THE TRANSMISSION OF MONETARY POLICY IN
THE EURO AREA: IMPLICATIONS FOR THE
EUROPEAN CENTRAL BANK

Gert Peersman

Promotor: Prof. Dr. Rudi Vander Vennet
Co-promotor: Prof. Dr. Frank Smets

Dissertation submitted to obtain the degree of Ph.D. in Economics

March 2001
PREFACE

In writing this dissertation, I owe a heavy intellectual debt to the many people that have stimulated my interest and guided me through the fields of economics over the years. I thank my promotor, Rudi Vander Vennet, for his enthusiastic and excellent support during the development of this dissertation. I gained enormously from a virtually continuous conversation about economics and other social topics. It has been a pleasure to be his research and teaching assistant for almost six years.

I would like to thank my co-promotor and co-author of several papers, Frank Smets. He introduced me in the academic world of monetary economists and central bankers. He has guided my work very closely, and he taught me to do applied research and to write publishable papers.

I want to address a special thanks to the other members of my Ph.D. committee, Freddy Heylen, Paul De Grauwe and Jan Smets. They provided detailed, thoughtful and constructive comments on almost every aspect of the thesis. Feedback from these people on the preliminary edition has been gratefully received and incorporated where appropriate into this edition. All remaining errors are my own responsibility.

In alphabetical order, I have also received critical, substantive suggestions from Ignazio Angeloni, Annick Bruggeman, Richard Clarida, Geert Dhaene, Shamik Dhar, Anil Kashyap, Lavan Mahadeva, Ben McCallum, Benoit Mojon, Gabriel Perez-Quiros, Peter Sinclair, Lars Svensson, John Taylor and Anders Vredin. They made valuable comments and suggestions concerning some chapters.

I also want to acknowledge seminar and conference participants at the European Central Bank, Bank of England, Sveriges Riksbank, De Nederlandsche Bank, Ghent University, the Banca d’Italia and Bocconi University conference on ‘Monetary policy of the ESCB: Strategic and Implementation Issues’, and the Federal Reserve Bank of San Francisco and Stanford University conference on ‘Monetary policy and Monetary Institutions’.

I am also grateful to the Directorate General Research from the European Central Bank. I worked a lot on this thesis while being in the ECB’s Graduate Research Programme. I benefited from talking with the permanent staff and from participating in the meetings of the Monetary Transmission Mechanism Network.

But I would be remiss not to mention the substantial debt of gratitude I owe to the secretarial staff, Olivia and Nathalie, my many friends and colleagues, especially
John and Benoit, from the time I have been at Ghent University. I thank also my parents because they gave me the opportunity to study in the first place, and lots of others.

Finally, I would like to thank Nathalie, for providing me with a warm and happy environment, for her continuous moral support and lots of patience.

Gert Peersman
Ghent, April 25, 2001
CONTENTS

Preface I

Contents III

1. The transmission of monetary policy in the euro area: an overview 1
   1.1. Introduction 2
   1.2. The channels of monetary transmission and their implications for EMU 6
      1.2.1. Models with flexible prices 7
         1.2.1.1. Imperfect information 7
         1.2.1.2. Limited participation models 8
      1.2.2. Models with sticky prices 9
         1.2.2.1. The interest rate channel 9
            Overview 9
            Monetary policy and the term structure of interest rates 10
            Implications for EMU 12
         1.2.2.2. The asset prices channel 20
            Overview 20
            Implications for EMU 20
      1.2.3. The credit channels 24
         1.2.3.1. Bank lending channel 24
         1.2.3.2. Balance sheet channel - Financial accelerator 24
         1.2.3.3. Empirical evidence: Is there a credit channel of monetary policy transmission? 25
         1.2.3.4. Implications for EMU 27
      1.2.4. Influence of changes in output on inflation 31
      1.2.5. Summary 32
   1.3. Empirical evidence for the euro area 35
      1.3.1. Large econometric models 35
      1.3.2. Small econometric models 36
   1.4. Conclusions 40
      1.4.1. Research conclusions 40
      1.4.2. Policy implications 44
      1.4.3. Further research 47
   1.5. Appendix 49
      Appendix 1.1. Monetary policy and long term interest rates in Germany 49
      Appendix 1.2. Some more evidence on the transmission mechanism in the euro area 53
   1.6. References 56
2. The monetary transmission mechanism in the euro area: more evidence from VAR analysis

