Monetary Policy and Asset Prices

'an introduction to the literature'

A master's thesis by
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** Expressed views and any errors are solely my own responsibility.*

ABSTRACT

How should monetary policy respond to asset price fluctuations? The vast literature concerning this area of economics does not provide unambiguous recommendations. This thesis serves as a review of the prominent models that analyze the interdependent relationship between monetary policy and asset prices. To increase the readability for novice readers, explanations of contextual key concepts and modelling frameworks are given. The available response strategies recommended by researchers, summarize the different views present in the literature. The thesis offers also a discussion on how monetary authorities in a small, open economy should conduct policy when there are fluctuations in domestic stock prices, domestic real estate prices, and the exchange rate.

Keywords: Monetary policy, inflation targeting, financial stability, asset prices & small, open economy

Supervisors: Associate professor Frode Meland & associate professor Bjørn Sandvik

Acknowledgements

The work on this thesis started January 2007 and it is submitted for the degree M*aster in Economics*. The literature on Asset Prices and Monetary Policy is immense and still growing – the purpose of this thesis is to serve as an introduction and guide for students of this fascinating area of economics.

During my work on this thesis I have faced two main challenges:
The first has been to map the literature - and to select the most important articles. In the search, and in the selection-process, I was fortunate to receive some guidance from special advisor in Norges Bank's Research Department, Q. Farooq Akram. I am grateful for this assistance.

The second challenge was to present and simplify complex models; to show their key features, and the intuition behind these features, in a brief manner. Helpful comments and assistance was given to me by my supervisor, associate professor Frode Meland. Also contributing was my co-supervisor, associate professor Bjørn Sandvik. I am grateful to both.

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University of Bergen - December 1. 2007.

Vegard Børdal

Contents:

FIGURES:

1.0 Introduction

1.1 Motivation

The financial stability of an economy is crucial for its long-run growth. Fluctuations in asset prices may increase the risk of financial instability. Since summer this year, 2007, there have been disturbances in the US stock market, due to the so-called 'sub-prime loans'. If the stock market falls sharply, how will this affect the real economy? Should monetary policy respond to the stock market bust?

Many countries have experienced sharp increases in real estate prices in recent years. If the increase in prices is caused by over-optimistic behaviour, and the prices on property should fall rapidly – could this transmit to the real economy? If so, could monetary policy have been used pre-emptively and responded to the price of real estate by increasing the interest rate?

An immense literature that has yet to establish unambiguous recommendations to monetary policy is obviously an interesting literature. The purpose of this thesis is to review the literature that connects monetary policy to asset prices. Consequently, the challenge is to evaluate which models are of most interest and to present the selected models in a compact and understandable way. This thesis is supposed to serve as an uncomplicated guide – to lead readers through the highlights of a vast and complex literature.

1.2 Structure

The modern monetary policy framework, inflation targeting, has been a success when it comes to providing low, and stable, inflation. By adopting this framework, monetary authorities have improved their economy's growth conditions (Fischer 1993; Judson & Orphanides 1999). A threat to growth, in addition to inflation, is financial instability caused by asset price fluctuations. The second chapter clarifies some of the contextual key concepts, namely inflation, inflation targeting, monetary policy, financial stability, and asset prices. Notation and terms in this chapter are seen throughout the thesis.

The relationship between monetary policy and asset prices is interdependent. The impact of monetary policy on asset prices is presented in this thesis' third chapter. Movements in the

short-term interest rate, both expected and unexpected, can temporarily affect the price of assets. Thus, a depicting of important, and contextual, transmission mechanisms will give readers knowledge of *how* monetary policy can affect asset prices. This chapter also identifies the problems in connection with exogenous bubbles in economic modelling.

Finally, the selected models are presented – both their key-features and the results researchers derive from them. Furthermore, limitations of the models will be given. The models that analyze how monetary policy should respond to asset price fluctuations differ in many ways. For instance, the trade-off between use of theory and data is evident in economic modelling. The fourth chapter addresses this problem when describing modelling frameworks.

The fifth chapter identifies available central bank response strategies to asset price fluctuations. This section summarizes the views of researchers and central bankers. Some evidence on how monetary policy *actually* responds to asset prices is presented, before a brief analysis of official statements from central bankers. The chapter ends with a discussion that attempts to point out what is most important - when it comes to asset price fluctuations - for central banks in small, open economies.

Finally, there will be conclusive thoughts on the questions that need to be addressed: Why is the literature ambiguous when analysing monetary policy and asset prices? And if monetary policy should respond to asset prices, which strategy is most favourable?

1.3 Limitations

The role of credit in financial stability is evident. However, in this thesis, credit will not be thoroughly accounted for. This is due to the fact that credit is not given much weight in large parts of the literature. That is, the role of credit is acknowledged, but in many cases, not analyzed.

2.0 Contextual Key Concepts

This chapter clarifies the content of some important concepts that dominate this thesis. In the literature on 'monetary policy and asset prices', the policy framework of interest is *inflation targeting*. Thus, one of the purposes of this chapter is to make readers familiar with this framework and its properties. First however, there will be short sections on inflation, monetary policy history, and transmission mechanisms.

Readers are also introduced to the financial stability concept. An important dimension of financial instability is asset price volatility. Consequently, asset price volatility is discussed, and the assets that are of interest in this thesis are identified. The last part of this chapter connects asset price fluctuations to modelling of bubbles in the literature that is to be reviewed.

The chapter establishes terminology and notation which is seen throughout the thesis. Thus, it may serve as a reference-chapter for readers.

2.1 Inflation targeting

The history of monetary policy contains both successful and poor regimes. The relatively new approach, inflation targeting, contains elements that needs to be clarified. First, a short and simple definition of inflation is given. A short passage, concerning the link between inflation and growth, follows. Then a break from the main topic; the fact that the history of monetary policy provides a reference point makes room for a summary of some earlier monetary approaches. This short history lesson leads on to an explanation of the main channels through which monetary policy affect the economy. Finally, the main subject of this section enters; the key-features of inflation targeting.

2.1.1 What is inflation?

Inflation is defined commonly as a sustainable increase in the general price level. Romer (2006) provides a similar, straightforward definition: "Inflation is an increase in the average price of goods and services in terms of money".

An equation to describe inflation can be given as

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{2.1}$$

where inflation in period *t*, π_t, equals the difference between the price level at period *t*, P_t, and the price level at *t-1*, P_{t-1}, dived by the price level at period *t-1*. This could be simplified by the use of first order Taylor-approximation, which is a method that is widely used in the literature that will be reviewed in this thesis:

$$\pi_t = p_t - p_{t-1} \tag{2.2}$$

(2.2) depicts that inflation in period *t*, π_t, is given by the difference between the *log* price level in period t, p_t, and the *log* price level in period *t-1*, p_{t-1}.

It is common to refer to the CPI, the Consumer Price Index, when the average price level is quantified. The CPI is a time-series measurement of a weighted average of prices on a specified set of goods and services.[1] The goods and services are specified to compose a market basket. The content of the basket is developed from information gathered from households and individuals in the economy. The numerical material also gives the producer of the CPI, often a government bureau, information on how different content should be given weight.

Inflation can also be expressed by a relation that includes the nominal and real interest rates:

$$\pi_t = r_t - i_t \tag{2.3}$$

The equation above (2.3) is known as the *Fisher-equation*. It says that the inflation, π_t, in period *t*, equals the difference between the real interest rate, r_t, and the nominal interest rate, i_t, both in period t. The Fisher-equation is a well-known relation that will come across several times in this thesis.

[1] Information from Statistics Norway (SSB) and U.S. Department of Labor - Bureau of Labor Statistics

2.1.2 How inflation affects the economy

Judson & Orphanides (1999) imply that there is a clear negative correlation between inflation level and growth. They also imply that inflation *volatility* is negatively correlated with growth. Fischer (1993) also concluded that growth is negatively associated with inflation. He found that this is due to a reduction in both investment and productivity.
Other studies confirm these results, and "there is a consensus in modern economics that low and stable inflation is important for market driven growth" (Bernanke et al. 2001).

Investment, which Fischer (1993) points out as a link between inflation and growth, is just one of many channels through which inflation hampers growth. Nevertheless, this thesis does not focus directly on the effect of inflation, so the key knowledge on how inflation affects the economy is that high inflation, and inflation volatility, should be avoided if market driven growth is the objective. Throughout this thesis, *low and stable* inflation is regarded to be beneficial to an economy.[2]

2.1.3 The history of monetary policy

Inflation targeting is a relatively new approach for monetary authorities and it succeeds a variety of approaches. The different regimes can be divided into two types. One based on convertibility into a commodity, the second type is based on fiat.

The Gold Standard

The gold standard, which was introduced by the Bank of England in 1694, was based on a system where the central bank issued money that was backed by the bank's gold deposit. A person holding English currency could exchange it for gold. This system spread over large parts of the industrialized world and every commodity was valuated in terms of gold.
One of the principal problems with the convertibility system was the risk of conversion attacks (Bordo et al. 1999). Both a situation where major parts of the public wanted to convert money into gold, and a strong foreign demand on the central bank's gold reserves, would lead to a drain, and consequently the system would be subject to distrust.

[2] Note that it is preferred to have low and stable inflation, rather than none. The reason for this is explained in section *2.1.5. How to Understand Inflation Targeting*.

The strength of the system was that it provided a nominal anchor that was relatively stable and that it also encouraged the monetary authorities to follow time-consistent policies; since monetary authorities could not control the stock of gold, the role of monetary authorities was in principle only to establish and guarantee the gold content of their own currency. Despite the fact that the gold standard was reincarnated several times after a collapse in 1914, it lost its credibility and was formally abandoned in 1971.

Bretton Woods

The Bretton Woods system was also of the convertibility type. It is strongly linked to the gold standard: The strongest commercial power in the world, the US, defined its parity in gold, and the other members of the system defined there parity in dollars (Bordo et al. 1999).
Even though it was developed to avoid problems in the interwar period, the system did not see its heyday before 1959. The dollar retained a pole position in the currency market and other countries pegged their currency to the dollar. This system was not sustainable due to several problems, namely adjustment, liquidity and confidence.

Regarding adjustments, the persistence of balance of payments deficit was a concern for the US. Some of the academics and politicians represented a view that sought an adjustment, while others found that this was a result of the rest of the world's demand for dollars. The fact that the dollar was anchored in gold led the monetary authorities into concern in the same manner as regimes under the gold standard; the fear for a conversion attack. There were numerous suggestions on how adjustments could be achieved, the main one was increased liquidity.

The liquidity problem arose in the late 1950s, when there was a shortfall of monetary gold. Because of the confidence problem, increasing amounts of dollars could not be a permanent solution. The confidence problem was the main problem for Bretton Woods. The growth of the world's gold stock had to be sufficient to finance the growth of world output, and to maintain US gold stock. If not, the system would be dynamically unstable.

The gold dollar system, Bretton Woods, collapsed between 1968 and 1971. Expansive monetary policy in the US exacerbated a time of world wide inflation. The lack of price stability in the US, an implicit rule of the regime, led to pressure form French and British politicians to convert dollars into gold. This situation was ended when President Nixon closed

the gold window and ended conversion in 1971. The system had been subject to many speculative attacks, and the lack of price stability in the US led to a situation that could not continue (Bordo et al. 1999).

Floating Exchange Rate

After the collapse of Bretton Woods, the world turned to generalized floating exchange rates in 1973. This system was first influenced by intervention from monetary authorities, so-called dirty float, but in the 1990s it evolved into a system where intervention only occurred when there was a need to smooth fluctuations.

Several European countries pegged their currency to the German D-mark in the European Monetary System (EMS) (1979 – 1992), but due to speculative attacks on countries who adopted inconsistent policies; not suited for a peg policy, led to the collapse of the EMS.

The introduction of floating exchange rates induced more power and independence for monetary authorities. And lessons from the past regimes and progress within academia led monetary authorities to focus on inflation and how to control it.

Over the past decades a new framework for monetary policy has been adopted in many countries. Considering the great costs of inflation, economies wish to achieve low and stable inflation through *inflation targeting*.

2.1.4 Monetary Policy Actions – The Transmission Mechanism

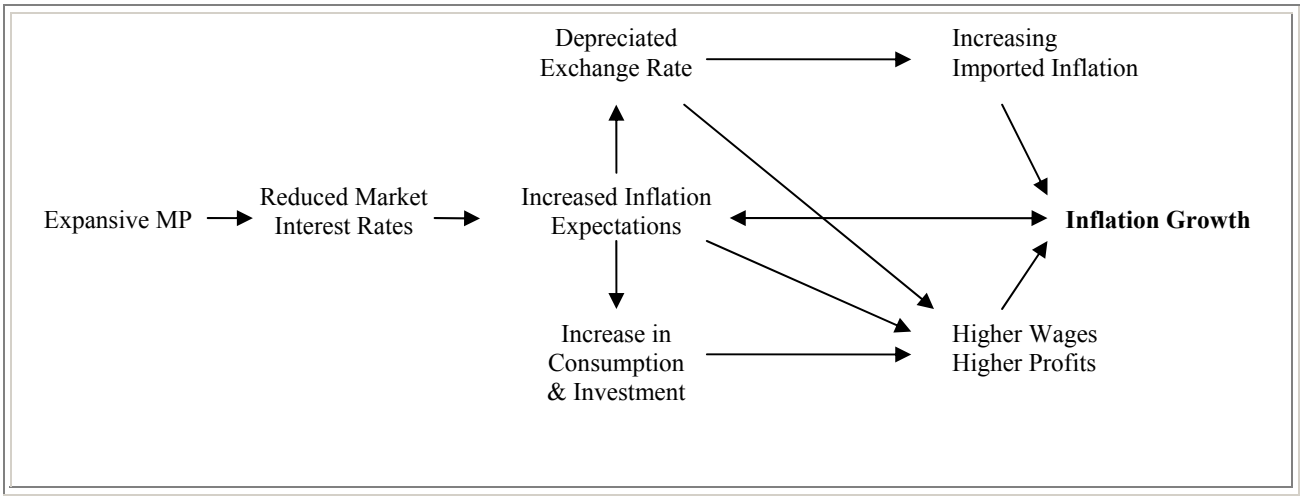
Before a review of vital elements of inflation targeting, it could be fruitful with some illustrations on how monetary policy affect the economy.[3] Changes in the short-term interest rate, the central bank's instrument, affect the economy through many channels. The most important are (Svensson 1997):

Figure 1: The aggregated demand channel

[3] Figure 1, 2 & 3 are modified versions of graphics from www.norges-bank.no.

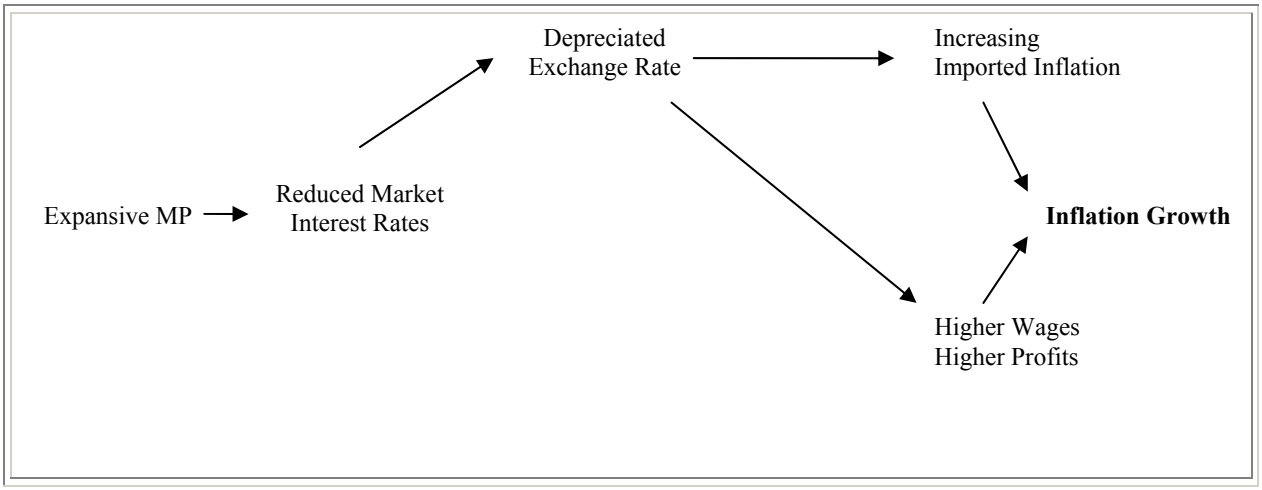
Figure 1 illustrates that a reduction in the short-term interest rate, expansive monetary policy (MP), will lead to an increase in aggregated demand, due to a positive interest rate effect on consumption and investment. The increased aggregated demand affects employment, which leads to increased wages and profits, and therefore inflation. There is only an increase in consumption if a dominating part of the population is net borrowers.

Figure 2: The expectations channel



Unexpected expansive monetary policy leads to a reduction in the market interest rates. This leads to increased inflation expectations. The altered expectations lead to a depreciation of the exchange rate which leads to an increase in the imported inflation; goods and services from abroad gets more expensive. The change in expectations from an expansive monetary policy also leads to an increase in consumption and investment; the price of money is reduced and it gets cheaper to borrow. The increase in aggregated demand drives wages and profits upwards and increase domestic inflation. Note that the increase in inflation expectations has an isolated effect on inflation. If the public expect higher inflation, this will affect wage settlements, which have a substantial effect on prices. Inflation expectations are important for inflation targeting regimes and there will be more on topics associated with expectations in section *2.1.5 How to understand Inflation Targeting*.

Figure 3: The exchange rate channel



The exchange rate channel is essential for small, open economies. It should be stressed that the response to monetary policy action typically comes about faster in this channel than the above mentioned. The reduction in market interest rates, which an expansive monetary policy leads to, is followed by a depreciation of the exchange rate. The depreciation increases the imported inflation. It also increases the demand for domestic goods, which leads to higher wages and profits. Consequently, there is a growth in inflation. A similarity among the inflation targeting countries, at least the first countries that adapted inflation targeting, is that they are *very* open economies. This implies a transmission mechanism with a relatively strong effect on the exchange rate, and that the economy is subject to foreign as well as domestic shocks (Svensson 1997).

