short-term interest rates at the lower bound because of other transmission channels (e.g. Mishkin, 1996). Meltzer (1963, 1995, 1999) and Brunner and Meltzer (1968) focus on the transmission mechanisms of monetary policy working through relative price adjustments of non-monetary assets that are imperfect substitutes in investors' portfolios. These relative price changes are transmitted along the yield curve and also impact on the exchange rate.[25] Meltzer's reasoning is based on the assumption that when the short-term nominal interest rate cannot fall due to the zero lower bound, yields on non-monetary assets are not necessarily

[24] Walsh (2003) presents a useful overview of monetary transmission channels and empirical evidence of their importance in Chapter 7.

[25] In this chapter, the monetary policy channel that works through foreign exchange markets is discussed in the context of Svensson's eclectic view.

at their lower bounds.[26] Bernanke and Gertler (1995) have emphasised the credit channel in the monetary policy transmission process. This channel is not hampered by the lower zero bound on nominal interest rates. Monetary easing will reduce the exposure by debtors to the wedge between the cost of external and internal funds. This will support current spending.

The Pigou effect can be seen as an abstraction of 'alternative' transmission channels that do not work through the nominal interest rate. To see this, the model 2.1-2.4 can be extended as follows (equations 2.11-2.15):

$$y_t = \rho_y y_{t-1} + \left(1-\rho_y\right) E_t y_{t+1} - \sigma r_t + \rho_{y,m} m_t + \varepsilon_t^y, \tag{2.11}$$

$$\pi_t = \omega \pi_{t-1} + (1-\omega) E_t \pi_{t+1} + \lambda y_t + \omega_m m_t + \varepsilon_t^\pi, \tag{2.12}$$

$$r_t = i_t - E_t \pi_{t+1}, \tag{2.13}$$

$$i_t = \rho_r i_{t-1} + \beta_\pi \pi_t + \beta_y y_t, \tag{2.14}$$

$$m_t = \gamma_0 + \gamma_1 y_t + \gamma_2 i_t + \varepsilon_t^m, \tag{2.15}$$

where m_t (in logs) is the percentage deviation from the steady state of the nominal value of the real money demand (i.e. nominal amount of money divided by the price level, M_t/P_t); γ_0, γ_1 and γ_2 are coefficients; ε_t^m is an error term. The parameters $\rho_{y,m}$ and ω_m have been added. The Pigou effect is incorporated in equation 2.11 through m_t. With output below potential, real balances will increase until the price level and output are back in equilibrium. Ireland (2004) has shown that the cross-equation restrictions require that real balances can be included in the demand function if and only if they are also contained in the supply function. As before, there is only one instrument variable. It is useful to regard m_t as the instrument variable, since lifting the real amount of money can boost output and inflation, even if the nominal interest rate is at the zero lower bound.

Does it make sense to add the Pigou effect to the short-term consensus model? At first sight, the Pigou effect seems at odds with the micro foundations of the consensus

[26] In practice, monetary easing with the short-term interest rate at the zero lower bound might involve additional open-market transactions in other assets, such as commercial paper. Since late 1995, the Bank of Japan is implementing repurchasing agreements using commercial paper. In 1998, the Bank of Japan held approximately one-third of the outstanding commercial paper stock. Transactions in longer-term debt, equity or property are also conceivable.

model, which is a representative agent model. Money is not perceived as net wealth in this kind of model, since wealth cannot be transferred across individuals. However, if the assumption of homogenous agents is relaxed, for instance by differentiating between different generations, money becomes net wealth Ireland (2001b). In the monetarist approach, the Pigou or real balance effect is incorporated in a short-run model. This is done to emphasise the role of monetary factors in the monetary policy transmission process.

From a theoretical point of view, the monetarist assertion that monetary transmission channels other than via nominal interest rates can prevent a liquidity trap is conditional on the assumption that the marginal utility of money eventually becomes zero as real balances expand.[27] However, if liquidity preference as defined in section 2 is assumed, the demand for money will asymptote to infinity as the interest rate asymptotes to zero. On mature financial markets, this can be thought of as a high preference by market participants for liquid assets. Monetary policy would then have no effect on total demand, because hoarding would absorb any additional money created. Money then becomes 'a bottomless sink for purchasing power.' The consensus model takes on board liquidity preference in so far that there is no explicit Pigou effect.

From a more practical point of view, an important caveat concerning alternative monetary transmission mechanisms in a zero lower bound environment is that empirical evidence on the effectiveness of these channels in such a context is lacking. For instance, Clouse et al. (2003) have investigated which theoretical options are available for the Fed to stimulate aggregate demand by increasing monetary supply after the short-term interest rate has reached zero. They concluded that the Fed has a wide range of policy responses at its disposal, but they did not find convincing evidence of substantial quantitative effects. The most farreaching policy option along these lines is allowing companies and individuals lending directly from the central bank on a massive scale. However, if the central bank is purchasing lower rated private sector securities, it will take substantial credit risks on its balance sheet. This can backfire on its credibility. Because of this risk, central bank legislation usually rules out these kinds of transactions.

[27] Preferences for money balances would then exhibit satiation and money creation would ultimately be translated in demand for other assets and spending.

2.3.3 Buiter's and Goodfriend's view: abolition of the zero bound

Buiter and Panigirtzoglou (2001) and Goodfriend (2000) have suggested the introduction of so-called *Gesell money*.[28] This would imply decreasing the zero nominal interest floor by taxing money (and other monetary liabilities on the central bank balance sheet). In terms of our model, the restriction that nominal interest rates cannot go negative is circumvented. With Gesell money it will always be possible to reduce the interest rate floor, even below zero.

The possible success of Gesell money is conditional on the availability of technologies that make it feasible without high costs. This is questionable in practice. The introduction of Gesell money will bring about high transaction and administrative costs, reducing its liquidity and thereby the main advantage of money (see Brunner, 1971). Moreover, the replacement of conventional money by Gesell money would make currency less attractive as compared to today's alternatives, such as foreign currency and e-money, assuming that e-money is not subject to the same tax (Gresham's law). This could impair the central banks monetary policy effectiveness, as explained by Friedman (1999).

2.3.4 Svensson's view: an important role for exchange rate policies

In line with monetarist reasoning about different transmission channels of monetary policy, some authors have stressed the exchange rate channel in a zero lower bound situation. A medium-term strategy to devaluate/depreciate the currency (an increase in $E_t s_{t+1}$ in the model embodied in equations 2.7-2.10) can increase inflationary expectations. This strategy is only applicable to relatively open economies. It is assumed that the targeted country is not in a zero lower bound situation. Johnson et al. (1999) show that – assuming UIP holds – foreign exchange interventions at the lower bound can only have direct effects if they signal further future depreciation, or if domestic and foreign assets are imperfect substitutes. Both channels can be expected to be of minor importance, as is well known from the literature on foreign exchange intervention (Edison, 1993; Eijffinger, 1999).

McCallum (2000) drops the UIP assumption explicitly.[29] In his model, the exchange

[28] Fisher (1932) and Keynes (1936) have hinted at this idea in the 1930s.

[29] Empirical research tends to suggest that exchange rate movements are inconsistent with UIP (e.g.

rate replaces the short-term nominal interest rate as the monetary policy instrument. The central bank can determine real exchange rates via its control over nominal exchange rates, as is the case in our model (2.7-2.10). In the absence of UIP, McCallum is able to show that monetary stabilisation policy can still be effective via foreign exchange markets.[30] In line with McCallum (2000), McKinnon and Ohno (2000) argue that if deflation is caused by expectations of appreciation of the domestic currency, the forward rate of the exchange rate should be brought down, e.g. by international exchange rate agreements. Elaborating on these ideas, Svensson (2000, 2001) indicates that exchange rate pegging, involving a commitment to arbitrary large non-sterilised foreign exchange interventions, might play an important role. Since this strategy would involve putting into circulation domestic currency and buying foreign reserves, the central bank cannot run out of reserves. He drops UIP for his short-term analysis by assuming a sticky domestic price level, so that the real exchange rate can be influenced in the short run. In Svensson (2001), he has presented a very transparent model to explain his ideas. He claims to have found a 'foolproof' way for an open economy to escape from the binding zero lower bound. The idea is to jump-start the economy by a real depreciation of the currency via unlimited interventions, and in so doing to increase inflationary expectations. Initially, an exchange rate peg is established, which is later replaced by a price-level or inflation target when the price-level target has been reached. In so doing the risk of overheating is avoided.

A problem with Svensson's 'foolproof' solution is that the expected real exchange rate depreciation in the initial phase will raise real interest rates with limited maturities relative to world real interest rates (Swank, 2001). This will counteract the exchange rate mechanism. If the real interest mechanism dominates, the inflation rate will not rise initially. A persistent low or negative inflation rate can undermine the credibility of the monetary authority and puts at risk the strategy as a whole. A practical problem is that the central bank cannot steer the exchange rate as it can steer interest rates. In the specific Japanese context, a problem is the relatively closed nature of the Japanese

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Froot and Thaler, 1990; Lewis, 1995).

[30] Meltzer (1999) is of the same opinion, stating 'Suppose that with its short-term interest rate at zero, the Bank of Japan announces that it wants the dollar exchange rate to fall by 25 percent and that it is prepared to print yen to buy dollars until that occurs. Does anyone doubt that the yen would depreciate or that the depreciation would affect spending, output and prices in Japan?' McCallum's arguments can be interpreted as a special case in Meltzer's rejection of the liquidity trap framework.

economy. Thus, very large exchange rate changes would be needed. Another practical obstacle to putting exchange rate targeting in place is that generally governments are in charge of exchange rate policies, not the central bank. This can make it difficult to pursue exchange rate policies as an integral part of the monetary policy strategy. Finally, such a large and persistent depreciation can significantly affect the economies of trading partners, which might give rise to retaliation measures.

2.4 Concluding remarks

What brings the suggested solutions to a binding zero lower bound together is their mechanical character. However, it is not certain that a solution that works in a specific economic model will also work in reality. Besides, all suggested solutions will in one way or another involve costs. These two considerations may explain why the Japanese authorities have so far not followed the non-orthodox recipes put forward.

A factor not incorporated in the models discussed is the general level of confidence. Using the concept of liquidity preference, Keynes has shown that lack of confidence is a crucial element of persistent zero lower bounds. In the current literature, the precondition that a high degree of confidence must be in place to escape from a binding zero lower bound is undervalued. Policies to increase the expected rate of inflation can only be effective if monetary policy is credible, or if a framework is introduced that makes it credible. This is only feasible in an environment in which the central bank can create inflation. This implies that confidence must be in place. Otherwise, economic agents would increase their hoarding after monetary easing. Alternative monetary transmission channels, which feature prominently in monetarist thinking, will only be effective if economic agents spend more after monetary easing, i.e. if they have confidence in the future. Then, economic agents will have no incentive for excessive hoarding. On the other hand, if confidence is lacking, the situation may arise that economic agents are characterised by liquidity preference, and do not increase spending after monetary easing. As discussed, *Gesell money* can only be expected to offer an effective escape route from a binding zero lower bound under strict conditions. However, it may help in restoring confidence by supporting nominal interest change effectiveness. As regards Svensson's (2001) promising approach offering a 'foolproof' way of escaping from a binding zero lower bound, it must be noticed that his solution works only in the specific context of his model. Because the central bank can devaluate the exchange rate of the domestic currency without limit, its policies will be credible. In practice, the economy is much more complicated than the stylised model suggests. E.g. a central bank cannot steer the exchange rate precisely, as assumed in his model. Hence, it is impossible to proof that a certain solution to the zero lower bound will work always and everywhere. Without 'foolproof' solutions to the zero lower bound, restoring confidence will be of paramount importance to steer the economic agents towards spending more.

As long as confidence remains firmly in place, an economy may hit the zero lower bound due to particular circumstances, but this situation will not cause severe output losses. The Swiss case in the late 1970s offers an example. In such an environment, monetary policy with nominal interest rates at the lower bound can be expected to be effective. Lacking confidence, monetary policy cannot help in escaping from the zero lower bound. With monetary policy impotent, the economy is in a liquidity trap. Japan is currently in such a dreadful situation.

So, if there is a persistent zero lower bound and monetary policy is ineffective, the lack of confidence may be the main challenge. Here, demand and supply factors meet. The zero lower bound problem is usually seen as a demand side phenomenon. As the Japanese example shows, a binding zero lower bound can persist much longer than usual demand side problems, suggesting that confidence and supply factors also play a role. A lack of confidence can undermine demand for a considerable span of time. The clearest example of a joint supply and demand shock is a financial stability crisis. By definition, such a shock implies that financial market intermediation is interrupted (supply side effect). This will go hand in hand with lower demand, since business activity is severely hampered. The mechanism also works the other way around. In terms of the illustrative model (equations 2.1-2.4) an increase in the degree of confidence will manifest itself in lifting potential output and the output gap (y), as well as the average *ex ante* real interest rate over the business cycle. The average *ex ante* interest rate is exogenous in the model, since it is specified in deviations from steady state. With favourable economic prospects, profit prospects will be high, as will investors' propensity to invest. Also, consumers' propensity to save will be low because future income prospects are advantageous. In general terms, good governance, adherence to the rule of law, well-defined property rights, financial sector stability, and flexible markets create an environment in which the economy can flourish, and steady state real interest rates will *ceteris paribus* be higher than without. What can government policies do to bring about such a situation?

In general terms, it is important that economic agents are confident that political leaders and economic and monetary policymakers are capable of their duties. If they lack public confidence, people that are trusted should replace them. The policymakers must pursue policies that restore confidence in economic prospects. As regards *monetary policy*, the monetary policy strategy is important for anchoring inflationary expectations. Actual policy decisions must show that the monetary authority acts according to its own words. *Budgetary policies* can be used to increase demand, and in so doing try to kick-start the economy. This will lift average *ex ante* real interest rates over the business cycle. The average real interest rate can rise partly through a direct expenditure channel. Expansionary fiscal policy will bring unemployed labour and capital into use, boosting output and tax revenues. However, this channel is conditional on the absence of Ricardian equivalence. The arguments in favour of and against Ricardian equivalence are discussed in Bernheim (1987). It is essentially an empirical question. Barro's (1989) findings suggest that partial Ricardian equivalence prevails.[31] Apart from the Ricardian equivalence argument, the government may not be in a position to borrow because of a mounting public debt,[32] a loss of credibility or Stability and Growth Pact-like constraints on government borrowing (Buiter and Panigirtzoglou, 2001). Government expenditure can also raise the average *ex ante* real interest rate through an indirect confidence channel by revitalising economic prospects. Budgetary policies can support structural policies, for instance in financing the writing off of possible bad loans. In this context, quality of government expenditure is important.[33] *Structural change* can offer a lasting channel

[31] Ricardian equivalence does not play an explicit role in the models presented.

[32] With the debt to GDP ratio clearly above 100%, Japan may reach a point where the government's creditworthiness is so impaired that it is no longer in a position to borrow. A large debt may raise questions about government solvency in the long run in spite of a zero interest rate, because this situation will not last forever.

[33] In contrast to popular believe, Keynes (1936) did care about the quality of public expenditure. He preferred productive public expenditure to 'wasteful' expenditure. He departed from classical economics only when he stated that – in absence of productive possibilities for public expenditure – also 'wasteful' expenditure such as pyramid-building will enrich the community on balance when the economy is characterised by involuntary unemployment.

to raise the average *ex ante* real interest rate. Of course, the direct effects of structural policies can take many years before they bear fruit. But in the short-term they can help in the reestablishment of confidence by improving the long-term prospects for the economy. From a longer-term perspective, what matters is that the economic structure determines to a large extent in what context macroeconomic demand policies work. In a zero lower bound environment, this regards above all trend productivity growth. The key insight is that higher productivity growth can lift low (average) *ex ante* real interest rates. Higher real interest rates can be achieved via a higher 'natural' rate of growth (summing the growth of the labour force and the rate of technical progress).[34] A higher natural rate of growth can result from exogenous factors, such as the emergence of a 'New Economy' (see e.g. Buiter, 2000), or good structural policies. It is basically about a mixture of credible policies that restore confidence by setting up sound old age pension systems, disability schemes, and promote competition by reducing trade barriers, pursuing microeconomic deregulation and similar policies. Safeguarding financial sector stability is also a key element of these structural policies, since an advanced market economy cannot function without efficient and effective credit intermediation.[35] In sum, it is unlikely that an economy with robust institutions and confidence firmly in place, such as the US, will end up in a situation with a binding zero lower bound on nominal interest rates. Of course, at the end of 2001, the Fed funds rate was reduced to the low level of 1.75%. But this must be seen against the background of sharp downward demand and confidence shocks (terrorist attacks, a confidence fall in the ICT sector), and a synchronised international cyclical downturn. As Fed chairman Greenspan has said at several occasions, the long-run economic prospects of the US economy remain favourable after the tragic events of September 11, 2001 (Greenspan, 2001b, 2002). Enhanced productivity growth is expected to lift the US standard of living. In particular, Greenspan has stressed the health of the financial sector, which is in sharp contrast to the Japanese situation. If an economy with a sound underlying structure would nevertheless hit the zero lower bound, an optimistic reassessment of expectations for economic growth by the public at large, and financial

[34] In the 1950s and early 1960s inflation in the US varied between approximately 0 and 4%, but the zero bound was never reached. This is because productivity growth and average economic growth were high, and therefore also the equilibrium real interest rate and the short-term policy rate of interest.

[35] Viñals (2001) discusses the interactions between financial and monetary stability in a low inflation environment.

market participants in particular, will be crucial for escaping from it.

Chapter 3

On the emergence of a binding zero lower bound

> "Drittens ergibt sich aus unserm Gedankengang, dass Irrtümer des Aufschwungs beim Eintritt und für den Verlauf der Depression eine erhebliche Rolle spielen müssen."
> (Schumpeter, 1934)

3.1 Introduction

The zero bound on nominal interest rates has attracted a lot of attention from economists in recent years.[1] In particular, the zero interest rate monetary policy by the Bank of Japan has triggered an intense debate on monetary policy effectiveness at low inflation and interest rate levels. Most contributions have focused on ways to escape from a situation in which the monetary authority is no longer able to stimulate the economy by reducing official interest rates. For instance, Krugman (1998) emphasises the importance of lifting expected inflation in order to reduce real market interest rates. Svensson (2001) suggests unlimited foreign exchange intervention to initially depreciate the home currency, so as to create inflationary expectations. The more fundamental issue of how a binding zero lower bound can arise has attracted far less attention in the recent literature.[2] This is

[1] This chapter is a revised version of Ullersma (2004).

[2] There exists a related literature on the sources of the Great Depression, with seminal contributions by Fisher (1933) and Friedman and Schwartz (1963).

surprising, since one might suspect that knowledge on the origins of a binding zero lower bound can be helpful in its prevention.

The focus of this chapter is on the causes of a binding zero lower bound. On the basis of shocks similar in magnitude to those observed historically, Orphanides and Wieland (1998) and Reifschneider and Williams (2000) conclude that hitting the zero bound is unlikely to occur in the US. Viñals (2001) draws the same conclusion for the euro area. Their models do not take into account structural factors that can undermine growth expectations and depress total demand. In Chapter 2 of this thesis it is argued that these factors can reinforce shocks, making a binding zero lower bound more likely to occur. In particular, mechanisms that work through the balance sheets of private households seem capable of exacerbating cyclical fluctuations in the economy (Borio et al., 2001). Balance sheet effects appear to have become more important over recent years, following the increased leverage of households on financial markets. This chapter examines these issues in a New Keynesian framework along the lines of Clarida et al. (1999), extended with a financial accelerator mechanism. Through this mechanism, financial market imperfections can cause pronounced amplifications of shocks. The model presented can be regarded as a variant of the Bernanke et al. (1999) model, where the financial frictions occur on the household instead of firm side. The dynamics are fully described by the New Keynesian Phillips curve, an IS type equation, the external finance premium and a specification of monetary policy. This allows for a transparent evaluation of the interaction of economic shocks and financial market imperfections.

The chapter's main contribution to the existing literature is that it shows analytically how a binding zero lower bound can emerge. Financial accelerator effects that affect households instead of firms, in conjunction with misperceptions regarding productivity growth, appear pivotal.

The focus on consumer households instead of firms is a deviation from the traditional approach, where cyclical variations tend to start with changes in investment. This is where expectations about future economic developments can influence expenditure in a non-forward looking model. However, the model of this Chapter lacks capital formation and investment, in line with most other stylized general equilibrium models. Expectations enter the model directly and through the balanced growth level of the real interest rate. More optimistic expectations have an upward effect on the latter, and thus result in a more expansionary monetary policy stance at a constant policy interest rate level. This lifts household expenditure. This effect is exacerbated by financial market frictions.[3] Private households have no access to the capital market, similar to small firms. Instead they have to turn to banks to attract loans. Banks charge a premium above the risk-free interest rate to cover the default risk. With more fragile household balance sheets, the risk premium increases, as is a clear feature of the US subprime mortgage market.

Uncertainty about productivity has caused an intense debate ever since US productivity growth moved to unprecedented rates in the second half of the 1990s (e.g. Roberts (2000)). In the model, waves of misperceptions about productivity growth tend to prolong economic cycles. A downward adjustment of overoptimistic expectations about (productivity) growth is reflected in lower labour income (labour is the only input factor). This increases the cost of borrowing by reducing the value of private wealth/collateral, thereby depressing current activity. The more fragile private sector balances are, the stronger will be the effects. In case of strong effects a sharp reduction in the nominal policy interest rate is required to boost the economy. This process can result in hitting the zero lower bound.

The remainder of this chapter is organised as follows. Section 2 presents the model. Section 3 shows how the interaction of misperceptions and financial accelerator effects can bring about a binding zero lower bound. Section 4 concludes.

3.2 Model

The model used in this paper is a New Keynesian general equilibrium model that allows for credit market imperfections in the vein of Barro (1976) and Jaffee and Russell (1976). Representative households maximise their utility subject to a solvency condition that implies no liability in the event of default. A competitive loan market is modeled in which banks charge a premium to cover the default risk on household liabilities. This is referred to as the financial accelerator mechanism. It generates an inverse relationship between the strength of household balance sheets and the magnitude of the risk premium,

[3] There are clear indications that consumer households are liquidity constrained. Consumption is linked to current income much more closely than one would expect on the basis of overlapping generations models (Campbell and Mankiw, 1991). Balance sheet channels affecting consumers instead of firms have also been studied by Ludvigson (1998, 1999) and Aoki et al. (2004).

and it creates a mechanism through which the magnitude and persistence of shocks are amplified. A Calvo (1983) type model of intermediate goods producers in a staggered price environment is used to generate a New Keynesian Phillips curve. Three alternatives for monetary policy are considered: an inflation targeting rule, optimal monetary policy under discretion and optimal monetary policy under commitment from a time-less perspective.