2.1. Introduction

2.2. A VAR-model for the euro area
   2.2.1. The specification of the benchmark model
   2.2.2. Basic estimation results
   2.2.3. A comparison with the United States

2.3. A robustness analysis
   2.3.1. The inclusion of M3 in the VAR
   2.3.2. Using the German interest rate instead of the area-wide interest rate
   2.3.3. Using the inflation rate instead of the price level
   2.3.4. Alternative identification schemes
      2.3.4.1. An interaction between short-term interest rate, exchange rate and the money aggregate
      2.3.4.2. A mixture of short and long-run restrictions

2.4. The effect of monetary policy on other macro variables
   2.4.1. The extended model
   2.4.2. The results

2.5. Concluding remarks

2.6. References

3. A VAR description of the effects of monetary policy in the individual countries of the euro area

3.1. Introduction

3.2. The effects of monetary policy in the countries of the euro area

3.3. VAR models for the individual countries in the euro area
   3.3.1. The specification of the benchmark VAR-model for the euro area
   3.3.2. VAR models for the individual countries in the euro area
      3.3.2.1. Germany
      3.3.2.2. France, Italy, Spain, Finland, Ireland, Portugal and Belgium
      3.3.2.3. Austria, the Netherlands (and Belgium)

3.4. Estimation results

3.5. Conclusions

3.6. References
4. Are the effects of monetary policy in the euro area greater in recessions than in booms?
4.1. Introduction
4.2. Is there a common cycle in the euro area?
4.3. The asymmetric effects of area-wide monetary policy shocks
   4.3.1. A monetary policy VAR for the euro area
   4.3.2. Monetary policy shocks in the multivariate MSM model
4.4. Are the monetary policy effects different across countries?
4.5. Does monetary policy change the likelihood of a recession?
4.6. Conclusions
4.7. References

5. The industry effects of monetary policy in the euro area
5.1. Introduction
5.2. The industry effects of monetary policy
   5.2.1. Methodology
   5.2.2. Estimation results
5.3. Industry characteristics and the monetary policy effects
   5.3.1. Industry characteristics
      5.3.1.1. The conventional interest rate channel
      5.3.1.2. The financial accelerator channel
   5.3.2. Specification and results
   5.3.3. One-step estimation
5.4. Conclusions
5.5. Appendix
   Appendix 5.1. Data sources and definitions
5.6. References

6. The Taylor rule: a useful monetary policy benchmark for the euro area?
6.1. Introduction
6.2. Taylor rules from the past
6.3. The Taylor rule in an aggregate model for the EU5
   6.3.1. An estimated aggregate model for the EU5
   6.3.2. How well does the Taylor rule perform?
      6.3.2.1. Instrument rules and the loss function
      6.3.2.2. Results
6.4. Uncertainty and the robustness of simple Taylor rules
   6.4.1. The effect of estimation error in the output gap
   6.4.2. The effect of uncertainty about the transmission mechanism
6.5. Conclusions
6.6. Appendix

Appendix 6.1. Some more evidence on the transmission mechanism in Europe

Appendix 6.2. Estimation and optimal control of the EU5 model

A.6.2.1. Estimation of the EU5 model

A.6.2.2. Optimal control of the EU5 model

6.7. References
CHAPTER 1

THE TRANSMISSION OF MONETARY POLICY IN THE EURO AREA: AN OVERVIEW

Overview

In this chapter, a general overview of the transmission mechanism of monetary policy in the euro area is provided. We give a brief overview of the different channels of monetary transmission and their implications for the EMU. Further, the existing empirical evidence on monetary transmission in the euro area is discussed. Also, the new empirical evidence provided in this thesis, is discussed in the context of the literature. Finally, the general conclusions of this thesis are reported.
1.1. INTRODUCTION