The review of models in chapter 4 presents recommended interest rate responses to asset price fluctuations. The effects of interest rate adjustments through the three transmission channels presented above are important to keep in mind. Even tough focus is on asset prices, the effects of interest rate changes transmit through different channels, especially through the demand channel, the expectation channel and the exchange rate channel.

2.1.5 How to understand Inflation Targeting

There have been many attempts on defining inflation targeting and this passage start off with two of these attempts. These definitions are followed by presentations of key elements in the

inflation targeting framework, to introduce readers to the logic of inflation targeting, as well as the terminology.

"Inflation Targeting is a framework for monetary policy characterized by the public announcement of official quantitative targets (or target ranges) for the inflation rate over one or more time horizons, and by explicit acknowledgement that low and stable inflation is monetary policy's primary long-run goal" (Bernanke et al. 2001).

A shorter definition is given by Svensson (2003) who refers to inflation targeting as "a successful stabilization of inflation around a low average level, with some concern for stabilizing output around potential output".

So, the floating exchange rate system is the worldwide regime, though some countries peg their currency to others. A growing proportion of economies within the floating exchange rate system have adopted inflation targeting. This is due to the fact that inflation targeting has been a success for the pioneer countries; therefore it has proven to be a superior framework if low and stable inflation is the main concern.

Inflation targeting regimes differs by having an inflation target, e.g. two percent, or a target range, e.g. one to three percent. The mean of a target range will in most cases be equivalent to a target. One of the reasons why the target, or the mean of a target range, is above zero percent is the fear of deflation.[4] Central bankers have to make sure that deflation is avoided in times when inflation is below target. Thus, a positive target makes room for actions before a deflation-scenario is seen.

Rules vs. Discretion

There is a spectrum of different strategies for monetary policy; the poles are known as ruled-based strategy and discretion-based strategy. McCallum & John (1999) describe *discretion* as "period-by-period re-optimization on the part of the monetary policy", whereas a *rule* "calls for period-by-period implementation of a contingency that has been selected to be generally applicable for an indefinitely large number of decision periods". The first inflation targeting

[4] *Deflation* is a decrease in the general price-level over time; the opposite of inflation.

definition given above is clear on the fact that inflation targeting is a *framework* and Bernanke et al. (2001) emphasize that inflation targeting is neither a rule- nor a discretion-based regime.

However, there is an ongoing discussion in the academic world connected to the trade-off between discretion and rules. Perhaps the most well-known rule connected to inflation targeting is the *Taylor-rule*:

$$i_t = \pi_t + r^* + \beta(\pi_t - \pi^*) + \alpha(y_t - y^*) \tag{2.4}$$

The short-term interest rate, i_t, equals the sum of: This periods inflation, π_t, the equilibrium level of the central banks real interest rate, r^*, the difference between this periods inflation rate and the inflation target, multiplied with a coefficient $\beta(\pi_t - \pi^*)$, and the output gap multiplied with a coefficient, $\alpha(y_t - y^*)$. The output gap is measured as the difference between this period's output, y_t, and potential output, y^*.

The rule calls for an increase in the short term interest rate when inflation is above target, or output is above its natural rate, and a decrease when opposite conditions appear.
To illustrate, a short and stylized example, using Taylor's assumptions, follows.
Taylor assumed that the equilibrium real interest rate was equal to the inflation target, and that their numerical value was two percent. He also assumed that the central bank would equally weight the inflation gap and the output gap:

$$i_t = \pi_t + 2 + 0.5(\pi_t - 2) + 0.5(y_t - y^*) \tag{2.5}$$

Assuming a situation where the output gap equals zero, that is, production equals the trend value, and a 3 percent inflation rate, the Taylor-rule "recommends" a short-term interest rate of 5.5 percent.

The standard Taylor-rule can also be *forward-looking*, where expected levels of inflation and output are incorporated, as well as *backward-looking*, which incorporates observed levels of inflation and output. Researchers use both in the literature of monetary policy and asset prices. In this thesis the *augmented Taylor-rules* are especially of interest; Taylor-rules that

incorporate a new variable that represents the price of an asset. Augmented Taylor-rules are seen throughout the thesis.

A *loss-function* describes the disutility of the central bank. Under a discretion-based strategy, monetary policy action seeks to minimize the central bank disutility. In this example, (2.6), and most often, it is quadratic in the deviation of inflation from target *and* the output-gap. The quadratic form leads to a higher disutility when there is a high deviation in either inflation or productivity, compared to a situation where there is a low deviation from targets in both variables.

$$L(\pi, y) = \frac{1}{2}\left[(\pi - \pi^*)^2 + \lambda(y - y^*)^2\right], \ \lambda > 0 \tag{2.6}$$

There is a connection between the Taylor-rule and the central bank's loss-function; since both capture that central banks have to consider both inflation, and the production gap.[5] The production gap is connected to the unemployment rate; therefore monetary policy has been given the responsibility of providing a policy where both inflation and the production gap are considered.

Most models in the literature of monetary policy and asset prices have a loss function that measure the success of the policy conducted by the central bank. These loss functions take different forms, but most focus on the level, and variability, of inflation and output. Readers will observe that monetary policy modelled in research, often conducts a rule-based strategy. However, the success of the policy is often measured by a loss-function.

The coefficient lambda, λ, represents the central banks weight on the output gap. Two policies that are of interest in this context are called *strict inflation targeting* and *flexible inflation targeting*. The next paragraphs discuss these policies.

[5] The loss-function is also known as the central bank's objective function.

Strict Inflation Targeting vs. Flexible Inflation Targeting

When lambda is equal to zero in the above loss function, (2.6), the policy is called *strict inflation targeting*. A central bank dedicated to this policy focus on keeping inflation as close to the target as possible. A policy like this requires a very activist central bank, which implies dramatic changes in the interest rate and the exchange rate (Svensson 1997). Although this policy might provide a stable inflation rate, the negative consequences of fluctuations in output, employment, the exchange rate and the interest rate, would outdistance the value of a stable inflation rate. Consequently, no central bank conducts such a policy.

Svensson's inflation targeting definition refers to *flexible inflation targeting* as a policy with "some concern for stabilizing output around potential output". This definition rules out a lambda equal to zero, and central bankers conducting this policy will evaluate both the productivity situation, and the inflation situation. This is the policy economies with inflation targeting central banks have adopted. It implies gradual adjustments if inflation deviate from the target. Gradual to ensure that other important macroeconomic factors, such as output, employment and the exchange rate, do not fluctuate immensely. The policy allows inflation deviations from the target (range) to last longer than a policy that only focuses on inflation.

Both *flexible* and *strict* inflation targeting regimes provide stability when a demand shock occurs. However, when there is a negative supply shock, strict inflation targeting aggravates the negative situation. An example, to illustrate, is given by Svensson (1997):

An increase in the oil price would lead to a negative supply shock for an oil-importing country. This implies higher inflation and lower productivity. A strict policy would add to the fall in output and employment, whereas a flexible policy would cushion the decline, by gradually bringing inflation down.

Inline with actual practice, in the recent literature on asset prices and monetary policy it is usually assumed that central banks conduct flexible inflation targeting.

Accountability, Time-Consistency & Transparency

The independence that monetary authorities have been given the last decades implies a responsibility, and to some extent accountability. The countries that have adopted inflation targeting have different guidelines for the accountability of the central bank. In New Zealand,

the central bank Governor may be relieved if inflation deviates from the inflation target range. Recently, the Governor of the Bank of England had to answer to parliament after a period of growing inflation. Thus, accountability serves as an incentive for the central bank authorities.

A related topic, which has been frequently discussed in the literature, is the time-consistency problem. The central bank could, despite a focus on providing low inflation, have an incentive to increase the level of inflation above its target; high productivity and low unemployment is always popular. This scenario is possible to pursue because wages and several other input-prices are fixed by contract. An increased inflation, above expectations, will therefore lead to higher productivity and profits, and lower unemployment. But are these short-run gains obtainable?

Kydland & Prescott (1977) concluded that it was unlikely to believe that the central bank could fool people and firms in a consistent manner. The rationality of the public would lead to an understanding of the central bank's incentives and therefore higher inflation expectations, leading to a state where only inflation is higher, not the output. Milton Friedman (1977) concluded that "*there is no long run trade-off between inflation and unemployment*". Due to the fact that inflation is negatively associated with growth, such a relationship would be opposite of what an opportunistic central bank would wish for. The time-inconsistency problem is related to the central bank's communication; people's trust in the central bank is strengthened by a policy in line with the communication.

If a central bank pursues a stabilization of an asset market through interest rate operations this may compromise the perceived time-consistency of monetary policy. Thus, one may argue that a response to asset prices must be systematic to remain credibility in the public. The time-consistency problem is indeed something to reflect on when assessing different responses to asset price fluctuations.

Transparency is connected to the openness of the central bank. A primary object for the central bank should be to make sure that the public knows what the inflation target is and how it is provided. If one consider the above loss function, should the central bank communicate how much weight they put on output-stabilization? There is uncertainty connected to the data upon which the central bank makes its decisions. Should all forecasts be available for the public?

Several topics are connected to transparency and there are differences in the degree of transparency shown by inflation targeting central banks. By sharing information the public will not be surprised and the central bank can control the expectation channel. However, if the weight on output-stabilization differs from one period to another period, or inflation forecasts are too uncertain, this could affect the central banks credibility and reduce the control over the expectation channel.

Transparency is clearly problematic in this context. A central bank that suggests that an asset market is overpriced will lose credibility if the prices are based on fundamentals. Thus, when the central bank shares its perception of an asset market, the central bank takes a risk where credibility is at stake. Readers of this thesis will see this transparency-problem throughout the paper.[6]

2.2 Financial Stability and Asset Price Volatility

In this thesis, the literature that explores how monetary policy should respond to fluctuations in asset prices is reviewed. The reason for monetary policy to react to asset price fluctuations is that it may lead to financial instability. The next sections will discuss financial stability, asset prices, and bubbles in asset markets – so that readers are familiar with these concepts.

2.2.1 Defining Financial Stability: Mission Impossible

Authors have tried to define Financial Stability for quite some time, but have not been able to provide a generally accepted definition. In the following some of the suggested definitions will be presented and partially discussed.

Many authors find it more convenient to focus on financial *in*stability, the counterpart of financial stability. Perhaps the most famous of these approaches is the "Financial Instability Hypothesis" (Minsky 1992). The hypothesis can be described as by the author himself:*" an interpretation of the substance of Keynes's "General Theory"*. In a capitalist economy - characterized by extensive capital assets and a complex, sophisticated, financial system - periods with prolonged prosperity will "stir" the financial structure. The hypothesis contradicts Walras and Smiths equilibrium-approaches. Instead of always seeking an

[6] For instance, the discussion between Bernanke & Gertler and Cecchetti et al. should be read with transparency in mind. This is located in chapter 4 under the title "Bernanke & Gertler vs. Cecchetti et al".

equilibrium, the economy from time to time exhibit reactions "that seem to have the potential to spin out of control". As time passes after a financial crisis there are behavioural changes that reduce the financial system's ability to withstand shocks without sustaining a rupture. Thus, the likelihood of a financial crisis increases in time (Friedman & Laibson 1989). In short, the overoptimistic behaviour of economic agents leads to financial instability.

Crockett (1997) presented a definition which says that financial stability requires "(i) that the key *institutions* in the financial system are stable, in that there is a high degree of confidence that they can continue to meet their contractual obligations without interruption or outside assistance; and (ii) that the key *markets* are stable, in that participants can confidently transact in them at prices that reflect fundamental forces and that do not vary substantially over short periods when there have been no changes in fundamentals".
This definition divides the problem concerning financial stability. The interpretation of the first italicized word, *institutions*, is essential. Crockett points out, of course, that banks are the key institutions of the financial system. Stability requires banks with a high degree of liquidity. Their assets are often illiquid compared to the liquidity their customers demands. Thus, the confidence in the banking system, and its ability to meet liabilities, is of great importance.

It is also to be noted that bank and credit institutions (in collaboration with the central bank) are responsible for the payment system in the economy. Unquestionably, that there will be severe injuries in the economy, if a breakdown in the payment system should occur. Banks are special since they compose such a great part of the financial system - this increasing the risk of major contagion. Thus, if banks go bankrupt it is likely that this will affect the real economy.

The second part of Crockett's definition concerns the stability of key markets. He points out the financial and asset markets to be the most important markets in this context. This, since they "have the largest capacity to cause wider economic damage". Put differently, fluctuations in the financial and asset markets have a stronger effect on macroeconomic variables than fluctuations in prices in the markets for goods and services.

The definition given by Crockett (1997) connects financial stability to credit. The importance of credit is evident when assessing the risk of financial instability. If borrowers go bankrupt,

and this is followed by a series of banks being insolvent, the risk of financial instability is clearly increased.

The "creative destruction" theory presented by Schumpeter platform a different angle. A one-sentence summary of the "creative destruction"-theory could simply be put as "a new thing kills an old one". This connects inventions with instability, since the "old things" actually are unsuccessful firms. This was indeed a popular theory during the *dotcom* boom from the late '90s to its bust early 2000. Many authors have discussed the connection between *creative destruction* and financial *in*stability. Crockett (2002) remarks that financial instability "…may well be a part of the price to pay for the undoubted long-run economic benefits of a free-market economic system". In the same manner Issing (2003) points out that "…large swings in asset prices possibly leading to some failures of monetary and financial institutions in the aftermath of a large real or financial shock could even be a sign of stability and of self-purifying powers of the system".

If competition in the finance markets worked efficiently, a direct effect of this could be financial instability (Allen & Gale 2004). However regulations that are counter efficient (for instance entry-barriers), and the fact that there is a strong concentration in these markets, reduce the probability of creative destruction (More on regulations in section 5.4 Regulations). It is to be noted that there is an ongoing discussion on whether there exist a trade-off between competition and financial stability in finance markets. The quest for efficiency is obvious, but there are strong arguments in favour of interventions. "If we wish to prevent regulators from fighting financial crises by reducing competition in normal times, we need to ensure that they have in place effective procedures to mitigate crises when they do arise"(Kahn 2004).

Many of the definitions above, and others, have been objective to criticism, or at least critic discussions, in articles focusing on financial stability definitions (Allen & Wood 2006; Bårdsen et al. 2006). Nevertheless they provide a fundamental understanding of the concept. In this thesis, there will be no definition proposal. The definitions discussed above should form a general idea of what financial stability is to be understood as.

2.2.2 Asset Price Volatility

An important dimension of financial stability is volatility of asset prices (Bernanke & Gertler 2000). There are different approaches to the measurement of volatility. Typically it refers to the square root of the variance of a variable (Engle 2004). Thus, the standard deviation of an asset price is a measure of its volatility. This approach clearly does not give much information due to the fact that asset prices change over time. The need for a measurement that includes time is apparent, and one of the approaches is known as *historical volatility*. Even though there are obvious challenges, like deciding how long (or short) the time period should be, this method is widely used.

However, the asset markets exhibit a high degree of volatility due to the nature of the assets traded. The fact that assets are durable is what separates it from goods and services. Computers, cars and toothbrushes eventually get outdated, whereas financial assets, such as stocks, do not. In addition, assets can be stored at a very low, often negligible cost, and tend to be traded on large markets without face-to-face contact between participants. Furthermore, assets are traded in stocks, whereas goods and services are traded in flows. So, the whole stock of assets can be dumped on the market, at very short notice, if the owners so desire (Burda & Wyplosz 2005).

In this context there are three types of asset prices that are of interest, taking debt instruments as given:

Stock market prices
Real estate prices
Exchange rates (Currency prices).

The literature refers to asset price volatility as price fluctuations in the corresponding markets: The stock market(s), the real estate market(s) and the foreign exchange market(s). As mentioned, these markets *do* exhibit a high degree of volatility. So when the literature refers to fluctuations in these markets, it is often to be understood as bubble-conditions. That is, sharp increase (decrease) in asset prices, which is not based on the fundamental value of the asset.

The real estate market can be separated into two; commercial property and residential property. Stocks of firms holding commercial property can be traded on the stock market.

Thus, commercial property can be traded directly in the real estate market, or indirectly in the stock market. Note however, the market for real-estate varies from country to country due to regulations.

The trade of foreign exchange, on an average day in the foreign exchange market, is estimated to be worth approximately 1.2 trillion dollars. This represents 15% of the annual GDP of both the United States and Europe (Burda & Wyplosz 2005). This implies that the market for foreign exchange is well-organized and that large quantities can be traded in short time. This is similar to the stock market; well-organized and with a vast trading-capacity.

As discussed under the graphic presentation of the exchange rate channel above: Exchange rates are special in this context; the dependency between monetary policy and the exchange rate is stronger than it is between monetary policy and real estate prices and stock prices.[7] A change in the interest rate leads to an immediate reaction in the exchange rate market, a reaction that can not be said to be representative for real estate markets or stock markets. For this reason, some parts of the literature separate asset prices and exchange rates.

2.2.3 Bubbles in Asset Markets

Before reviewing large parts of the literature, it could be useful to go through some theories and facts about bubbles.

Identifying bubbles

One of the difficulties connected to bubbles in asset markets are that they are difficult to observe before a burst. In the stock market, for example, one has to know the fundamental value of firms to identify bubbles. In a Walrasian world, the stock price represents the fundamental value. In a world where over-optimistic behaviour may occur, the stock price might be much higher than what is justified by fundamentals.

Central bankers might ask how they are better suited to identifying a bubble in the stock market, when there are numerous specialists that analyse the values of firms on a daily basis. Which information, if any, do the central bank possess that the market participants do not possess? One can argue that the central bank is an outsider to the stock market, and might

[7] Especially in small, open economies.

therefore not be infected by the irrationality that is present in a stock market where a bubble exists. Nevertheless, it is clear that identifying bubbles, in any asset markets, is difficult.