3.2.1 IS curve

The aggregate behavioural equations follow from explicit optimisation by households and firms along the lines of King and Wolman (1996), Woodford (2003) and Yun (1996). The representative household is infinetely-lived. In line with Ireland (2001a) and others an isoelastic utility function is assumed. The household's objective is to maximise:

$$E_t \left\{ \sum_{i=0}^{\infty} \omega^{t+i} \left(\frac{Y_{t+i}^{1-\sigma}}{1-\sigma} + \phi_1 \frac{(D_{t+1+i}/P_{t+i})^{1-\eta}}{1-\eta} - \phi_2 \frac{L_{t+i}^{1+\phi}}{1+\phi} \right) \right\}, \tag{3.1}$$

subject to a flow budget and a solvency constraint, respectively:

$$D_{t+1} - \pounds_{t+1} = \max[0, D_t - \pounds_t + W_t L_t - P_t Y_t + i_{D,t} D_{t+1} - i_{L,t} \pounds_{t+1}], \tag{3.2}$$

$$\lim_{T\to\infty} \left(\frac{1}{1+i_{L,T}} \right)^T \left(D_{T|t} - \pounds_{T|t} \right) \geq 0, \tag{3.3}$$

where Y is the level of consumption, D deposits, P the consumption-based price level, L the amount of labour supply, $\pounds$ loans, W the nominal wage rate, ω the discount factor, t the time index, and σ, η and ϕ are elasticities. All coefficients (mostly in Greek) are positive, unless specified otherwise. At time t, D_t and $\pounds_t$ are given and the household decides on $D_{t+1}, \pounds_{t+1}, Y_t$ and L_t. $\pounds_{T|t}$ denotes $E_t \pounds_T$, i.e. the expected value of $\pounds$ at T, expected at t. i_D is the risk-free nominal interest rate on D, while i_L is the risk-bearing nominal interest rate on $\pounds$. Therefore, $i_{L,t} \geq i_{D,t}$.[4] It is assumed that the monetary authority sets i_D. In a similar way as money enters the utility function in the Money-In-the-Utility (MIU) approach, deposits enter the utility function directly. Deposits in the utility function is used to reflect the value of deposits to facilitate transactions and to store wealth. Since deposits yield direct utility in addition to interest income, it is rational for households to borrow and lend at the same time. Note that negative values

[4] $i_{L,t} = i_{D,t}$ holds only if $\pounds_{t+1} = 0$. This ensures that the optimum is also defined in case $i_{L,t} = i_{D,t}$.

for end of period net financial wealth ($V_{t+1} = D_{t+1} - \pounds_{t+1}$) are ruled out by eq. 3.2. In case of default the household will have a zero net financial wealth position at the end of the period (see Section 2.2). Utility maximisation by the household leads to a familiar IS curve, except that the risk-bearing nominal interest rate i_L replaces the risk-free rate i_D (see Appendix B):

$$x_t = x_{t+1|t} - \frac{1}{\sigma}\left(i_{L,t} - \pi_{t+1|t} - \bar{i}_{L,t} + \overline{\pi}\right), \tag{3.4}$$

where $x_t \left(= \log Y_t - \log \overline{Y_t}\right)$ is the output gap, and $\pi_t \left(= \log P_t - \log P_{t-1}\right)$ is the inflation rate.[5,6]

3.2.2 External finance premium

The risk-bearing interest rate i_L is determined in the credit market, where all borrowers are treated symmetrically by the banks. This follows from the representative household framework, which implies that there is no role for idiosyncratic risks or distributional issues among households.

Following Barro (1976), consider a standard single period loan of amount $\pounds$ provided by a bank to a household at the beginning of period t. The full principal plus interest is due at the end of the period, with the loan secured by collateral (C). Collateral consists of all means to fulfill the household's loan obligations, i.e. the sum of his assets and income minus his expenditure at the end of the period:

$$C_{t+1}^{ep} = D_t + i_{D,t}D_{t+1}^{ep} + W_t^{ep}L_t^{ep} - P_t^{ep}Y_t^{ep}, \tag{3.5}$$

where the superscript ep denotes ex-post values. C_{t+1} is stochastic at the time of loan negotiations, since the ex-post value of W_tL_t may deviate from its ex-ante value. This follows from the assumption that changes in firms' turnover translate one-for-one into labour income changes. It is assumed that C_{t+1} is characterised by a normal distribution

[5] An upper bar denotes the value that is consistent with a balanced growth path.

[6] The model is log-linearised around its initial balanced growth path. Of course, the accuracy of the approximation tends to decrease if substantial divergences occur. But even then, errors due to linearisation generally remain modest according to simulation studies (Meijdam and Verhoeven, 1998).

with positive mean $\overline{C}_{t+1} = D_t + i_{D,t} D_{t+1}$ and variance σ_C^2.[7] If the ex-post collateral value (C_{t+1}^{ep}) appears equal or higher than principal plus interest, the household will comply with its loan obligations, and financial wealth (V) at the end of the period is:

$$V_{t+1} = C_{t+1}^{ep} - \pounds_t - i_{L,t} \pounds_{t+1} = C_{t+1}^{ep} - (1 + i_{L,t}) \pounds_{t+1}, \tag{3.6}$$

since the principal paid back at the end of the period equals the amount received at the beginning. If the ex-post collateral value turns out to be lower than its loan obligations, the household will default, implying that $V_{t+1} = 0$. The probability of default is (see Appendix C):

$$d_t = \Pr_t \left[C_{t+1}^{ep} < (1 + i_{L,t}) \pounds_{t+1} \right] = \int_{-\infty}^{(1+i_{L,t})\pounds_{t+1}} f(C) dC, \tag{3.7}$$

where $f(C)$ is a probability density function and where:

$$\frac{\partial d}{\partial ((1 + i_L) \pounds)} = f((1 + i_{L,t}) \pounds_{t+1}). \tag{3.8}$$

For clarity of exposition, it is assumed that the collateral value to the lender is zero, which is relevant if the household were to fail.[8] In addition, it is assumed that banks obtain their funds at the constant risk-free interest rate i_D and that they have no other costs. The banking sector is characterised by representative banks and constant returns to scale, implying that banks serve as many borrowing households as are forthcoming. They are assumed to be risk-neutral and to maximise the expected value of their profits (Π^{bank}):

$$\Pi_{t+1|t}^{bank} = (1 - d_t)(1 + i_{L,t}) \pounds_{t+1} - (1 + i_{D,t}) \pounds_{t+1}, \tag{3.9}$$

subject to eq. 3.7. With a competitive loan market, a zero expected profit condition must hold. Therefore:

$$1 + i_{D,t} = (1 - d_t)(1 + i_{L,t}). \tag{3.10}$$

[7] $E_t(W_t L_t) = E_t(P_t Y_t)$ since firms are assumed to earn zero ex-ante profits and labour is the only factor of production. See Appendix A and Appendix D.

[8] Decisions are taken ex ante, when the collateral is held by the borrower, who attaches value to it. The expected value to the borrower, conditional on the fact of default, is $\widetilde{C}_t = \frac{1}{d_t} \int_{-\infty}^{(1+i_L)\pounds_{t+1}} C \times f(C) dC < (1 + i_L) \pounds_{t+1}$ (see also Appendix C). The difference between the value to the lender and the borrower can be interpreted as transaction costs.

For small values of i_D, i_L and d, this means:

$$i_{L,t} \cong i_{D,t} + d_t. \tag{3.11}$$

The wedge between the interest rates on loans and (risk-free) deposits is the risk premium. Its magnitude is determined by the probability of default.

3.2.3 Role of technological progress

It can be shown that the level of the nominal interest rate that is consistent with a balanced growth path ($\bar{i}_L$) is determined by technological progress (see Appendix E):

$$\bar{i}_{L,t} \equiv \bar{r}_{L,t} + \bar{\pi} = \rho + \mu\left(a_{t+1} - a_t\right) + \bar{\pi}, \tag{3.12}$$

where r_L is the real interest rate on £, $\rho\,(= -\log\omega)$ is the time discount rate, μ is a constant determined by σ and ϕ in eq. 3.1, $a = \log A$, and A is labour productivity per hour in units of consumption goods. Higher productivity growth lifts the marginal product of labour, and therefore the equilibrium interest rate. The relationship between productivity growth and the interest rate in not one-for-one because it depends also on the marginal utility of consumption (through μ). The corresponding production function reads:

$$y_t = a_t + l_t, \tag{3.13}$$

where l is $\log L$. Technological progress is represented by:

$$a_{t+1} - a_t = \alpha + \varepsilon^a_{t+1}, \tag{3.14}$$

where it is assumed that the technology shock is characterised by $\varepsilon^a_{t+1} = \gamma\varepsilon^a_t + \varepsilon_{t+1}$. The AR parameter γ signals the persistence of technology shocks. It is assumed that technology shocks ε^a are unobservable. This implies that $\bar{i}_{L,t}$ is also unobservable. Economic agents are assumed to base their decisions on constant $\bar{i}_L$. A positive $\varepsilon^a_{t+1} = \gamma\varepsilon_t$ shock will then imply a negative deviation of the market interest rate from its balanced growth path $(i_{L,t} - \bar{i}_{L,t})$, where $\bar{i}_{L,t} = \bar{i}_{L,t|t} + \mu\left(a_{t+1} - a_{t+1|t}\right) = \bar{i}_{L,t|t} + \mu\varepsilon^a_{t+1} = \bar{i}_{L,t|t} + \mu\gamma\varepsilon_t$. The loosening of the monetary policy stance raises demand:

$$\widehat{x}_t = \widehat{x}_{t+1|t} - \frac{1}{\sigma}\left(\widehat{i}_{L,t} - \widehat{\pi}_{t+1|t}\right) + \frac{\mu}{\sigma}\gamma\varepsilon_t, \tag{3.15}$$

where hats over variables indicate log deviations from the initial balanced growth path (= trend), except variables already in percentage terms, which are simple deviations from their initial balanced growth path.

3.2.4 Phillips curve

Staggered nominal price setting in the spirit of Calvo (1983) is assumed. The output gap varies proportionally with marginal costs. This results in a New Keynesian Phillips curve (see Appendix D):

$$\pi_t = \omega \pi_{t+1|t} + \kappa x_t, \tag{3.16}$$

where the discount factor is $\omega \, (\cong 1 - \rho)$.

3.2.5 Monetary policy

The model is closed by a specification of monetary policy. Three different specifications are evaluated. First, a strict inflation targeting rule. Second, optimal monetary policy under discretion. Third, optimal monetary policy under commitment from a time-less perspective.

In a strict inflation targeting regime, the nominal policy interest rate is steered in such a way that the nominal market interest rate responds to inflation according to the rule:

$$\widehat{i}_{L,t} = \rho_i \widehat{\pi}_t + \varepsilon_t^i, \tag{3.17}$$

where ε^i covers zero-mean policy interest rate shocks. Combining eq. 3.14-3.17 results in:

$$\begin{bmatrix} x_{t+1|t} \\ \pi_{t+1|t} \\ \varepsilon_t^a \end{bmatrix} = B \begin{bmatrix} x_t \\ \pi_t \\ \varepsilon_{t-1}^a \end{bmatrix} + \begin{bmatrix} \sigma^{-1}\varepsilon_t^i - \frac{\mu}{\sigma}\gamma\varepsilon_t \\ 0 \\ \varepsilon_t \end{bmatrix}, \tag{3.18}$$

where

$$B = \begin{bmatrix} 1 + \frac{\kappa}{\sigma\omega} & \frac{\omega\rho_i - 1}{\sigma\omega} & 0 \\ -\frac{\kappa}{\omega} & \frac{1}{\omega} & 0 \\ 0 & 0 & \gamma \end{bmatrix}. \tag{3.19}$$

There exists a unique stationary equilibrium if $\rho_i > 1$ (Bullard and Mitra, 2002). Assume that the initial balanced growth path, which is characterised by $\overline{x} = 0,\ \overline{\pi},\ \left(1 + \overline{i}_D\right)\overline{D}$, $\left(1 + \overline{i}_L\right)\overline{\pounds}$ and σ_C, is also known. Then the behaviour of d_t and $i_{D,t}$ can be derived from eq. 3.7, 3.8 and 3.11.

Now consider an environment where the contemporaneous values of output, inflation and shocks cannot be observed. The IS and Phillips curve eq. can be written as:

$$\widehat{x}_t = \widehat{x}_{t+1|t-1} - \frac{1}{\sigma}\left(\widehat{i}_{L,t}|\Omega_t - \widehat{\pi}_{t+1|t-1}\right) + \frac{\mu}{\sigma}\gamma\varepsilon_t, \tag{3.20}$$

$$\widehat{\pi}_t = \omega\widehat{\pi}_{t+1|t-1} + \kappa\widehat{x}_t, \tag{3.21}$$

where Ω_t is the monetary authority's information set at the time it determines the monetary policy stance. The time lag in information rules out that the monetary authority can always fully stabilise the output gap and the inflation level, even though the New Keynesian Phillips curve eq. 3.16 does not contain a cost-push shock.

Under discretion, the monetary authority acts each period to minimize the loss function:

$$Loss_t = E_t\left\{\sum_{i=0}^{\infty}\omega^i\left(\widehat{\pi}_{t+i}^2 + \lambda\widehat{x}_{t+i}^2\right)\right\}, \tag{3.22}$$

subject to eq. 3.21. The corresponding optimality condition is (Walsh, 2003):

$$E_t\left\{x_t|\Omega_t\right\} = -\frac{\kappa}{\lambda}E_t\left\{\pi_t|\Omega_t\right\}. \tag{3.23}$$

It follows that:

$$\widehat{x}_t^I = \frac{\mu}{\sigma}\gamma\varepsilon_t, \tag{3.24}$$

$$\widehat{\pi}_t^I = \frac{\kappa\mu}{\sigma}\gamma\varepsilon_t, \tag{3.25}$$

where the superscript I refers to equilibrium values under imperfect information. Solving for $\widehat{i}_{L,t}$ from eq. 3.20 yields $\widehat{i}_{L,t} = 0$. $\widehat{i}_{D,t}$ and d_t can be determined in the same way as in the inflation targeting case.

Under commitment, the monetary policy authority determines a path for current and future levels of inflation and the output gap in order to minimize the loss function eq. 3.22 subject to eq. 3.21. The optimality conditions are (Walsh, 2003):

$$E_t\left(\widehat{\pi}_{t+i} + \Lambda_{t+i} - \Lambda_{t+i-1}\right) = 0 \qquad i \geq 0, \tag{3.26}$$

$$E_t\left(\lambda \widehat{x}_{t+i} - \kappa \Lambda_{t+i}\right) = 0, \tag{3.27}$$

where Λ is a Lagrangian multiplier. The time-less perspective implies that condition 3.26 is also implemented in the current period ($i = 0$). This is the case because current values of the output gap and inflation are the outcome from previous optimal decisions. It follows that current levels of inflation and output depend on past developments. Combining eq. 3.16, 3.26 and 3.27 yields:

$$\left(1 + \omega + \frac{\kappa^2}{\lambda}\right) E_t\left\{\widehat{x}_t|\Omega_t\right\} = \omega \widehat{x}_{t+1|t-1} + \widehat{x}_{t-1}. \tag{3.28}$$

The solution of this expectational difference eq. for the output gap is of the form:

$$E_t\left\{\widehat{x}_t|\Omega_t\right\} = \alpha_x \widehat{x}_{t-1}, \tag{3.29}$$

where α_x is the solution less than 1 of the quadratic eq.:

$$\omega \alpha_x^2 - \left(1 + \omega + \frac{\kappa^2}{\lambda}\right) \alpha_x + 1 = 0. \tag{3.30}$$

It follows that:

$$\widehat{x}_t^I = \frac{\mu}{\sigma} \gamma \varepsilon_t, \tag{3.31}$$

$$\widehat{\pi}_t^I = \frac{\lambda}{\kappa}\left(1 - \alpha_x\right) \widehat{x}_{t-1}^I. \tag{3.32}$$

Eq. 3.32 shows how past outcomes influence current policies. It implies that the monetary authority is committed to inertia. This means that the monetary authority can steer more effectively expected future inflation, which leads to a more favourable trade-off between output gap and inflation variability. Again, $\widehat{i}_{L,t}$ can be determined on the basis of eq. 3.20, and $\widehat{i}_{D,t}$ and d_t in the same way as in the inflation targeting case.

3.3 Transmission of technology shocks

The impact of technology shocks is illustrated in Figures 3.1-3.3, showing the impulse responses of key variables in the case of both inflation targeting and optimal policy. The parameter values of the quarterly model are based on Galí (2003). The time discount factor ω is 0.99, which is consistent with a time discount rate ρ of about 1 percent. As to the elasticities in the utility function it is assumed that $\sigma = \eta = \phi = 1$, which implies that $\mu = 1$. The scaling parameters are $\phi_1 = \phi_2 = 1$. Trend productivity growth α is 0.25 percent, whereas the markup in the steady state m is 0.10 (consistent with elasticity of substitution $\theta = 11$) and the technology shock is characterised by 50% persistence ($\gamma = 0.5$). In the New Keynesian Phillips curve (eq. 3.16 and 3.21), κ equals 0.17, which follows from combining the other parameter values with the assumption that prices are fixed on average for a year (the fraction of firms that cannot change their price at t is $\vartheta = 0.75$). In the case of inflation targeting, it is assumed that the monetary authority lifts the real market interest rate when inflation divergences from target: $\rho_i = 1.5$. In the case of optimal monetary policy, a weight on output fluctuations $\lambda = 0.25$ is used in the loss function.

If there is no initial indebtness ($\overline{\pounds} = 0$) there is no lending that would cause financial frictions. Therefore the risk premium equals 0 ($d = 0$), $i_D = i_L$ and the model reduces to a standard New Keynesian Model. With initial indebtness, the initial conditions influence the risk premium and thus are relevant for the economy's dynamics. The initial balance growth level for the real market interest rate $\overline{r}_L = \rho + \mu\alpha = 0.01 + 0.0025 = 1.25\%$ (5% per annum). In addition, the inflation target $\overline{\pi}$ is set at 0.5% (2% per annum), whereas it is assumed that $\overline{D} = 100\%\ GDP$, $\overline{\pounds} = 80\%\ GDP$ and $\sigma_C = 1$, so that $\bar{i}_L = 1.75\%, d_0 = 0.75\%$ and $\bar{i}_D = 1\%$. These numbers imply that a 1 %-point output gap changes the external finance premium by 0.3 %-point.

According to the model positive technology shocks can drive up the balanced growth level of the market interest rate. With a constant actual market interest rate, this will cause higher demand. The positive output gaps that emerge lead to increases in collateral value and net worth, driving down the risk premium. This gives an extra boost to demand. The monetary policy authority will react to move the economy towards the new balanced growth path.

On the other hand, a downward revision in technology growth prospects will lower demand and inflation pressure, both by reducing the balanced growth level of the market interest rate and by lifting the risk premium via lower net worth. The monetary policy authority will react by lowering the monetary policy interest rate. Economic agents adjust their expectations gradually and variables converge towards their new balanced growth path, unless the necessary monetary policy loosening is unatainable because of the zero lower bound restriction. Then, there is no stable solution and the nominal interest rate hits the zero lower bound.

Consider the inflation targeting regime first (Figure 3.1). A downward revision in technology growth prospects ($\varepsilon_t = -1\%\ GDP$) lowers the balanced growth level of the market interest rate ($\bar{i}_L$). This implies that $i_{L,t} - \bar{i}_{L,t}$ increases. In other words, monetary conditions are tightened. This negative shock to demand puts downward pressure on inflation, leading to offsetting monetary policy loosening. The monetary policy authority has to steer i_D in such a way that the i_L pattern as required by the inflation targeting rule emerges. This requires a stronger reduction in i_D than i_L, since the negative output gap implies a fall in net worth, increasing the default risk and driving up the risk premium. A relatively modest downward revision of expected technological progress over 1.5% GDP would require a reduction of the nominal monetary policy interest rate below 0. The zero lower bound restriction rules out such a policy reaction. With no policy option left, there is no stable solution to the system of equations 3.18.

In the case of optimal monetary policy, the technological shocks are not observed contemporaneously. Therefore, the negative demand shock following a reduction in technology growth prospects causes a negative output gap and downward pressure on inflation, as in the inflation targeting regime. Both the case of discretion (Figure 3.2) and of commitment from a time-less perspective (Figure 3.3) are assessed. In both variants the information noise is the same, which means that the negative effects on the output gap are the same. Since the risk premium is linked to the output gap, there is no difference either in the behaviour of this premium, which rises due to lower net worth. However, the inflation patterns differ, which is clear from comparing eq. 3.25 and 3.32. It appears that the deviations of inflation from target are larger in the case of commitment (from a time-less perspective) than in the case of discretion. This is because the advantages of commitment to inertia do not extent to unobservable shocks such as the one considered. The difference in inflation pattern influences the market interest rate, and therefore also the policy interest rate. In period 1 and 2 the level of the policy interest rate is slightly lower in the commitment case, which implies that the risk of a binding zero lower bound is marginally larger. In both cases a negative technology misperception shock of about

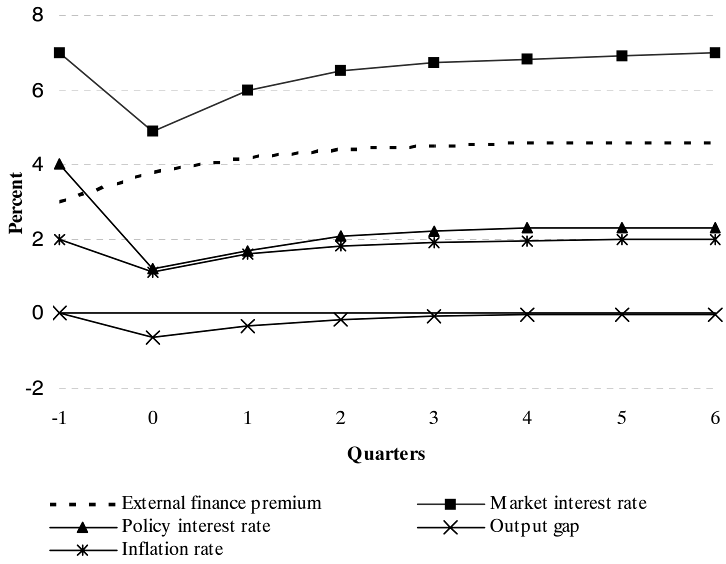

Figure 3.1: Inflation targeting

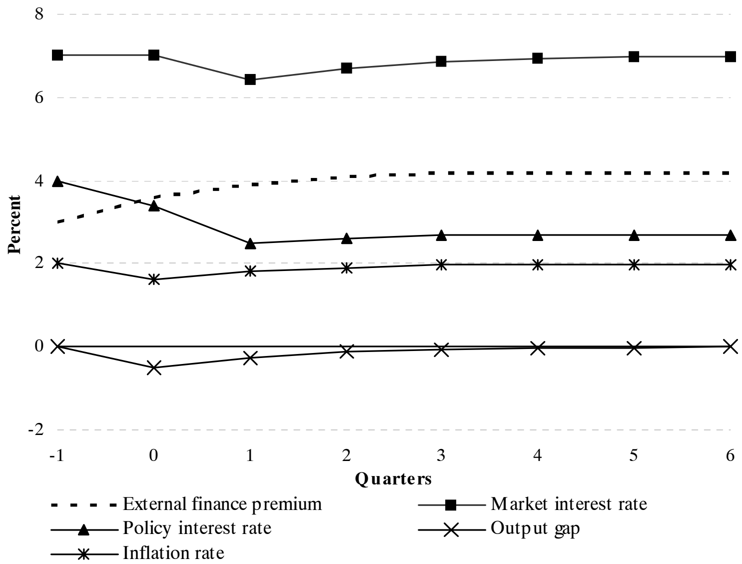

Figure 3.2: Optimal policy (discretion)

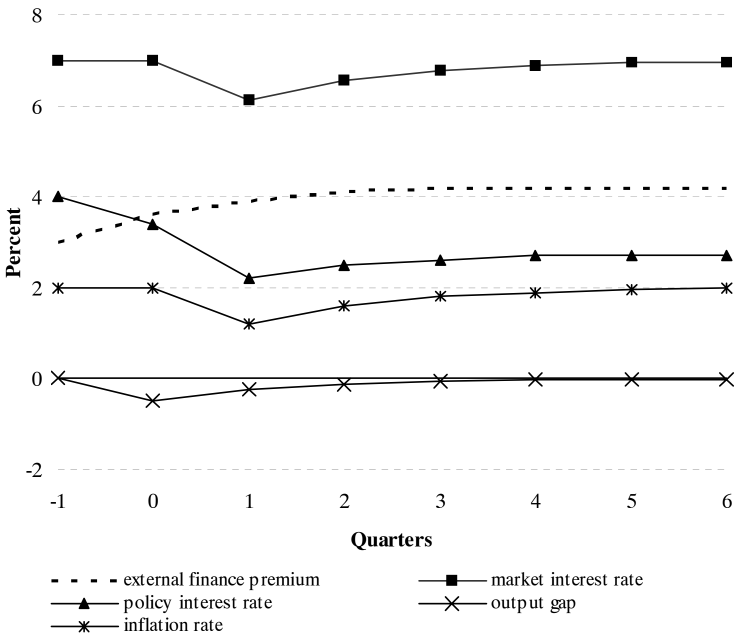

Figure 3.3: Optimal policy (commitment from a time-less perspective)

2.5% GDP suffices to fall into a situation with a binding zero lower bound.