The Eurosystem still faces some important challenges since the birth of the euro on January 1, 1999. The main task of the European Central Bank (ECB) is to conduct monetary policy for the euro area. Following the Maastricht Treaty, the primary objective of the ECB is to ensure price stability. Moreover, without prejudice to the objective of price stability, the ECB shall support the general economic conditions in the area, such as a sustainable and non-inflationary growth. In order to achieve these final goals, the ECB has some instruments under control to conduct monetary policy. Primary among these is the control of the short-term interest rate and the monetary base. There is however still a lot of uncertainty regarding the impact and timing of these instruments on the final objectives. More generally, monetary policy has become the central tool of macroeconomic stabilisation over recent years, but one that has sometimes unexpected and unwanted consequences. To be successful in conducting monetary policy, the monetary authorities must have an accurate assessment of the effects of their policy on the economy. This requires a good understanding of the transmission mechanisms through which monetary policy affects the economy.

This challenge is even more complicated for the euro area because while the ECB may conduct monetary policy based on union-wide aggregates, the impact of its policy can be different across the member countries. Specifically, under the EMU, member countries will be subject to common monetary policy shocks. Given the diversity in the economic and financial structures across the economies, these common monetary shocks can be expected to have a different impact, in terms of timing, magnitude and distributional effects. Little is known about what differences might arise, given the absence of any historical experience in Europe with a common monetary policy. Moreover, the creation of the Eurosystem constitutes an enormous regime shift, which can change the transmission mechanism, making the job of the European Central Bank even more difficult.

In this thesis, we discuss the transmission mechanism of monetary policy. More specifically, empirical evidence is provided for the euro area. There has been already a large body of literature concerning the transmission mechanism. In this first chapter, we try to give a brief overview of this existing literature. An understanding of the transmission channels is essential for the design and implementation of monetary policy. These channels are discussed in the next section. Distinction is made between the traditional money view (we make a distinction between models with flexible prices and models with sticky prices) and the more recent credit view. We also document in some detail differences in the structures of the member countries that may be relevant for potential asymmetries of the monetary policy transmission in the euro area. Besides the EMU members, two possible future candidates, Sweden and the UK, are also included. Since the
introduction of the euro causes a regime shift, a discussion of the consequences of EMU on the different channels is reported. The question is asked whether the potential asymmetric effects will disappear or become stronger with the introduction of the euro. Section 1.3 gives an overview of the existing empirical evidence, and section 1.4 discusses the general conclusions. New empirical evidence is provided in chapters 2 till 6. These chapters can be viewed as separate and independent papers. Most of these chapters contain work with co-authors, and some of them are already published or forthcoming in books or journals. Chapter 2, “The monetary transmission mechanism in the euro area: more evidence from VAR analysis” is joint work with Frank Smets, and is forthcoming as a chapter of an ECB book concerning the monetary transmission mechanism. An extensive version of Chapter 3, “A VAR description of the effects of monetary policy in the individual countries of the euro area”, together with Benoit Mojon is also forthcoming in the same book. Chapters 4, 5 and 6 are again joint work with Frank Smets. Chapter 4, “Are the effects of monetary policy in the euro area greater in recessions than in booms?” is currently an ECB Working Paper, and will be published in a Bank of England CCBS book on the monetary policy process from Cambridge University Press. Chapter 6, “The Taylor rule: A useful monetary policy benchmark for the euro area?”, has been published in “International Finance”, 1999, No. 1. This thesis contains the working paper version.