Borio & Lowe (2002) develops one method where asset prices and credit are incorporated; where large deviations from trends indicate a bubble.[8] The role of credit is obviously essential when analyzing financial instability. However, this thesis concentrates on the models that studies asset price fluctuations.

In the literature on asset prices and monetary policy bubbles are assumed. That is, there is no need to identify them since they are part of the assumptions. However, the assumed bubbles are incorporated with use of different techniques. The most important differences will be presented in the following paragraphs.

Different kinds of bubbles

Bubbles come in various forms, in the real world and in the models that are to be reviewed. For instance, the burst of a bubble in the stock market leads to an immediate response in the respective market, whereas a burst of a bubble in the real estate market may first lead to a rise in the number of properties for sale before prices fall. The different reactions could be explained by a lower information-frequency; stock prices are updated constantly, whereas real estate prices are updated less frequently. One can also discuss the difference in proficiency between agents in these markets. Traders of stocks are most often specialists with suited education, whereas house buyers and house sellers in general take part in real estate transaction a few times during their lifetimes.

A *deterministic bubble* is modelled with no uncertainty; in the time periods during which the bubble develops and the time it bursts are known to all with a probability of one. This stands in contrast to a *stochastic bubble*, which is modelled with uncertainty. When a bubble is *exogenous*, the component of the asset price that composes the bubble can not be affected by monetary policy (Roubini 2006), whereas an endogenous bubble will be affected by monetary policy.

[8] Ex-post identification is obviously easier to develop. See e.g. Bordo & Jeanne (2002).

In chapter four, where models from the literature is presented, readers will observe that bubbles have different properties in the selected models, and it will be questioned if these differences may affect the results of simulations/computations.

2.3 Recapitulation

Empirical evidence shows that inflation hampers growth. Both academics and practicians agree that the monetary policy framework that is best suited to control inflation is *inflation targeting*. This monetary policy framework succeeds a number of frameworks that did not provide sustainable growth conditions.

The literature identifies two alternatives within inflation targeting – *strict* and *flexible* inflation targeting. The operable alternative for central banks is flexible inflation targeting, where the output-gap is considered when setting the interest rate – in addition to inflation. Readers will see that most researchers model monetary policy as a flexible inflation targeting regime. Inflation targeting is also associated with *rules* and *discretion*. The literature seems to find rules more systematic, and thus, more capable of preserving the central bank's credibility. Therefore, rules similar to the Taylor-rule accounted for in this chapter will be seen, and discussed throughout the thesis.[9]

The most important channels, through which monetary policy affects the economy, are depicted in section 2.1.4. These should be kept in mind when potential interest rate responses to asset price fluctuations are considered. The effect of an interest rate response can not be isolated. Thus, reacting to an asset price affects the economic performance.

In this thesis, financial instability caused by asset price volatility is in focus. This phenomenon is usually investigated in economics by incorporating asset price 'bubbles' in various models. Thus, the concepts clarified in chapter 2 will come across all the way through this thesis.

[9] The success of the rules is often measured by loss-functions similar to the one depicted in section 2.1.5.

3.0 The impact of Monetary Policy on Asset Prices

Chapter 2 includes simple illustrations of how monetary policy actions affect the economy through the "most important" channels. In this thesis however, the focus is on asset prices. The relation between asset prices and monetary policy is interdependent. The literature, that is to be presented in this thesis, focuses mainly on how asset prices affect monetary policy. Still, the impact of monetary policy on asset prices should also be accounted for – as well as the real economic reactions to changes in asset prices.

First, the main points in Mishkin (1995), which discusses the monetary transmission mechanism, will be given. As before, the channels will be divided into three; stock market prices, real estate prices and exchange rates. Then follow some paragraphs on quantification of the effect monetary policy has on stock prices.

3.1 Stock Market Prices

Stock market prices are affected by monetary policy in several ways. Below, some effects from the monetary transmission mechanisms are briefly discussed.

An unexpected increase of the interest rate will generally lower the price on a firm's stock. This is, for instance, caused by the reduction in future cash flows(C): the discount rate (r) is increased leading to lower present value (PV) of the firm. A simple equation to illustrate this could be expressed with:

$$PV(C,r) = \sum \frac{C_t}{(1+r)^t} \tag{3.1}$$

Contractive monetary policy (M↓) leads to a reduction in stock prices (P_s), especially when it is unanticipated, which reduces Tobin's Q (q), which reduces investment (I), and as a result also aggregated demand and output (Y).[10] The logic this is based upon is that the reduction in

[10] Tobin's Q is defined as the market value of firms divided by the replacement cost of capital. For more on Tobin's Q: Hayashi, Fumio (1982).

stock prices, and the corresponding reduction in Tobin's Q, leads to a situation where it is cheaper to buy other companies, and acquire their production facilities, than to build new plants. Investments will be lower and therefore also output. As the chart below illustrates, this leads to lower investments:

The size of a firm's Net Worth matters in a credit market with moral hazard and adverse selection problems.[11] A firm with low net worth will find it hard to receive the required amount of finance in a credit market with incentive problems. An increase in the interest rate lowers the value of a firm's stock portfolio, the value of its collateral, and increases the value of outstanding debt obligations (if the debt interest rate is not fixed). These effects reduce net worth, which consequently lowers investment and thus output. This is called the *balance-sheet effect*. It is central in the work of Bernanke & Gertler (e.g. 2000) which will be reviewed in chapter 4.

The balance-sheet effect also concerns households. Households' durables and housing are very illiquid assets. This is due to the fact that there is asymmetric information between lender and borrower when it comes to these assets' condition. If a borrower defaults and, for instance, she is forced to sell her house in a limited amount of time, there is a smaller chance of getting market price compared to a situation where time is less scarce. Thus, holding a large proportion of liquid assets, such as stocks, bonds and currency, will reduce the risk of financial distress. A contractive policy will reduce the value of some of households' liquid assets, such as stocks, and increase the likelihood of financial distress. This leads to a decrease in consumer durable expenditure, because of the more insecure financial situation. Furthermore, it leads to a reduction in aggregated demand.

3.2 Real Estate Prices

Monetary policy affects the real estate prices, which again affect the macroeconomy.
A contractive policy, an increase in the interest rate, will raise the cost of financing houses. This affects the real estate market negatively by lowering prices. The decrease in prices makes

[11] *Net worth* could be defined as a firm's liquid assets, plus collateral value of illiquid assets, less outstanding obligations. More on this in section *4.4.1 The Bernanke & Gertler (2000)-model.*

it relatively cheaper to buy old houses, compared to building new ones.[12] This leads to a fall in real estate investments, which leads to a fall in aggregated demand.

Due to the fact that a large proportion of consumers own, or partially own, real estate, prices in this market are of great importance. A fall in the real estate market will negatively affect a household's wealth, which reduce consumption and therefore output.

Banks are the most important intermediary of credit to households and firms. A substantial part of the credit that is given by banks is collateralized through real estate. It is obvious that a rise in real estate prices would lead to lower losses if borrowers default. Banks increase their capital, which gives them the opportunity to lend more. And thus, investment and output will rise.

Obviously, a fall in prices may increase losses for intermediaries such as banks. As discussed under Financial Stability in Chapter 2 – large losses for financial intermediaries may lead to financial instability.

3.3 Exchange rates

As stated in chapter 2: Exchange rates are very important to small, open economies. Fluctuations in the exchange rate could have a major impact on inflation and also the ability to compete on international markets. The effect of monetary policy on exchange rates affects the economy primarily through two types of mechanisms.

Assuming a positive relationship between the interest rate and the exchange rate, contractive monetary policy will lead to an increase in the exchange rate, which weakens the economy's ability to compete internationally. This lowers both net exports and output. Thus, for small, open economies, the exchange rate is extremely important.

Expansive monetary policy affects balance-sheets of firms with a large amount of debt in foreign currency. The reduction in the interest rate leads to a depreciation of the domestic currency, and thus increase the debt-burden of these firms. Net worth is reduced, resulting in a

[12] Notice the link to Tobin's Q.

decrease in lending as discussed above. Of course, there is an opposite scenario: Where firms with large deposits (claims) in foreign currency find their net worth increased.

A presentation of the work of Batini & Nelson (2000), which investigates monetary policy response to exchange rate fluctuations, can be found in chapter 4.

3.4 Quantification of the effect Monetary Policy has on Asset Prices

The research in this field is dominated by work on how stock market prices react to shocks in monetary policy (unexpected interest rate changes). The following paragraphs will briefly discuss how this effect is measured and the results of some of the research. Some theories on why the market reacts will be offered.

The methods used when estimating the impact monetary policy has on the stock market are within the econometric modelling framework called VAR.[13] The most common method is the *event-study approach.* This is a regression of daily changes in market interest rates on changes in the central bank's interest rate. The sample consists of dates where the federal funds rate changed. There are numerous studies applying this approach, or a modified version of it.

A different approach was developed by Rigobon & Sack (2002). They introduced a heteroskedasticity-based estimator that identifies the increase in the variance on days that the FOMC had meetings.[14] This estimator is then implemented as an instrument variable in the regression.

Bernanke & Kuttner (2005) emphasize that the event-study approach does not measure anticipated monetary policy. Only reactions to unexpected changes in the short-term interest rate are measured. It should also be clear that monetary policy only explains a small portion of the overall variability of stock prices. However, using the event-study approach Bernanke & Kuttner (2005) find that, on average, a hypothetical and unexpected decrease in the Federal funds rate of 25 basis-points (0,25%), leads to a one percent increase in broad stock indexes. They confirmed the work of Thorbecke (1997), who also used the event-study technique, and

[13] Vector Auto Regression - An econometric modelling framework - More on VARs in chapter 4.
[14] The Federal Open Market Committee, a component of the Federal Reserve System, the US central bank.

concluded that monetary policy indeed affects stock market *returns*, implying that stock prices are affected.
Rigobon & Sack (2002), mentioned earlier, found that an increase of 25 basis-points in the short-term interest rate leads to a decline in both the S&P 500 index (1.9%) and the NASDAQ index (2.5%).[15,16]

There are many obstacles when it comes to estimating the impact of monetary policy on asset prices. Even though the results presented indicates that monetary policy affects stock market prices, it should be noted that a concrete measurement of the effect should be carefully absorbed. The fact that the effect is relatively modest should also be noted. With that in mind, the above effects are related to the properties of the bubbles modelled in the literature.[17] Research states that monetary policy affects asset prices, thus to model exogenous bubbles is not optimal. Additionally, the link between interest rate movements and credit is indeed central. The larger is the interest rate; the lower is the demand for finance. As stated earlier, credit is not subject to analysis in this thesis. However, the central part of credit should always be kept in mind when analyzing monetary policy response to asset prices.

[15] S&P 500 is an index containing stocks of 500 firms, most of them American, with a market value above 10 billion dollars.
[16] On average the largest stock market in the US (measured in firms noted and daily transactions).
[17] See section 2.2.3 *Bubbles in Asset Markets*

4.0 Models and Modelling Frameworks

"Models identify particular features of reality and study their consequences in isolation. They thereby allow us to see clearly how different elements of the economy interact and what their implications are" (Romer 2006). Models simplify the actual economy and omit several features. However, the purpose of models is to answer questions about *particular* features of the actual economy.

In this chapter, the prominent models of the 'monetary policy and asset prices' literature will be reviewed. Chapter 3 explained how asset prices are affected by monetary policy – this chapter focuses on how researchers find that monetary policy should respond to asset prices, according to their analysis.

The review of models will be done in the following manner: First, a general overview of the trade-off between data and theory is given. The modelling frameworks of interest to this thesis will be placed in a chart that illustrates their use of data and theory. Then follows a brief presentation of the real business cycle framework, due to its influence on other frameworks. The vector autoregression framework is also briefly presented, due to the fact that some empirical evidence in this thesis is derived from models within this framework.

Then, a presentation of dynamic stochastic general equilibrium models, with a general critique. Within this framework there are two models that are interesting in the context of this paper. These models will be presented as well as some of their limitations. Next are the dynamic aggregative estimated models. One of the models within this framework is reviewed. The last framework will be labelled 'theoretical models'. Two models from this framework are presented.

The models that are reviewed are chosen because of their influence on the literature.

4.1 Theory vs. Data

There is a variety of modelling frameworks. Some are primarily based on the first principles; the theories on which economics is based. Others are primarily based on data; real observations from the real economy. Between these poles there are model frameworks that

combine use of theory and data. The figure below illustrates the trade-off between theory and data, with a positioning of the frameworks that are to be explained below.

Figure 4: Pagan classification chart

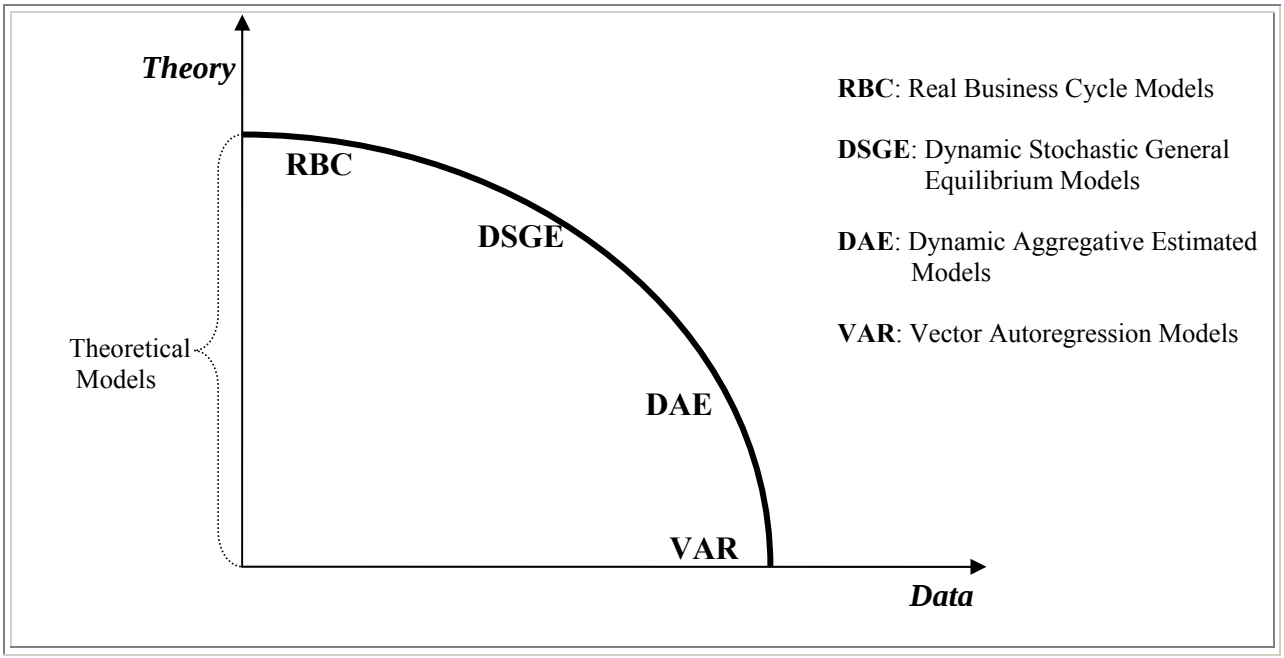


Figure 4 was introduced by Pagan (2003) in a context where he illustrated the coherency of different model frameworks. This is a modified version of his illustration, only displaying the model-frameworks that are of interest in this context. Obviously, models within the same framework varies in the use of theory and data, however the Pagan classification system may serve as a rough guide.

The trade-off-problem is articulated by Bårdsen et al. (2006): "Direct translation of theoretical relationships to econometric specifications is likely to lead to misspecified models with inefficient estimates and unnecessary bad forecasts. On the other hand, models without due attention to relevant theory is needed to get a clear interpretation of estimation results and of model properties".

So, theory-oriented models are usually based on calibration, whereas data-oriented models are based on estimates. Romer (2006) points out two potential advantages with calibration: First, due to the fact that parameters are selected on the basis of microeconomic evidence, a large

body of information, beyond the usually employed, can be incorporated into the model. Second, he points out the fact that statistical rejection, or lack of rejection, is often hard to interpret; a model that fits the data well along every dimension except one unimportant one may be overwhelmingly rejected statistically. On the other hand, calibrated models have been subject to critique. Some of the arguments behind this critique are discussed below.

4.2 Real Business Cycle Models

One of the theory-oriented frameworks is called Real Business Cycle (RBC) models. "These models are theories, given explicit functional forms, and with parameters chosen so the model generates "plausible" time paths in the sense of being able to replicate observable business cycle fluctuations" (Bårdsen et al. 2006). Even though there will be no reviews of RBC models in this thesis they played a great part in the evolution of new Keynesian models. Therefore, a brief summary of the RBC framework is given.

In general, the core of a RBC model is a classical growth model with a micro foundation, expanded to allow for an incorporation of productivity shocks. If the shocks are large enough, they can simulate actual business cycles.

The purest of RBC models are based on *all* Walras' assumptions. Romer (2006) summarizes these assumptions by describing a Walrasian model as "a competitive model without any externalities, asymmetric information, missing markets, or other imperfections". The shocks are transmitted throughout the economy by consumption-smoothening, investment effects and inter-temporal substitution of labour. These effects are called *propagation mechanisms*.

A basic RBC model contains representative agents, firms and households, which optimize explicit objective functions. By using representative agents the researcher simplifies aggregation. Cycles are driven by exogenous technology shocks that are enforced by, for instance, inter-temporal substitution of leisure.[18] That is, "a rise in productivity raises the cost of leisure, causing employment to increase" (Stadler 1994).

Numerical values in the model are implemented by calibration. Calibration is when the values of parameters are chosen from "findings in other applied areas of economics…" (Kydland &

[18] Technology shocks are supply shocks. That is, there are no demand shocks in RBC models.

Prescott 1982). Due to the fact that RBC models are quite complicated, they are usually solved by simulations.