3.4 Concluding remarks

It follows from the analysis that a binding zero lower bound on nominal policy interest rates can emerge when overoptimistic expectations about technological progress are revised downward in an environment with fragile household balance sheets. At times, these factors have been driving forces behind strong reductions in nominal policy interest rates towards the zero lower bound. Calomiris (1993) draws attention to the collapse of the 'new-age' optimism of the 1920s during the early phase of the Great Depression and its long-run effects through the structure of credit markets and the balance sheet of borrowers: from 1932 to the mid 1940s the US nominal monetary policy interest rate was close to zero. The Japanese slump of the 1990s was also preceded by a period of overoptimism on future economic growth. The subsequent downscaling of economic prospects, which was reflected in asset price declines, has lowered perceived future earning capacity and reduced private sector balance sheets (e.g. Borio et al. (2001)). This has resulted in a surge in non-performing loans, higher default risks and a rise in risk premiums, putting downward pressure on the policy interest rate. From 1999 onwards the Japanese nominal monetary policy interest rate was at or very close to the zero lower bound. Similar, but more modest, patterns as in Japan have been observed in the US and Europe in the early 2000s, after the downward revision of 'new economy' optimism. Nominal monetary policy interest rates in both the US and Europe have fallen to levels not seen since the early 1960s, but they have not reached the zero lower bound. More optimistic views on future economic growth than in Japan might be an important factor, in particular in the US. On the other hand, in Europe household indebtness in relation to production has remained substantially below that in the US.

Against this background, future work could focus on the empirical validation of the model. In addition, future research could shed light on how the emergence of a binding zero lower bound can be avoided. This paper suggests that fighting misperceptions and the build-up of high levels of indebtness would be the best way forward. Choosing an inflation target substantially higher than zero, increasing the room for manoeuvre for nominal interest rates, would also be helpful.

3.5 Appendices

3.5.1 Appendix A

Social accounts

This Appendix presents an overall picture of the current transactions among the different sectors in the economy. There are three sectors in the economy: (consumer) households, firms, and banks. It is assumed that firms and banks have abundant net worth; they can not default. Within the firm sector, a distinction is made between intermediate and final goods producing firms. The banking sector also consists of two subsectors: the central bank and the commercial banks that are the financial intermediaries. The behavioural relations of the sectors are studied in the main text and in appendices B and D. This appendix sketches the complete macroeconomic representation of the current operations in the model economy. To do so, the social accounts are presented in the tradition of Malinvaud (1985).

The equality between resources and uses of goods requires that production in value terms ($P_tY_t^s$) equals nominal household demand ($P_tY_t^d$) plus stock accumulation ($\Delta Stock$). Labour income is paid by firms to housholds: $W_tL_t^d = W_tL_t^s$. The model features fully flexible labour markets, so that the labour market clears continuously (balanced market for labour). Therefore, changes in firms' turnover ($P_tY_t^s$) translate one-for-one into labour income changes. Similarly, households' interest income on deposits equals banks' costs ($i_{D,t}D_{t+1}^s = i_{D,t}D_{t+1}^d$). The central bank steers the (risk-free) interest rate on deposits. On the other hand, households' interest costs on loans are a source of income for the banks ($i_{L,t}\pounds_{t+1}^d = i_{L,t}\pounds_{t+1}^s$). For households, the excess of income over costs results in an increase in deposits or a decrease in loans. For banks, this implies higher cash holdings, while firms' cash holdings decline and their stock levels rise. This is presented in the social accounts below, no default case.

Note that savings by different sectors ($S^{hholds}, S^{firms}, S^{banks}$) can not be measured on their own. Savings are notional in the sense of Clower (1965). Note also that the social accounts involve ex-post amounts, whereas supply and demand decisions involve ex-ante amounts. In this respect, it is assumed that firms earn zero ex-ante profits, implying that stock accumulation is not planned, nor is a change in cash holdings. Ex-post, unanticipated real shocks can cause a rise or fall in $P_tY_t^s$. W_tL_t and $P_tY_t^s$ cancel out. If a rise occurs in $P_tY_t^s$, the balanced labour market implies that there is an instantaneous distribution of additional labour income to households. Hence, there is excess supply of goods, a buyers' market for goods cf. Malinvaud (1985): $P_tY_t^d < P_tY_t^s\,(= W_tL_t)$. If $P_tY_t^s$ falls, there is excess demand for goods, a sellers' market for goods in terms of Malinvaud: $P_tY_t^d > P_tY_t^s\,(= W_tL_t)$. With excess demand for goods, there are two possibilities. Either the households will still be able to comply with their loan obligations, or they will default. In the former case, there will be a deposit/cash transfer from households via the banking sector to firms, which will lower their stocks (social accounts, no default case). In the latter case, collateral will be transfered from the insolvent households to the banks, which will replenish the households' payments (social accounts, default case).

Social accounts, no default

Households resources	Households uses	Firms resources	Firms uses	Banks resources	Banks uses
	$P_tY_t^d$	$P_tY_t^s$	$\Delta Stocks_t$		
$W_tL_t^s$			$W_tL_t^d$		
$i_{D,t}D_{t+1}^s$	$i_{L,t}\pounds_{t+1}^d$			$i_{L,t}\pounds_{t+1}^s$	$i_{D,t}D_{t+1}^d$
	S_t^{hholds}		S_t^{firms}		S_t^{banks}
S_t^{hholds}		S_t^{firms}		S_t^{banks}	
$\pounds_{t+1} - \pounds_t$	$D_{t+1} - D_t$			$D_{t+1} - D_t$	$\pounds_{t+1} - \pounds_t$
			$\Delta Cash_t$		$\Delta Cash_t$

Social accounts, default

Households resources	Households uses	Firms resources	Firms uses	Banks resources	Banks uses
	$P_tY_t^d$	$P_tY_t^s$	$\Delta Stocks_t$		
$W_tL_t^s$			$W_tL_t^d$		
$i_{D,t}D_{t+1}^s$					$i_{D,t}D_{t+1}^d$
	S_t^{hholds}		S_t^{firms}		S_t^{banks}
S_t^{hholds}		S_t^{firms}		S_t^{banks}	
	$-D_t + C_{t+1}$[9]			$-D_t + C_{t+1}$	
			$\Delta Cash_t$		$\Delta Cash_t$

3.5.2 Appendix B

Derivation of the IS curve

This Appendix shows how the consumer maximisation problem (eq. 3.1, 3.2, 3.3) leads to the Euler equation/IS curve (eq. 3.4 in the main text).

Taken together, the flow budget constraint eq. 3.2 and the solvency constraint eq. 3.3 can be rewritten as an intertemporal budget constraint:

[9] $\pounds_{t+1} - D_{t+1} = 0, C_{t+1} = D_t + i_{D,t}D_{t+1} + W_tL_t - P_tY_t$.

$$\begin{aligned} D_t - \pounds_t &= \frac{1}{1+i_{L,t}} E_t\left(D_{t+1} - \pounds_{t+1}\right) + P_t Y_t - W_t L_t + \left(i_{L,t} - i_{D,t}\right) D_{t+1} \\ &= E_t \sum_{i=0}^{\infty} \frac{1}{\left(1+i_{L,t}\right)^{t+i+1}} \left\{ \begin{array}{c} P_{t+i} Y_{t+i} - W_{t+i} L_{t+i} \\ + \left(i_{L,t} - i_{D,t}\right) D_{t+i+1} \end{array} \right\}. \end{aligned} \tag{3.33}$$

Combining this eq. with eq. 3.1 leads to the following Lagrangian:

$$Z_t = E_t \left\{ \begin{array}{c} \sum_{i=0}^{\infty} \omega^{t+i} \left(\frac{Y_{t+i}^{1-\sigma}}{1-\sigma} + \phi_1 \frac{\left(D_{t+1+i}/P_{t+i}\right)^{1-\eta}}{1-\eta} - \phi_2 \frac{L_{t+i}^{1+\phi}}{1+\phi} \right) + \\ z_t \left(V_t - \sum_{i=0}^{\infty} \frac{1}{\left(1+i_{L,t}\right)^{t+i+1}} \left(\begin{array}{c} P_{t+i} Y_{t+i} - W_{t+i} L_{t+i} \\ + \left(i_{L,t} - i_{D,t}\right) D_{t+1+i} \end{array} \right) \right) \end{array} \right\}, \tag{3.34}$$

where z_t is the Lagrange multiplier and initial financial wealth $V_t\,(= D_t - \pounds_t)$ is predetermined.

The first order conditions are:

$$\begin{aligned} \frac{\delta Z_t}{\delta Y_{t+i|t}} &= \omega^{t+i} Y_{t+i|t}^{-\sigma} - z_t \frac{P_{t+i|t}}{\left(1+i_{L,t}\right)^{t+i+1}} = 0, & (3.35) \\ \frac{\delta Z_t}{\delta\left(\frac{D_{t+1+i|t}}{P_{t+i|t}}\right)} &= \omega^{t+i} \phi_1 \left(\frac{D_{t+1+i|t}}{P_{t+i|t}}\right)^{-\eta} - z_t \frac{\left(i_{L,t} - i_{D,t}\right) P_{t+i|t}}{\left(1+i_{L,t}\right)^{t+i+1}} = 0 & (3.36) \\ \frac{\delta Z_t}{\delta L_{t+i|t}} &= -\omega^{t+i} \phi_2 L_{t+i|t}^{\phi} + z_t \frac{W_{t+i|t}}{\left(1+i_{L,t}\right)^{t+i+1}} = 0. & (3.37) \end{aligned}$$

By combining the equations for Y_t with their $t+1$ counterpart, one obtains the Euler equation:

$$\omega \left(\frac{Y_{t+1|t}}{Y_t}\right)^{-\sigma} = \frac{1}{1+i_{L,t}} \left(\frac{P_{t+1|t}}{P_t}\right). \tag{3.38}$$

Linearisation of eq. 3.38 around its balanced growth path results in the IS curve (eq. 3.4):

$$x_t = x_{t+1|t} - \frac{1}{\sigma}\left(i_{L,t} - \pi_{t+1|t} - \rho\right), \tag{3.39}$$

where $\rho = -\log \omega$.

3.5.3 Appendix C

This Appendix elaborates on eq. 3.5- 3.11 on the risk premium.

Probability of default

The value of the collateral at the end of the period (C_{t+1}) is a random variable at the start of the period. It is assumed that C_{t+1} is distributed with a normal distribution with positive mean $\overline{C}_{t+1}(= (1 + i_{D,t})D_{t+1}$, since $W_t L_t$ and $P_t Y_t$ cancel out ex-ante) and variance σ_C^2.

As regards the numerical example in Section 3 of the main text: initial deposits are 100% GDP, initial loans are 80% GDP, $\sigma_C = 1$ and $\bar{i}_L = 1.75\%$. It follows from the cumulative Normal distribution that $\overline{C}_{t+1} = (1 + 0.01)100 = 101$ and $\Pr[C_{t+1}^{ep} < (1 + i_{L,t})\, \pounds_{t+1}] = \Pr[C_{t+1}^{ep} < (1 + 0.0175)\, 80] = 0.75\%$. The external finance premium is also 0.75% (eq. 3.11). The corresponding z-value in the cumulative normal distribution for a default risk of 0.75% is 2.43. An output gap shock results in a shock of the same magnitude to the collateral value, which implies that a 1% GDP negative output gap lowers $\overline{C}_{t+1} - (1 + i_{L,t})\pounds_{t+1}$by 5% of its initial magnitude. This corresponds to a fall in the z-value to 2.31, or a default risk of 1.05%.

Alternative loan contract

Suppose that the borrower transfers the collateral to the bank in case of default and that the collateral value to the bank equals that to the borrower. Then the banks maximise expected profits:

$$\Pi_{t+1|t}^{bank} = (1 - d_t)\,(1 + i_{L,t})\, \pounds_{t+1} + d_t \widetilde{C}_t - (1 + i_{D,t})\, \pounds_{t+1}, \tag{3.40}$$

where the mean value of the collateral, conditional on the fact of default is:

$$\widetilde{C}_t = \frac{1}{d_t} \int_{-\infty}^{(1+i_L)\pounds_{t+1}} C \times f\,(C)\, dC. \tag{3.41}$$

Under the same assumptions as in the main text, the equilibrium condition is:

$$1 + i_{D,t} = (1 - d_t)\,(1 + i_{L,t}) + d_t \frac{\widetilde{C}_t}{\pounds_{t+1|t}}. \tag{3.42}$$

Assuming fixed $\pounds$, this implies $i_{D,t} \approx i_{L,t} - d_t + const.$

3.5.4 Appendix D

This Appendix explains the derivation of the New Keynesian Phillips curve (eq. 3.16).

Firms: real aspects

Final output is produced using inputs from a continuum of intermediate goods producers. The model features perfect competition among final goods producers. The production function for final output is given by the following CES aggregator (in the tradition of Dixit and Stiglitz (1977)):

$$Y_t = \left(\int_0^h Y_t(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} \quad j \in [0,h], \theta > 1, \tag{3.43}$$

where θ is the elasticity of substitution between inputs. As θ increases, inputs become closer substitutes; alternatively, market power of intermediate goods producers is decreasing in θ. Y_t is the period-t final output of consumption goods and $Y_t(j)$ is the input of intermediate good j in period t. There are h intermediate goods producing firms.[10] Final goods producers minimise the costs of producing Y_t:

$$\int_0^h P_t(j) Y_t(j) \, dj \tag{3.44}$$

subject to the production function of final output eq. 3.43. $P_t(j)$ is the price of input j in period t. The first order condition is:[11]

$$-P_t(j) + \Lambda_1 \frac{\theta}{\theta-1} \left(\int_0^h Y_t(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{1}{\theta-1}} \frac{\theta-1}{\theta} Y_t(j)^{-\frac{1}{\theta}} = 0, \tag{3.45}$$

where marginal costs (=Lagrangian multiplier (Λ_1)) equal the price of the final output, since the final goods producer operates in a competitive market. Therefore, the demand for a single input j is a decreasing function of its relative price:

$$\frac{Y_t(j)}{Y_t} = \left(\frac{P_t(j)}{P_t} \right)^{-\theta}, \tag{3.46}$$

where

$$P_t = \left(\int_0^h P_t(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}}. \tag{3.47}$$

[10] A limited number of intermediate goods producing firms gives rise to a discrete production function for final output. This discrete function is approximated by its continuous representation in eq. 3.43.

[11] Note that eq. 3.43 is continuously differentiable and satisfies the Inada conditions.

P_t represents the amount the final goods producer obtains for one unit of the composite good C_t. Eq. 3.46 can be rewritten in log-linear terms as:

$$y_t(j) = -\theta(p_t(j) - p_t) + y_t. \tag{3.48}$$

The intermediate goods market is monopolistically competitive, so that suppliers behave as price setters. Cournot behaviour is assumed. In other words, all firms behave as if they are completely independent of each other. Each firm produces a differentiated good with technology:

$$Y_t(j) = A_t L_t(j), \tag{3.49}$$

where A_t is an aggregate technology index. Eq. 3.49 can be expressed in log-linear form as:

$$y_t(j) = a_t + l_t(j). \tag{3.50}$$

Given the representative agent character of the model, this eq. can be written as eq. 3.13. Technological progress is characterised by:

$$\log\left(\frac{A_t}{A_{t-1}}\right) = \alpha + \varepsilon_t^a, \tag{3.51}$$

where ε_t^a is a technology shock. In line with the real business cycle theory (e.g. Cogley and Nason (1995)) it is assumed that new techniques, once introduced, will be available forever. Eq. 3.51 can be rewritten as in eq. 3.14.

The intermediate goods producing firm's objective is to maximise profits ($\Pi(j)$):

$$\Pi_t(j) = P_t(j) Y_t(j) - W_t L_t(j) \tag{3.52}$$

subject to the demand function eq. 3.46 and the production function for intermediate goods eq. 3.49. The wage rate is assumed exogenous to the firm. The first order conditions with respect to $Y_t(j), P_t(j)$ and $L_t(j)$ are:

$$P_t(j) - \Lambda_2 + \Lambda_3 = 0, \tag{3.53}$$

$$Y_t(j) - \theta \Lambda_2 P_t(j)^{-1} \left(\frac{P_t}{P_t(j)} \right)^{\theta} Y_t = 0, \tag{3.54}$$

$$-W_t + \Lambda_3 A_t = 0. \tag{3.55}$$

It follows that:

$$\Lambda_2 = \frac{P_t(j)}{\theta}, \tag{3.56}$$

$$\Lambda_3 = \frac{W_t}{A_t}, \tag{3.57}$$

$$P_t(j) = \frac{\theta}{\theta - 1} \frac{W_t}{A_t}, \tag{3.58}$$

where $\frac{\theta}{\theta-1}$ is the mark-up per unit $Y_t(j)$. Real marginal costs are the inverse of the mark-up: $\frac{\theta-1}{\theta}$. Combining eq. 3.49 and eq. 3.58 results in the labour demand function:

$$L_t^d(j) = \frac{Y_t(j)}{A_t(j)} = \frac{\frac{\theta-1}{\theta} Y_t(j)}{\frac{W_t}{P_t(j)}}, \tag{3.59}$$

which can be rewritten in log-linear form as:

$$l_t^d(j) = y_t(j) - a_t = y_t(j) - w_t + p_t + \log \frac{\theta - 1}{\theta}. \tag{3.60}$$

It is assumed that positive economic profits will instantaneously attract new firms into the intermediate goods industry, competing the profits away. Similarly, negative profits will drive away firms from the industry. This assumption is more common in long-term than in short-term models such as the one under consideration. It simplifies the analysis without changing it significantly. In line with this entry/exit assumption, a zero-profit restriction is introduced:

$$P_t(j) Y_t(j) = W_t L_t(j). \tag{3.61}$$

Since all firms behave in exactly the same way, it follows from eq. 3.49 and 3.58 that the price set by the representative firm can be written as:

$$P_t(j) = \frac{1}{h}\left(\int_0^h P_t(i)^{1-\theta}\,di\right)^{\frac{1}{1-\theta}} = \frac{\frac{\theta}{\theta-1}W_t\frac{1}{h}\int_0^h L_t(i)\,di}{\frac{1}{h}\left(\int_0^h Y_t(i)^{\frac{\theta-1}{\theta}}\,di\right)^{\frac{\theta}{\theta-1}}}. \tag{3.62}$$

For the economy as a whole, this eq. can be rewritten as follows:

$$P_t(j) = \frac{h\frac{\theta}{\theta-1}W_tL_t}{Y_t}. \tag{3.63}$$

With representative firms, $\frac{L_t(j)}{Y_t(j)} = \frac{L_t}{Y_t}$. It is clear from eq. 3.61 and 3.63 that $h\frac{\theta}{\theta-1} = 1$; the number of intermediate producing firms equals $\frac{\theta-1}{\theta}$.

Firms: price setting[12]

Some sort of price stickiness is critical to generating significant real effects of monetary policy. Intermediate goods producing firms do not adjust their product prices flexibly to maintain a constant, profit-maximising mark-up. Instead, firms balance over time the one-time cost of changing prices against the benefit of staying close to the profit-maximising level of the mark-up.[13] This is a common assumption in the New Keynesian literature. Staggered nominal price setting along the lines of Calvo (1983) is assumed. The intermediate goods producing firm is in a position to set a new price for her good at time t. The price will apply at time t with certainty, with probability ϑ at time $t+1$, with probability ϑ^2 at time $t+2$, and so on. Provided a profit maximising solution exists, such a solution is characterised by the minimisation of production costs, which are conditional on the frequency of future price adjustments:

$$\min_{P_t^*}\sum_{k=0}^{\infty} E_t\left\{\left(\frac{Y_{t+i}}{Y_t}\right)^{-\sigma}(\omega\vartheta)^k\frac{\left(\frac{Y_{t+k}(j)}{A_{t+k}}\right)^{1+\theta}}{1+\theta}\right\} \tag{3.64}$$

subject to:

$$\sum_{k=0}^{\infty}\vartheta^k E_t\left\{\left(\frac{1}{1+i_{L,t}}\right)^k P_t^* Y_{t+k}(j)\right\} \leq V_t, \tag{3.65}$$

[12] For a complete treatment of the derivation of the New Keynesian Phillips Curve, see Goodfriend and King (1997), King and Wolman (1996) and Woodford (2003).

[13] Deviations from the optimal price level trigger the entry or exit of new firms.

$$\frac{Y_{t+k}(j)}{Y_{t+k}} = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\theta}. \tag{3.66}$$

This results in a solution for the optimal price P_t^*. Since the optimal price is the same for all goods, the actual price at time T will either equal the price at $T-1$, or be at the optimal level. The price index eq. 3.47 can be simplified as follows:

$$P_t = \left(\vartheta P_{t-1}^{1-\theta} + (1-\vartheta)\left(P_t^*\right)^{1-\theta}\right)^{\frac{1}{1-\theta}}. \tag{3.67}$$

The fraction of firms $1-\vartheta$ that can change their price at t all choose the price level P^*, since the optimal price level is the same for the differentiated products produced. The index of prices for non-adjusting firms equals the lagged price level due to the law of large numbers. Eq. 3.67 can be used to derive an expression in terms of inflation:

$$\pi_t = \omega\pi_{t+1|t} + \frac{(1-\vartheta)(1-\omega\vartheta)}{\vartheta}\left(mc_t - \overline{mc}\right), \tag{3.68}$$

$$\pi_t = \omega\pi_{t+1|t} + \frac{(1-\vartheta)(1-\omega\vartheta)}{\vartheta(1+\theta\phi)}(\phi+\sigma)\left(y_t - \overline{y}_t\right), \tag{3.69}$$

$$\pi_t = \omega\pi_{t+1|t} + \kappa x_t. \tag{3.70}$$

This is the so-called New Keynesian Phillips curve, which is reproduced in eq. 3.16 in the main text. It expresses that firms base their pricing behaviour on expected future marginal costs. Rotemberg and Woodford (1997) show that there is an approximate relation between marginal costs and output. The longer prices are fixed on average, the less sensitive is inflation to changes in the output gap. Expected inflation is incorporated, since expected future output gaps influence current inflation.