In chapter 2, we investigate the effects of an unanticipated change in monetary policy using the vector autoregression (VAR) methodology. We focus on the area as a whole, and estimate the model using synthetic euro area data from 1980 till 1998. We show that using a standard identification scheme delivers plausible effects of monetary policy. An unexpected, temporary rise in the short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output after two quarters. The effect on output reaches a peak after five quarters, to slowly return to baseline after twenty quarters. Prices are more sluggish and only start to fall significantly below zero some quarters after GDP. The effect on prices is also more persistent. We investigate also the reaction of other macro variables, and the GDP components to a monetary policy shock. As expected, investment reacts more, and private consumption reacts less than GDP. We also find a strong and immediate liquidity effect on M1, and a slow decrease of M3 and other credit aggregates.

One criticism of the area-wide approach is, of course, that because there was no single monetary policy regime, a model based on synthetic euro area data is likely to be misspecified. In order to check the robustness of the area-wide estimates, in the third chapter, we therefore modify the basic euro area model and estimate it for each of the countries in the euro area separately. In doing so, we minimise the changes in the specification. We show that three relatively simple identification
schemes, depending on the monetary policy decision process in the ERM, obtain similar and consistent effects for the individual countries as in the area-wide model.

In chapter 4, we investigate whether there is a different impact of monetary policy in recessions and expansions for eight countries of the euro area (Germany, France, Italy, Spain, Finland, Belgium, Austria, and the Netherlands). To do so, we take a euro area-wide approach. We proceed in various steps. In the first step, we test whether there has indeed been a common cycle in these countries using a multivariate extension of Hamilton’s (1989) two-state Markov Switching Model (MSM). In other words, we ask whether before the start of EMU their business cycles were sufficiently synchronised. This is of independent interest because it allows us to see whether differences in cyclical situation are likely to complicate monetary policy. We the exception of Finland, we find that we cannot reject the hypothesis that there was a common business cycle in these countries. We then extend the multivariate MSM to test whether the area-wide monetary policy impulses, estimated in chapter 2, have different effects on output in booms versus recessions. We find that monetary policy has considerably larger effects on activity when the economy is in a recession. These asymmetries are most pronounced in Germany, France, Spain, Italy, and Belgium. We also find weak evidence that a tightening of monetary policy reduces the probability of staying in a boom and no evidence that an expansionary monetary policy increases the probability of going from a recession to a boom.

In chapter 5, we switch from the country level to the industry level. The effects of the area-wide monetary policy shocks on output growth, obtained in chapter 2, are investigated for eleven industries of seven euro area countries. On average, the negative effect of an interest rate tightening on output is significantly greater in recessions than in booms. There is, however, considerable cross-industry heterogeneity in both the overall policy effects and the degree of asymmetry across the two business cycle phases. We then explore which industry characteristics can account for this heterogeneity. Differences in the overall policy effects can mainly be explained by the durability of the goods produced in the sector, the capital intensity of production and the degree of openness. This can be regarded as evidence for the conventional interest rate/cost-of-capital channel. In contrast, differences in the degree of asymmetry of policy effects seem to be related to differences in financial structure, in particular the maturity structure of debt and the need for working capital. This suggests that financial accelerator mechanisms can partly explain cross-industry differences in asymmetry.

Finally, the contents of chapter 6 are somewhat different from the other chapters. This chapter explores the Taylor rule as a benchmark for analysing monetary policy in the euro area. The focus is mainly on the endogenous part of monetary policy, i.e. the reaction function of the central bank. First, it presents evidence that interest
rates in Germany and the euro area can be described by a Taylor rule with interest rate smoothing. Second, it shows that an optimised Taylor rule performs quite well in a closed economy model of the euro area. Finally, the robustness of these results to estimation errors in the output gap and the effect of uncertainty about the transmission mechanism are examined.
1.2. THE CHANNELS OF MONETARY TRANSMISSION AND THEIR IMPLICATIONS FOR EMU

The money view has been the traditional way of explaining the monetary transmission mechanism. It consists of several channels, all of them interlinked and each of them having several stages. We divide them into two groups: one group assumes flexible prices, while the other assumes that prices are sticky. The models of the money view do not make a distinction between the different sources of investment financing. In line with the Modigliani and Miller (1958) theorem, these models assume that the manner of financing investment is irrelevant for the investment decision taken by the enterprises. In contrast, models of the credit view, also discussed in this section, explicitly distinguish between bank loans and bond issuing. The different channels, with their implications for EMU are discussed in the next subsections. The explanation of the different channels, and their interlinkages, is based on Graph 1.1.