General critique:
Critics of the RBC-theory points out that there is no independent evidence that proves that economies are subject to the large shocks that drives the business cycles in these models. In addition, the models can not be hypothesis tested in the same manner as econometric models. Their ability to predict are often tested by comparing moments derived from the model with moments from real data sets. Furthermore, the technology is developed exogenously. This should be done endogenously if innovation is pursued due to profit possibilities. It should also be mentioned that there are economic depressions. Are these to be understood as negative technology shocks? This has, for instance, been explained to be motivated by weaker incentives to use productive technology, due to government regulations.

Some of the propagation mechanisms are probably weak:
- The consumption-smoothening implies a consumption pattern as in the permanent-income hypothesis. This is not consistent with the buffer-stock-saving; which is the leading theory today.
- The inter-temporal substitution of labour is probably also small, because technology shocks most often is regarded as permanent. If that is the case, there are no incentives to substitute leisure in nearby periods with leisure in later periods, due to the fact that the wages also change permanently.
- The shocks must therefore be transmitted through an investment-effect. The fact that it takes "time to build" (there are lags in the investment process) implies that this assumption could be strong. Most RBC models focus on this propagation mechanism.

4.3 Vector Autoregression

One of the econometric frameworks is called Vector Autoregression (VAR). The next paragraphs will clarify some of the properties of this framework. Some of the empirical evidence referred to in this thesis comes from VARs.[19] However, there will not be any review of VAR models in this thesis.

[19] Rigobon & Sack (2004) in chapter 3, Bernanke & Kuttner (2005) in chapter 3, Iacoviello 2005 in chapter 4, and Cadha et al. (2004) in chapter 5.

An example of an *autoregression* is the process (Wooldridge 2006):

$$y_t = \beta_0 + a_1 y_{t-1} + e_t \quad , t = 1, 2,\ldots \quad , |a|<1 \tag{4.1}$$

The starting point in the sequence is y_0 ($t = 0$), and the error, e_t, is an i.i.d. sequence with zero mean and a constant variance. The process is called autoregressive of order one [AR(1)] due to the fact that there is one lag. The coefficient a_1 tells us how much of the variation in the dependent variable y_t that is explained by the independent variable, y_{t-1}. Thus, an autoregression could be put as modelling a single series, y_t, in terms of its own past. Shocks in the 'monetary policy and asset prices'-literature are often AR (1) processes.

VAR includes the word vector, which indicates modelling of several series in term of their own past. A formulation of a general VAR is given by Thomas (1997) – a short reproduction follows to provide an illustration of how VARs work:

$$\mathbf{y}_t = \sum_{i=1}^{k} \mathbf{A}_i \mathbf{y}_{t-1} + \mathbf{e}_t \tag{4.2}$$

In (4.2) $\mathbf{y}_t$ is a column vector of observations in period t on all the variables in the model, while $\mathbf{e}_t$ is a column vector of random disturbance values. The errors may be contemporaneously correlated, but are assumed to be non-autocorrelated over time. $\mathbf{A}_i$ represents matrices of parameters. An example of a three-equation model, with two lags of periods, ($k=2$) could take the algebraic form:

$$\begin{aligned} w_t &= a_{11}w_{t-1} + a_{12}x_{t-1} + a_{13}z_{t-1} + b_{11}w_{t-2} + b_{12}x_{t-2} + b_{13}z_{t-2} + e_{1t} \\ x_t &= a_{21}w_{t-1} + a_{22}x_{t-1} + a_{23}z_{t-1} + b_{21}w_{t-2} + b_{22}x_{t-2} + b_{23}z_{t-2} + e_{2t} \\ z_t &= a_{31}w_{t-1} + a_{32}x_{t-1} + a_{33}z_{t-1} + b_{31}w_{t-2} + b_{32}x_{t-2} + b_{33}z_{t-2} + e_{3t} \end{aligned} \tag{4.3}$$

Notice that each variable in the VAR model depends on the other variables, with an identical lag structure applied to each variable in all the equations.

The vectors in (4.2) are in this example given by:

$$\mathbf{y}_t = \begin{pmatrix} w_t \\ x_t \\ z_t \end{pmatrix}, \qquad \mathbf{e}_t = \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{pmatrix}$$

Due to the fact that this example has two lags, there are two 3x3 matrices representing $\mathbf{A}_i$:

$$\mathbf{A}_1 = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}, \qquad \mathbf{A}_2 = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix}$$

General critique:

In a VAR with, e.g. 10 equations and 5 lags, each equation will contain 50 regressors. If the sample sizes are relatively small, precise estimation is impossible. Even though VARs have several advantages when it comes to forecasting and that they also are used in policy analysis, they are termed "*atheoretical*" because they are not based on economic theory. Since there are no restrictions on any parameters in any equations in the model - "everything causes everything".

4.4 Dynamic Stochastic General Equilibrium Models

First, the name Dynamic Stochastic General Equilibrium (DSGE) models, reveals some properties of the framework. It is dynamic, in the sense that there are several periods. It is stochastic, which means that it is non-deterministic; the state in period *t*, does not give a complete determination of the state in *t+1*. Finally, the general equilibrium part tells us that the model incorporates a complete set of markets.

DSGE models are derived from first principles and compute equilibrium prices and allocations of the economy. Agents in the modelled economy maximize objective functions dynamically - subject to constraints. The fact that there are objective functions implies that there are parameters which describe the agents' preferences.

So, how do DSGE models differ from RBC models? In fact, is not RBC models dynamic, stochastic and based on general equilibrium? Formally, DSGE models could be divided into two; New-Keynesian models and RBC models. However, large parts of the literature have made New-Keynesian models in sole possession of the DSGE label. Thus, in this thesis, New-Keynesian models will *alone* be labelled DSGE models – by clarifying the content of a framework this should not lead to any misunderstandings.

So, DSGE models are within the New-Keynesian structure. That is, as mentioned above, they incorporate a great deal of microeconomics - however, they focus on market imperfections and connect these to price rigidities. In contrast to the RBC models, DSGE models do not fulfil the Walrasian assumptions. "Various types of imperfections and rigidities in the markets for goods, for factors of production and for financial assets have been introduced alongside a broader set of random disturbances" (Kremer et al. 2006). With the incorporation of sticky prices, DSGE models can also incorporate monetary policy and hence, analyze monetary policy.[20]

Kremer et al. (2006) formulated a four-step-recipe for construction and solving of DSGE models, which will be presented in short. First, a basic DSGE model is constructed by choosing a set of economic assumption appropriate, given the questions of interest. Thus,

[20] In models with perfect markets (RBC), money does not matter ("The classical dichotomy").

DSGE models incorporate budget constraints, aggregated resource constraints, technology and demand. In addition, if monetary policy is of interest, one can implement a monetary rule, such as the Taylor-rule described in chapter 2.

The second step is to derive the first-order conditions of the optimisation problems expressed in the construction step. These conditions are typically non-linear. The usual way of simplifying is to obtain the first-order Taylor approximation of the non-linear functions around a stable steady state, to make the analysis locally valid. Thus, a researcher would have to find the steady state first.

The third step is to compute the solution to the approximated dynamic system, that is, the solution to the linear system. Finally, and fourth, the researcher is required to assign numerical values to the parameters of the model. There is an ongoing debate about how this is to be done. One approach is to apply calibration such as in RBC-models. A second approach is estimation, where the parameters are derived from a statistical material. The third approach is known as Bayesian estimation, a method that roughly could be described as a combination of calibration and classical estimation.

General critique:
The data has often been filtered and linearized to simplify computation and aggregation. In our context, non-linear properties, e.g. bubbles, are of interest and therefore this limits the worth of the results. However, there has been progress in this area – some of this progress is due to increased 'assistance' from advanced computers.
As mentioned, there is a debate on how to choose the parameter values. This indicates that the accuracy of the results should be questioned.

4.4.1 The Bernanke & Gertler (2000)-model

Bernanke, Gertler & Gilchrist (1999) present a dynamic general equilibrium model with the purpose to clarify the role of credit market frictions in business fluctuations. The model was extended in Bernanke & Gertler (2000), and for contextual reasons the content in that paper, which focuses on monetary policy and asset prices, will be accounted for in this thesis.

The model is developed within the DSGE-framework. To enhance the empirical relevance several features are incorporated: As in RBC-models, there are lags in investment to create hump-shaped output dynamics. To capture the fact that there are differences in access to capital markets there is heterogeneity among firms. Finally, to allow for studies of the transmission of monetary policy, the model incorporates money and price stickiness.

There are three types of representative agents in the model: entrepreneurs, households and retailers. In addition, there is a government that conducts both fiscal and monetary policy. The entrepreneurs play a crucial part for the inducement of the *financial accelerator*. The financial accelerator is an important part of the model, because it amplifies shocks in the modelled economy. This is the key-concept, and consequently it will be accounted for in the next passages:

"The financial accelerator"

Bernanke et al. (1999) use the principal-agent framework to illustrate how the financial accelerator works. The following scenario is based on three earlier findings from economics:

i) External finance, unless fully collateralized, is more expensive than internal. The higher the difference in costs between internal and external finance is, the higher the agency costs of lending.

ii) Given the amount of finance required, there is an inverse relationship between net worth and the premium on external finance.[21]

iii) By raising the external finance premium and increasing the finance required, a fall in net worth will reduce the borrowers spending and production.

[21] *Net worth* is defined as a firm's liquid assets, plus collateral value of illiquid assets, less outstanding obligations. This is depicted below on the right hand side of equation (4.6).

Bernanke et al. (1999) points out the third result as the heart of the financial accelerator; to the extent a negative (positive) shock reduce (increase) a firm's net worth, the reduction (augmentation) in that firm's spending and production will amplify the initial shock.

The following example illustrates the three results listed above. The example is a reproduction of the example in Bernanke et al. (1996).

Key assumptions:

There are two periods, 0 and 1.

Two types of input: A fixed factor K (land and/or structure – that does not depreciate), and a variable factor x_1 (materials, labour, etc.). The fixed factor can be sold at the end of period 1, at the price q_1 per unit, while the variable input depreciates fully in use. The price of the variable input is normalized to one.

The production function $a_1 f(x_1)$ is increasing and concave in x_1 and represent output in period 1. Technology, a_1, is exogenous and demands input in period 0 to produce output in period 1.

The entrepreneur begins period 0 with gross cash flow from previous production, $a_0 f(x_0)$, and a corresponding debt obligation, $r_0 b_0$, where r_0 is the real gross real interest rate to the past borrowing, b_0.

The accounting identity that links the entrepreneur's purchases of the variable factor x_1 and new borrowing is expressed through:

$$\underbrace{x_1}_{\text{Purchase of variable input}} = \underbrace{a_0 f(x_0)}_{\text{Gross cash flow from previous production}} + \underbrace{b_1}_{\text{New borrowing}} - \underbrace{r_0 b_0}_{\text{Debt obligation from previous production}} \tag{4.4}$$

The funds the entrepreneur borrows in period 0 are repaid in period 1 and bear a gross real interest rate of r_1.

Maximizing the period 1 output net of debt repayment, $a_1 f(x_1) - r_1 b_1$, the entrepreneur chooses x_1 and b_1 in period 0.

Enter an incentive problem:

It is costly for a lender to seize the entrepreneur's output if the borrower defaults. On the other hand, it is not costly to enforce a contingency that the borrower's fixed factor (collateral) is transferred to the lender if the borrower defaults.

Due to the incentive problem, the entrepreneur will be offered funds in period 0 equal to the time-discounted market value of his fixed factor:

$$b_1 \leq \left(\frac{q_1}{r_1}\right) K \tag{4.5}$$

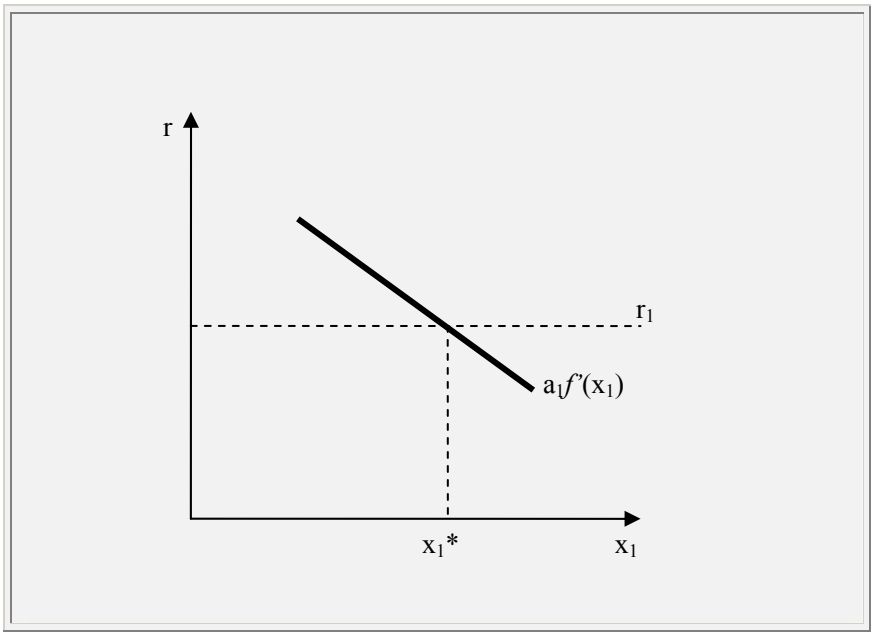
In words: Lending without collateral is not feasible. Combining (4.4) and (4.5) leads to an incentive, or "collateral-in-advance", constraint:

$$x_1 \leq a_0 f(x_0) + \left(\frac{q_1}{r_1}\right) K - r_0 b_0 \tag{4.6}$$

Remembering the definition of net worth, (4.6) says that spending on the variable input cannot exceed the entrepreneur's net worth.

If the optimal x_1 exceeds the entrepreneur's net worth, the incentive constraint binds.

Figure 5: The optimal x_1 satisfies $a_1 f'(x_1) = r_1$



This illustrative example is easily linked to the introductory results of the financial accelerator. The agency cost is measured as the difference between the marginal value of money inside and outside the firm, $a_1 f'(x_1) - r_1$. If the incentive constraint (4.6) binds, the shadow value of an additional unit of internal funds exceeds the gross real interest rate in external markets, $a_1 f'(x_1) > r_1$.
If the entrepreneur's net worth falls, the agency cost will increase and reduce the entrepreneur's spending and production.

Equation (4.6) shows that three factors can influence the entrepreneur's net worth, a decline in gross cash flow, $a_0 f(x_0)$, a fall in asset prices, q_1, or a rise in the initial debt obligation, $r_0 b_0$. Note also that a rise in the prospective real interest rate, r_1, reduces the values of the entrepreneur's fixed capital. Considering the interest rate on the pre-existing debt as floating, an increase in r_0 would reduce the net cash flow, $a_0 f(x_0) - r_0 b_0$.

This simple example shows the basic nature of the financial accelerator; that fluctuations in borrower's net worth leads to fluctuations in the real activity.

Extensions

An extension of the Bernanke et al. (1999)-model was presented in Bernanke & Gertler (2000). The extension was made to address the ongoing discussion on how central banks should respond to asset price volatility.

The principal modification is an incorporation of "bubbles"; the market price of capital may differ from the fundamental value of capital. The non-fundamental component in stock prices is modelled as an exogenous stochastic process. It is assumed that agents in the model know the ex-ante stochastic process, but not when the bubble will burst. By being exogenous, the bubble by itself will not be affected by monetary policy.

The real activity is affected by the bubble in two ways. There is a small wealth effect on consumption. This effect is argued by Bernanke & Gertler (2000) to be modest according to data.[22] The second effect is reflected by the financial repositioning that firms experience. Their net worth is related to the market value of their assets, not the fundamental value, and thus, the external finance premium is affected, (as described in the example above, *the financial accelerator*). Thus, a balance-sheet effect due to over-optimism in the stock market improves the borrowing-position of firms (see *3.1. Stock Market Prices* for more on balance-sheet effects). This increases aggregated demand through the increase in consumption and investment.

The monetary policy is conducted through four forward-looking instrument rules, similar to the Taylor-rule accounted for in chapter 2.[23] The first two relate the nominal interest rate to the next periods expected inflation, and the steady state value of the nominal interest rate.[24] These two differ in the weight given to expected inflation; one that is *accommodative* (small weight), and one that is *aggressive* (large weight). The remaining two rules are identical to these, except that they are augmented by including the current level of the stock market. Thus, they can be described as 'accommodative with response to current stock prices', and 'aggressive with response to current stock prices'.

[22] This may be due to the fact that "...equity ownership tends to be concentrated among the wealthy – people who are much less likely to adjust their consumption levels" (Cecchetti 2005).
[23] Under 'Rules vs. Discretion', in section *2.1.5.*
[24] Note that the output gap is not included in the rule. Bernanke & Gertler (2000) state that they "…do this primarily for simplicity and to reduce the numbers of dimensions along which the simulations must be varied".

Results

The results are reported for four policy rules. The "success" of the rules is measured in the variability of the output gap and the variability of the inflation. Bernanke and Gertler (2001) conclude that the "aggressive" inflation targeting rules, where the central bank puts much weight on the next period's expected inflation, is far better then the "accommodative" rules, which implies little weight on next period's expected inflation. Thus, aggressive inflation targeting reduces inflation variability and in almost every case, output variability.

In regards to this thesis's topic, Bernanke and Gertler (2000) find that the optimal policy, that is, the optimal rule, *never* involves a response to stock prices. Including stock prices in interest rate rules could lead to a small reduction in the variability of the output gap, but the authors point out that the benefits of this are likely to be outweighed by the associated increase in inflation variability. So, an augmented version of the Taylor-rule where stock prices are included is not recommended by Bernanke & Gertler (2000). They conclude that central banks "should not respond to asset price fluctuations, except in so far as that they signal changes in expected inflation".

Bernanke & Gertler vs. Cecchetti et al.