3.5.5 Appendix E

This Appendix explains the derivation of eq. 3.12, which specifies the balanced growth path for the nominal interest rate.

Balanced growth path

At the balanced growth path, all intermediate goods producing firms will choose a markup $\left(\frac{\theta}{\theta-1}\right)$ in conformity with eq. 3.58 of the Appendix. This implies that log real marginal costs (mc) and the log of the markup ($-m$) can be written as (Galí, 2003):

$$\overline{mc} = -\overline{m} = \log\left(\frac{\theta-1}{\theta}\right) = w_t - p_t - a_t. \tag{3.71}$$

Taking acount of the first order conditions that follow from the household's utility maximisation and eq. 3.60, the balanced growth equilibrium is characterised as follows:

$$\overline{mc} = -\log\phi_2 + (\phi+\sigma)\,y_t - (1+\phi)\,a_t, \tag{3.72}$$

$$\overline{y}_t = -\frac{-\log\phi_2 + \overline{m}}{\phi+\sigma} + \frac{1+\phi}{\phi+\sigma}a_t, \tag{3.73}$$

$$\bar{l}_t = \overline{y}_t - \overline{a}_t = -\frac{-\log\phi_2 + \overline{m}}{\phi+\sigma} + \frac{1-\sigma}{\phi+\sigma}a_t, \tag{3.74}$$

$$\overline{r}_{L,t} \equiv \bar{i}_{L,t} - \overline{\pi} = \rho + \sigma\frac{1+\phi}{\phi+\sigma}\left(a_{t+1} - a_t\right) = \rho + \mu\left(a_{t+1} - a_t\right), \tag{3.75}$$

where $\mu = \sigma\frac{1+\phi}{\phi+\sigma}$. Eq. 3.75 corresponds to eq. 3.12.

Chapter 4

Financial acceleration of booms and busts

> "A central bank can contain inflation over time under most conditions. But do we have the capability to eliminate booms and busts? The answer, in my judgment, is no, because there is no tool to change human nature or to predict human behaviour with great confidence."
> (Greenspan, 2001a)

4.1 Introduction

Since the 1970s, many countries have gone through equity busts.[1] Stock price corrections are often associated with sharp falls in economic activity and financial instability. Nonetheless, the importance of equity and other financial variables has long been ignored in the mainstream macro-economic literature. Under the Modigliani-Miller propositions, financial factors are irrelevant for firms' investment behaviour. Recently, the so-called 'credit channel' or 'financial accelerator' theory has drawn attention to financial frictions. This new literature, which is based on micro foundations, attaches a key role to credit and asset prices in the transmission mechanism (e.g. Bernanke et al., 1999).

A key question is whether the role of financial factors in propagating and amplifying economic shocks can also be observed in practice. Given the surge in financial markets in

[1] This chapter is a revised version of Kakes and Ullersma (2005).

the past decades, this issue has become increasingly relevant. In particular, studies based on micro-data have established that financial constraints indeed play a role in explaining the behaviour of individual firms and consumers (see Hubbard, 1998, for a survey). So far, evidence based on macro-economic data has been less conclusive, largely on account of identification problems. Although less rigorous, macro-based studies are important to get insight into the quantitative importance of financial accelerator effects at the aggregate level. This chapter provides new evidence on the financial accelerator based on macro-data. The focus is on periods around equity busts, which represent strong downward revisions in economic prospects and losses in financial wealth.

Section 2 presents a brief outline of the underlying theory, on the basis of which hypotheses are formulated. After discussing the methodology for testing these hypotheses in Section 3, Section 4 discusses the empirical results. Section 5 concludes. I find empirical support for financial accelerator effects around asset price busts in the second half of the sample, with the typical bust followed by a reduction in nominal policy interest rates.

4.2 Financial determinants of economic cycles

Kindleberger (1978) and Minsky (1982) present early examples of macro-economic theories in which financial frictions play a prominent role. They stress the instability of the interaction between credit, equity prices and economic activity. Others have focused on financial wealth accumulation, in particular the relationship between asset prices and consumption. A survey by Poterba (2000) shows that this link is modest – with a $1 increase in financial assets leading to 3 cents of additional income – as one would expect on the basis of Friedman's permanent income hypothesis. In addition, financial factors can influence investment through Tobin's q. If the market value of a firm's capital is higher than its replacement value ($q > 1$), expansion of the capital stock is profitable. However, the empirical link between Tobin's q and investment is weak (e.g. Hayashi, 1982).

In the more recent literature, financial frictions have been studied in a financial accelerator framework (Bernanke et al., 1999, and the references therein). The emphasis is on credit market imperfections, which are caused by problems of information, incentives and enforcement. These imperfections can be mitigated by aligning the borrower's incentives to those of the lender, which will be the case if the borrower risks substantial financial losses. Hence, credit will be extended at a lower cost to borrowers with strong financial positions. The wedge between the cost of external funds and the risk-less interest rate is inversely related to the borrower's net worth. Bernanke et al. (1999) refer to this wedge as the external finance premium. Since net worth is procyclical, the external finance premium declines in booms and rises in recessions. This creates an amplification mechanism, which is called the financial accelerator. Typically, a financial cycle starts with a build-up phase during which real and financial imbalances accumulate (Bordo and Jeanne, 2002, and Borio and Lowe, 2002). This phase is characterized by an increase in spending, overoptimistic growth expectations, and a low risk assessment by both borrowers and lenders (Asea and Blomberg, 1998). This process can be self-reinforcing, as rising asset prices improve borrower net worth, stimulating credit expansion and investment, which further drives up asset prices, etcetera. At some point, however, economic agents will realize that developments are unsustainable and the process will be reversed. Hence, economic growth perceptions are revised, leading to a downward correction in stock prices. Experiences since the mid-1990s seem to be in line with this description of the financial cycle, given the favourable economic prospects that were widely attributed to new developments in Information and Communication Technology (ICT). In the event, however, market sentiment turned against this notion of a 'New Economy' and stock prices collapsed, followed by an economic downturn in most countries.

The effects of the financial accelerator may be particularly severe in a low inflation environment, where the lower bound on nominal interest rates is an impediment to monetary policy. Demand can decline sharply after a downward revision of long-term growth perspectives, since the initial effects are exacerbated by financial factors, particularly through higher external finance premiums (see Chapter 3). As a result, the central bank has a strong incentive to lower the nominal policy interest rate, in order to limit the impact of a bust. This may result in policy interest rates hitting the lower zero bound, which seems close to the situation in Japan in the 1990s.

The most convincing empirical evidence for the existence of a financial accelerator is provided by micro-based studies. Disaggregated data show that particular groups of firms and households face more financial constraints than others, which can be linked to differences in their financial positions and information asymmetries (see e.g. Gilchrist and Zakrajsek, 1998; Hubbard, 1998). So far, the macro-economic evidence for financial accelerator effects is limited. Gertler and Lown (1999) and Mody and Taylor (2003) present some macro evidence for the United States, using the bond spread as a proxy for the external finance premium. In an earlier paper, Bernanke (1983) presents evidence that financial factors explain the severity of the Great Depression. Another strand of literature based on aggregate data, initiated by Bernanke and Blinder (1992), investigates the importance of credit market imperfections in the transmission of monetary policy. In this chapter, I take the existence of a financial accelerator from micro-based studies as given and consider some implications of the financial accelerator at the aggregate level. This chapter provides insight into the macroeconomic importance of the financial accelerator. In particular, the following three macroeconomic consequences of the financial accelerator prior to and after an equity bust are investigated:

1. Given the build-up phase that characterizes financial cycles, an equity bust is likely to be preceded by buoyant credit growth.

2. If equity busts are triggered by deteriorating financial conditions, this should be reflected by an external finance premium hike.

3. If equity busts reflect downward revisions of economic prospects and lift external finance premiums, they are expected to be followed by expansionary monetary policy.

4.3 Methodology and data

The hypotheses formulated in the previous section are investigated by using a probit model. In particular, I look at the explanatory power of several macro-economic variables prior to equity busts, which reflect downward revisions in the long-term economic growth perspective. A panel of 20 industrialized countries over the period 1970 - 2002 is considered, which includes a sufficient number of equity busts to investigate general patterns.[2]

[2] The countries concerned are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Particularities of individual cases are not the focus of this paper. All results are pooled estimations of all countries, using annual observations.

An equity price bust is an extended period of unusual equity price declines in comparison to normal trend growth. Although annual data are used in the estimations - partly due to data constraints - the identification of equity busts is based on quarterly stock prices in order to obtain a more refined pattern.[3] I follow Bordo and Jeanne (2002) and define a bust as a period in which the real average asset price change over a 12-quarter window is smaller than a threshold. This threshold is the average growth rate of asset prices in all countries over the entire sample ($\overline{g}$), minus x times its standard deviation v:

$$\sum_{l=1}^{12} \frac{g_{i,t-l}}{12} \leq \overline{g} - xv. \tag{4.1}$$

There are two ad-hoc elements in this definition: the length of the window and the value of parameter x. Following Bordo and Jeanne I choose a twelve-quarter window, which is sufficient to filter out short-term volatility. The number of bust episodes is not sensible to the exact choice of the timespan. The parameter x is calibrated such that the main bust episodes are selected, without including too many observations. For this purpose, x is set at 0.8, but alternative values have been considered, see Section 4.2 below. The main boom-bust periods are plausible when compared to other sources. In particular, most boom-bust patterns for individual countries closely match the results of Bordo and Jeanne, despite some differences between their data set and ours. Furthermore, the IMF (2003) finds similar patterns using a very different methodology (Figure 4.1).[4] Following the procedure of this chapter, 35 stock market busts have occured over the period we consider (see Appendix B). Busts are concentrated in three subperiods, reflecting the strong correlation of international stock markets.

Both real and financial indicators are examined in relation to equity busts: industrial production, gross domestic product, private investment (capital formation), inflation, short-term and long-term interest rates, money, credit, asset prices (equity and residential

[3] In our estimations a year is considered part of a bust period if it includes one or more quarters that have been identified as a bust in our procedure.

[4] Bordo and Jeanne (2002) and IMF (2003) do not include the most recent equity busts. In addition, they consider slightly different groups of countries. Bordo and Jeanne do not include Austria, Belgium, Korea, New Zealand, Portugal and Switzerland; the IMF does not include Korea and Portugal.

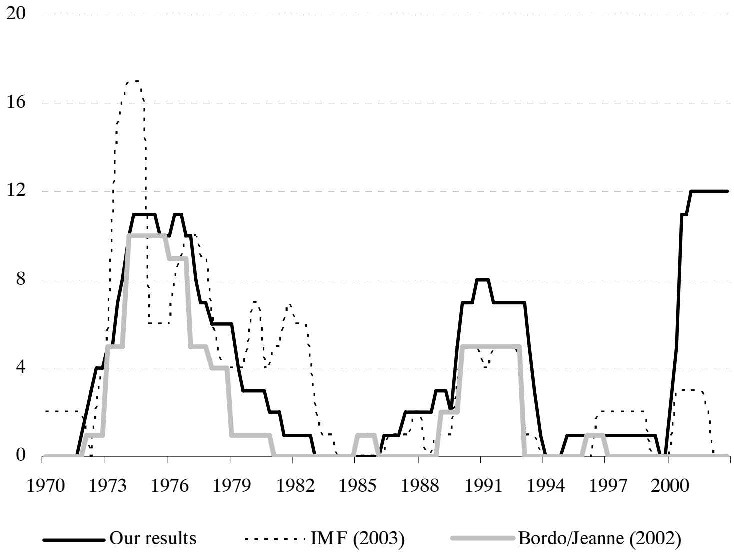

Figure 4.1: Equity busts

property), and the external finance premium.[5] For the latter, I use the interest rate spread of private debt over government debt, a standard measure of the private sector's risk premium. While the private debt interest rate series are not as accurate and consistent across countries as one would like (see Appendix A), the results show that the spread does have important characteristics of the external finance premium.

Appendix C presents cross-correlations of all variables included in the analysis, at an annual frequency. Most of these have plausible signs. Nominal interest rates are positively correlated with each other and with inflation, and negatively related to real activity (industrial production, GDP, investment), money and credit growth, and asset prices. Positive correlations also exist between real activity measures, and between money and credit. The interest rate spread is negatively related to real activity, again in line with what one would expect.

In the estimations, two subperiods are considered: 1970-1986 and 1987-2002. This splits the sample into two equal parts, which roughly corresponds to a distinction between

[5] Most data are taken from the IMF's International Financial Statistics database, see Appendix A for an overview.

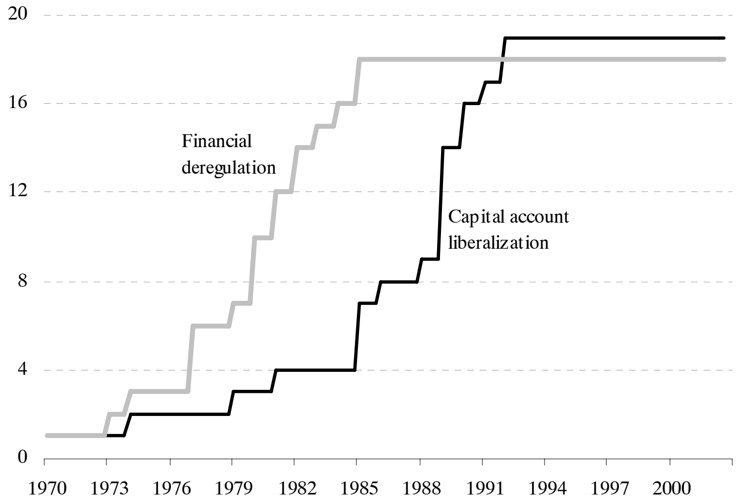

Figure 4.2: Deregulation and liberalization

pre and post financial liberalization (Bakker and Chapple, 2002; see Figure 4.2). These subsamples are more homogeneous periods than the entire sample, and also allow to take into account changes over time.

4.4 Empirical results

4.4.1 Explaining equity busts

Table 4.1 presents the results of probit estimations with only one explanatory variable. Each entry in the table represents a separate equation, in which the equity bust dummy is explained by a constant and one particular lag of a variable. Including lags up to 8 years, it can be investigated to what extent equity busts are related to developments several years earlier.[6] This accords with the idea that imbalances build up over a long period prior to a correction. As the estimated coefficients of probit models are difficult to interpret

[6] This approach follows Estrella and Mishkin (1998), who investigate leading indicator properties of several financial variables in order to predict recessions in the United States.

directly, the table reports the marginal impact of the regressors. This so-called 'slope derivative' is evaluated at the sample means of the data and can be interpreted as the increase in the probability of an equity bust due to a one-unit change in the explanatory variable. The results in Table 4.1 are useful to address the first two hypotheses that were formulated in Section 2.

The *first hypothesis* states that a financial accelerator manifests itseld by increasing credit growth in the years before equity bust. This is only supported for the most recent subperiod.

According to our *second hypothesis*, a stock market bust should be triggered by an increase in the external finance premium. Again, this is supported only for the most recent subperiod, for which the proxy for the external finance premium – the interest rate spread – is significant for the one-year lag. For the first subperiod, none of the lags is significant.

An interesting observation for both subperiods is that several variables seem to be relevant long before a stock market correction takes place. The explanatory power of industrial production, gross domestic product and investment is strongest two to six years prior to the equity bust. The same holds for money and credit growth. This suggests that stock market exuberance may be the result of long cumulative processes initiated by loose monetary conditions. In this context, it is worthwhile to observe that higher inflation significantly raises the probability of an equity bust up to three years in advance. Inflation is a sign of overheating, which may induce the downward revision of economic prospects. More specifically, inflation may drive up interest rates. It is interesting to see that the coefficients for interest rates and the interest rate spread - albeit not always significant - have a negative sign for long lags and a positive sign for short lags. Altogether, these results suggest that easy financial conditions in combination with high production and investment growth contribute significantly to the boom-bust cycle in equity prices.

Finally, asset prices have significant explanatory power. For stock prices themselves, this is an obvious result as it directly reflects the boom-bust cycle. For house prices, the explanatory power is likely to be related to the investment boom prior to the stock price correction, also given the correlation between house prices and investment, money and credit growth.

The next step is to analyse the external finance premium in a probit model with several

Lag	1	2	3	4	5	6	7	8
Variable	*Estimated slope coefficients 1970-1986**							
Short-term interest	0.60	0.13	-0.67	-1.22^b	-1.00^b	-1.31^b	-1.39^a	-0.93^a
Long-term interest	0.73	0.40	0.10	-0.26	-0.41	-0.75	-1.17^c	-1.43^b
Inflation	2.19^a	1.77^a	0.88^b	-0.05	-0.87^c	-1.64^a	-1.73^a	-1.92^a
Industrial production	0.25	0.55	0.73^b	1.02^a	1.04^a	1.32^a	1.24^a	1.22^a
Gross domestic product	0.76	1.34^b	1.11^c	1.55^a	1.37^b	1.11^c	0.94	0.47
Investment	0.48^c	0.64^b	1.34^a	1.44^a	1.35^a	0.92^a	0.71^b	0.66^b
M3 growth	-0.11	0.07	0.58^c	1.15^a	1.11^a	1.17^a	0.95^b	0.85^b
Credit growth	-0.47	-0.10	0.30	0.45	0.30	0.45	0.49	0.57
Interest rate spread	2.00	2.97	0.10	-0.31	-1.04	1.08	0.98	0.72
Stock prices	-0.44^a	-0.40^a	-0.22^b	0.09	0.32^a	0.31^a	0.34^a	0.26^b
House prices	0.64^b	1.08^a	1.09^a	0.85^a	0.08	-0.06	-0.12	-0.03
	Estimated slope coefficients 1987-2002*							
Short-term interest	1.20^b	0.48	-0.29	-0.65	-0.59	-0.71	-0.80	-0.44
Long-term interest	1.35^b	0.40	-0.33	-0.79	-0.58	-0.43	-0.42	0.06
Inflation	3.86^a	2.46^a	1.22	0.59	0.33	0.08	0.22	0.53
Industrial production	-0.27	0.97^c	1.41^a	1.25^b	1.25^b	1.69^a	1.29^a	0.75
Gross domestic product	0.71	2.60^a	3.28^a	2.76^a	2.00^b	1.83^b	1.35	0.07
Investment	0.85^a	1.64^a	1.27^a	0.81^b	0.70^b	0.73^b	0.09	-0.54^c
M3 growth	0.95^b	1.21^b	1.73^a	1.50^a	1.03^b	0.53	0.02	-0.14
Credit growth	0.88^b	1.09^a	0.99^b	0.75^c	0.29	0.30	-0.19	-0.60
Interest rate spread	4.29^b	-0.06	-1.94	-3.94	-4.30^b	-3.43	-3.97^b	-7.20^a
Stock prices	-0.33^a	0.01	0.37^a	0.39^a	0.31^a	0.16	0.22^b	0.10
House prices	0.82^a	1.34^a	1.28^a	0.68^b	0.13	-0.15	-0.46	-0.69^b

*Explanation: the subscripts a, b and c denote, respectively, statistical significance at the 1%, 5% and 10% level. Slope derivatives, which report the marginal impact at the sample means, are multiplied by 100 to convert them into percentage points. The number of observations varies between 135 and 338 in the first subperiod, and between 264 and 320 in the second.

Table 4.1: Probit analysis for individual regressors

regressors (Table 4.2). I consider a baseline equation including three key macroeconomic variables – inflation, industrial production and the long-term interest rate – which is extended by several representations of the interest rate spread. All regressors are included with one lag. Table 4.2 also includes the 'pseudo R^2' as a goodness of fit measure.[7] Like in Table 4.1, the spread and the interest rate are more significant for the recent subsample.

The approach in Table 4.2 is also useful to investigate the *third hypothesis* in Section 2, i.e. whether equity busts are followed by a more expansionary monetary policy. To explore this, the observations are split into two parts: those that are followed by a monetary expansion – i.e. decreasing short-term interest rate – in the subsequent year, and those followed by a monetary contraction. The results for the two subsamples are very different. In the first period, the spread is only significant for observations followed by a monetary contraction, while in the most recent period, the spread is only significant when accompanied by a monetary expansion. Hence, only the latter is in line with the hypothesis that a downward revision of long-term prospects which is exacerbated by financial factors causes downward pressure on the nominal policy interest rate. Presumably, the role of financial variables has increased on account of financial deepening. To investigate this, $\log\left(\frac{credit}{GDP}\right)$ is added as a proxy for financial development, multiplied by the external finance premium. Again, this interaction term is only statistically significant in the second subperiod, implying a positive relationship between financial development and the short-run impact of the external finance premium.

4.4.2 Robustness

Several robustness checks were performed:

- In the results shown in the tables a threshold value $x = 0.8$ is used to determine

[7] The pseudo R^2 can be directly derived from the regression, which is estimated by maximum likelihood, and is defined as

$$1 - \left(\frac{\log L_u}{\log L_c}\right)^{-(2/n)\log L_c}$$

where L_u is the estimated likelihood of the equations presented in Table 2 (i.e. 'unconstrained'). L_c is the likelihood under the constraint that all coefficients except the intercept are zero, i.e. the dependent variable is explained by only a constant. n is the number of observations. The pseudo R^2 will always be between zero (no fit) and one (perfect fit). See Estrella and Mishkin (1998) for a further discussion.

Variable	*Estimated slope coefficients 1970-1986**				
Constant	-28.4[a]	-32.0[a]	-33.0[a]	-30.3[a]	-31.7[a]
Inflation (t-1)	1.76[a]	2.26[a]	2.31[a]	2.15[a]	2.27[a]
Industrial production (t-1)	0.46[c]	0.68[b]	0.96[a]	0.44	0.68[b]
L-t interest rate (t-1)	-0.62	-0.51	-0.44	-0.64	-0.56
Interest rate spread (t-1)		2.01			1.40
Mon. expansion spread (t-1)**			0.99		
Mon. contraction spread (t-1)**				4.65[c]	
Spread (t-1) * financial deepening					-0.26
# observations	306	245	134	111	240
pseudo R^2	0.08902	0.18035	0.21608	0.17331	0.18058
Variable	*Estimated slope coefficients 1987-2002**				
Constant	-31.33[a]	-24.7[a]	-18.9[c]	-34.4[b]	-25.3[a]
Inflation (t-1)	9.79[a]	4.56[b]	2.48	6.74[c]	4.66[b]
Industrial production (t-1)	-0.24	0.18	1.07	-1.08	0.07
L-t interest rate (t-1)	-3.94[b]	-3.05[c]	-2.90	-2.63	-2.74[c]
Interest rate spread (t-1)		4.68[b]			5.07[c]
Mon. expansion spread (t-1)**			6.28[c]		
Mon. contraction spread (t-1)**				1.88	
Spread (t-1) * financial deepening					2.31[a]
# observations	319	268	148	120	262
pseudo R^2	0.07915	0.03918	0.06113	0.05286	0.07669

*See Table 1.