Graph 1.1
The channels of monetary transmission
1.2.1. MODELS WITH FLEXIBLE PRICES

There are two classes of models that can explain short-run real effects of monetary policy with flexible prices and wages. The first is based on imperfect information, and the second on trading restrictions in financial markets.

1.2.1.1. Imperfect information

The models based on imperfect information (channel 1 in Graph 1.1) focus on misperceptions of the public about aggregate economic conditions, originally developed by Friedman (1968) and extended by Lucas (1972). They believe that prices and wages are fully flexible in the short-term, but price rigidities arise as a result of limits on information. The mechanism for limiting information is that trading takes place in several distinct markets with individuals who have imperfect information about aggregate economic variables. Then, an increase in the price in one of the markets can signal either that the money stock has increased, in which case there is a general increase in all prices and no need to change production, or that the relative price has increased, in which case it makes sense to increase production. This implies that, with limited information about the source of the price rise, suppliers must solve a signal extraction problem. The solution to this problem is to increase supply when the price rises, but by an amount that depends on the relative variability of money supply changes and market specific shocks in the past.

The Lucas model has the following policy implications. First, only monetary policy actions that are not systematic have a short-run influence on output. Systematic policy changes are fully reflected in the price level. Secondly, the greater the unpredictability of monetary growth (i.e. the less credible the monetary authority), the less the influence of monetary policy shocks on real output. A third influential implication of Lucas’ model is known as the ‘policy irrelevance hypothesis’ and was demonstrated by Sargent and Wallace (1975) and Barro (1976). If systematic monetary policy has no real effects, the choice of the monetary policy rule by the central bank is of no consequence for output developments.

The early empirical evidence was in favour of Lucas’ model. Lucas (1973) finds that nominal shocks have smaller real effects when aggregate demand is more volatile, as his model predicts. Barro (1977, 1978) and Barro and Rush (1980) find that only the unpredictable component of monetary growth affects real output and unemployment. Anticipated monetary policy was irrelevant. However, subsequent empirical work has criticised this. Gordon (1982) and Mishkin (1982) show that also

---

anticipated changes in the money supply have important output and employment effects, and therefore the choice of policy rule is not irrelevant for the behaviour of real economic activity. Pesaran (1982) and Ball et al. (1988) test the Lucas model against respectively an alternative Keynesian and new-Keynesian model and find that they can reject the former, but not the latter. As a consequence, these models are no longer viewed as an adequate explanation for the short-run real effects of monetary policy. However, the distinction between anticipated and unanticipated monetary policy is still very important in recent empirical and theoretical work. For example, we will recognise the influence of an unanticipated monetary policy shock, modified for systematic monetary policy, on real output in section 1.3.2, where we discuss the literature of VARs. Also, it is likely that a complete theory of price rigidities, as the foundation of the interest rate channel, will eventually involve elements of the limited information theory. Individuals setting prices do not change them frequently, or in response to every change in market conditions, because they have many things to think about and limited time to do different tasks of data-gathering and analysis (Sims, 1998). Moreover, the microeconomic foundations of the staggered contract models involve imperfect information about whether a shock is temporary or permanent or local or economy-wide (Taylor, 1998).

Since this channel depends on the relative variability of aggregate and relative prices, nothing from the past can be used to assess the strength of this channel in the Eurozone. This is because the ECB is a new institution. Asymmetric effects between the member countries, due to the direct monetary channel, are also impossible since there is only one single monetary policy. We can expect that the importance of this channel is decreasing over time because it is much easier to have access to information about evolutions of prices with the developments of technology.