Cecchetti et al. (2000) concluded differently then Bernanke & Gertler (2000) – both using the Bernanke & Gertler (2000)-model.[25] Cecchetti et al. (2000) found that a central bank, with a flexible inflation targeting policy, should react to asset prices, as well as inflation and the output gap. However, they emphasize that this means that the central bank should react systematically to asset price misalignments, not that the central bank should *target* asset prices.[26]

Nevertheless, how could the researchers' results be so different when simulations are done with the same model? First, Bernanke & Gertler (2000) optimize monetary policy with respect to several scenarios; different shocks (bubble shocks, technology shocks and both shocks), and their bubbles have a probabilistic nature. Cecchetti et al. (2000) optimize monetary policy with respect to one scenario; a bubble shock that lasts for five periods. Thus,

[25] Cecchetti et al. (2000) investigates monetary policy response to asset prices, using several models, e.g. the Bernanke & Gertler (2000)-model and the Batini & Nelson (2000)-model.
[26] More on this issue in section 5.1 under the headline *Targeting Asset Prices.*

Bernanke & Gertler (2000) assume that the central bank can not distinguish between a technology-shock and a non-fundamental driven bubble, whereas Cecchetti et al. (2000) only investigate a scenario where the shock *is* a bubble.[27]

Second, Bernanke & Gertler (2000) do not include the output gap in the interest rule. Cecchetti et al. (2000) incorporates this in their monetary rules. As discussed in chapter 2 , flexible inflation targeting would involve weight on output stabilization.[28]

Third, Cecchetti et al. (2000) find that the rules used by Bernanke & Gertler (2000) are not optimal. That is, Bernanke & Gertler (2000) use fixed weights in their four rules, whereas Cecchetti et al. (2000) minimize a loss-function. Thus, Cecchetti et al. (2000) conduct a discretion-type policy (as described in chapter 2, section *2.1.5*) to find the optimal rule.

Fourth, Cecchetti et al. (2000) introduce interest rate smoothing, whereas Bernanke & Gertler (2000) do not incorporate the lagged interest rate in their rules.[29] Several papers document their disagreement (e.g.: Cecchetti et al. 2000; Bernanke & Gertler 2001; Cecchetti et al. 2002).

Model Limitations:[30]

The fact that the Bernanke & Gertler (2000)-model is of a closed economy may reduce the value of the model if one is interested in implications for the central bank in a small, open economy. First, the lack of a foreign sector, which (as argued in chapter 2) constitute a very important transmission channel for small, open economies, exclude a scenario where asset prices give conflicting signals; e.g. if the stock market indicate a tightening of monetary policy and the exchange rate indicate an expansive monetary policy.

Second, a stock market bubble may be caused by developments in *external* financial markets, in which the influence of a central bank is small or absent (Cecchetti 2002); a global trend will not be affected by the policy conducted by the central bank in a small, open economy.

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[27] Cecchetti et al. (2002) confirm that they remain to believe that central bankers *can* distinguish between these types of bubbles and that there are "clearly times when egregious misalignments exist".
[28] More on *flexible inflation targeting* can be found in section *2.1.5 How to understand Inflation Targeting.*
[29] Interest rate smoothing is when the central bank moves the interest rate in a sequence of small steps in the same direction (Lowe & Levine 1997).
[30] These limitations concerns the Bernanke & Gertler (2000)-model. Changes are made in Bernanke & Gertler (2001), and Cecchetti et al. (2000).

Furthermore, due to the fact that stock markets are globalized, the wealth effects of a stock market bubble may not be as strong as they would in a closed economy.

Also, the fact that the bubble is exogenous should be noted. As Chapter 3 shows, monetary policy affects asset markets; would endogenous bubbles give more representative results? Bernanke & Gertler (2001) state that "A deficiency of the literature to date is that the non-fundamental component of stock prices has generally been treated as exogenous".

In addition, some of the objections made by Cecchetti et al. (2000) should be mentioned. Monetary policy is normally conducted with a degree of interest smoothing. This should probably be incorporated in the Bernanke & Gertler (2000)-simulations. Only four rules, which are given quite different properties the parameters, are evaluated. A wider range of rules should probably be evaluated. Since flexible inflation targeting is dominating strict inflation targeting, inclusion of the output-gap would probably reflect modern monetary policy. Thus, incorporating the output-gap in the rules for evaluation may have improved the insight derived from the simulation.

4.4.2 The Iacoviello (2005)-model

Iacoviello (2005) develops a model which is a variant of Bernanke et al. (1999). That is, a dynamic stochastic general equilibrium model where two main features are added; collateral constraints tied to real estate values for firms, and for a subset of households, nominal debt. The reasoning behind these features follows.

i) Collateral constraints

Iacoviello (2005) argues that this feature is practical and substantial; practical because a large proportion of borrowing is secured by real estate, substantial because the real estate markets seem to play a role in business fluctuations and the channels through which the real estate markets affect the economy are far from being understood.

ii) Nominal debt

This feature is incorporated due to the fact that almost all debt contracts are in nominal terms in low inflation countries.

The transmission mechanism in the model corresponds to the financial accelerator in Bernanke et al. (1999), however a decelerator is introduced. Iacoviello (2005) exemplifies the transmission mechanism with a positive demand shock:

The rise in demand leads to an increase in consumer prices *and* asset prices. The rise in asset prices increases the borrowing capacity of firms through the balance sheet, which allow them to spend and invest more. The increase in consumer prices reduces the real value of outstanding debt obligations, which raise the value of firm's net worth. So, the demand shock is amplified by the financial accelerator.

However, the consumer price inflation trims down the shocks that induce a negative correlation between inflation and output. That is, adverse supply shocks are beneficial to borrowers because the inflation in consumer prices reduce the real value of their outstanding debt obligations.

The model

As mentioned above, the Iacoviello (2005)-model is based on Bernanke et al. (1999). There are households, entrepreneurs and retailers. A government conducts fiscal and monetary policy.

Iacoviello (2005) presents some VAR evidences which are checkpoints for what the model should deliver. First, there should be a significant response to real estate prices and nominal prices to tight monetary policy. The response of output, to contractive monetary policy, should be small, but also negative. Second, there should be a negative response of real estate prices to inflation, and a small negative response of output to inflation. Third, there should be a positive co-movement of asset prices and output, in response to asset price shocks as well as in response to output shocks.

So, while Bernanke & Gertler (2000) and Cecchetti et al. (2000) examine the effect of stock market fluctuations in their model, Iacoviello (2005) examines the effect of *real estate fluctuations* – both papers assessing the implications for monetary policy. An interesting feature in Iacoviello (2005) is that the central bank is able to respond to *current* asset prices, whereas in Bernanke & Gertler (2000) allows monetary policy to respond to previous period's

asset prices. This feature shifts the bias in favour of finding a non-zero coefficient, r_q, on asset prices in the interest rate rule.

The interest rate rule in Iacoviello is given as:

$$i_t = 0.73 i_{t-1} + 0.27\left(r_q q_t + (1 + r_\pi)\pi_{t-1} + r_Y Y_{t-1}\right) \tag{4.7}$$

where the interest rate, i_t relates to a lag of itself i_{t-1}, in addition to the sum of current asset prices, q_t, last periods inflation, π_{t-1}, and last periods output, Y_{t-1}. (4.7) states that interest rate smoothing is important for the central bank, the numerical weight are from VAR-estimations also presented in Iacoviello (2005). The success of different rules is measured with a central bank loss-function, which is based on the assumption that "output and inflation volatility are the only two goals of monetary policy". Thus, the rule is optimized, whereas the performance of the rule is measured by a loss-function (with different weights on inflation and output).

Results

Iacoviello (2005) finds that the optimal response coefficient for asset prices, in this case real estate, is non-zero. The size is increasing in the weight given to output stabilization in the central banks loss-function. However, the gains of responding to asset prices, is marginal. So, even if the central bank has information on current asset-price movements there is only a petit improvement of welfare if the central bank responds to these movements.

Model Limitations

As in Bernanke et al. (1999, 2000) the model is of a closed economy. This may exclude some scenarios that are clearly of interest to central banks of small, open economies. Furthermore, even if the real-estate market is less volatile than the stock market, the idea of a central bank responding to *current* real estate prices is questionable. Nevertheless, this is commented by Iacoviello (2005) and it is incorporated to shift the bias in favour of finding a positive coefficient on asset prices in the interest rule.

4.5 Dynamic Aggregative Estimated Models

In lack of a better label, the framework that covers the models in this chapter will be referred to as Dynamic Aggregative Estimated Models (DAE).[31] These models are also called Cowles commission type models. The reason for the latter framework-name should obviously be explained.

The Cowles Commission was established in the aftermath of the stock-crash in 1929. The motivation behind the establishment was "to advance the scientific study and development…of economic theory in its relation to mathematics and statistics".[32] So, by combining economic theory with statistical methods and observed data, the Cowles commission derived methods to construct and estimate a system of simultaneous equations that could describe the workings of the economy.

The key-concept is simultaneous equations. Researchers at the Cowles commission regarded economic behaviour as the result of the simultaneous interaction of different agents (Christ 1994). The base-recipe for a DAE could be summed up in three steps. First, the researcher picks relevant variables for a particular problem.[33] Second, he obtains a suitable system of equations. Third, he estimates the values of its parameters.

Some key-terms in this framework will now be accounted for through a simple example based on Christ (1994). First, *structural equations*:

$$y_{1t} + \beta_1 y_{2t} = \gamma_1 x_{1t} + \gamma_2 x_{2t} + e_{1t} \tag{4.8}$$

$$\beta_2 y_{1t} + y_{2t} = \gamma_3 x_{1t} + e_{t2} \tag{4.9}$$

Changes in the parameters of a structural equations (above these are $\beta_1, \beta_2, \gamma_1, \gamma_2, \gamma_3$) do not affect the other structural equations. Variables can be endogenous or exogenous. The value of endogenous variables is determined inside the model, whereas exogenous variables have predetermined values. Above, y_1 and y_2 are endogenous, x_{1t} and x_{2t} are exogenous.

[31] The label (DAE) is adapted from Bårdsen et al. (2006).
[32] From "The Commission's Articles of Incorporation".
[33] At first these variables where picked *without* a theoretical foundation. Now these variables are chosen *with* a solid theoretical foundation.

Researchers may want to forecast the future value of an endogenous variable. Structural equations can generally not provide such forecasts due to the fact that they often include more than one endogenous variable. This leads to the second term, *reduced form*. This is derived by solving the system for the endogenous variables; illustrated below for y_{1t}:

First, equation (4.9) is solved for y_{2t}:

$$y_{2t} = -\beta_2 y_{1t} + \gamma_3 x_{1t} + e_{2t} \tag{4.10}$$

The right-hand-side substitute y_{2t} in equation (4.8) which is solved for y_{1t}: [34]

$$y_{1t} = \frac{1}{1-\beta_1\beta_2}\left[(\gamma_1 - \beta_1\gamma_3)x_{1t} + \gamma_2 x_{2t} + (e_{1t} - \beta_1 e_{2t})\right] \tag{4.11}$$

When reduced form is computed it can be useful to rename parameters and disturbances in the expressions for y_{1t} and y_{2t}:

$$y_{1t} = \pi_{11}x_{1t} + \pi_{12}x_{2t} + v_{1t} \tag{4.12}$$

$$y_{2t} = \pi_{21}x_{1t} + \pi_{22}x_{2t} + v_{2t} \tag{4.13}$$

Since all variables are dated *t* this example is static if all variables are different. However, if one of, or both of, the *x*'s represents a previous period's value of one of the *y*'s, then the system is *dynamic*. To illustrate, x_{2t} equals y_{1t-1}. As the name of this framework implies the models that will be presented later are dynamic.

In modern Keynesian DAE models, the equation systems represent aggregated demand and aggregated supply. These systems are often based on the IS-relation which represents aggregated demand – and the Phillips Curve which represents aggregated supply.

DAE models where prominent in Macroeconomics from the late 1950s to the early 1970s. The lack of knowledge on how to incorporate rational expectations reduced their popularity. However, DAE models "have been updated to incorporate rational expectations and are still heavily used for forecasting and policy-making by central banks…" (Bårdsen et al. 2006). Thus, in modern DAE models – both the IS-relation and the Phillips Curve have been derived

[34] The determinant, δ, for this system is $\delta = 1 - \beta_1\beta_2$

from a system of representative and dynamic optimizing problems by the economy's private agents.

General critique:

The fact that there *usually* was no micro-foundation in DAE models reduced the possibility to interpret results.[35] So, as with any modelling framework that gives more weight to data compared to theory, convincing implications are harder to obtain.

A critique on early DAE models that depreciated their value is connected to the above mentioned *rational expectations*. Lucas (1976) pointed out that some of the parameters of a model reflect the adaptation of private behaviour to a previously maintained policy reaction function: "Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models". Among others, Mishkin (1983) developed estimation methods to take account of rational expectations.

4.5.1 The Batini & Nelson (2000)-model

In their forward-looking structural model, Batini and Nelson (2000) examine the effects of a bubble in the foreign exchange market, and evaluate the performance of different monetary rules. So, this is an open-economy-model where the asset price of interest is the exchange rate.

The model

First, there will be a presentation of the structural equations:[36]

$$y_t = E_t y_{t+1} - \sigma(R_t - E_t \pi_{t+1}) + \delta \tilde{q}_{t-1} + v_t \tag{4.14}$$

Equation (4.14) is the economy's IS equation. This periods (log) output, y_t, equals the expected (log) output for next period, $E_t y_{t+1}$, less the difference between the nominal interest

[35] The model that is reviewed in this thesis have a solid micro-foundation.
[36] The micro-foundation which these structural equations are derived from can be found in McCallum & Nelson (1998).

rate, R_t, and the expected inflation next period, $E_t\pi_{t+1}$, plus a moving average of the exchange rate, $\tilde{q}_{t-1}$, and a stationary shock, v_t.[37] A period is assumed to be three months.

So, output depends on future output, the real interest rate, and the development of the exchange rate. R_t, y_t, π_t and q_t are all expressed relative to steady-state equilibrium values. The coefficients are estimates from the UK and US economy. Note that q_t is measured so that a rise is a depreciation of the exchange rate.

$$\pi_t = \alpha\pi_{t-1} + (1-\alpha)E_t\pi_{t+1} + \varphi_y y_{t-1} + \varphi_q \Delta\tilde{q}_{t-1} + u_t \tag{4.15}$$

Equation (4.15) is the Phillips curve. This period's inflation, π_t, relates to both the last period's inflation π_{t-1}, and next period's expected inflation, $E_t\pi_{t+1}$, in addition to last period's output, y_{t-1}, the change in the exchange rate last four periods, $\Delta\tilde{q}_{t-1}$, and a stationary shock, u_t, that is assumed to be an AR(1) process (for more on AR(1) processes, see *4.3 Vector Autoregression*). Thus, inflation relates both to previous inflation and expected future inflation, as well as previous output, and previous changes in the exchange rate.

$$E_t q_{t+1} = q_t + R_t - E_t\pi_{t+1} + \kappa_t + z_t \tag{4.16}$$

In (4.16), the left side represents this period's expectations on next period's exchange rate, $E_t q_{t+1}$. This equals the sum of: this period's (log) exchange rate, q_t, and the nominal interest rate, R_t, less the expected inflation next period $E_t\pi_{t+1t}$. κ_t is a stationary shock assumed to be an AR(1) process, whereas z_t is introduced to create "bubble-like" deviations from uncovered interest parity (UIP). *UIP* is a hypothesis that states that if there is an increase in a country's interest rate, then the exchange rate would have to fall so that there is no change in profits from a placement in the country's currency.

The bubble is defined as an exogenous process that temporarily shifts the exchange rate away form its fundamental value. The instrument-rules relate to the expected inflation and lagged real asset prices (exchange rates). The rules also incorporate a degree of interest rate

[37] A year contains four periods, so that the moving average of the exchange rate equals $\tilde{q}_t = \frac{1}{4}\Sigma_{j=0}^{3} q_{t-j}$.

smoothing by also relating the nominal interest rate to its lagged value. The nominal interest rule is expressed as:

$$R_t = \phi_\pi E_t \pi_{t+k} + \rho_R R_{t-1} + \phi_q q_{t-1} \tag{4.17}$$

where the response coefficients are assumed to be $\phi_\pi > 0$, $\rho_R \in [0,1]$ and $\phi_q \geq 0$.

Note the subscript $t+k$ on expected inflation. This illustrates the horizon the central bank considers. If $k=1$ then the horizon is next period; that is a next-quarter-perspective. If $k=8$ the central bank consider expected inflation two years ahead. Thus, the subscript tells us how forward-looking the central bank is when setting the nominal interest rate. The k is defined by Batini & Nelson (2000) as "*the best period in the future for which the authorities should form their inflation forecast that enters their policy rule*".

The performances of the different rules are measured with an objective function which represents the welfare-loss:

$$L = \lambda_\pi Var(4\pi_{t+j}) + \lambda_y Var(y_t) + \lambda_{\Delta R} Var(4\Delta R_t) \tag{4.18}$$

where $4\pi_{t+j}$ is annualized quarterly inflation, y_t, is log output, and λ_π, λ_y and $\lambda_{\Delta R}$ are the coefficients that tells how much weight the central bank assign to inflation deviations from target, output deviation from potential output, and nominal interest rate volatility, respectively.[38]

The experiments of Batini & Nelson (2000) are divided into four groups; with and without "bubbles" – with and without response-coefficient optimization.

Results:

First, they simulate a scenario with no bubble, and no optimization of response coefficients. Batini & Nelson (2000) find that aggressive inflation targeting dominates accommodative inflation targeting. Also, rules with an interest rate smoothing dominate corresponding rules without interest rate smoothing. Batini & Nelson (2000) believe that this is because of the

[38] Compared to the loss-function presented in chapter 2, this function also penalizes interest rate variations. The weights used by Batini & Nelson (2000) in (4.18) are: $\lambda_\pi = \lambda_y = 1.0$, and $\lambda_{\Delta R} = 0.5$.

reduction in inflation volatility which does not cost much in output variability. In this scenario, a very low response to the exchange rate slightly improves the welfare, $\phi_q = 0.025$ in (4.17).

Second, they simulate a scenario with an operative bubble with no optimization of response coefficients. The loss is larger when the bubble is operative, but attempts on reducing the effect of the bubble on the exchange rate magnify the increase in loss.