**Only includes observations that are followed, respectively, by a monetary expansion or a monetary contraction (measured by the short-term interest rate).

Table 4.2: Extended probit analysis

equity bust episodes. Although this gives plausible equity bust episodes which broadly correspond with other studies, it is important to check the robustness of the results to a change in x. Using $x = 1.0$ already leads to a substantial reduction in crisis observations (by about half), but the main results and conclusions remain intact. When larger thresholds are used, too many crisis observations are thrown away to be able to perform analyses.

- I repeated the analysis with the equity busts episodes derived by Bordo and Jeanne (2002) and IMF (2003). As shown in Figure 4.1, both patterns of aggregated equity busts are similar to this chapter's indicator, although some countries and most of the recent bust episodes are missing in these studies. With some exceptions, the results of these two alternative indicators are similar, and do not lead to different conclusions. In many cases the results are even more pronounced. At the same time, the proxy for the external finance premium – the credit spread – performs worse than in the estimations with this chapter's indicator for busts. Presumably, this is because the recent equity busts – which largely determine the results of the second subsample – are missing for the two alternative indicators.

- As an alternative proxy for the external finance premium, the level of stock price volatility perceived by market participants is considered. More specifically, I used the conditional variance of stock prices, generated by a GARCH process. This measure of uncertainty is a key determinant of the risk premium required by investors to hold shares instead of deposits, and therefore indicative of the external finance premium. At the same time, a serious drawback of this measure is that it is directly derived from the same variable (equity prices) that is used to generate the equity bust dummy. In most equations, however, including stock price volatility instead of the interest rate spread leads to the same conclusions.

- The extended analysis (Table 4.2) was re-estimated with alternative baseline equations, including gross domestic product and the short-term interest rate instead of industrial production and the long-term interest rate, and including the oil price. In addition, I experimented with different lag structures. Neither of these alternatives had much impact on the results.

- I analysed smaller subsamples, in particular the periods 1970-1980 and 1990-2002.

In general, this leads to stronger differences between periods. Recursive estimations also confirm the finding that financial variables have become more important over time.

4.5 Concluding remarks

The results are in line with a financial accelerator mechanism in the post-1986 period. Probably, the growing importance of the financial accelerator over time is due to the rapid development of financial markets. Comparing stock market performance in the 1970s and in recent years, Davis (2003) draws a similar conclusion. More specifically, he concludes that the 1970 busts were characterized by a sharp deterioration of fundamentals, while the recent equity busts reflect the correction of overvaluation (i.e. a correction of an incorrect perception of fundamentals).

The outcomes for the external finance premium and interest rates around equity busts support the existence of downward pressure on policy interest rates after a downscaling of long-term growth prospects in an environment with strong financial accelerator effects. Expansionary monetary policy in reaction to busts has been the typical reaction in the recent period, but not in the 1970s and early 1980s.

In 2007, the world economy had witnessed several years of strong economic growth, at unprecedented levels since the early 1970s. In those years, optimism had boosted credit growth in many countries. In 2007, shocks to the US subprime mortgage market triggered the downward revision of economic prospects, and risks around the central projections have come to the fore. This has undermined collateral values and driven up premiums and market interest rates from levels that are very low by historical standards. High market interest rates exacerbate the initial downward economic shocks. This puts pressure on monetary authorities to reduce policy interest rates, in many cases from low levels at the outset.

4.6 Appendices

4.6.1 Appendix A: data

Most data are taken from the IMF's International Financial Statistics (IFS), extended by various other (mostly national) sources. Table 4.3 gives an overview of data availability for each country in our sample.

- *Real activity and prices.* Real Gross Domestic Product, Industrial Production and Investment (Gross Capital Formation) are included as measures for real activity. Inflation is based on the consumer price index.

- *Money and credit markets.* The short-term interest rate is a (mostly three-month or overnight) market interest rate, and the long-term interest rate is in most cases the ten-year government bond yield. The interest rate spread proxy for the external finance premium is the difference between the interest rates of long-term private debt and government bonds. For most countries, private-sector interest rates are based on corporate bonds, taken from Globalfindata. Obviously, several characteristics, such as the average maturity, are likely to differ between corporate bonds and government bonds and across countries. Therefore, this measure for the risk premium may also capture a yield curve effect. However, because the direction of this effect varies across countries, its aggregate impact on the results is probably limited. Furthermore, the yield curve itself (measured by difference between long-term and short-term interest rates) has no significant explanatory power in most of our estimations. The alternative proxy for the external finance premium, the conditional volatility of stock prices, is calculated with a GARCH(1,1) model. M3 and credit data from the IFS are extended by data from many other sources.

- *Asset markets and financial crises.* Most stock prices are taken from the IFS, while house prices are based on various national sources and mostly taken from the BIS Datase. An episode is considered a banking crisis if it qualifies as such according to either Bordo et al. (2001) or Mehrez and Kaufmann (1999).

	GDP	IP	I	π	r_S	r_L	r_{spread}	$M3$	CR	S	H
Australia	65-02	65-02	65-02	65-02	68-02	65-02	83-02	65-02	65-02	65-02	70-02
Austria	65-02	65-02	88-02	65-02	65-02	70-02	65-02	65-02	65-02	65-02	87-99
Belgium	80-02	65-02	80-02	65-02	65-02	65-02	65-02	69-98	65-02	65-02	70-02
Canada	65-02	65-02	65-02	65-02	65-02	65-02	65-02	68-02	65-02	65-02	70-02
Denmark	70-00	68-02	88-02	65-02	71-02	65-02	71-02	68-02	65-02	65-02	70-02
Finland	75-02	65-02	75-02	65-02	78-02	78-02	–	75-99	65-02	65-02	70-02
France	70-02	65-02	78-02	65-02	65-02	65-02	65-02	65-98	65-02	65-02	70-02
Germany	65-02	65-02	91-02	65-02	65-02	65-02	65-02	65-02	65-02	65-02	71-99
Italy	65-02	65-02	70-02	65-02	71-02	65-02	71-02	80-02	70-98	65-02	72-01
Japan	65-02	65-02	80-02	65-02	65-02	65-02	65-02	65-02	65-02	65-02	70-01
Korea	70-02	70-02	70-02	70-02	76-02	73-02	76-02	65-02	65-02	78-01	–
Netherlands	65-02	65-02	77-02	65-02	65-02	65-02	70-98	65-98	65-02	65-02	70-02
New Zealand	70-01	77-02	70-02	65-02	73-02	65-02	–	71-02	65-02	65-00	70-02
Norway	65-02	65-02	78-02	65-02	71-02	65-02	83-02	65-02	65-02	65-00	70-02
Portugal	77-02	68-02	86-02	65-02	82-02	65-02	–	80-02	65-02	88-02	88-02
Spain	65-02	65-02	80-02	65-02	74-02	78-02	74-02	65-02	65-98	70-00	75-02
Sweden	70-02	65-02	70-02	65-02	65-02	65-02	65-02	65-02	70-00	65-02	70-01
Switzerland	65-02	65-02	70-02	65-02	65-02	65-02	65-02	72-02	65-02	65-02	70-02
United Kingdom	65-02	65-02	65-02	65-02	65-02	65-02	65-02	82-02	65-02	65-02	68-02
United States	65-02	65-02	65-02	65-02	65-02	65-02	70-02	65-02	65-02	65-02	70-02

$GDP =$	real gross domestic product
$IP =$	industrial production
$I =$	investment
$\pi =$	inflation
$r_S =$	short-term interest rate
$r_L =$	long-term interest rate
$r_{spread} =$	spread
$M3 =$	M3 growth
$CR =$	credit growth
$S =$	stock prices
$H =$	house prices

Table 4.3: Data used

4.6.2 Appendix B: equity busts

The busts presented in Table 4.4 are calculated using the methodology explained in Section 3.

	Equity busts		*Equity busts*
Australia	1972Q2-1977Q1	Netherlands	2000Q1-
Austria	1990Q4-1992Q3	New Zealand	1973Q3-1977Q4
Belgium	1974Q1-1977Q3		1987Q2-1991Q2
Canada	2001Q1-	Norway	1974Q1-1979Q1
Denmark	1977Q4-1980Q3	Portugal	1986Q2-1989Q2
			1989Q4-1993Q3
Finland	1973Q4-1979Q2		2000Q2-
	1988Q4-1993Q1	Spain	1973Q3-1981Q2
	2002Q2-2001Q1	Sweden	1990Q1-1993Q1
France	1974Q2-1977Q2		2000Q2-
	2000Q3-	Switzerland	1972Q1-1976Q3
Germany	2000Q1-		2000Q3-
Italy	1973Q1-1979Q1	United Kingdom	1971Q4-1977Q1
	1990Q1-1993Q2		2000Q3-
	2000Q3-	United States	1972Q3-1975Q2
Japan	1989Q4-1993Q3		2000Q3-
	2000Q3-		
Korea	1976Q2-1982Q4		
	1989Q4-1993Q2		
	1995Q1-1999Q2		

Table 4.4: Equity busts

4.6.3 Appendix C: cross-correlations

	r_S	r_L	π	IP	GDP	I	$M3$	CR	r_{spread}	S	H
r_S	1.00										
r_L	0.82	1.00									
π	0.78	0.55	1.00								
IP	-0.22	-0.19	-0.34	1.00							
GDP	-0.24	-0.12	-0.38	0.89	1.00						
I	-0.24	-0.23	-0.31	0.80	0.80	1.00					
$M3$	-0.34	-0.30	-0.51	0.33	0.45	0.51	1.00				
CR	-0.36	-0.30	-0.58	0.60	0.69	0.72	0.88	1.00			
r_{spread}	-0.07	0.01	-0.09	-0.68	-0.61	-0.57	0.18	-0.68	1.00		
S	-0.26	-0.13	-0.52	0.21	0.32	0.12	0.22	0.21	-0.12	1.00	
H	-0.44	-0.52	-0.51	0.45	0.54	0.58	0.74	0.45	-0.12	0.16	1.00

Table 4.5: Cross-correlations

Chapter 5

Zero lower bound worries

"There is no trap so deadly as the trap you set for yourself."
(Raymond Chandler)

5.1 Introduction

Central banks tend to avoid reducing policy interest rates to very low levels.[1] They prefer a safety margin above the zero lower bound, where further monetary policy expansion by reducing interest rates is ruled out. Nonetheless, the Bank of Japan has kept the policy interest rate at or very close to the zero lower bound since 1999. Also the central banks of the US, the euro area and Switzerland lowered policy interest rates to unprecedented levels in the early 2000s. These developments have triggered a debate on whether monetary policy really is impotent at the zero bound, as most stylized macro-economic models suggest. Bernanke and Reinhart (2004) argue that unorthodox policies will allow further monetary expansion when policy interest rates cannot be reduced further.

Central banks' aversion to very low interest rates may influence the way it conducts monetary policy. I investigate how a central bank should set policy under the assumption that hitting the zero lower bound exhausts the monetary policy expansion possibilities. This influences the choice of the level of the inflation target, which preceeds deciding on the level of the interest rate on a daily basis. The analysis is done in a New-Keynesian framework along the lines of Clarida et al. (1999), which is today's workhorse model for examining monetary policy issues. I incorporate an explicit zero lower bound restriction

[1] This chapter is a revised version of Ullersma and Hieminga (2006).

on the nominal interest rate. The focus is on a one-off demand shock instead of stochastic shocks, since shocks that bring about a binding zero lower bound are likely to be uncommon events (Jung et al., 2005). Because of the one-off character of the shock I only solve for optimal monetary policy under discretion. Considering the commitment case would be artificial in a deterministic world.

This introduction is followed by a presentation of the model in Section 2. Section 3 shows how the optimal level of the inflation target is determined. In Section 4 optimal monetary policy reactions to a demand shock are shown. Section 5 concludes.

5.2 Model

In the standard New-Keynesian set-up the central bank minimizes a loss function conditional on the specification of the economy. The loss function L at time t is:

$$L_t = E_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[\alpha x_{t+j}^2 + (\pi_{t+j} - \pi^*)^2 \right] \right\}, \tag{5.1}$$

where x is the output gap, π is the inflation rate, $\alpha\,(\geq 0)$ is the weight on the output gap, β is the discount factor, and * refers to a policy target level. The central bank tries to close the output gap ($x^* = 0$) and to stabilize inflation around π^*.

The demand side is represented by a linear approximation of the household's Euler equation for optimal consumption. This expectational IS curve is:

$$x_t = E_t x_{t+1} - \varphi \left(i_t - E_t \pi_{t+1} - r_t^n \right), \tag{5.2}$$

where $\varphi > 0$, r is the real interest rate ($r_t = i_t - E_t \pi_{t+1}$), r^n is the natural rate of interest, i.e. the real rate of interest that is compatible with a flexible price solution (absence of nominal price rigidities). r^n is determined exogenously and can deviate from its steady state level, which is assumed to be non-negative. Changes in r^n, for instance due to a technology shock, can trigger fluctuations in output and inflation.

The supply side is derived under the assumption of monopolistic competition with staggered price setting, which results in a Phillips curve:

$$\pi_t - \overline{\pi} = \lambda x_t + \beta \left(E_t \pi_{t+1} - \overline{\pi} \right), \tag{5.3}$$

where $\lambda > 0$ and $\overline{\pi}$ refers to the steady state of the inflation level.

In deviation from the standard set-up, I follow Jung et al. (2005) and add an explicit non-negativity constraint on the nominal interest rate:

$$i_t \geq 0. \tag{5.4}$$

The nominal interest rate cannot be reduced below zero, since a negative nominal interest rate would make zero-interest bearing currency a superior investment to holding short-term bonds. The jury is still out on whether the zero lower bound poses an obstacle to monetary policy effectiveness. According to Bernanke and Reinhart (2004) the central bank has alternative means of providing monetary stimulus when the zero bound is binding, such as increasing the size of the central bank balance sheet beyond what is needed to set the nominal interest rate at zero.

With an explicit zero lower bound on nominal interest rates, the inflation target π^* becomes relevant, since higher average levels of the nominal interest rate relax the zero bound restriction ($i_t = r_t + \pi_t$). Therefore, the inflation target level is not set at 0, as is common practice, but is determined separately below.

Since there is no disturbance term in the Phillips curve, there is no trade-off between the output and inflation target of the central bank.[2] Without loss of generality I set $\alpha = 0$. A clear focus on price stability is in line with current practice at the European Central Bank and at inflation targeting central banks such as the Bank of England.

5.3 Inflation target

Before the central bank starts minimizing the loss function, the level of the inflation target must be determined. The inflation target is set at the optimal level of steady state inflation.

If inflation is anticipated by economic agents, they can take it into account when making decisions. Therefore, expected inflation is less costly than unexpected inflation

[2]The absence of a disturbance term rests on the assumption of a proportionate relationship between marginal costs and the output gap. If this assumption is relaxed, a 'cost push' shock could also result in a binding zero lower bound. Such a shock is less interesting than a demand shock, since a deflationary cost push shock goes hand in hand with higher production than in the case of a demand shock. It would not change the results of the analysis substantially.

in terms of welfare. If anticipated inflation comes at zero costs and the zero bound is a serious impediment to monetary policy, then the inflation target would be set sufficiently high to completely circumvent the zero lower bound constraint. The higher the inflation target is set, the lower is the risk of hitting the zero lower bound. This outcome would also result when downward nominal rigidities on nominal wages is the only relevant factor in the determination for the inflation target. Akerlof et al. (1996) have underlined the desirability to allow for real wage declines without nominal wage cuts. Since the zero lower bound restriction is irrelevant for the high level of inflation that is chosen as target (π^H), the steady state is characterised by: $\overline{\pi} = \pi^H, \overline{x} = 0, \overline{i} = \overline{r^n} + \pi^H$. This is the optimal outcome, since the value of the central bank's loss function L is zero.

The traditional discussion on the optimal level of the inflation rate (see Friedman, 1969) focuses on the (private) opportunity cost of holding non-interest bearing money, which is the nominal interest rate. Inflation can be regarded as a tax on holding cash balances when the nominal interest rate is positive. Private agents have to make so-called shoe leather costs to keep cash balances at an efficient level. The private opportunity cost of holding money should equal the social marginal cost of printing money, which is practically zero. Therefore the steady state level of the nominal interest should be zero ($\overline{\overline{i}} = 0$)[3]. This requires that $\overline{\overline{\pi}} = -\overline{r^n} < 0$. The output gap of this corner solution steady state (Friedman equilibrium) can be derived by substitution: $\overline{\overline{x}} = -\left(1-\beta\right)\lambda^{-1}\left(\overline{r^n} + \overline{\pi}\right)$. With positive $(\overline{r^n} + \overline{\pi})$ the steady state is characterised by deflation and output below potential.

In the new-Keynesian framework without a zero bound on nominal interest rates, the optimal inflation level is 0. This is because nominal price rigidities prevent continuous reoptimization of prices (Calvo-style pricing). Instability of the price level would result in distortions in relative prices. This argument in favour of price level stability is closely related to traditional pleas for zero inflation because of menu costs associated with changing prices or costs due to incomplete indexation of prices.[4] The steady state solution is: $\overline{\pi} = 0, \overline{x} = 0, \overline{i} = \overline{r^n}$.

Since there is a trade-off between the different aims, the decision on the optimal level

[3] Here, I refer to the steady state as $\overline{\overline{i}}$ instead of $\overline{i}$ to indicate it is a corner solution. The interior solution ($\overline{\pi}$, $\overline{x} = 0$ and $\overline{i} = \overline{r^n} + \overline{\pi} > 0$) cannot be reached because of the restriction $i \geq 0$.

[4] I abstract from measurement errors. It has been argued that official inflation numbers overstate actual inflation, for instance due to quality improvements.

involves an optimizing problem on its own. It is a one-off problem, since the target will be fixed over an extended period of time. Actual inflation outcomes will involve limited deviations from the inflation target, because the target equals the steady state inflation level. The optimization problem involves minimizing a loss function L^* :

$$L^* = -\gamma_1 \pi^* + \gamma_2 \left(\pi^* + \overline{r^n}\right)^2 + \gamma_3 \left(\pi^*\right)^2, \tag{5.5}$$

where γ_1 reflects the costs associated with the zero lower bound, γ_2 is linked to shoe-leather costs, and γ_3 is connected to costs associated with deviations from price level stability. Minimizing this eq. leads to:

$$\pi^* = \frac{1}{2\left(\gamma_2 + \gamma_3\right)} \left(\gamma_1 - 2\gamma_2 \overline{r^n}\right). \tag{5.6}$$

If the zero lower bound constraint is the only factor that matters ($\gamma_2, \gamma_3 = 0; \gamma_1 > 0$) the inflation target is indefinitely high. If the Friedman target prevails ($\gamma_1, \gamma_3 = 0; \gamma_2 > 0$), then $\pi^* = -\overline{r^n}$. If $\gamma_1, \gamma_2 = 0, \gamma_3 > 0$, then $\pi^* = 0$. Usually, γ_2 is close to zero since the Friedman distortion is small in comparison to other rigidities. γ_3 is large under normal circumstances since nominal rigidities work out much more distortionary when the price level is changing substantially. High aversion to hitting the zero lower bound (high value of γ_1) makes sense in an environment where shocks to the natural interest rate cause strong fluctuations in the optimal nominal policy interest rate, and where the possibilities for monetary policy expansion are exhausted at the zero bound.

5.4 Day-to-day interest rate setting

It cannot be ruled out completely that a large shock forces the central bank to lower the interest rate to its lower bound. I examine a situation with a positive inflation target, where the zero lower bound does not bite in the steady state. Following Jung et al. (2005) I consider a one-off large-scale negative demand shock that leads to a large negative value of the real natural rate of interest at period t. It is assumed to gradually converge to its steady state level in later periods:

$$r^n_{t+j} = \rho^{t+j} \varepsilon^n_j + \overline{r^n} \qquad \text{for } j = 0, ..., \tag{5.7}$$

where $0 \leq \rho < 1$.

Given the inflation target that was determined before the shock occured, the central bank chooses a time path for the instrument i to steer x and π in order to minimize the loss function eq. 5.1, subject to the constraints implied by eqs. 5.2, 5.3 and 5.4. I solve this problem under discretion, where it is assumed that the central bank takes private sector expectations as given. The central bank and the public play a one-shot game without private information. The optimisation problem is described by a Lagrangian that takes on board the loss function and the IS and Phillips Curve constraints, as well as the non-negativity constraint on the nominal interest rate:

$$Z_t = \sum_{j=0}^{\infty} \beta^j \left\{ \begin{array}{c} (\pi_{t+j} - \pi^*)^2 \\ +2\Lambda_{1,t+j} \left(x_{t+j} - x_{t+j+1} + \varphi \left(i_{t+j} - \pi_{t+j+1} - r^n_{t+j} \right) \right) \\ +2\Lambda_{2,t+j} \left(\pi_{t+j} - \lambda x_{t+j} - \beta \pi_{t+j+1} \right) \end{array} \right\}, \tag{5.8}$$

$$i_{t+j} \geq 0, \tag{5.9}$$

where Λ represents a Lagrange multiplier. The first order condition to this problem defines the central bank's reaction function:

$$\pi_{t+j} - \pi^* + \Lambda_{2,t+j} = 0, \tag{5.10}$$

$$\Lambda_{1,t+j} - \lambda \Lambda_{2,t+j} = 0, \tag{5.11}$$

$$i_{t+j} \Lambda_{1,t+j} = 0, \tag{5.12}$$

$$i_{t+j} \geq 0, \tag{5.13}$$

$$\Lambda_{1,t+j} \geq 0. \tag{5.14}$$

Given the large negative shock to the real natural interest rate that fades away gradually, it can be guessed that the zero lower bound is binding until period T, but non-binding afterwards. With $\Lambda_{1,t+j} = 0$ for $t+j > T$ the interior solution emerges: $\pi_{t+j} = \pi^* = \overline{\pi}, x_{t+j} = 0, i_{t+j} = r^n_{t+j} + \overline{\pi}$. For $t+j \leq T, i_{t+j} = 0, \pi_{t+j+1} = \beta^{-1}\pi_{t+j} - \beta^{-1}\lambda x_{t+j} + \frac{\beta-1}{\beta}\overline{\pi} < \pi^*$, $x_{t+j+1} = -\varphi\beta^{-1}\pi_{t+j} + \left(1 + \varphi\beta^{-1}\lambda\right) x_{t+j} - \varphi r^n_{t+j} - \varphi \left(\frac{\beta-1}{\beta}\right) \overline{\pi}$. If monetary policy expansion is still possible at the zero lower bound, for instance by increasing the size of the central bank balance sheet beyond what is needed to set the nominal interest rate at zero, the zero bound poses no serious obstacle to monetary policy. In this situation the non-negativity constraint on the nominal interest rate does no longer apply. i can be regarded as a proxy for the monetary policy stance. Negative values signal strongly expansionary policies. Without the non-negativity constraint, the central bank can set the interest rate so that the real interest rate equals its natural level, implying zero losses.