1.2.1.2. Limited participation models

Short-term effects of monetary policy on the economy in an environment of fully flexible prices and wages can also be generated with 'limited participation' models, developed by Grossman and Weiss (1983), Rotemberg (1984), Lucas (1990), Christiano and Eichenbaum (1992), and Christiano, Eichenbaum and Evans (1996). Starting from a basic cash-in-advance framework, these models generate real effects of monetary policy because certain restrictions limit the ability of economic agents to make financial transactions. So, most people do not participate in financial markets continuously and have to make their cash decisions for more than one period. Generally, three different representative agents are assumed: households, enterprises and financial intermediaries. An unanticipated increase of money is injected into the economy through the financial intermediaries. Because households are staggered in their visits to financial markets, they can not adjust their money
balances. The additional liquidity is offered to the enterprises who will only accept this at a lower interest rate. This lower interest rate will stimulate investment and output.\textsuperscript{2} If the households were not restricted to participate in financial markets, this lower interest rate would induce lower household savings and thereby offset the interest rate effect.

The relevance of the channels emphasized in limited-participation models for understanding the broader effects of monetary policy on the aggregate economy remains an open debate. Dotsey and Ireland (1995), and King and Watson (1996) show that the predictions of this class of models do not account the magnitude actually found in the data. However, Christiano, Eichenbaum and Evans (1996) show that their limited participation model is able to match the evidence on the effects of a monetary policy shock if the labour supply wage elasticity is assumed to be very high. Again, we could not expect asymmetric effects of this channel across countries in the euro area because financial markets are equally developed. However, the impact of this channel can change over time (and probably has changed the last decade) as financial sectors evolve and the cost of transactions falls (Walsh, 1998).

1.2.2. MODELS WITH STICKY PRICES

1.2.2.1. The interest rate channel

Overview

The interest rate channel is the standard feature of the traditional textbook IS/ LM model.\textsuperscript{3} Roughly spoken, the transmission works along the following lines: The central bank raises the real money balances of households. For a given interest rate, this means an excess of cash in the perception of households. When households start to reduce their real balances through the acquisition of bonds they thereby also reduce the interest rate (step 2 in Graph 1.1) and thereby the cost of capital, which leads to an increase in investment and output (step 3).\textsuperscript{4} This is the conventional interest rate channel. Policy-induced changes in open market interest rates discourage or encourage investment spending, and thereby affect aggregate demand and output. The inflexibility of the price level is the crucial assumption in

\textsuperscript{2} Remark that the effect of monetary policy on investment and output goes through a liquidity effect: An increase of money results in a decrease of the real and nominal interest rate. However, we do not call this the interest rate channel (as in the next subsection) because the latter is traditionally based on models with sticky prices, while we still have flexible prices in the limited participation models.

\textsuperscript{3} See e.g. Hall and Taylor (1988) and Romer (1996).

\textsuperscript{4} This cost of capital effect also plays a role for durable consumer goods of households, such as houses and cars.
this framework. As long as the price level is fixed, the central bank can change the amount of real balances and therefore influence real economic activity. Once nominal rigidities are introduced, it follows that both systematic and unexpected monetary policy actions have an effect on output. This implies that the choice of policy rule by the monetary authority is relevant for the short-run movements of both prices and output.

The implication of sticky prices and wages is also investigated in general equilibrium models (e.g. Blanchard and Kiyotaki, 1987, and Chari, Kehoe and McGrattan, 1996). These models start from explicitly specified market imperfections and examine optimal behaviour under such imperfections. They also find non-neutrality of monetary policy. Most of these models also explicitly model the form of price stickiness. Examples of models that explain the rigidity of prices are the staggered prices model of Taylor (1979, 1980), the predetermined prices model of Fischer (1977), and Phelps and Taylor (1977), Calvo (1983) price setting behaviour models, or the models with endogenous price setting behaviour of Sheshinski and Weiss (1977, 1983) and Caplin and Spulber (1987).\(^5\)\(^6\)