Third, they simulate a scenario with no bubble but optimization of response coefficients. When the horizon is *k=1*, then the optimal policy includes a response, quite low, to the exchange rate. However, when the horizon is optimized, it is not optimal to respond to the exchange rate.

Finally, a simulation of a scenario where a bubble is operative, and there is optimization of response coefficients. The result here depends on whether one believes that import prices moves mechanically with the exchange rate, or that such movements are not plausible. Batini & Nelson (2000) substitute the Phillips curve (4.15) with a modified one that allows for such a mechanism. A response to the exchange rate is optimal in a model where price-setting is strongly influenced by the exchange rate, but it is not optimal in the baseline-model depicted above.

Extensions

Batini & Nelson (2000) introduce two extensions; one that allows agents to view the bubble probabilistically, and one that drops UIP and forward-looking price setting.
The results of simulations where the latter extension is incorporated rules in favour of responses to the exchange rate. "Therefore, a crucial issue in determining whether it is appropriate to respond to exchange rates is whether one views the UIP condition as an essential part of the structure of a macroeconomic model…"(Batini & Nelson 2000).

Batini & Nelson vs. Cecchetti et al.

Cecchetti et al. (2000) employs a variant of the Batini & Nelson (2000)-model, however they do not allow for several shocks in the same scenario. That is, when they simulate a scenario where there is a financial shock they do not allow for a shock in the IS-curve (Demand-shock)

or the Phillips-curve (Supply-shock). When they simulate scenarios with demand shock they do not allow for financial- or supply-shocks. They conclude that the central bank should "lean against the wind" when there is a pure financial shock, and that it is counterproductive to "lean against the wind" when there is a demand shock.[39]

Batini & Nelson (2000) find that the analysis conducted by Cecchetti et Al. (2000) leaves out the question on whether a separate response to the exchange rates is justified when *all* shocks are present. Cecchetti et al. (2002) replies that the results that Batini & Nelson (2000) presents are model-specific; that the assumptions may have reversed the results.

4.5.2 Further reading

Ball (1997) and Svensson (1997a) are important papers when it comes to analyzing inflation targeting and instrument rules such as the Taylor rules. These papers investigate the topic by use of DAE models with a solid micro-foundation. Ball (1998) extends the Svensson-Ball model to an open economy and examines if there is a place for the exchange rate in the monetary policy. The conclusion of Ball (1998) is that monetary policy rules without the exchange rate are dominated by a Monetary Condition Index (MCI).[40]

Filardo (2000) investigates the inclusion of asset prices in an instrument rule using a DAE model and US data. He finds that the inclusion of stock prices and real estate prices will not improve the US economic performance.

In a recent paper, Semmler & Zhang (2007) develops a model within the DAE framework where they use data (mainly) from Germany, Italy & France. In their closed-economy model, they incorporate an "advanced" endogenous bubble. Advanced because it can be a positive bubble or a negative bubble, the growth rate can vary, it does not have to burst in specific periods, and it can re-occur after a burst.

[39] To "*lean against the wind*" is to increase the interest rate in a smoothing manner, above the level needed to achieve targeted inflation, with the purpose to reduce the growth of the asset price bubble. More on this in *5.1. Response Strategies*.

[40] Monetary Conditions Indices (MCIs) are weighted averages of changes in an interest rate and an exchange rate relative to their values in a base period (Batini & Turnbull 2000). Such a MCI has been used by e.g. the central bank of New Zealand, which gave up this strategy due to poor performance.

Semmler & Zhang (2007) concludes that "a financial market depression can make deflation and an economic recession worse, implying that policy actions aiming at escaping a liquidity trap should not ignore asset prices".

4.6 Theoretical models

Theoretical models are obviously theory-oriented models; there is no data input. In the Pagan classification chart these models will be found along the y-axis; the position depending on how much theory is incorporated.

4.6.1 The Kent & Lowe (1997)-model

Kent and Lowe (1997) present a theoretical model. The authors state that "*a large and rapid fall in the nominal price of assets that form the basis of collateral for loans from financial intermediaries can have adverse effects on financial system stability*". Thus, real estate is the asset of interest. It should be mentioned that the model is Fisherian, that is, it combines the Fisher-equation with a monetary policy rule.[41]

Key-elements

The model is based on four key elements that the authors find to be representative for reality. These are:

i) An *asymmetric effect* of asset price increases, and decreases, on goods and services price inflation. The effect on output and inflation of a rise in asset prices is weaker than the effect on output and inflation of a fall in asset prices. The reasoning for this asymmetry is the effect a collapse in asset prices has on financial intermediation. This implies that assets that are used as collateral are pointed out as particularly important. Rise in prices of this group of assets can back additional loans; a credit-growth boom. A correction in the markets for these assets can cause large losses for financial intermediaries since the value of collateral is reduced. The outcome of such a scenario could be a slowdown in economic activity and inflation below target.

ii) A central bank with a target that is both concerned about inflation and inflation variability.

iii) The interest rate influences the likelihood for an asset price bubble-burst.

iv) An assumption that a bubble that has burst, does not return.

[41] More on the Fisher-equation in section *2.1 What is inflation?*

The model contains three periods. In the first period, a bubble emerges.

Inflation is given as

$$\pi_t = \alpha A_t + \beta D_t \Delta A_t - R_{t-1} \qquad \alpha \geq 0, \beta \geq 0 \tag{4.19}$$

where π_t is the deviation of inflation from the central bank target, A_t is the deviation of the asset price from its fundamental value, R_{t-1} is the deviation of the policy interest rate from its neutral level, and D_t is a dummy variable that takes the value 1 if the asset price has fallen and 0 otherwise. So, inflation this period depends on the level of the asset price this period, and last periods policy interest rate. The larger is α, the larger is the direct effect on inflation of an increase in the asset price. In addition, if the asset price has fallen, inflation also relates to the change in the asset price, which corresponds to i); the larger is β, the larger is the asymmetric effect.

It is assumed that the central bank knows that the increase in the asset price is not justified by fundamentals.[42]

The asset price bubble is assumed to return to its fundamental value next period with probability *p*. This probability is assumed to be a function of the deviation of the interest rate from its neutral level this period, which corresponds with iii). The relationship between this period's interest rate and the probability of the bubble collapsing in next period is modelled as:

$$p_{t+1} = \phi + \varphi R_t \qquad \varphi \geq 0 \tag{4.20}$$

(4.20) states that the larger is φ, the larger is the effect of the interest rate on the probability of the bubble collapsing. As mentioned in *iv)*, it is assumed that if a bubble burst, it does not return. However, if the bubble does not burst, it grows by *g**:

[42] See the discussion "Bernanke & Gertler vs. Cecchetti" in section 4.4.1.

$$A_{t+1} = gA_t \quad \text{, where } g = 1+g^* \tag{4.21}$$

The growth rate is one of the model specifications that point out that the model is not consistent with rational expectations; changes in the interest rate would change both the size and the growth rate of an asset price bubble in a world of rational expectations (Kent & Lowe 1997).

The central bank minimizes its objective function, which is given as:[43]

$$L_1 = E_1(\pi_2^2) + E_1(\pi_3^2) \tag{4.22}$$

The objective function corresponds to ii) in key-elements presented above. Since the central bank can not affect this period's inflation, the objective function for the central bank is given in (4.22), and is reduced to $L = E_2(\pi_3^2)$ in the second period.

Kent & Lowe (1997) solve the central bank's problem recursively: First they solve for the two possible interest rates in period 2; one for the case in which the bubble bursts in period 2, and one for the case in which the bubble continues. These solutions are used in the second step where they solve for the optimal interest rate in period 1. Thus, it is assumed that the central bank "knows that it will be able to change the rate in period 2, depending on whether the bubble has burst or not".

Due to the fact that the solutions are "analytically quite complicated since non-linearities are introduced" in (4.20) Kent & Lowe (1997) do not show the algebraic solution. Instead they present solutions for different parameters.

[43] To see that the objective function (4.22) considers both level *and* variability examine the first expression on the right hand side, where $E_1[\pi_2] = \pi_{A2} - \pi^*$. π_{A2} equals the actual inflation in period 2, and π^* is the central bank's target. Introducing the inflation mean $E_1[\pi_{A2}] = \bar{\pi}$, we can manipulate the expression for $E_1[\pi_2^2]$ and obtain: $E_1[\pi_2^2] = E[(\pi_{A2} - \pi^*)^2] = \text{var}\,\pi_{A2} + (\pi^* - \bar{\pi})^2$.

Results

Kent and Lowe conclude that "there may be circumstances where monetary policy should be tightened in order to bring on the collapse of the bubble before it becomes too large, even though this means that expected inflation is (temporarily) below target". In their presentation of solutions they find that a response is desirable when the central bank can affect the probability of the bubble collapsing using the interest rate. Other scenarios are also presented.

The conclusion is *driven* by three elements form their theoretical framework: First, contractive monetary policy increases the likelihood of the bubble to burst. Second, a bubble does not reappear after its burst. Third, monetary policy wants to avoid the possibility of extreme outcomes for inflation. These compose three of the four key-elements that are the theoretical framework.

Model Limitations

The assumption that central banks can distinguish between bubbles and asset-price increases that are driven by fundamentals is a very strong assumption that is hard to meet; which information does the central bank hold that market participants do not? Furthermore, the results of a theoretical model like this depend on the values of parameters; even though Kent & Lowe (1997) points out that that "the insight of the model holds true for a wide range of parameter values".

In addition it could be mentioned that in this framework the bubble grows by a constant rate; it is a deterministic bubble. This is not reconcilable with either rational expectations or empirical evidence. However, the authors argue that if one focus on property prices, which they do, "the failure of rational expectations is not a major crises". They refer to the fact that property prices do not jump immediately after an interest rate movement. The fact that data on property prices is not reported in a high-frequency basis weakens that argument.
The model is small and simple to focus on the key-elements mentioned above; its purpose is to be a framework for policy analysis. The model may be useful in a theoretical perspective, but the shortages should be assessed when evaluating the implications it brings fourth. Foremost, several authors have excluded the thought that monetary policy can burst bubbles (e.g.: Trichet 2005; Posen 2006).

4.6.2 The Bordo & Jeanne (2002b)-model

Through the articles, Bordo & Jeanne (2002a,b) state that a response to asset price fluctuations should be thought of in terms of *insurance*. That is, monetary policy can be proactive by increasing the interest rate; obtain benefits by decreasing the chance of a collateral induced credit crunch. However, this is associated with a policy that will reduce output, and perhaps lead to a lower inflation than wanted. So as with any other insurance, there is a cost.

The model

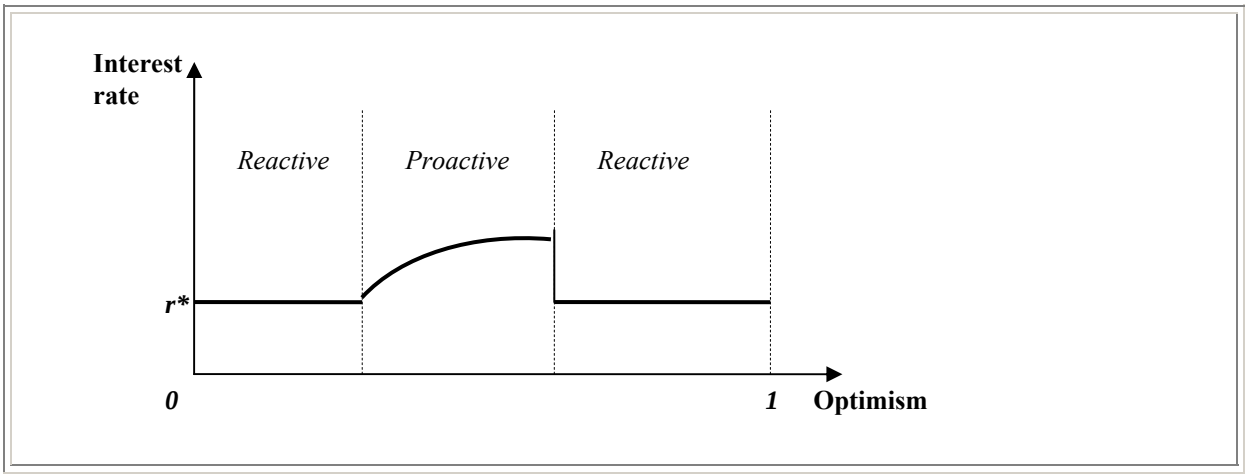
The model is a new Keynesian with equations for aggregate supply and aggregated demand. However, a key difference is that in Bordo & Jeanne (2002a,b) the supply-shock is not exogenous. A supply shock in this model is a "financial" shock, and it is not entirely exogenous. Partly endogenous because the variables that distribute the shock, firms' debt and asset prices, can be influenced by monetary policy. The model does not separate fluctuations due to bubbles or those backed by fundamentals. The economy is closed.

There are two periods in the model. The first period is the ex-ante period; the period in which a proactive monetary policy can act. The performance of the economy in period one will be poorer if monetary policy is proactive, compared to a reactive monetary policy. In period two, a realization of the collateral value will be revealed. If the realization is "bad" it can lead to a credit crunch. The demand for debt is increasing in optimism, and decreasing in the interest rate. Thus, the optimal monetary policy depends on the degree of optimism of the private sector. If monetary policy is proactive, this will pay-off in period two by the reduced risk of credit-crunch.

Results

The results of Bordo & Jeanne (2002b) are best explained through an illustration:

Figure 6: Optimal values of the interest rate depending on degree of optimism



The vertical axis in Figure 6 represents the optimal values of the real interest rate. The degree of optimism is depicted on the horizontal axis, where the value one represent a state where collateral values will be high for certain next period. Bordo & Jeanne (2002) argues that a reactive policy is preferred for a low degree of optimism, due to the fact that firms will not borrow extensively in such a scenario. Such a policy means a real interest rate at the natural level, *r**. However, when optimism is rising, a real interest rate raise is preferred to some point; a proactive policy is optimal for intermediate levels of optimism. When optimism is beyond these intermediate levels, the costs of being proactive exceed the benefits.

The reason for a rising real interest rate in the area where a proactive policy is beneficial is that the more optimistic the private sector gets, the higher interest rates are needed to forestall debt accumulation.

An important difference from a large part of the associated literature is that the optimal policy can not be summarized by a simple rule.[44]

[44] In large parts of the literature the optimal policy is connected to a rule that is close to the Taylor-rule discussed in chapter 2.

Model Limitations

Since the model is of a closed economy exchange rate effects are omitted. This may depreciate the value of the model in a context where implications for small, open economies are of interest. Furthermore, parameterization may affect the results. The fact that monetary policy can affect investments immediately by raising the interest rate is not reconcilable with reality. Debt is indexed, which is not the case in most inflation targeting countries. The difference between indexed and nominal debt is that nominal debt can be inflated, which leads to an increase in net worth of firms.

4.6.3 Further Reading

In a recent paper, Berger et al. (2007) extends the model of Bordo & Jeanne (2002a,b). Their main extension is the incorporation of forward-looking expectations. They conclude that the welfare losses to a reactive monetary strategy increases when forward-looking expectations are incorporated, whereas the welfare implications of a proactive strategy do not change. Thus, they recommend a more proactive strategy.

5.0 Monetary Policy Response to Asset Prices

This chapter will first present some response strategies to asset price fluctuations. The views in the literature will be connected to the different strategies available. Then follows a section that shows some empirical evidence on how monetary policy *does* react to asset prices. This is followed by what central bank officials *say* they do. Next, some thoughts will be offered on how small, open economies may relate to 'monetary policy and asset prices'. Finally, the role of regulations is discussed.

5.1 Response strategies

According to the literature that has been reviewed in chapter 4 there are several response strategies to asset price booms. The next passages give brief explanations of these strategies, and connect them to the reviewed models. There are several articles, by researchers and practitioners, where response strategies are discussed (e.g. Cecchetti 2005; Trichet 2005).

1) "No direct response to asset prices"

i) The orthodox view is that there is no special role for asset prices when assessing the optimal monetary policy. Thus, monetary policy should only focus on keeping inflation low and stable, with some consideration for output. However, the view that there is no role for asset prices in monetary policy has been empirically challenged (Trichet 2005); financial instability caused by asset prices is possible in an economy with low and stable inflation. Thus, keeping inflation low and stable is not enough to achieve financial stability.

However, there is a question of ex-ante or ex-post response. A 'no response'-strategy to an asset boom does not leave out a response to the inevitable bust. Such an ex-post response is labeled 'benign neglect' by Bordo & Jeanne (2002). The bust of an asset bubble leads to lower productivity and low inflation, (maybe even deflation), which will call for an expansive monetary policy.

ii) A moderate version of this view is that asset prices should be given weight if they affect inflation through transmission mechanisms; reacting indirectly to asset prices. This is the view

of Bernanke & Gertler (2001), who find that reacting directly to asset prices may lead to destabilization of output and inflation. Svensson (2004) states a corresponding view when discussing the Eurosystem and asset prices: "The ECB and the Eurosystem should normally take asset-price movements and potential asset-price bubbles into account only to the extent these are deemed to have an impact on the inflation and output-gap forecasts that should guide monetary policy".

2) Pre-emptive use of the interest rate

i) "Leaning against the wind"

If a potential asset price boom is identified this strategy implies that the central bank should raise the interest rate in a *smoothening* manner above the necessary level needed to provide low and stable inflation over the short to medium term. The impact of a negative asset price shock is assumed to be harder than the impact of a positive. Thus, by raising the interest rate the central bank deviate from its target with the purpose to restrain the bubble's growth. This strategy is consistent with the view of Cecchetti et al. (2000), Borio & Lowe (2002) and Bordo & Jeanne (2002).