5.5 Concluding remarks

Before a central bank determines the level of the monetary policy interest rate to maximise welfare, it has to decide on the level of the inflation target. It will account for shoe leather costs associated with (steady state) inflation levels deviating from minus the real rate of interest, costs that emerge from price level instability in an environment with nominal price rigidities, and the risk of hitting the zero lower bound at low steady state inflation levels. If the zero lower bound poses a serious obstacle to monetary policy, the central bank will choose a positive inflation target. Given this target, the central bank can follow standard maximising techniques to determine the level of the nominal monetary policy interest rate. This may imply keeping the nominal interest rate at the zero lower bound for some time after a sharp negative shock to the real natural rate of interest has occured.

Chapter 6

Money rules

"Χρήματα νεῦρα τῶν πραγμάτων"
(Aeschines)

6.1 Introduction

In recent years the New Keynesian model has emerged as the consensus model for monetary policy analysis.[1] It is well-known that money plays no crucial role in the standard version of this model. The money demand function only identifies the amount of money that the central bank will have to supply when it sets interest rates. At most, money can function as a leading indicator of inflation or output for policy makers (Dotsey and Hornstein, 2003).[2] Several authors have argued that the standard New Keynesian model does insufficient justice to the role of money in the monetary policy transmission process (e.g. Meyer, 2001, and Nelson, 2003). Allowing for such a role for money in an otherwise standard New Keynesian model could justify monetary policy makers devoting attention to monetary developments. This motivates the main objective of this chapter, which is to assess the welfare implications of including money in the monetary policy rule. The issue is also of practical relevance since the European Central Bank explicitly attaches a prominent role to money in its monetary policy strategy, in contrast to other major central banks (ECB, 2003).

Two different approaches that allow for a distinct role for money are assessed: by

[1] This chapter is a revised version of Ullersma, Berk and Chapple (2006).

[2] Gerlach and Svensson (2003) find the same using a P* model.

incorporating a real balance effect in the aggregate demand function and by interpreting money as a proxy for yields that matter for aggregate demand in addition to the short-term interest rate. In contrast to Andrés et al. (2007) the optimal monetary policy reactions to shocks are derived, under both discretion and commitment from a timeless perspective. This allows for the assessment of the welfare gains of taking money explicitly into account in setting monetary policy. The following section describes the model. Section 3 discusses the effects of different policy settings on the response to economic shocks. Section 4 concludes.

6.2 Model

The model is an extension of the New Keynesian model that is today's consensus macroeconomic model for monetary policy analysis (Clarida et al., 1999). An attractive feature of the standard New Keynesian model is that the aggregate behavioral equations can be derived from intertemporal optimization by rational economic agents (e.g. Yun, 1996). However, a drawback is that it summarizes overall financial conditions in one interest rate, which is a gross simplification of the monetary policy transmission process (Mishkin, 1996). To overcome this drawback, two different perspectives that provide a theoretical rationale for a separate role for money are assessed. The modified forward-looking New Keynesian model that allows for a distinct role for money from both of these perspectives is based on a representative household that maximizes utility:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t a_t \left[\Psi\left(C_t, \frac{M_t}{P_t}\right) - \frac{N_t^{1+\varphi}}{1+\varphi} \right] - G\left(\frac{\frac{M_t}{P_t}}{\frac{M_{t-1}}{P_{t-1}}}\right), \tag{6.1}$$

$$G\left(\frac{\frac{M_t}{P_t}}{\frac{M_{t-1}}{P_{t-1}}}\right) = \frac{d}{2}\left\{ \exp\left(c\left\{\frac{\frac{M_t}{P_t}}{\frac{M_{t-1}}{P_{t-1}}} - 1\right\}\right) + \exp\left(-c\left\{\frac{\frac{M_t}{P_t}}{\frac{M_{t-1}}{P_{t-1}}} - 1\right\}\right) - 2\right\}, \tag{6.2}$$

where C_t is a CES aggregator of the quantities of the different goods consumed, $\frac{M_t}{P_t}$ represents real balances (with M_t broad money and P_t the price level), N_t represents hours worked, a_t is a preference shock, $\beta \in (0,1)$ is a discount factor, $G\left(\frac{\frac{M_t}{P_t}}{\frac{M_{t-1}}{P_{t-1}}}\right)$ represents portfolio adjustment costs, and $d > 0$, $c > 0$. This utility function diverges in two respects from a standard representation. First, for analytical convenience many authors assume separability in preferences among consumption and real balances. By relaxing this assumption, the link between consumption/output and real balances/money gets tighter. With utility non-separable in consumption and real balances, money is regarded as wealth in its own right by consumers. Second, following Andrés et al. (2007) portfolio adjustment costs are added. Other things equal, the G function implies that households have a preference to maintain the amount of purchasing power they hold in the form of real money balances relatively stable over time. Recall that the traditional representation, without adjustment costs, allows for just two asset categories: money and bonds. In reality, many varieties of assets can be distinguished. It is not feasible to insert all these asset categories in the utility function. Instead, portfolio adjustment costs in real balances can cover the role played by yields beyond the short-term interest rate. This is because money demand is not only a function of its own rate of return, but also of the rate of return of alternative assets. Therefore, money demand, like aggregate demand, is a function of a wide range of interest rates. If real money balances increase, they offer higher liquidity services, which lower risk premia on financial assets that are less liquid than money. The modified New Keynesian model that results from standard optimizing procedures can be specified in deviations from the steady state as follows (Andrés et al., 2006, 2007):

$$x_t = x_{t+1|t} - \sigma\left(i_t - \pi_{t+1|t}\right) + \alpha\left(m_t - m_{t+1|t}\right) + \varepsilon_t^x, \tag{6.3}$$

$$\varepsilon_t^x = \rho_x \varepsilon_{t-1}^x + u_t^x, \tag{6.4}$$

$$\pi_t = \omega \pi_{t+1|t} + \lambda mc_t, \tag{6.5}$$

$$mc_t = \kappa x_t - \frac{\alpha}{\sigma} m_t, \tag{6.6}$$

$$m_t = \beta_1 x_t - \beta_2 i_t + \beta_3 m_{t-1} + \beta_3 \omega m_{t+1|t} + \varepsilon_t^m, \tag{6.7}$$

$$\varepsilon_t^m = \rho_m \varepsilon_{t-1}^m + u_t^m, \tag{6.8}$$

where x_t is the output gap (log deviation of output from its steady state level) at time t, and $x_{t+1|t}$ the value of x at time t+1, expected at time t. i_t is the nominal interest rate, π_t the inflation rate, $m_t = \frac{M_t}{P_t}$, mc_t real marginal costs, ε_t^x an AR(1) demand shock, ε_t^m an AR(1) money shock and u_t a white noise disturbance term. If money is regarded as wealth by consumers, the marginal utility of consumption depends upon real balances, and higher real balances increase demand. In equation 6.3 this is the case if $\alpha > 0$, see also Ireland (2004) and Andrés et al. (2006). Otherwise, equation 6.3 is a regular forward-looking IS curve, with the level of output depending on the real interest rate. Equation 6.5 is a regular New Keynesian Phillips curve. It allows for sticky prices in the short term and fully flexible prices in the long run. Equation 6.6 shows that there is no longer a one-to-one relationship between real marginal costs and the output gap if there is a real balance effect. Ireland (2004) demonstrates that cross restrictions in the underlying micro structure generate a direct effect of money on marginal costs. This implies that money affects the supply side if it is incorporated in the demand side (equation 6.3). Intuitively, higher real money is an input factor that offers liquidity services and reduces capacity constraints that stem from the output gap conditions. Equation 6.7 is a standard money demand equation, except that past and expected future real balances can enter the money demand function. Given portfolio adjustment costs (i.e. $\beta_3 > 0$), money is no longer a static indicator of current economic conditions. Instead, real money balances are changed in anticipation of expected future conditions. This makes current real balances a function of expected future real balances. Rewriting equation 6.7 clarifies that current real balances depend on expected future output and interest rate levels. Therefore, real balances are informative on current and future levels of the natural rate of interest, which is the equilibrium real interest rate in the absence of nominal rigidities (Nelson, 2003). Andrés et al. (2007) show that the forward-looking nature of money demand can allow for a very accurate estimation of the natural real interest rate. In sum, if $\alpha > 0$ the real balance channel operates, while if $\beta_3 > 0$ the portfolio adjustment channel, where money serves as a proxy for a variety of yields, comes into play. When both $\alpha = 0$ and $\beta_3 = 0$ the model reduces to the standard New Keynesian macro-economic model.

6.3 Transmission of shocks

The transmission of shocks is compared under different (quasi) optimal monetary policy rules. This involves minimizing the expected value of the policy maker's loss function:

$$Loss_t = E_t \sum_{j=0}^{\infty} \omega^j \left(\pi_{t+j}^2 + \gamma x_{t+j}^2 \right), \tag{6.9}$$

with respect to the nominal short-term interest rate i_t, which is the monetary policy instrument, subject to the economic structure represented in equations 6.3-6.8. For clarity of exposition a sharp distinction between the conventional interest rate transmission channel and the real balance channel is assumed by setting $\beta_2 = 0$.[3] The reader should have a broad concept of money, such as M3, in mind, because money is regarded as a financial asset along with alternative assets. A low interest elasticity of money demand is consistent with a broad money concept, where an interest rate change leads to substitution between different components of the money stock in addition to substitution between money and other assets. Empirical evidence confirms this finding (Bruggeman et al., 2003).

6.3.1 Real balance effects

Consider the real balance variant of the model ($\alpha > 0, \beta_2 = 0, \beta_3 = 0$). By substituting equation 6.7 in equation 6.3 and equations 6.6 and 6.7 in equation 3.16 the IS and Phillips curve functions can be rewritten as:

$$x_t = x_{t+1|t} - \frac{\sigma}{1-\alpha\beta_1}\left(i_t - \pi_{t+1|t}\right) + \frac{1}{1-\alpha\beta_1}\varepsilon_t^x + \frac{\alpha}{1-\alpha\beta_1}\varepsilon_t^m, \tag{6.10}$$

$$\pi_t = \omega\pi_{t+1|t} + \lambda\left(\kappa - \frac{\alpha}{\sigma}\beta_1\right)x_t - \frac{\lambda\alpha}{\sigma}\varepsilon_t^m. \tag{6.11}$$

It is assumed that the policy maker can observe money shocks contemporaneously. Then, the money shocks should be in the information set that determines the monetary authority's policy setting. First, the minimization problem is solved under discretion, where the monetary authority acts each period without limiting future policy options. This can be regarded as a representation of a central bank that wants to have full flexibility in reacting to shocks. The optimality condition under discretion is (Clarida et al., 1999 and Walsh, 2003):

$$E_t\left\{x_t|\Omega_t\right\} = -\frac{\lambda\left(\kappa\sigma - \alpha\beta_1\right)}{\sigma\gamma}E_t\left\{\pi_t|\Omega_t\right\}, \tag{6.12}$$

where Ω_t is the monetary authority's information set at the time it determines i_t. If the monetary authority neglects the information on money shocks it will be surprised by these shocks, and both inflation and output disturbances will be higher, since the ε^m disturbances are neglected.

Second, the minimization problem is solved under commitment from a time-less perspective. Commitment means that the monetary authority can precommit to a policy rule. Under a time-less perspective it is assumed that the current approach was followed

[3] Assuming $\sigma = 0$ would also imply a sharp distinction between both transmission channels. However, this would lead to diverging solutions in equation 3.4 if $\alpha = 0$, or in equation 6.6 if $\alpha > 0$.

from the distant past onwards. Commitment from a time-less perspective improves the predictability of monetary policy and avoids time-inconsistent behaviour. This approach represents state-of-the-art central bank behaviour. Under commitment from a time-less perspective, the optimality conditions are (Walsh, 2003):

$$E_t\left(\pi_{t+i}|\Omega_{t+i} + \Lambda_{t+i} - \Lambda_{t+i-1}\right) = 0 \qquad i \geq 0, \tag{6.13}$$

$$E_t\left(\gamma x_{t+i}|\Omega_{t+i} - \frac{\lambda}{\sigma}\left(\kappa\sigma - \alpha\beta_1\right)\Lambda_{t+i}\right) = 0 \qquad i \geq 0, \tag{6.14}$$

where Λ is a Lagrangian multiplier. The time-less perspective implies that condition 6.13 also holds in the current period ($i = 0$). In this way, time inconsistency due to the possibility of implementing policies that cannot affect prior expectations is avoided. Again, money shocks ε^m_{t+i} influence the model's dynamics and should be in the information set Ω_{t+i} at time t+i.

Both for discretion and for commitment from a timeless perspective the optimal paths for x_t, π_t and i_t can be derived. Figures 6.1-6.2 display the impulse responses when the economy is hit by a money demand shock (ε^m_t), which generates positive real balance effects. The parameter values are based on quarterly EMU data from Andrés et al. (2006, 2007): $\sigma = 1, \alpha = 0.9, \rho_x = 0.5, \rho_m = 0.5, \omega = 0.99, \lambda = 0.14, \kappa = 10, \beta_1 = 0.2, \beta_2 = 0, \beta_3 = 0, \gamma = 0.25$. The output and inflation patterns after a money shock are shown, both when the policy maker takes money demand shocks explicitly into account and when she disregards information on money demand shocks. If the policy maker does not take the ε^m_t-shocks into account when setting interest rates, output and inflation deviations from steady state are higher than otherwise. The higher level of output and inflation volatility in case of neglecting money implies lower welfare. Note that inflation falls (marginally) below its steady state level when money shocks are taken into account. This is because of the negative supply shock associated with ε^m_t (see equation 6.11). If money is neglected, this supply effect is dominated by the indirect influence of stronger demand on inflation. Note also that the persistence of the deviations from the steady state is higher under commitment from a time-less perspective than under discretion, as one would expect. The initial deviation is the same, since commitment has no impact on shocks that are not in the information set of the policy maker.

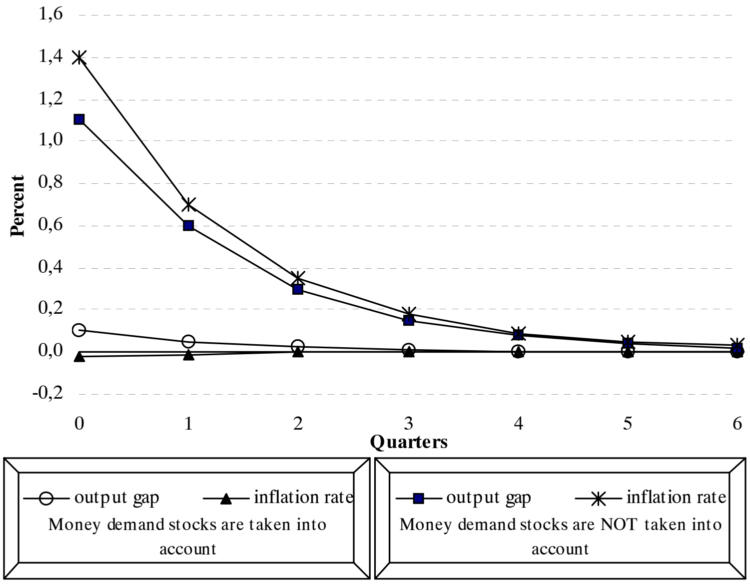

Figure 6.1: Money shock (discretion)

6.3.2 Money as indicator of the natural rate of interest

Consider the alternative modification of the New Keynesian model where yields of financial assets are proxied by money ($\alpha = 0, \beta_3 > 0$). As explained above, this approach offers an accurate estimate of the real natural interest rate. I assume that this estimate is perfect, and depart from the benchmark New Keynesian approach in which the real natural interest rate is assumed to be constant. Galí (2003) shows that the real natural interest rate is:

$$\overline{r}_t = (1 - \omega) + \phi \Delta a_t, \tag{6.15}$$

where a_t is (log) productivity. Bars refer to natural levels. If an observed productivity shock affects $\overline{r}_t$, optimal monetary policy ensures that the real interest rate $r_t \left(= i_t - \pi_{t+1|t}\right)$ coincides with its natural value. On the other hand, if economic agents assume a constant $\overline{r}$, the IS equation 6.3 can be rewritten as:

$$x_t = x_{t+1|t} - \sigma \left(i_t - \pi_{t+1|t}\right) + \sigma \phi \varepsilon_t^a, \tag{6.16}$$

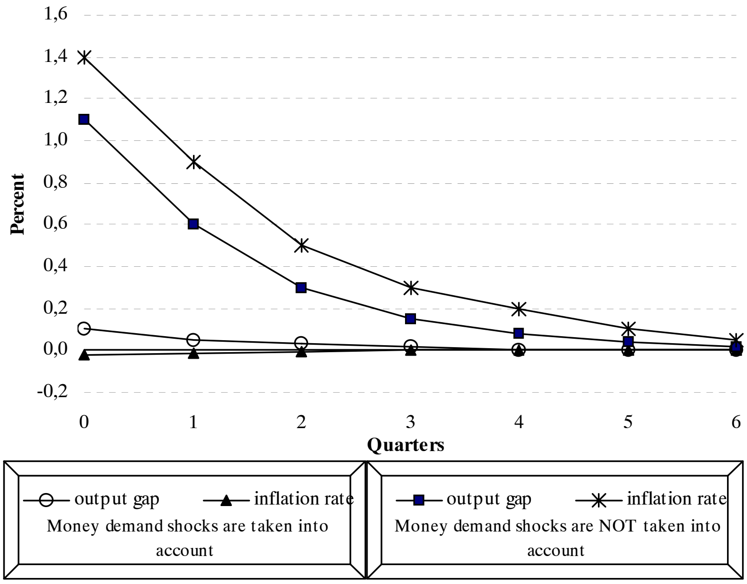

Figure 6.2: Money shock (commitment from a time-less perspective)

where $\varepsilon_t^a \left(= \rho_a \varepsilon_{t-1}^a + u_t^a\right)$ is a shock to Δa_t. The optimality condition under discretion is (Clarida et al., 1999 and Walsh, 2003):

$$E_t \left\{ x_t | \Omega_t \right\} = -\frac{\lambda \kappa}{\gamma} E_t \left\{ \pi_t | \Omega_t \right\}. \tag{6.17}$$

Under commitment from a time-less perspective, the optimality conditions are (Walsh, 2003):

$$E_t \left(\pi_{t+i} | \Omega_{t+i} + \Lambda_{t+i} - \Lambda_{t+i-1} \right) = 0 \qquad i \geq 0, \tag{6.18}$$

$$E_t \left(\gamma x_{t+i} | \Omega_{t+i} - \lambda \kappa \Lambda_{t+i} \right) = 0 \qquad i \geq 0. \tag{6.19}$$

Figures 6.3 and 6.4 display the impulse responses for the portfolio adjustment modification of the model where $\alpha = 0, \beta_3 = 0.4, \rho_a = 0.5, \phi = 0.9$ (other parameter values as in the real balance version of the model) when the policy maker does not use money for the determination of the real natural interest rate after a positive technology shock (ε_t^a). The increase in the real natural interest rate after the ε_t^a-shock implies a more expansive monetary policy by decreasing the deviation of i_t from its natural rate. This drives up the output gap. Again, commitment from a time-less perspective results in more persistent

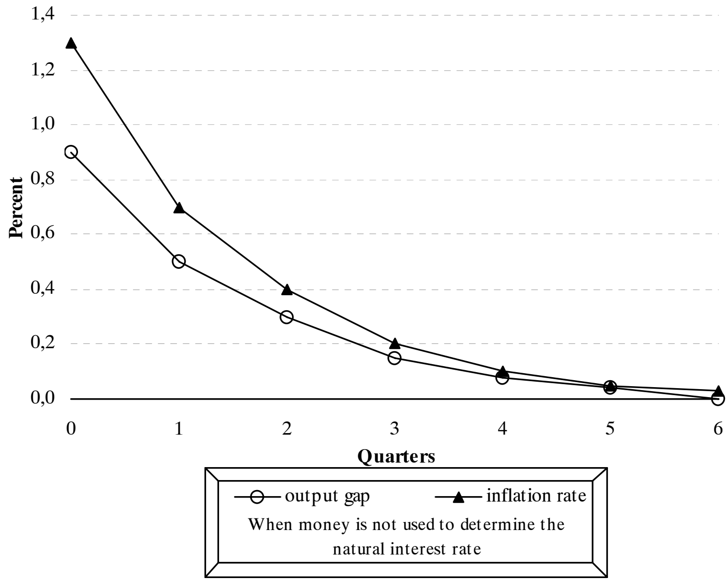

Figure 6.3: Technology shock (discretion)

deviations from steady state than discretion. When the policy maker does use money to determine the real natural interest rate a technology shock will not cause disturbances in output and inflation, since she will ensure that the real interest rate equals its natural level. The deviations from steady state in the case when the policy maker disregards the information on the natural interest rate imply a welfare loss, which is higher when the natural interest rate fluctuates more.

6.4 Concluding remarks

In this chapter two modifications of the standard New Keynesian macro-economic model are assessed that allow for a more complete representation of monetary policy transmission. Money can either have real balance effects or can indicate changes in the natural interest rate. In the former case the monetary authority should take the direct impact of money on demand and supply into account when setting monetary policy, in the latter case she should take the implied changes in the monetary stance into account. If empirical

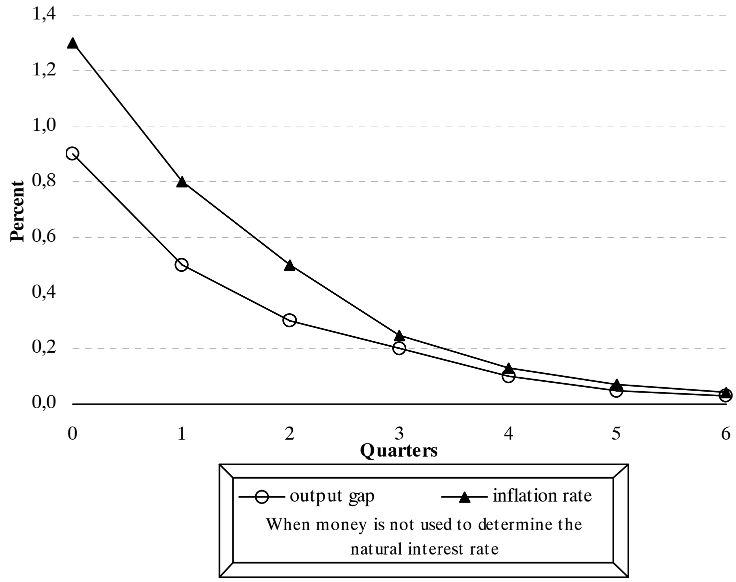

Figure 6.4: Technology shock (commitment from a time-less perspective)

evidence were to show that at least one of these channels is relevant, neglecting money in setting monetary policy would imply a suboptimal outcome, i.e. incur welfare losses.