**Monetary policy and the term structure of interest rates**

Aggregate spending decisions are generally viewed as more closely related to long-term interest rates and bank lending rates, while the monetary policy instrument is best represented by the short-term interest rate. Changes in the short-term interest rate will only affect aggregate spending decisions if longer-term rates and lending rates are affected. The impact of short-term rates on long-term rates is difficult to assess. This is because the relationship between short rates and long rates is believed to be based on the expectations theory of interest rates. In this theory, long-term rates are an average of current short-term rates and expected future short-term rates. So, monetary policy affects long-term rates to the extent that it influences current and expected short-term rates. This effect on long rates of a change in the stance of monetary policy will partly depend on the impact of the policy change on inflation expectations. The influence of monetary policy on the interest rates of different maturities is an important issue for the European Central Bank, because the reaction of the economies of the euro area to a monetary policy impulse could be different due to differences in the reaction of longer term interest rates and bank lending rates to a monetary policy shock.\(^7\)

---

\(^5\) On the other hand, we have also the New Keynesian economics models with small menu costs (Mankiw, 1985, and Akerlof and Yellen, 1985).

\(^6\) For an overview of the empirical evidence of price and wage stickiness, both at the macroeconomic and microeconomic level, see Taylor (1998).

\(^7\) See the discussion in the next subsection.
The empirical evidence on the quantitative effect of monetary policy on the long-term interest rates finds on average a positive relationship: an increase in the central bank rate leads to an increase in interest rates of all maturities. Romer and Romer (1996) find this positive movement in the long rate inconsistent with standard monetary theory, because an increase in short rates should reduce inflation, and hence reduce the level of sufficiently long rates. Also, there are many exceptions to this empirical phenomenon. Examples are declines of long-term rates in response to a monetary tightening.

Romer and Romer (1996) explain this empirical finding by arguing that when the Central Bank tightens monetary policy, market participants infer that it has unfavourable private information about the likely behaviour of inflation, and they therefore revise their expectations of inflation upward. Ellingsen and Söderström (2001) construct a model for the US within which the mechanism of Romer and Romer fits. The model they use is taken from Svensson (1997), and is a dynamic version of a simple aggregate supply-aggregate demand model, where they add an equation for the term structure of interest rates. They presume that a change in monetary policy can come about for two reasons: either the monetary authorities respond to new and possibly private knowledge about the economy (such as supply and demand shocks), or their policy preferences change (which is a monetary policy shock). In the first case, policy is essentially endogenous, reflecting new input into a given objective function. In the second case, policy is exogenous, in the sense that the input is the same but the objective function has changed. After an endogenous policy action, their model predicts that interest rates of all maturities move in the same direction as the policy innovation. On the other hand, after an exogenous policy action, short and long interest rates should move in the opposite directions.

Ellingsen and Söderström (2001) find positive empirical evidence for their propositions by interpreting newspaper reports from the Wall Street Journal immediately before and after each meeting of the FOMC. In appendix 1.1, we estimate a simple structural VAR for Germany to test the model of Ellingsen and Söderström. First, we look at the impulse responses of the interest rates of all maturities to supply and demand shocks. These shocks are symmetrically observed by all agents or the central bank may have private (advanced) information about these shocks. In both cases, we find that interest rates of all maturities move in the same direction. Second, the impact of pure exogenous monetary policy shocks is investigated. In that case, the preferences of the central bank have changed and sufficiently long interest rates move in the opposite direction, because expected inflation is reduced.