A 'leaning against the wind'-strategy is advisable when the likelihood of a bubble-burst in the near future is small, the growth in asset prices is sufficiently interest rate sensitive, and the efficiency losses rise strongly with the size of the bubble (Trichet 2005). A central bank following this strategy must therefore assess what "small", "sufficient" and "strong" should mean in practice. The credibility of monetary policy may be tested if a central bank applies this strategy. However, since such a response to asset prices is supposed to be systematic (and smooth) in time, monetary authorities may avoid loosing credibility.

ii) Pricking asset price bubbles

This strategy is connected to the liquidity-effect of a contractive monetary policy, thus, it requires *sharp* movements in the interest rate. It is no longer in focus of research and is widely rejected. Posen (2006) articulates the insufficiency of cutting down on liquidity by raising the interest rate: "But central banks, and the commercial banks they lend to, are not investors' only source of liquidity. Just as drunkards or gambling addicts who have less money will forego basic needs or sell personal items to continue their binges, investors who wish to ride a boom upwards will sell or mortgage safer assets to do so, or they will look

abroad for credit, as necessary. If investors believe in supra-normal market returns being available to them, a mere rise in short-term interest rates will only tell them they need to invest more". The same author states as many others: "monetary policy is too blunt an instrument to prick bubbles with anyway" (2006). Researchers that have supported "asset price pricking" are e.g. Kent & Lowe (1997) and Roubini (2006).

A comment that concerns *i)* and *ii)* is given by Gruen et al. (2003) who find activist monetary policy impractical; *a)* interest rates influence economic activity with a lag, but *b)* affect the bubble immediately. Thus, due to *a)*, the central bank would like to have the interest rate low for some periods before a crash. However, due to *b)*, this would affect the bubble by reducing the likelihood of its burst. They proceed to find that activist monetary policy requires that the central bank can detect the bubble when it is just developing - which a majority would agree is close to impossible. This argument is supported by Cecchetti (2005).

3) Targeting asset prices

If central banks include asset prices in the consumer price index the strategy could be labeled *asset price targeting*. It is argued that the central bank can create a "cost-of-life"-index by including asset prices; assets are claims to future consumption and represent future prices of consumer goods. This view is widely rejected, and there are few that believe the inclusion of asset prices in the CPI provides a better measure of future inflation. "Central banks lack sufficient control of asset prices. In the long run, asset prices are driven by fundamental factors and not monetary policy" (Trichet 2005).[45] Goodhart (e.g. 2001) has been a promoter of broader measures of inflation that includes housing and stock market prices. Goodhart's view is rejected by Filardo (2000) who find that implementing a broader measurement of inflation would not improve economic performance.[46]

A targeting strategy could also imply that the central bank seeks to direct the prices-level of an asset, for instance stocks toward a price-level that is justified by fundamentals. This, of course, means that the central bank would have to know the fundamental value of firms in the stock market. However, this is a profession that already exists, and it seems infeasible that the central bank can dominate the huge community of financial-analysts that conducts this type of

[45] This is consistent with the new Keynesian view that monetary policy only affects real economic variables in short- to medium-term periods, whereas asset prices represent long-term variables.
[46] It should be noted that Filardo (2000) research concerns the US economy.

work in the private sector. In addition, assets represent long-term variables which monetary policy may not affect. Thus, the credibility of a central bank that conducts such a strategy would be at stake.

4) Communication

Can statements from the members of a central bank dampen pressure on asset prices? The head of the Norwegian central bank, Governor Gjedrem, discusses the residential real estate market in his annual report (2007). In this discussion he states that "the real estate market can be influenced by euphoria", before he concludes that prices in this market may stagnate, or fall, for a period.[47] The Norwegian media did indeed transmit this to the public. The behavior of the Governor Gjedrem deserves a discussion.

So, can this type of communication reduce the demand, and therefore prices in the market for residential property? Obviously the answer to that question depends on the influence monetary policy officials in Norway possess. Note however, that the credibility of the central bank may be at stake when such unambiguous statements are made. If prices continue to rise in the Norwegian real estate market, the public may consider the competency of their central bank to be insufficient.

Kohn & Sack (2003) find that central bank talk is not associated with significant stock market reactions when statements on valuation of asset prices are made.[48] They suggest that this can be due to the fact that the statements assessed have been "not that forceful" and in some cases "very indirect". However, they believe that a more likely explanation is that market participants "choose not to strongly update their belief about the appropriate valuation of assets" based on central bank talk.

The results in Kohn & Sack (2003) *may* be representative for all inflation targeting regimes. Nevertheless, there are obvious differences between central banks. The degree of transparency, time consistency and accountability could however lead to different reaction patterns between inflation targeting regimes.

[47] The phrase in quotes is translated from Norwegian to English by this thesis' author.
[48] Kohn & Sack study stock market reactions to speeches and testimonies made by Chairman Greenspan from 1995 to 2000.

It is difficult to know if the statements given by Gov. Gjedrem are connected to a strategy. *If* it is part of a strategy, the Norwegian central bank has to believe that it possesses a strong influential power. By forecasting a stagnation or fall in the residential real estate market, a central bank with influential power may dampen prices in this market; the prophecy could be self-fulfilling.

5.2 Do central banks respond to asset price fluctuations?

The next passages address the question by accounting for some of the empirical evidence and by discussing statements made by monetary officials.

5.2.1 Empirical evidence

Cadha et al. (2004) examine whether asset prices and exchange rates may be admitted into a standard interest rate rule, using approximately two decades of data from the economies of the US, the UK and Japan. In their paper they asses two types of rules; standard "Taylor-type" rules and *augmented interest rate rules*.

The standard Taylor-type rules are close to the forward-looking Taylor-rule discussed in section *2.1.5*. Neither asset prices nor exchange rates are incorporated in these. Thus, asset prices and exchange rates can only be employed as information variables.

Augmented interest rate rules allow for both asset prices and the exchange rate, or just one of them, to be incorporated as arguments.[49] An important matter regarding forward-looking rules is that, if stock prices are included, they will be lagged. This is because a central bank would not intervene before stock-prices deviate from fundamentals; central banks do not anticipate misalignments.

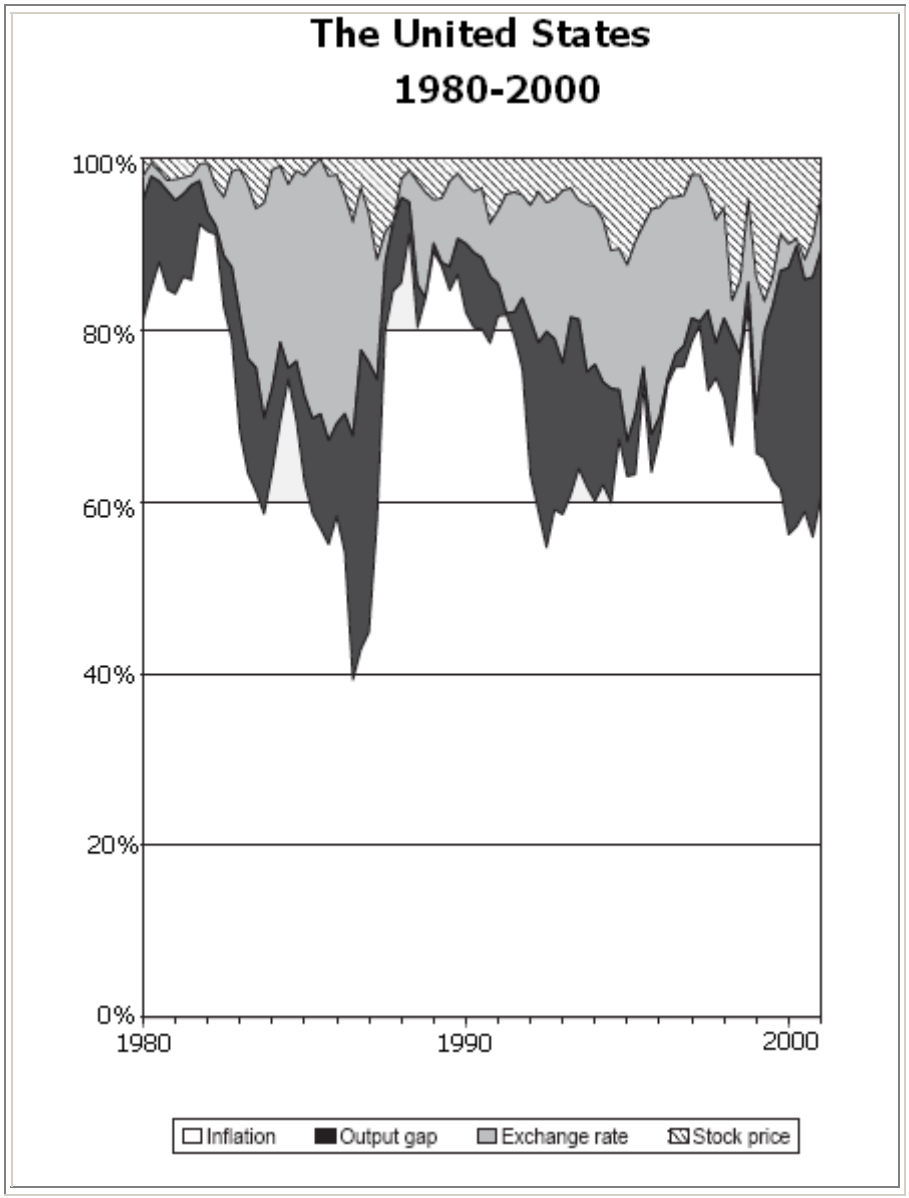
Cadha et al. (2004) find that asset prices and the exchange rate may have been used as part of the central banks information sets. They also find that central banks may have used the interest rate to offset deviations in asset prices or exchange rates from their equilibrium levels. Cadha et al. (2004) do not suggest that asset prices or exchange rates have been systematically

[49] E.g. Bernanke & Gertler (2000), who only incorporate stock prices, see the Bernanke & Gertler (2000)-model in chapter 4.

targeted, but they find that the investigated central banks may have reacted on a few occasions when there has been "a need to prevent abrupt corrections in asset markets that could be destabilizing for the economy".

A graphic presentation of their US-results illustrates this:[50]

Figure 7: Contribution of four variables on explaining the interest rate



In figure 7 the contribution of inflation, the output gap, the exchange rate and stock prices, in explaining the interest rate policy, are given in percentage points. It is not surprising that the

[50] This is a modified version of a figure presented in Cadha et al. (2004).

inflation rate explains large parts of monetary policy behaviour. The flexibility of the US central bank is given by the weight given to the output gap, which clearly varies. The illustration also suggests that there are occasions where the exchange rate, especially, and stock prices are given weight.

The results of Cadha et al (2004) are based on an investigation of three large economies. Central banks tend to act differently, thus one cannot expect the results in Cadha et al. (2004) to be representative for other economies. Note that parts of the data are from a time-period prior to the introduction of *inflation targeting*. [51]

Rigobon & Sack (2003) investigates the reaction of the US central bank to the stock market by use of the VAR-framework. They find that the a five percent rise (fall) in the S&P 500 index increase the likelihood of a 25 basis point tightening (easing) by about a half.

5.2.2 Official Statements

Ms. Hessius, former Deputy Governor of the Swedish central bank, stated in 1999: "…the general view nowadays is that central banks should not try to use the interest rate policy to control asset price trends by seeking to burst any bubbles that may form. The normal strategy is rather to seek, firmly and with the help of a great variety of instruments, to restore stability on the few occasions when asset markets collapse". This strategy is referred to as 'benign neglect' by Bordo & Jeanne (2002).

However, Ms. Hessius' statement was given in the dawn of the academic discussion on this part of literature. Another former Deputy Governor of the Swedish central bank, Ms. Eva Srejber, gave a speech (2005) that implies a change of strategy: "In my opinion, the costs of waiting can become so great that it is better to try to intervene with the limited knowledge we nevertheless have if we see an accumulation of large financial imbalances". This statement, even though it is subjective, gives an impression of a central bank that intends to respond to asset prices. If one considers the strategies that are accounted for above, the statement given by Ms. Srejber indicates a strategy close to the "lean against the wind"-strategy.

[51] For instance, the sterling was part of different fixed exchange rate systems, before starting to practice inflation targeting in 1997.

Governor Gjedrem of the Norwegian central bank clarified his view in a speech (2006): "Asset prices and household credit and debt are inputs for the analysis of future developments in inflation and the output gap. In this way, the assessment of asset prices and debt levels may influence interest rate policy". This statement relates to view of Bernanke & Gertler (2001). However Gov. Gjedrem continues: "…we have chosen to incorporate financial stability considerations into the monetary policy decision-making process, partly because asset prices and debt are important for inflation and output, and partly because it provides focus on potential risks to financial stability". Thus, the Norwegian central bank seems to have a pre-emptive attitude towards letting financial stability indicators, such as asset prices, influence the interest rate settings.

Mr. Bernanke, the Governor of the US central bank, the Federal Reserve, clarified his view in a speech (2002): "First, the Fed cannot reliably identify bubbles in asset prices. Second, even if it could identify bubbles, monetary policy is far too blunt a tool for effective use against them". Thus, his point of view as a researcher has not changed after his transfer in to practical monetary policy.

Mr. Bernanke took over the office of Mr. Greenspan who clearly shares his successor's view on monetary policy and asset prices: "The notion that a well-timed incremental tightening could have been calibrated to prevent the late 1990s bubble while preserving economic stability is almost sure an illusion" (2004).[52]

If one considers these statements from monetary officials, it seems as if there has been a change in the Nordic view, whereas the Federal Reserve seems to be sceptic toward interest rate reactions to asset price fluctuations. Obviously, one would have to analyze thousands of statements from a broad selection of central bankers to conclude that there has been a repositioning of views (or not). Due to the lack of knowledge and information – and of course the individual differences between bubbles – central bankers seems to be careful when they articulate their view and, especially, their practical strategy.

[52] Mr. Greenspan was head of the Federal Reserve during the *dot.com*-boom that started in 1995 and peaked in 2000.

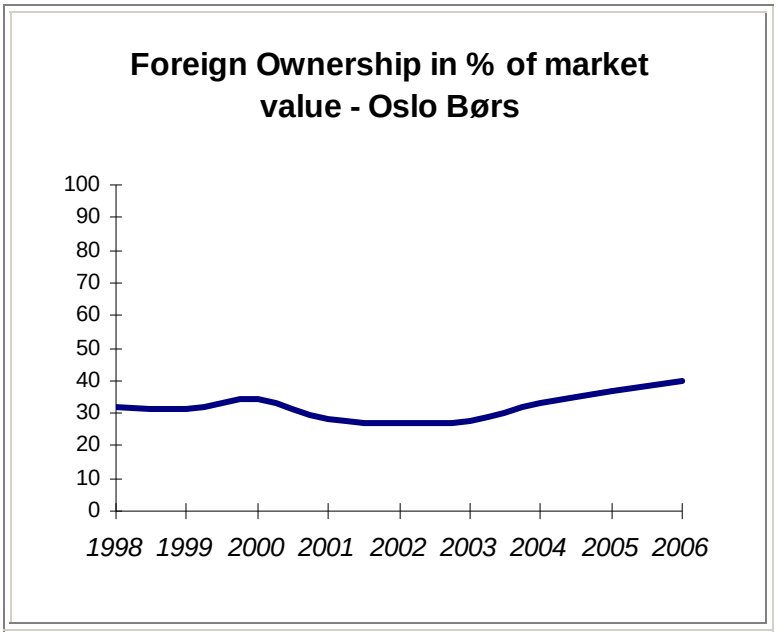
5.3 Small, Open Economies and Asset Prices

Closed economy models dominate the literature on 'monetary policy and asset prices'. In this section I will therefore seek to discuss how a small, open economy should respond to fluctuations in asset markets.

5.3.1 Stock Prices

When it comes to stock market prices in small, open economies, some important issues need to be clarified. First, if a stock price bubble arises, the wealth effects are of interest. Who holds stocks in the economy? If the stock market is dominated by few, large agents the effects of a bubble will not include significant inflationary pressure (Cecchetti 2005). However, if large parts of the economy's citizens hold stocks, the wealth effects of a stock price bubble will lead to inflationary pressure. In addition, one must consider indirect ownership of stocks, since many pension funds participate in the stock market(s).

Figure 8: Development of foreign ownership at Oslo Børs



Second, one has to consider that the financial markets are highly globalized. This can be illustrated by figure 8, which shows the development in foreign ownership on the Norwegian stock market, Oslo Børs.[53] The figure shows a small, positive trend in the proportion of foreign stockowners at the Norwegian stock market, and roughly 40% of stocks are held by

[53] Figure 8 is made by use of data from Oslo Børs.

foreigners (in the aftermath of the dot.com-bubble there was a slight decrease). Even tough (a small, positive trend on) the stock market of one small, open economy is not representative for all similar economies; there has indeed been a globalization-process in stock markets.

Third, how large is the stock market? The larger is the stock market, the larger is the risk of financial instability if a stock price bubble busts. As Cecchetti (2005) articulates it: "…equity markets are small in most countries, and so stock-price bubbles are not of any significance in most of the world…". More to the point, Cecchetti (2005) finds that there are only a few stock markets in the world that are large enough to cause significant real economic damage.

Fourth, some stock markets have been influenced by debt-financed takeovers. If this represents a trend in a stock market, financial institutions would be fragile if a bubble busts through balance-sheet effects (see section *3.1 Stock Market Prices*). Thus, regulations and bank supervision would also have to be considered in this context, in addition to a potential interest rate reaction. Regulations will be discussed below (in section *5.4 Regulations*).

Finally, if the stock-price bubble is present due to a global trend, e.g. the dot.com-bubble, central bankers of a small, open economy would find it infeasible to react to the bubble – because central bank policy in a small economy would not make an impact on the global trend. Thus, a domestic stock market bubble, due to an external trend, is hard to bring to an end.

So, if the small open, economy's stock market is small, with few participants (domestic and foreign) the effects of a stock price bubble (and bust) would be relatively small.

5.3.2 Real Estate Prices

It is hard to see how real estate market(s) in small, open economies should be different to real estate market(s) in other types of economies. Topics like immigration, mobility and regulations seem to be of interest.