6.5 Appendix

6.5.1 Real balance effects: discretion

Following a ε^m-shock, the pattern for x_t and π_t consistent with equation 6.12, assuming that the policy maker uses all available information, is (compare Walsh, 2003):

$$x_t = \frac{\lambda^*}{(\lambda^*)^2 + \gamma (1 - \omega \rho_m)} \frac{\lambda \alpha}{\sigma} \varepsilon_t^m, \tag{6.20}$$

$$\pi_t = \frac{-\gamma}{(\lambda^*)^2 + \gamma (1 - \omega \rho_m)} \frac{\lambda \alpha}{\sigma} \varepsilon_t^m, \tag{6.21}$$

where $\lambda^* = \lambda \left(\kappa - \frac{\alpha}{\sigma} \beta_1 \right)$. i_t can be determined on the basis of IS equation 6.10.

If money is not in the information set of the monetary authority, the pattern for x_t

and π_t is (compare Clarida et al., 1999):

$$x_t^I = \frac{\alpha}{1-\alpha\beta_1}\varepsilon_t^m, \tag{6.22}$$

$$\pi_t^I = \frac{-\lambda\alpha}{\sigma}\varepsilon_t^m + \lambda^* \frac{\alpha}{1-\alpha\beta_1}\varepsilon_t^m, \tag{6.23}$$

where the superscript I refers to equilibrium values under imperfect information.

6.5.2 Real balance effects: commitment from a time-less perspective

If money is in the information set, combining equations 6.5, 6.13, 6.14 and 6.15 yields (compare Walsh, 2003):

$$\left(1+\omega+\frac{(\lambda^*)^2}{\gamma}\right) E_t\left\{x_t|\Omega_t\right\} = \omega x_{t+1|t} + x_{t-1} + \frac{\lambda^*}{\gamma}\frac{\lambda\alpha}{\sigma}\varepsilon_t^m. \tag{6.24}$$

The solution to this expectational difference equation for the output gap is of the form:

$$E_t\left\{x_t|\Omega_t\right\} = a_x x_{t-1} - b_x \times \frac{\lambda\alpha}{\sigma}\varepsilon_t^m, \tag{6.25}$$

where a_x is the solution less than 1 of the quadratic equation:

$$\omega a_x^2 - \left(1+\omega+\frac{(\lambda^*)^2}{\gamma}\right) a_x + 1 = 0, \tag{6.26}$$

$$b_x = -\left(\frac{\lambda^*}{\gamma\left(1+\omega\left(1-\rho_m-a_x\right)\right)+(\lambda^*)^2}\right). \tag{6.27}$$

It follows that:

$$E_t\left\{\pi_t|\Omega_t\right\} = \frac{\gamma}{\lambda^*}\left(1-\alpha_x\right)x_{t-1} - \frac{\gamma}{\gamma\left(1+\omega\left(1-\rho_m-a_x\right)\right)+(\lambda^*)^2}\frac{\lambda\alpha}{\sigma}\varepsilon_t^m. \tag{6.28}$$

If money is not in the information set (Clarida et al., 1999):

$$x_t^I = a_x x_{t-1} + \frac{\alpha}{1-\alpha\beta_1}\varepsilon_t^m, \tag{6.29}$$

$$\pi_t^I = \frac{\gamma}{\lambda^*}\left(1-\alpha_x\right)x_{t-1}^I - \frac{\lambda\alpha}{\sigma}\varepsilon_t^m + \lambda^*\frac{\alpha}{1-\alpha\beta_1}\varepsilon_t^m. \tag{6.30}$$

6.5.3 Money as indicator for the natural rate of interest

If money is not used for determining the natural rate of the interest rate, the output shock will come as a surprise. Then, the optimal monetary policy under discretion implies:

$$x_t = \sigma\phi\varepsilon_t^a, \tag{6.31}$$

$$\pi_t = \lambda\kappa\sigma\phi\varepsilon_t^a. \tag{6.32}$$

Under commitment from a timeless perspective:

$$x_t = a_x x_{t-1} + \sigma\phi\varepsilon_t^a, \tag{6.33}$$

$$\pi_t = \frac{\gamma}{\lambda\kappa}\left(1 - \alpha_x\right) x_{t-1} + \lambda\kappa\sigma\phi\varepsilon_t^a, \tag{6.34}$$

where a_x is the solution less than 1 of the quadratic equation:

$$\omega a_x^2 - \left(1 + \omega + \frac{(\lambda\kappa)^2}{\gamma}\right) a_x + 1 = 0. \tag{6.35}$$

Chapter 7

Summary and conclusions

The Western world has reached a situation with low and stable consumer price inflation. To central bankers this sounds as though they have reached the promised land, since safeguarding the purchasing power of money (price stability) is their overarching objective. To others it may just be a sign that macro-economic stability is higher than in the last decades. Nonetheless, problems can arise.

First, in an environment with low and stable inflation, the room for manoeuvre for monetary policy is smaller than in an environment with higher inflation. With price stability, central banks can get into a situation where they can no longer reduce the inflation-adjusted monetary policy interest rate, which is their main instrument to boost economic activity. The point is that average nominal interest rates, which include compensation for inflation, are lower than in an environment with higher inflation. Low interest rates may pose an obstacle to stimulatory monetary policy, since the nominal interest rate cannot fall below zero, due to the availability of currency with a zero yield. Currency would offer a superior alternative to investors in comparison to bonds with a negative yield.

Second, in a low and stable inflation environment, boom-bust cycles in asset prices may arise. One factor is that stable macro-economic conditions are conducive to the accumulation of financial wealth. At the same time, the valuation of assets is sensitive to interest rate changes, in particular at low nominal interest rate levels. Therefore, these changes can have a strong impact on the real economy. Another factor is that in an environment with price stability, unsustainable economic expansion may not lead to strong inflationary pressures due to high central bank credibility anchoring inflation expectations. Without a firm basis for determining long-term growth prospects, people tend to extrapolate current real economic growth numbers into the future, in particular when the economy does not show obvious signs of overheating. In such an environment, where optimism prevails, growth in credit and asset prices can be expected to be high. This is even more likely when financial liberalization has eased the access to credit. However, eventually investors will observe that asset prices have moved out of line with economic fundamentals. Then, they will downscale their expectations and reprice asset prices - the bust phase. This leads to a repricing of risks, higher market interest rates and lower economic activity.

This thesis brings together the phenomenon of the zero lower bound and the phenomenon of boom-bust cycles in asset prices. A recurrent theme is that monetary policy can reach the zero lower bound to nominal interest rates in a low inflation environment after the collapse of an asset price boom.

Chapter 2 is a survey of what characterises an economy in a zero lower bound, and how it can escape from such a situation. This chapter shows that a weakness in the general level of confidence is a crucial factor. This is because expectations drive agents' behaviour, in particular spending. Without confidence, monetary easing leads to hoarding instead of spending. The level of confidence influences not only demand, but also supply. This is seen clearly when financial markets, which bring together creditors and debtors, no longer run smoothly. Risk premiums are driven up, lifting market interest rates and reducing demand. Supply is affected when financial market intermediation is interrupted, for instance when banks go bust. Both the demand and supply factors depress the policy interest rate, in severe cases pushing it to the zero lower bound. The survey demonstrates that the issue of how a binding zero lower bound arises has received little attention to date.

Chapter 3 elaborates, in a theoretical model, on the findings in Chapter 2. It shows analytically how a binding zero lower bound can emerge from a correction of overoptimistic expectations. Since the price of an asset is the present discounted value of the future expected income stream, a downward correction of the outlook for productivity and income growth drives down net wealth. This is what happened, for example, after the excessive optimism of the so-called New Economy in the late 1990s. Lower net wealth implies that the value of collateral declines, making lending more risky. This translates into a higher risk premium on the risk-free interest rate, depressing economic activity and consumer price inflation. In line with the decline in productivity growth the inflation-adjusted policy interest rate at which economic activity is neither boosted nor contracted (neutral interest rate) falls. Therefore, a sharp reduction in the (risk-free) policy interest rate is required to boost the economy. In this environment, the central bank may have to reduce its policy interest rate to the zero lower bound.

Chapter 4 is the empirical counterpart of Chapter 3. It presents new empirical evidence on the macro-economic financial accelerator effects that play a crucial role in the amplification of shocks in the preceding chapter. It confirms that unsustainable asset booms, which are followed by asset busts, also occur in times of low and stable inflation. The explanatory power of financial factors appears to be high in the post 1986 period, but not in the period 1970-1986. In essence, asset booms and busts used to be by-products of inflationary cycles. In the post 1986 period, they have become catalysts of economic events. These results suggest that the financial accelerator mechanism played a role in the latter period, when financial markets had grown larger and more sophisticated. In this environment, the typical bust is followed by a substantial reduction in the nominal policy interest rate, as one would expect on the basis of Chapter 3. Taken together, Chapters 3 and 4 have two major implications for monetary policy. First, the emergence of financial cycles as catalysts for economic activity and inflation suggests that the policy horizon of monetary authorities must be long enough to take these effects into consideration. Since financial imbalances can take a long time to accumulate, the policy horizon sufficient to deal with these issues may stretch over several years. Second, since it is very difficult to detect financial imbalances and to foresee their collapse, monetary authorities would be well advised to put emphasis on the analysis of uncertainties around central projections in economic forecasts. This implies undertaking scenario analyses, and taking explicitly into account the small probability of events with a high impact.

While the low inflation environment is taken as a starting position in Chapters 3 and 4, this assumption is relaxed in Chapter 5. Here, the choice of a higher inflation objective (higher average inflation level) is studied as an alternative way to increase the room for manoeuvre for monetary policy. The benefit of a smaller probability of facing a zero lower bound problem is balanced against the costs associated with high average levels of inflation. One of the main costs follows from the fact that prices tend to be sticky, preventing the continuous reoptimization of prices by firms. An unstable price level would lead to distortions in relative prices, even without shocks hitting the economy. A complication for monetary policy makers is that they cannot change the inflation objective often, and that it is difficult to determine the risk of hitting the zero lower bound in the remote future. Once they have chosen the inflation regime, they pursue price stability given the objective for the rate of inflation. In exceptional circumstances, this could result in reducing the nominal policy interest rate to zero.

Although the probability of reaching the binding zero lower bound appears likely to be small, it is nevertheless greater than zero. It is an unresolved issue as to whether a substantial monetary policy expansion remains still possible when monetary policy interest rates cannot be reduced further. If the monetary policy interest rate can no longer be used to stimulate the economy, increasing the money supply may still be effective. This is because the money supply can influence the monetary stance, aside from its influence on interest rates. Chapter 6 examines monetary policy in a theoretical model that allows for such a role for money. In contrast to previous work by other authors, who use ad-hoc monetary policy rules, optimal policy is investigated. It appears that overall welfare is higher when the central bank takes money explicitly into account when setting interest rates. First, increases in the money stock can boost aggregate demand through wealth effects. This is because money is an asset to the public (real balances). At the same time, money is a liability to the central bank, but with no consequences for its creditworthiness due to its power to meet claims with newly created money. Second, increasing the money stock lowers risk premiums on financial assets that are less liquid than money, since higher market liquidity implies lower transaction costs. The latter effect shows that financial market liquidity and liquidity as a yardstick for the monetary policy stance cannot be separated completely. The emphasis on money aggregates in this chapter completes the circle. Here, the focus is on the role money can still play when the monetary policy interest rate cannot be reduced further. But money aggregates, and in particular their credit counterparts, can also be indicative of risks associated with the build-up of financial imbalances, as discussed in previous chapters.

Bibliography

1. Akerlof, G.A., W.T. Dickens and G.L. Perry (1996), 'The macro-economics of low inflation', *Brookings Papers on Economic Activity,* 1996-1, pp. 1-76.

2. Amirault, D. and B. O'Reilly (2001), 'The zero bound on nominal interest rates: how important is it?', Bank of Canada Working Paper no. 6.

3. Andrés, J., J.D. López-Salido and E. Nelson (2007), 'Money and the natural rate of interest: structural estimates for the UK, the US and the euro area', Fed of St. Louis Working Paper no. 2007-005A.

4. Andrés, J., J.D. López-Salido and J. Vallés (2006), 'Money in an estimated business cycle model of the euro area', *The Economic Journal*, 116, pp. 457-477.

5. Aoki, K., J. Proudman and G. Vlieghe (2004), 'House prices, consumption, and monetary policy: a financial accelerator approach', *Journal of Financial Intermediation*, 13 (4), pp. 414-435.

6. Asea, P.A. and S.B. Blomberg (1998), 'Lending cycles', *Journal of Econometrics*, 83, pp. 89-128.

7. Bakker, A.F.P. and B.R. Chapple (2002), 'Advanced country experiences with capital account liberalization', *IMF Occassional Paper*, no. 214.

8. Barro, R.J. (1976), 'The loan market, collateral, and rates of interest', *Journal of Money, Credit and Banking*, 8, pp. 439-456.

9. Barro, R.J. (1989), 'The Ricardian approach to budget deficits', *Journal of Economic Perspectives*, 3, pp. 37-54.

10. Barro, R.J. and D.B. Gordon (1983), 'A positive theory of a monetary policy in a natural rate model', *Journal of Political Economy*, 91 (4), pp. 589-610.

11. Batini, N. and A. Yates (2003), 'Hybrid inflation and price level targeting', *Journal of Money, Credit and Banking*, 35 (3).

12. Beranek, W. and R.H. Timberlake (1987), 'The liquidity trap theory: a critique', *Southern Economic Journal*, 84, pp. 387-396.

13. Berg, C. and L. Jonung (1999), 'Pioneering price level targeting: the Swedish experience 1931-1937', *Journal of Monetary Economics*, 43, pp. 525-551.

14. Bernanke, B. (1983), 'Nonmonetary effects of the financial crisis in the propagation of the Great Depression', *American Economic Review*, 73 (3), pp. 257-276.

15. Bernanke, B.S. (1995), 'The macroeconomics of the Great Depression: a comparative approach', *Journal of Money, Credit and Banking*, 27 (1), pp. 1-28.

16. Bernanke, B. and A. Blinder (1992),'The federal funds rate and the channels of monetary policy transmission', *American Economic Review*, 82 (4), pp. 901-921.

17. Bernanke, B.S. and M. Gertler (1989), 'Agency costs, net worth, and business fluctuations', *American Economic Review*, 79, pp. 14-31.

18. Bernanke, B.S. and M. Gertler (1995), 'Inside the black box: the credit channel of monetary policy transmission', *Journal of Economic Perspectives*, 9 (4), pp. 27-48.

19. Bernanke, B.S., M. Gertler and S. Gilchrist (1999), 'The financial accelerator in a quantitative business cycle framework', in: J.B. Taylor and M. Woodford (eds.) (1999), *Handbook of Macroeconomics*, Elsevier Science.

20. Bernanke, B.S. and V.R. Reinhart (2004), 'Conducting monetary policy at very low short-term interest rates', *American Economic Review*, 94 (2), pp. 85-90.

21. Bernheim, B.D. (1987), 'Ricardian equivalence: an evaluation of theory and evidence', *NBER Macroeconomics Annual II*, pp. 263-303.

22. Blinder, A.S. (1998), *Central banking in theory and practice*, MIT Press.

23. Bordo, M., B. Eichengreen, D. Klingebiel, M.S. Martinez-Peria (2001), ‘Is the crisis problem growing more severe?’, *Economic Policy*, April, pp. 53-82.

24. Bordo, M.D. and O. Jeanne (2002), ‘Monetary policy and asset prices: does ’benign neglect’ make sense?’, *International Finance*, 5 (2), pp. 139-164.

25. Borio, C., C. Furfine and Ph. Lowe (2001), ‘Procyclicality of the financial system and financial stability: issues and policy options’, in: Marrying the Macro and Micro Prudential Dimensions of Financial Stability, *BIS Papers*, 1, pp. 1-57.

26. Borio, C. and P. Lowe (2002), ‘Asset prices, financial and monetary stability: exploring the nexus’, BIS Working Paper no. 114.

27. Bronfenbrenner, M. and T. Mayer (1960), ‘Liquidity funcions in the American economy’, *Econometrica*, 28, pp. 810-834.

28. Bronfenbrenner, M. and T. Mayer (1963), ‘Rejoinder to Professor Eisner’, *Econometrica*, 31, pp. 539- 544.

29. Bruggeman, A., P. Donati and A. Warne (2003), ‘Is the demand for euro area M3 stable?’, ECB Working Paper no. 255.

30. Brunner, K. (1971), ‘A survey of selected issues in monetary theory’, *Schweizerische Zeitschrift für Volkswirtschaft und Statistik*, CVII, pp. 1-146.

31. Brunner, K. and A.H. Meltzer (1968), ‘Liquidity traps for money, bank credit, and interest rates’, *Journal of Political Economy*, 76 (1), pp. 1-37.

32. Buiter, W.H. (2000), ‘The new economy and the old monetary economics’, *Bank of England Quarterly Bulletin*, May, pp. 173-183.

33. Buiter, W.H. and N. Panigirtzoglou (2001), ‘Liquidity traps: how to avoid them and how to escape them’, in: W.F.V. Vanthoor and J. Mooij (eds.), *Reflections on economics and econometrics, essays in honour of Martin Fase*, De Nederlandsche Bank, pp. 13-58.

34. Bullard, J. and K. Mitra (2002), ‘Learning about monetary policy rules’, *Journal of Monetary Economics*, 49 (6), pp. 1105-1129.

35. Calomiris, Ch.W. (1993), 'Financial factors in the Great Depression', *Journal of Economic Perspectives*, 7 (2), pp. 63-85.

36. Calvo, G. (1983), 'Staggered price setting in a utility maximizing framework', *Journal of Monetary Economics*, 12, pp. 383-398.

37. Campbell, J.Y. and N.G. Mankiw (1991), 'The response of consumption to income: a cross-country investigation', *European Economic Review*, 35 (4), pp. 723-756.

38. Carlstrom, C. and T. Fuerst (1997), 'Agency costs, net worth, and business fluctuations: a computationable general equilibrium analysis', *American Economic Review*, 87 (5), pp. 893-910.

39. Cecchetti, S. (1988), 'The case of the negative nominal interest rates: new estimates of the term structure of interest rates during the Great Depression', *Journal of Political Economy*, 96 (6).

40. Clarida, R., J. Galí, and M. Gertler (1998), 'Monetary policy rules in practice: some international evidence', *European Economic Review*, pp. 1033-1067.

41. Clarida, R., J. Galí and M. Gertler (1999), 'The science of monetary policy: A New Keynesian perspective', *Journal of Economic Literature*, 37, pp. 1661-1707.

42. Clouse, J., D. Henderson, A. Orphanides, D. Small, and T. Tinsley (2003), 'Monetary policy when interest rates are bounded at zero', *Topics in Macroeconomics*, 3 (1), article 12.

43. Clower, R. (1965), 'The Keynesian counter-revolution: a theoretical appraisal', in: F. Hahn and F. Brechling (eds.), *The Theory of interest rates*, Macmillan.

44. Cogley, T. and J.M. Nason (1995), 'Output dynamics in real business cycle models', *American Economic Review*, 85 (3), pp. 492-511.

45. Davis, E.P. (2003), 'Comparing bear markets, 1973 and 2000', *National Institute Economic Review*, no. 183, pp. 78-89.

46. DeLong, J.B. and L.H. Summers (1986), 'Is increased price flexibility stabilizing?', *American Economic Review*, 76 (5), pp. 1031-1044.

47. Dimand, R.W. (1999), 'Irving Fisher's debt-deflation theory of Great Depressions,' in: H.E. Loef and H.G. Monissen eds. , *The economics of Irving Fisher, reviewing the scientific work of a great economist*, Edward Elgar, pp. 141-156.

48. Dixit, A. and J. Stiglitz (1977), 'Monopolistic competition and optimum product diversity', *American Economic Review*, 67 (3), pp. 297-308.

49. Dotsey, M., and A. Hornstein (2003), 'Should a monetary policymaker look at money?', *Journal of Monetary Economics*, 50, pp. 547-579.

50. ECB, European Central Bank (2003), *The monetary policy of the ECB*, ECB.

51. Edison, H.J. (1993), 'The effectiveness of central bank intervention: A survey of the Literature after 1982', *Princeton Special papers in international economics*, 18.

52. Eggertsson, G.B. (2003), 'How to fight deflation in a liquidity trap: committing to being irresponsible', IMF Working Paper no. 03/64.

53. Eijffinger, S.C.W. (ed.) (1999), *Foreign exchange intervention: objectives and effectiveness*, Edward Elgar.

54. Eisler, R. (1932), *Stable money: the remedy for the economic world crisis: a programme of financial reconstruction*, The Search Publishing Co.

55. Eisner, R. (1963), 'Another look at liquidity preference', *Econometrica*, 31, pp. 531-538.

56. Eisner, R. (1971), 'Non-linear estimates of the liquidity trap', *Econometrica*, 39, pp. 861-864.

57. Estrella, A. and F.S. Mishkin (1998), 'Predicting US recessions: financial variables as leading indicators', *The Review of Economics and Statistics*, 80, pp. 45-61.

58. Fischer, S. (1994), 'The costs and benefits of low inflation', in: J.A.H. de Beaufort Wijnholds, S.C.W. Eijffinger and L.H. Hoogduin eds. , *A framework for monetary stability*, Kluwer Academic Publishers, pp. 31-42.

59. Fisher, I. (1896), 'Appreciation and interest', in: *Publications of the American Economic Association*, XI, Macmillan.

60. Fisher, I. (1932), *Booms and depressions*, Adelphi.

61. Fisher, I. (1933), 'The debt-deflation theory of great depressions', *Econometrica*, 1 (1), pp. 337-357.

62. Friedman, B.M. (1999), 'The future of monetary policy: the central bank as an army with only a signal corps', *International Finance*, 2 (3), pp. 321-338.

63. Friedman, M. (1969), 'The optimum quantity of money', in: *The optimum quantity of money and other essays*, Aldine, Chicago.

64. Friedman, M. and A.J. Schwartz (1963), *A monetary history of the United States 1867-1960*, Princeton University Press.

65. Froot, K.A. and R.A. Thaler (1990), 'Anomalies: foreign exchange', *Journal of Economic Perspectives*, 4, pp. 179-192.

66. Fuhrer, J.C. and B.F. Madigan (1997), 'Monetary policy when interest rates are bounded at zero', *Review of Economics and Statistic*s, 79, November, pp. 573-585.

67. Galí, J. (2003), 'New perspectives on monetary policy, inflation and the business cycle', in: M. Dewatripont, L. Hansen and S. Turnovsky (eds.), *Advances in economics and econometrics III,* Cambridge University Press, pp. 151-197.

68. Gerlach, S., and L.E.O. Svensson (2003), 'Money and inflation in the euro area: a case for monetary indicators?', *Journal of Monetary Economics*, 50, pp. 1649-1672.

69. Gertler, M. and C.S. Lown (1999), 'The information in the high-yield bond spread for the business cycle: evidence and some implications', *Oxford Review of Economic Policy*, 15 (3), pp. 132-150.

70. Gilchrist, S. and E. Zakrajsek (1998), 'The importance of credit for macroeconomic activity: identification through heterogeneity', in: S. Brakman, H. van Ees and S.K Kuipers (eds.), *Market behaviour and macroeconomic modelling*, Macmillan, London, pp. 129-157.

71. Goodfriend, M. (2000), 'Overcoming the zero bound on interest rate policy', *Journal of Money, Credit and Banking*, 32 (4), part 2, pp. 1007-1035.