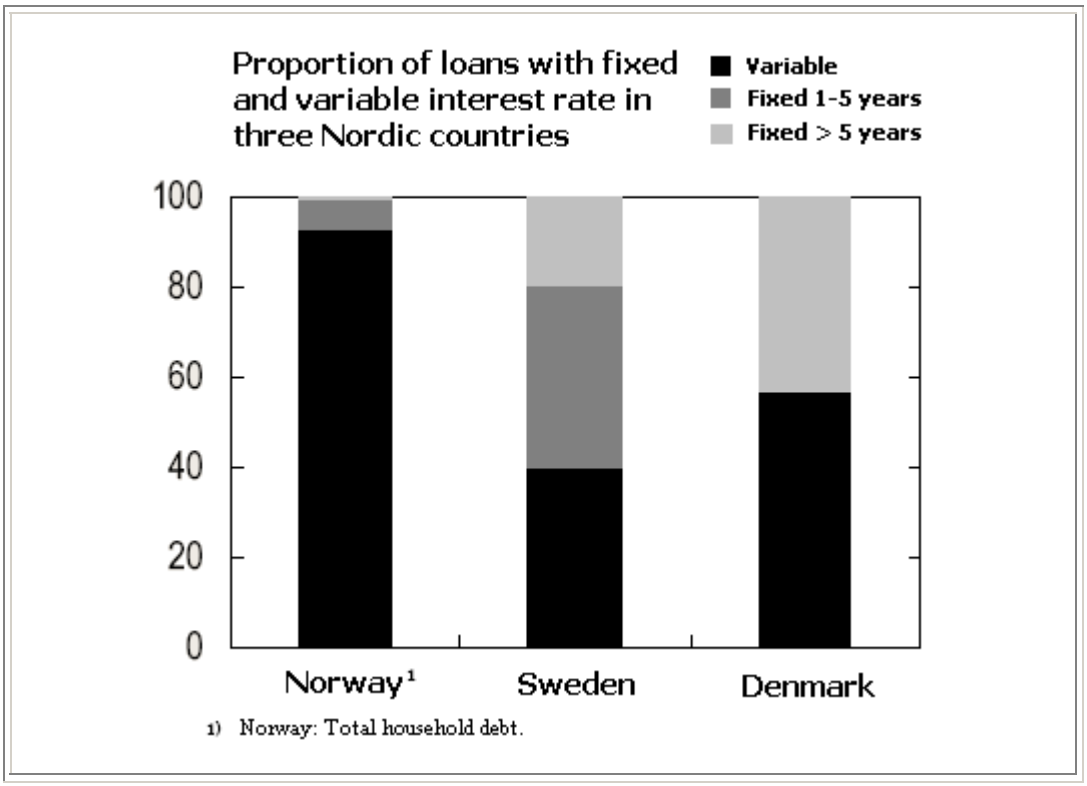
Real estate differs clearly to stocks. First, real estate is a good that is also consumed. The marketplace for real estate also differs from stock markets – both the capacity of transaction, and the professionalism of agents that are participating in the market. In a small, open

economy context, real estate price fluctuations may be of much more concern for monetary policy than stock market price fluctuations are (as argued above). This is due to the link from the real estate market to the credit market (discussed below in section *5.4 Regulations)*.

Real estate also differs from the other assets by composing such a large portion of consumption expenditure; Cecchetti (2005) argues that 15 to 20 % is the standard. If one assumes that a large proportion of citizens in an economy do own, or partly own, real estate, then a large fall (increase) in real estate prices could affect the real-economy through household's balance sheet effects and wealth effects (See chapter 3 under *Real Estate Prices*).

It is also important to consider how interest rate sensitive the real estate market is when assessing monetary policy action. If the finance in a real estate market is based on an interest-rate that is fixed for long terms, (for instance 3-5 years), a rise in the short term interest rate would not change the liquidity-situation for borrowers (instantly). Thus, monetary reactions to increasing real estate prices would not be as effective as wanted.

Figure 9: The proportion of fixed and variable interest rate on real estate loans in three Nordic countries.



As figure 9 illustrates, there are clearly differences between the Nordic countries, and Norway seems to be the economy where households are most likely to be sensitive to interest rate action from the central bank.[54]

In conclusion, fluctuations in real estate prices may very well be of interest to monetary policy in a small, open economy. However, there are no reasons identified in this section that would suggest special concerns for monetary policy in small, open economies.

Real estate markets are broadly linked to the credit markets. Therefore real estate prices will also be seen in section *5.4 Regulations.*

5.3.3 The Exchange Rate

"For a country that chooses not to "permanently" fix its exchange rate through a currency board, or a common currency, or some kind of dollarization, the only alternative monetary policy that can work well in the long run is one based on the trinity of (i) a flexible exchange

[54] Figure 9 is based on figure 10 in Almklov et al. (2006).

rate, (ii) an inflation target, and (iii) a monetary policy rule" (Taylor 2001).[55] The first two are given for most inflation targeting economies. Taylor (2001) specifies a monetary policy rule as a contingency plan that specifies how the central bank should adjust the interest rate. Thus, he refers to rules that are associated with the Taylor-rule accounted for in Chapter 1 under *1.1.5 How to Understand Inflation Targeting*. Thus, the question at hand is: Should small, open economies incorporate the exchange rate in their interest rate rules?

Consider a Taylor-rule that incorporates the exchange rate (i.e. an open economy monetary policy rule):

$$i_t = \alpha\pi_t + \beta y_t + h_0 e_t + h_1 e_{t-1} \tag{5.1}$$

where the nominal interest rate relates to the inflation rate, π_t, the deviation from potential output y_t, the exchange rate this period, e_t , and the previous period's exchange rate e_{t-1}. A response to the exchange rate would imply that the *h* parameters of (5.1) are non-zero.[56] Note that there is no intercept term; this implies that the inflation target is zero, and that the interest rate and exchange rate are measured relative to the long-run steady-state values (Taylor 2001).

First, in the case where the *h* parameters equal zero, it seems as if the central bank does not respond to the exchange rate. However, this deserves a discussion due to indirect effects. In a rational expectation model, an appreciation of the exchange rate would lead to expected decrease in output and inflation. This will lead to expectations of a decrease in the nominal interest rate, which again increase the likelihood of an interest rate decrease in the future period(s). Thus, even though the exchange rate is not incorporated in the interest rate rule, the exchange rate indirectly affects the policy, due to the fact that an appreciation/depreciation leads to altered expectations. However, the effect of an appreciation/depreciation on inflation and output expectations is crucial for this argument.

[55] In section *2.1.5 How to Understand Inflation Targeting*, readers were introduced to an option, namely discretion. However, Taylor (2001) may find that discretion is not optimal in the long run, due to the credibility problem. Period-by-period re-optimization may lead to inconsistent policy, which again reduce the credibility of monetary policy.

[56] The lagged exchange rate in (5.1) is incorporated to allow for "slightly more complicated dynamics" (Taylor 2001). For instance, it allows for an analysis of reaction to *changes* in the exchange rate.

If the *h* parameters are non-zero, this would imply a direct reaction to exchange rate fluctuations.

It could be useful to distinguish between developing countries and industrialized countries. For developing countries with large foreign debt a collapse of the domestic currency would lead to financial instability; borrowers which are, besides the state, mainly financial institutions face a raised real value of their foreign-currency-denominated liabilities. Such banking crises induced by currency collapse affected Mexico and several East Asian countries (Gertler 1998).

The openness of an economy matters. In a closed economy, expansive monetary policy raises the value of assets. In an open economy, expansive monetary policy leads to depreciation of the domestic currency and deteriorates the position of borrowers with liabilities in units of foreign currency. Thus, if asset prices fall rapidly, an expansive response from the central bank may not be as effective in an open economy as it would be in a closed economy (Gertler 1998).

The exchange rate is unambiguously important for small, open economies when it comes to financial stability. As shown above, a policy rule that does not incorporate the exchange rate does react to the exchange rate indirectly. Several studies suggest that the exchange rate should be incorporated directly.[57] For small, open developing economies it may be even more important due to weaker capital-conditions and less sophisticated financial systems. Note, however, that a direct response to the exchange rate could depreciate the credibility of monetary authorities; it may lead to larger, and more frequent, deviations from the inflation target.

5.4 Regulations

The reason for writing some passages on regulation could be summed up with a sentence from Kent & Lowe (1997): "In principle, the adverse effects of asset-price bubbles on the stability of the financial system can be moderated through appropriate financial system regulation and supervision". Thus, functioning regulations for asset-markets may allow monetary policy to focus on inflation targeting alone.

[57] For instance, Ball (1999) and Svensson (2000) find non-zero 'h-parameters'.

The Economist defines *regulation* as: "Rules governing the activities of private sector enterprises".[58] Regulations are imposed directly by the government, or indirectly by appointed regulators. There is a cost to regulations, they restrain market forces. However, the benefit which a regulatory government wants to obtain is lower risk of financial instability. All asset markets are subject to some sort of regulations. However, in this section the focus will be on credit markets. As stated earlier, this thesis focuses on asset prices, and debt instruments have to some extent been neglected. In this section, the broad linkage between asset markets and savings and investment decisions will be briefly accounted for – with a focus on real estate.

As mentioned, regulation of the banking sector may very well be ineffective, but it can also lead to fewer fragile scenarios for economies. The Basle Core Principles for Effective Banking Supervision was developed to give a global framework for supervisors of banking systems.[59] Global guidelines are preferable in a globalizing economy; many economies experience cross-border banks. For instance, the Swedish bank Nordea Group has large market shares in all Nordic countries. Thus, if they face comparable rules, the "nationality" of a bank will not matter. Gjedrem (2005) states that this is not the case in the Nordic region: "One particular problem in the Nordic region is the differences in the countries' deposit guarantee schemes". With regulatory differences come differences in the degree of risk. Thus, coordination of regulations of the credit sector may be a challenge for governments in a globalized world.

The balance-sheet effect of a bubble, or a positive cyclical change in asset prices, may lead to increased lending with assets as collateral.[60] This can increase the size, and growth rate, of a potential bubble. Thus, a simple regulation to avoid such a scenario may be to increase the loan to valuation ratio. Kent & Lowe (1997) points out that this may lead to a situation where non-bank financial institutions fund investment in asset markets that booms. They illustrate this by describing the early 1970's experience in Australia when a bubble in the real estate market developed. Due to bank-regulations, there was a growth of non-bank financial

[58] For more details, see *http://www.economist.com/research/Economics/alphabetic.cfm?letter=R#regulation*
[59] The Basle Core Principles can be found at *http://www.bis.org/publ/bcbs30a.pdf*
[60] The balance-sheet effect is explained in section *4.4.1 The Bernanke et al. (1999)-model*

institutions.[61] When the bubble burst, these institutions took the main losses. However, the scenario still led to considerable contractionary effects on the economy.

The regulation of a country's credit market is an intervention from governments that should reduce the risks that arise in relations where asymmetric information appears. For instance, banks are not allowed to lend to borrowers which does not meet specific criterions – such as capital and income requirements. Regulations, in the credit market, are especially important for the real estate market.

Cecchetti (2005) discusses some restriction on lenders, such as using the long term interest rates instead of short term interest rates when testing borrower's income coverage. Thus, banks would have to deny customers that are able and willing to pay market rent, due to their inability to pay future market rent.

Banking behaviour is interesting in a bubble-perspective: If a bust in the real estate market is followed by borrower-defaults, the bank would have to consider selling the properties that has served as collateral to high leverage loans. Obviously, to dump large numbers of property on a falling real estate market would increase the fall in prices. Thus, it could be profitable to hold the properties and sell them when the market is stable or prices are rising. Also, one could question a possible cyclical behaviour of banks; the higher is the (mean) prices on real estate, the lower is the capital requirements. The behaviour of banks differs from country to country, due to regulation and earlier practice.

If one turn to the stock market's link to credit, one can consider Posen's (2006) argument to why central banks should not burst bubbles (this chapter under *5.1 Response strategies*) he clearly states that investors in a booming market will find credit elsewhere if banks will not be their source of liquidity. Stock market transactions are often founded on credit – if lenders, under a regulation that "considers a transaction to risky", declines the investor(s) application, they can seek other providers of finance, such as non-bank financial institutions.

In the currency market, a typical governmental intervention would appear when an economy's currency is under downward pressure. The interest rate is increased to restore stability. Thus,

[61] Some examples of non-bank financial institutions: Venture capital companies, mutual funds, pension funds and investment trusts.

the cost of stability in this case would be a downfall in economic activity (see section *2.1.4 The Transmission Channels*).

6.0 Conclusion

The purpose of inflation targeting is to keep inflation low and stable. How to achieve this, without too large welfare losses, has consequently been of most interest to researchers and central bankers. After finding a policy-framework that seems to function, and provides superior performance compared to earlier frameworks, practitioners and researchers have turned to examine other threats than inflation. Among these are asset price movements.

According to statements from monetary authorities, there has been a shift in central banks when it comes to assessing their role in asset price fluctuations: From a reactive "clean up the mess"-attitude, to a more proactive attitude, where pre-emptive use of the interest rate may be initiated.

In an independent review of the monetary policymaking in Norway, Norges Bank Watch (2006), the authors Dørum & Holden state that: "Recent literature on monetary policy does not provide unambiguous recommendations as to what extent monetary policy should be concerned about financial stability". A statement supported by this review.

In the literature, there are different assumptions about how monetary policy is conducted, and how bubbles are modelled. This may explain a large proportion of the deviating results in this literature. Thus, one has to ask which assumptions are correct to apply, and which modelling framework is best suited for analysis of this economic area. Readers will be left to take a stand, but I will address these questions with thoughts about some of the assumption that may shift results.

As mentioned, monetary authorities tend to adjust the interest rate in a smoothing manner. Thus, a realistic model would incorporate this; by augmenting the loss-function or the interest rate rule.[62] Flexible inflation targeting implies that the central bank also is concerned about the output-gap. Consequently, realistic modelling of monetary policy should include the

[62] For instance, Batini & Nelson (2000) incorporate interest rate smoothing by penalizing interest variations in their loss-function, and by incorporating interest smoothing in the interest rate rule. Cecchetti (2005) incorporates interest rate smoothing only by augmenting the interest rate rule.

output-gap in the interest rate rule.[63] In addition, since the literature investigates bubbles in asset markets, assuming that the central bank can distinguish between fundamental and non-fundamental fluctuations could lead to increased pre-emptive use of the interest rate.[64] The risk of worsening economic performance, for instance by hampering a technology shock, is probably reduced when this assumption is present.

If interest rate smoothing, consideration of the output-gap, and monetary authorities that can not distinguish between bubbles and fluctuations due to bubbles, represents characteristics of monetary policy, then the only model in this thesis that seems to model monetary policy "realistically" is the Iacoviello (2005)-model. Iacoviello (2005) concludes that there is a marginal reward from responding to real estate prices. However, this is under the assumption that monetary policy can respond to *current* real estate prices. In addition, the interest rate rule is backward-looking. Is not monetary policy more interested in signals of future inflation rates? It seems that there may be reasons to question the assumptions in Iacoviello (2005) as well.

Assumptions about the bubbles are also interesting. A dominating part of the literature incorporates exogenous bubbles, i.e. bubbles that are not affected by monetary policy. However, chapter 3 shows that monetary policy may affect asset prices (at least in the short-run). Bernanke & Gertler (2001) state that their view is that "the macroeconomic stability associated with inflation targeting is likely to reduce the incidence of panic-driven financial distress that could destabilize the economy". Thus, endogenously modelled bubbles may improve the insight derived from models. What is more, the bubble process should also be mentioned. In the models presented in this thesis, some bubbles are stochastic, others are deterministic. Some are distributed probabilistically, whereas others last for a specified number of periods. One could argue that the latter is not realistic; history proves that shocks come in various forms, both in strength and length.

I will leave it to readers to decide whether the realistic assumptions of monetary policy would affect the analysis, and thus, the results.

[63] For instance, Bernanke & Gertler (2000) do not incorporate the output-gap in their instrument rules – see section *4.4.1*.
[64] As discussed in Bernanke & Gertler vs. Cecchetti et al. in section *4.4.1*.

Turning to monetary policy in small, open economies, there are some issues regarding asset price fluctuations that may differ to other economies. In my opinion, most small, open economies may not need to worry too much about domestic stock price fluctuations. For instance, a stock market trend arisen due to external factors will not be affected by monetary policy. Also, the real economic damage caused by a bubble in the stock market will be small in most cases (if the market composes a small proportion of the national wealth).

Real estate bubbles, however, are clearly problematic when they occur. History proves that many of the past real estate bubbles have caused severe economic damages in the countries that have experienced them.[65] I see no reason, however, for monetary policy in small, open economies to be more or less concerned with real estate prices than monetary policy in other economies. I believe that the close relationship between credit and real estate prices suggests that a rapid increase in real estate prices should be closely monitored by monetary authorities. Whether an interest rate response is useful or counter-efficient, I will leave for readers to decide.

An inflation targeting regime that faces exchange rate fluctuations would have to choose an indirect response, or a more direct intervention. As stressed through the thesis, the exchange rate is important for small, open economies. Therefore, I find it likely that monetary policy in small, open economies (with a substantial sector exposed to competition) should respond directly to the exchange rate when it is regarded necessary; when the effect of the nominal exchange rate on employment, for instance in the export-sector, is regarded as damaging. Obviously, this could depreciate the credibility of monetary policy, but under a flexible inflation targeting regime there is also room for output-gap considerations.

So if monetary policy should respond to asset price fluctuations, which strategy is optimal? The literature suggest that the operable strategies are the proactive "lean against the wind"-strategy, or a response strategy where monetary policy only reacts to inflationary pressure due to the fluctuations. Clearly, both options would have to be assessed in times when asset prices fluctuate. The fact that asset price fluctuations varies in strength and length, could imply that there are times when the optimal strategy is an activist one, and times when a more casual strategy is optimal.

[65] More on past real estate bubbles in e.g. Bordo & Jeanne (2002).

The role of regulations should not be underestimated. Functioning regulations may provide financial stability in most cases, which lessens the role of monetary policy when asset prices fluctuate. Thus, proper regulations could allow monetary policy to focus on keeping inflation low and stable, i.e. providing best possible growth conditions. In a world where markets are highly globalized, the regulatory guidelines should probably cross borders. A continuation of this thesis, should probably investigate the literature on credit and regulations.

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