72. Goodfriend, M. and R.G. King (1997), 'The New Neoclassical synthesis and the role of monetary policy', in: B. Bernanke and J. Rotemberg (eds.), *NBER Macroeconomics Annual*.

73. Greenspan, A. (1989), 'Statements to congress', *Federal Reserve Bulletin*, 75, pp. 272-277.

74. Greenspan, A. (2001), 'Economic developments', speech before the Economic Club of New York, May 24.

75. Greenspan, A. (2001), 'The September 11 tragedy and the response of the financial industry', speech at the American Bankers Association convention, October 23.

76. Greenspan, A. (2002), Testimony of chairman Alan Greenspan before the Committee on the Budget, US Senate, January 24.

77. Hayashi, F. (1982), 'Tobin's marginal q and average q: a Neoclassical interpretation', *Econometrica*, 50, pp. 213-224.

78. Homer, S. (1977), *A history of interest rates*, Rutgers University Press.

79. Hubbard, R.G. (1998), 'Capital market imperfections and investment', *Journal of Economic Literature*, 36, March, pp 193-225.

80. IMF, International Monetary Fund (1999), *World economic outlook*, October.

81. IMF, International Monetary Fund (2003), *World economic outlook*, April.

82. Ireland, P. N. (2001a), 'Sticky-price models of the business cycle: specification and stability', *Journal of Monetary Economics*, 47, pp. 3-18.

83. Ireland, P.N. (2001b), 'The real balance effect', NBER Working Paper no. 8136.

84. Ireland, P.N. (2004), 'Money's role in the monetary businsess cycle', *Journal of Money, Credit and Banking*, 36 (6), pp. 969-984.

85. Jaffee, D. and T. Russell (1976), 'Imperfect information, uncertainty, and credit rationing', *Quarterly Journal of Economics*, 90 (4), pp. 651-666.

86. Johnson, K., D. Small, and R. Tryon (1999), 'Monetary policy and price stability', *Fed Board International Finance Discussion Papers*, 641.

87. Jung, T., Y Teranishi and T. Watanabe (2005), 'Optimal monetary policy at the zero-interest-rate bound', *Journal of Money, Credit, and Banking*, 37 (5), pp. 813-835.

88. Kakes, J.I. and C.A. Ullersma (2005), 'Financial acceleration of booms and busts', DNB Working Paper no. 35.

89. Keynes, J.M. (1923), *A tract on monetary reform*, Macmillan.

90. Keynes, J.M. (1936), *The general theory of employment, interest and money*, Macmillan.

91. Kindleberger, C. (1978), *Manias, panics and crashes*, Cambridge University Press, Cambridge; 2000: 4rd edition.

92. King, M. (1994), 'Debt deflation: theory and evidence', *European Economic Review*, 38, pp. 419-445.

93. King, M. (1999), 'Challenges for monetary policy: new and old', *Bank of England Quarterly Bulletin*, November, pp. 397-415.

94. King, R.G. and A.L. Wolman (1996), 'Inflation targeting in a St. Louis model of the 21st century', *Federal Reserve Bank of St. Louis Review*, 78 (3).

95. Krugman, P.R. (1998), 'It's back: Japan's slump and the return of the liquidity trap', *Brookings Papers on Economic Activity*, 2, pp. 137-205.

96. Krugman, P.R. (1999a), 'Deflation spirals', paper available on the official Paul Krugman website.

97. Krugman, P.R. (1999b), *The return of depression economics*, Norton and Company.

98. Kydland, F.E. and E.C. Prescott (1977), 'Rules rather than discretion: the inconsistency of optimal plans', *Journal of Political Economy*, 85, pp. 473-491.

99. Lerner, A.P. (1952), 'The essential properties of interest and money', Quarterly Journal of Economics, reprinted in: A.P. Lerner 1953 , *Essays in Economic Analysis*, Macmillan, pp. 354-385.

100. Lewis, K. (1995), 'Puzzles in international financial markets', in: G.M. Grossman and K. Rogoff eds., *Handbook of International Economics*, 3, Elsevier Science.

101. Loef, H.E. and H.G. Monissen (eds.) (1999) , *The economics of Irving Fisher, reviewing the scientific work of a great economist*, Edward Elgar.

102. Ludvigson, S. (1998), 'The channel of monetary transmission to demand: evidence from the market for automobile credit', *Journal of Money, Credit and Banking*, 30 (3), pp. 366-383.

103. Ludvigson, S. (1999), 'Consumption and credit: a model of time-varying liquidity constraints', *Review of Economics and Statistics*, 81 (3), pp. 434-447.

104. Malinvaud, E. (1985), *The theory of unemployment reconsidered*, Basil Blackwell, 2nd edition.

105. Mauro, P. (1995), 'Current account surpluses and the interest island in Switzerland', IMF Working Paper no. 95/24.

106. McCallum, B.T. (1983), 'The liquidity trap and the Pigou effect: a dynamic analysis with rational expectations', *Econometrica*, 50, pp. 395-405.

107. McCallum, B.T. (2000), 'Theoretical analysis regarding the zero lower bound on nominal interest rates', *Journal of Money, Credit and Banking*, 32 (4), part 2, pp 870-904.

108. McFarlane, H. and P. Mortimer-Lee (1994), 'Inflation over 300 years', *Bank of England Quarterly Bulletin*, May.

109. McKinnon, R.I. and K. Ohno (2000), The foreign exchange origins of Japan's economic slump and low interest liquidity trap, manuscript, June.

110. Mehrez, G. and D. Kaufmann (1999), 'Transparency, liberalization and financial crises', World Bank Policy Research Working Paper no. 2286.

111. Meijdam, A.C. and M.J. Verhoeven (1998), 'Comparative dynamics in perfect-foresight models', *Computational Economics*, 12, pp. 115-124.

112. Meltzer, A.H. (1963), 'Yet another look at the liquidity trap', *Econometrica*, 31, pp. 545-549.

113. Meltzer, A.H. (1995), 'Monetary credit and other transmission processes: a Monetarist perspective', *Journal of Economic Perspectives*, 9 (4), pp. 49-72.

114. Meltzer, A.H. (1999), 'The transmission process', in: Deutsche Bundesbank, *The monetary transmission process: recent developments and lessons for Europe*, Macmillan.

115. Meyer, L. H. (2001), 'Does money matter?', *Federal Reserve Bank of St. Louis Review,* September/October 2001, pp.1-15.

116. Minsky, H.P. (1982), 'Can it happen again?', *Essays on Instability and Finance*, Armouk.

117. Minsky, H.P. (1982), 'Debt deflation processes in today's institutional environment', *Banco Nazionale del Lavoro Quarterly Review*, 143, pp. 375-393.

118. Mishkin, F.S. (1991), 'Assymmetric information and financial crises: a historical perspective', in: R.G. Hubbard (ed.), *Financial markets and financial crises*, University of Chicago Press, pp. 69-108.

119. Mishkin, F.S. (1996), 'The channels of monetary transmission: lessons for monetary policy', NBER Working Paper no. 5464.

120. Modigliani, F. (1944) , 'Liquidity preference and the theory of interest and money', *Econometrica*,12, pp. 45-88.

121. Mody, A. and M.P. Taylor (2003), 'The high-yield spread as a predictor of real economic activity: evidence of a financial accelerator for the United States', *IMF Staff Papers*, 50 (3), pp. 373-402.

122. Mundell, R.A. (2000), 'A reconciliation of the twentieth century', *American Economic Review*, 90 (3), June, pp. 327-340.

123. Nelson, E. (2002), 'Direct effects of base money on aggregate demand: theory and evidence', *Journal of Monetary Economics*, 49, pp. 687-708.

124. Nelson, E. (2003), 'The future of monetary aggregates in monetary policy analysis', *Journal of Monetary Economics*, 50, pp. 1029-1059.

125. OECD, Organisation for Economic Cooperation and Development (2000), *Economic outlook*, June.

126. Okina, K. (1999), 'Monetary policy under zero inflation', *IMES Discussion Paper*, 99-E-20.

127. Ono, Y. (1994), *Money, interest, and stagnation, dynamic theory and Keynes' Economics*, Clarendon Press.

128. Orphanides, A. and V. Wieland (1998), 'Price stability and monetary policy effectiveness when nominal interest rates are bounded at zero', *Fed Board Finance and Economic Discussion Series.*

129. Patinkin, D. (1965), *Money, interest and prices*, 2nd ed., Harper and Row.

130. Patinkin, D. (1974), 'The role of the liquidity trap in Keynesian Economics', *Banca Nazionale del Lavoro*, 108, pp. 3-11.

131. Pigou, A.C. (1943), 'The Classical stationary state', *Economic Journal*, 53, pp. 343-351.

132. Pigou, A.C. (1947), 'Economic progress in a stable environment', *Economica*, 14, pp. 180-188.

133. Poterba, J. (2000), 'Stock market wealth and consumption', *Journal of Economic Perspectives*, 14, pp. 99-118.

134. Reifschneider, D. and J.C. Williams (2000), 'Three lessons for monetary policy in a low inflation era', *Journal of Money, Credit and Banking*, 32 (4), part 2, pp. 936-966.

135. Roberts, J.M. (2000), 'Estimates of the productivity trend using time-varying parameter techniques', Fed Board, mimeo.

136. Rotemberg, J. and M. Woodford (1997), 'An optimization-based econometric framework for the evaluation of monetary policy', in: B. Bernanke and J. Rotemberg (eds.), *NBER Macroeconomics Annual*.

137. Schumpeter, J. (1934), *Theorie der wirtschaftlichen Entwicklung*, 4. Auflage, Duncker & Humblot.

138. Siebert, H. (2000), 'Japan's policy trap: a European view', *International Economy*, January/February, pp. 31-33.

139. Smets, F. (2003), 'Maintaining price stability: how long is the medium term?', *Journal of Monetary Economics*, 50 (6), pp. 1293-1309.

140. Spitzer, J.J. (1976), 'The demand for money, the liquidity trap, and functional forms', *International Economic Review*, 17, pp. 220-227.

141. Summers, L. (1991), 'How should long-term monetary policy be determined?', *Journal of Money, Credit and Banking*, 23 (3), pp. 625-631.

142. Sutton, G.D. (2002), 'Explaining changes in house prices', *BIS Quarterly Review*, September, pp. 46-55.

143. Svensson, L.E.O. (2000), 'How should monetary policy be conducted in an era of price stability?', NBER Working Paper no. 7516.

144. Svensson, L.E.O. (2001), 'The zero bound in an open economy: a foolproof way of escaping from a liquidity trap', *Bank of Japan Monetary and Economic Studies*, 19 (S-1), pp. 277-312.

145. Swank, J. (2001), 'Comments [to Svensson 2001]', *Bank of Japan Monetary and Economic Studies*, 19 (S-1), pp. 317-319.

146. Taylor, J.B. (2001), 'Low inflation, deflation and policies for further price stability', *Bank of Japan Monetary and Economic Studies*, 19 (S-1), pp. 35-51.

147. Tobin, J. (1975), 'Keynesian models of recession and depression', *American Economic Review*, 65, pp. 195-202.

148. Tobin, J. (1980), *Asset accumulation and economic activity*, Basil Blackwell.

149. Ullersma, C.A. (2002), 'The zero bound on nominal interest rates and monetary policy effectiveness: a survey', *De Economist*, 150 (3), pp. 273-297.

150. Ullersma, C.A. (2004), 'On the emergence of a binding zero lower bound', MEB Series no. 2004-02.

151. Ullersma, C.A., J.M. Berk and B. Chapple (2006), 'Money rules', DNB Working paper no. 96.

152. Ullersma, C.A. and G. Hieminga (2006), 'Note on zero lower bound worries', DNB Working Paper no. 117.

153. US Congress (1935), *Banking Act of 1935*, Hearings before the Committee on Banking and Currency, House of Representatives, US Government printing office.

154. Vickrey, W.S. (1954), 'Stability through inflation', in: K.K. Kurihara (ed.), *Post Keynesian Economics*, Rutgers University Press, pp. 89-122.

155. Viñals, J. (2001), 'Monetary policy issues in a low inflation environment', in: A. García Herrero, V. Gaspar, L. Hoogduin, J. Morgan and B. Winkler (eds.), *Why price stability?*, Druckhaus Thomas Müntzer, pp. 113-157.

156. Walsh, C.E. (2003), *Monetary theory and policy*, 2nd ed., MIT Press.

157. Wolfson, M.H. (1996), 'Irving Fisher's debt-deflation theory: its relevance to current conditions', *Cambridge Journal of Economics*, 20, pp. 315-333.

158. Wolman, A.L. (1998), 'Staggered price setting and the zero bound on nominal interest rates', *Fed Richmond Economic Quarterly*, 84 (4).

159. Woodford, M. (2003), *Interest and prices: foundations of a theory of monetary policy*, Princeton University Press.

160. Yun, T. (1996), 'Nominal price rigidity, money supply endogeneity, and business cycles', *Journal of Monetary Economics*, 37, pp. 345-370.

Samenvatting (Summary in Dutch)

De economieën van de Westerse wereld zijn beland in een situatie met lage en stabiele consumentenprijsinflatie. Centraal bankiers klinkt dit in de oren als het bereiken van het beloofde land, aangezien stabiele koopkracht van het geld (prijsstabiliteit) hun hoofddoel is. Anderen beschouwen de huidige prijsstabiliteit wellicht als een teken dat de macro-economische stabiliteit groter is dan in eerdere decennia. Ondanks deze positieve associaties kent een klimaat met prijsstabiliteit specifieke complicaties.

Ten eerste is de manoeuvreerruimte voor het rentebeleid van de centrale bank in een omgeving met lage en stabiele inflatie kleiner dan in een omgeving van hoge inflatie. Lage inflatie impliceert dat de rentevoet, die ook een compensatie voor de verwachte inflatie bevat, in doorsnee lager is dan in een inflatoir klimaat. Het probleem is dat de centrale bank de monetaire beleidsrente slechts tot nul kan reduceren om de economie te stimuleren. Lagere rentes zijn niet te bereiken, omdat beleggers altijd kunnen investeren in beleggingstitel met een rendement van nul. Dat is immers het rendement dat bankbiljetten (en munten) bieden.

Ten tweede kunnen in een omgeving van lage en stabiele consumentenprijsinflatie grote schommelingen optreden in de prijzen van aandelen en andere vermogenstitels. Eén factor hierbij is dat stabiele macro-economische omstandigheden gunstig zijn voor de groei van financieel vermogen. Tegelijkertijd is de financiële waardering van vermogenstitels gevoelig voor renteveranderingen bij lage renteniveaus. Deze bewegingen in de vermogensprijzen beïnvloeden de economische activiteit. Een andere factor is dat onhoudbare economische expansie in een omgeving van lage en stabiele inflatie langdurig kan aanhouden zonder dat de inflatie stijgt. Dit is het gevolg van groot publiek vertrouwen in het vermogen van de centrale bank om een situatie van prijsstabiliteit te continueren.

Bij gebrek aan signalen dat de economische groei onhoudbaar is, bestaat het gevaar dat te rooskleurige verwachtingen over de economische groei op langere termijn postvatten. Deze verwachtingen zullen zich uiten in onhoudbare koersontwikkelingen van vermogenstitels en in hoge groei van de kredietverlening tijdens de zogeheten *boom*-fase. Dit is des te waarschijnlijker wanneer financiële liberalisering de toegang tot kredietverlening heeft verruimd. Uiteindelijk zal de economische ontwikkeling beleggers tot het inzicht brengen dat de koersen niet in overeenstemming zijn met het onderliggende economische beeld. Dit leidt tot forse koersdalingen tijdens de zogeheten *bust*-fase, en in het verlengde daarvan een minder optimistische beoordeling van de aan kredietverlening verbonden risico's, opwaartse druk op marktrentevoeten en terugvallende economische activiteit.

Dit proefschrift brengt het verschijnsel van de nulvloer van de rente en het verschijnsel van *boom-bust* cycli in vermogensprijzen met elkaar in verband. Een terugkerend thema is dat de monetaire beleidsrente in een omgeving van lage inflatie de rentevloer kan raken na een scherpe daling van vemogensprijzen.

Hoofdstuk 2 biedt een overzicht van de academische literatuur over de rentevloer. Doorgaans heeft een economie die kampt met een nulrente te maken met een algeheel gebrek aan vertrouwen. Vertrouwen speelt een centrale rol omdat economisch gedrag in het algemeen, en bestedingsgedrag in het bijzonder, in belangrijke mate wordt gestuurd door toekomstverwachtingen. Bij gebrek aan vertrouwen leidt versoepeling van het monetaire beleid niet tot extra uitgaven, maar tot het oppotten van middelen. In de literatuur blijft onderbelicht hoe (gebrek aan) vertrouwen een economie in een situatie met een nulrente kan doen belanden, bijvoorbeeld wanneer een crisis op financiële markten optreedt. Niet alleen wordt de marktrente dan opgedreven door hogere risicopremies, waardoor de vraag naar goederen en diensten daalt, maar ook kan de productiecapaciteit dalen, bijvoorbeeld wanneer banken failliet gaan. Zowel lagere bestedingen als lagere productiecapaciteit vragen om reductie van de monetaire beleidsrente, waarbij de nulvloer van de rente geraakt kan worden.

Hoofdstuk 3 borduurt in een theoretisch model voort op de belangrijkste bevindingen in hoofdstuk 2. Het toont modelmatig aan hoe de centrale bank gedwongen kan worden de rente tot nul te verlagen wanneer overoptimistische verwachtingen over het groeipotentieel van de economie bijgesteld worden. Een reductie van de groeivooruitzichten leidt tot lagere koersen van aandelen en andere vermogensbestanddelen, zoals zich bijvoorbeeld voordeed toen de groeiprestaties eind jaren '90 achterbleven bij de verwachting van een Nieuwe Economie. Vermogen wordt gebruikt als onderpand bij kredietverlening. Lagere waardering van het onderpand maakt kredietverlening risicovoller en leidt daarom tot een hogere risico-opslag (risicopremie) bovenop de risicovrije rentevoet, die de centrale bank bepaalt. De stijging van de marktrente remt zowel de economische activiteit als de inflatoire druk af. Omdat de initiële schok wordt versterkt door financiële factoren spreekt men van een financieel acceleratormechanisme. Wegens de bijstelling van het lange-termijn groeipotentieel van de economie daalt bovendien het niveau van de voor de inflatie gecorrigeerde rente waarbij de economische activiteit noch gestimuleerd noch afgeremd wordt (neutrale rente). De centrale bank zal de beleidsrente vervolgens aanzienlijk moeten verlagen om de economische activiteit op peil te houden en prijsstabiliteit te handhaven. Hierbij kan de beleidsrente de nulvloer raken.

Hoofdstuk 4 bevat de uitkomsten van empirisch onderzoek naar financiële acceleratoreffecten die cruciaal zijn voor de versterking van schokken zoals beschreven in hoofdstuk 3. Een klimaat van prijsstabiliteit blijkt *boom-bust* cycli in vermogensprijzen niet te kunnen beletten. Anders dan in de jaren 1970-1986 geldt voor de jaren daarna dat financiële factoren verklarende kracht hebben voor het optreden van scherpe neerwaartse correcties in vermogensprijzen. De resultaten zijn consistent met het optreden van financiële acceleratormechanismen vanaf de tweede helft van de jaren '80, toen financiële markten omvangrijker en geavanceerder werden dankzij liberalisatie. In dit klimaat wordt een reductie in vermogensprijzen in de regel gevolgd door een substantiële daling in de beleidsrente, in overeenstemming met de theoretische bevindingen in het voorgaande hoofdstuk. Hoofdstuk 3 en 4 tezamen suggereren dat de monetaire autoriteiten rekening moeten houden met de accumulatie van financiële onevenwichtigheden, die zich over verscheidene jaren kan uitstrekken. Dit vraagt om een beleidshorizon waarbij de centrale bank enkele jaren vooruit kijkt. Aangezien het ondoenlijk is de omvang van financiële onevenwichtigheden precies vast te stellen, en niemand het moment van de correctie kent, is het verstandig scenario's op te stellen waarbij ook aandacht wordt geschonken aan de kleine kans op uitkomsten met ernstige gevolgen.

Terwijl hoofdstuk 3 en 4 uitgaan van een klimaat van lage en stabiele inflatie in de uitgangssituatie, staat in hoofdstuk 5 juist de keuze van de inflatiedoelstelling van het monetaire beleid centraal. Een hoger niveau van de inflatiedoelstelling mondt uit in hogere (nominale) rentevoeten en biedt de centrale bank dus meer manoeuvreerruimte om de rente te verlagen. Dit voordeel moet de centrale bank afwegen tegen de aan gemiddeld hogere inflatie verbonden kosten. Die kosten vloeien onder andere voort uit het feit dat bedrijven hun prijzen niet voortdurend kunnen aanpassen. Dergelijke prijsrigiditeiten brengen met zich mee dat inflatie gepaard zou gaan met prijsdistorties, zelfs wanneer er zich geen economische schok zou voordoen. In haar afweging wordt de centrale bank geconfronteerd met de complicatie dat zij de inflatiedoelstelling voor lange tijd moet vastleggen, terwijl het gevaar op toekomstige schokken die omvangrijke monetaire versoepeling noodzakelijk maken slecht te beoordelen valt. Wanneer het inflatieregime eenmaal vastligt, kan de centrale bank slechts zo goed mogelijk beleid voeren gegeven dit uitgangspunt. In uitzonderlijke omstandigheden kan dat uitmonden in een monetaire beleidsrente van nul.

De constatering dat een situatie met een monetaire beleidsrente van nul niet kan worden uitgesloten, roept de vraag op of daarmee alle instrumenten voor monetaire stimulering zijn uitgeput. Een mogelijkheid is dat verruiming van de geldhoeveelheid effecten heeft los van haar invloed op de monetaire beleidsrente. Ten eerste genereert een hogere geldhoeveelheid zogeheten vermogenseffecten. Particulieren ervaren een hogere geldhoeveelheid als vermogensgroei, op basis waarvan zij hun bestedingen verhogen. Weliswaar betekent een hogere geldhoeveelheid ook dat de verplichtingen van de centrale bank toenemen, maar hierdoor wordt haar kredietwaardigheid niet aangetast wegens haar vermogen tot geldschepping. Ten tweede leidt een hogere geldhoeveelheid tot betere verhandelbaarheid van vermogenstitels met een lagere liquiditeit dan geld. Daardoor kan de risicopremie voor het aanhouden ervan dalen. Monetair beleid is dan niet alleen bepalend voor de risicovrije rentevoet, maar heeft ook invloed op de risicocomponent van marktrentes. In hoofdstuk 6 blijkt monetair beleid dat rekening houdt met dergelijke effecten tot betere uitkomsten te leiden. De nadruk op de geldhoeveelheid in hoofdstuk 6 sluit de cirkel. Hier ligt de nadruk op de rol die verruiming van de geldhoeveelheid nog kan hebben als het rente-instrument is uitgeput. De geldhoeveelheid, en de daaraan gerelateerde kredietverlening, kan ook bepalend zijn voor de accumulatie van financiële onevenwichtigheden, zoals aan bod kwam in eerdere hoofdstukken.