---

Implications for EMU

A necessary condition for the interest rate channel to be operative is that price adjustment does not occur instantaneously. In the traditional literature,9 firms’ price-setting decisions largely depend on the level of the average inflation rate. Again, the distributional consequences of this behaviour have disappeared since the start of the monetary union. However, asymmetric effects are still possible because of differences in, e.g. the labour market. In the latter, wage setting behaviour plays a crucial role. Table 1.1 presents some indicators of price flexibility. The employment protection variable is a weighted average of indicators pertaining to regular labour contracts, temporary contracts, and collective dismissals calculated by the OECD. Protection is very low, and thus labour markets are more flexible in the UK and Ireland. Employment protection is more similar in the other countries, and rather high in the southern countries (Italy, Portugal and Spain). The second indicator is a measure of real wage rigidity obtained from Berthold et al. (1999). They estimate the effect of a wage-push shock on unemployment using SVAR. Low values indicate that real wages are very flexible. The countries can be put into three groups. Sweden, Finland and Portugal have highly flexible real wages. Germany, the Netherlands and the UK exhibit a medium level of real wage flexibility, whereas Italy, Austria, Belgium, Spain, Ireland and France have highly rigid real wages. The last column presents the price response of firms to a change in their capacity utilisation, estimated by Roeger and in’t Veld (1999). Prices are relative flexible in Portugal, the Netherlands, Austria and Ireland, and rigid in Spain en Finland.

We have to remark that the shift to the EMU could considerably change the working of the labour market. The resistance of policymakers to labour market reforms might decline because they realize that monetary policy is no longer available to accommodate asymmetric shocks. Moreover, the bargaining power of the unions is expected to decline, leading to more flexible labour markets, and thus convergence across countries towards more flexible wages and prices. However, there is considerable disagreement in the literature that this will indeed be the case.10 One motivation for labour market reforms is the reduction of equilibrium inflation. The higher equilibrium unemployment is, the higher is the credibility problem of monetary policy and the higher is therefore the equilibrium inflation rate. The benefits of labour market reforms in terms of a lower equilibrium inflation rate are higher under monetary autonomy than in EMU. In the latter, labour market reforms produce positive externalities as the inflation bias is also reduced for the other member countries. As is well known from standard welfare theory, the amount of activities producing positive externalities is below the social optimum.

---

9 See the previous subsections for the references.
10 For an overview, see Bean (1998), Calmfors (1998) or Berthold et al. (1999).
Another reason why EMU might lead to less labour market reforms is that it takes a long time for supply side policies on their own to result in employment gains. The government therefore runs the risk that it takes too long before the positive effects of the reforms undertaken are felt. A parallel demand side policy, such as monetary policy, speeds up the process of employment gains and is thus helpful to enforce labour market reforms. The latter is, however, only possible if labour market policies and monetary policies are at the national level. It is also unlikely that labour market reforms will be realised quickly because these reforms are mostly implemented in acute crisis situations, when unemployment rises sharply due to negative shocks. We can at least expect that it will take some time before labour market reforms will take place, and that these differences across countries are still important for the transmission of monetary policy in the short to medium term.

<table>
<thead>
<tr>
<th></th>
<th>Employment protection a</th>
<th>Measure for real wage rigidity b</th>
<th>Price response to capacity utilisation changes c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>2.6 (20)</td>
<td>1.730</td>
<td>0.35</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2.2 (13)</td>
<td>1.581</td>
<td>0.52</td>
</tr>
<tr>
<td>Belgium</td>
<td>2.5 (16)</td>
<td>2.486</td>
<td>0.38</td>
</tr>
<tr>
<td>France</td>
<td>2.8 (21)</td>
<td>2.055</td>
<td>0.41</td>
</tr>
<tr>
<td>Spain</td>
<td>3.1 (22)</td>
<td>2.414</td>
<td>0.28</td>
</tr>
<tr>
<td>Italy</td>
<td>3.4 (23)</td>
<td>2.641</td>
<td>0.41</td>
</tr>
<tr>
<td>Austria</td>
<td>2.3 (15)</td>
<td>2.518</td>
<td>0.51</td>
</tr>
<tr>
<td>Finland</td>
<td>2.1 (11)</td>
<td>1.253</td>
<td>0.29</td>
</tr>
<tr>
<td>Ireland</td>
<td>1.1 (5)</td>
<td>2.334</td>
<td>0.48</td>
</tr>
<tr>
<td>Portugal</td>
<td>3.7 (26)</td>
<td>1.302</td>
<td>0.61</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.6 (18)</td>
<td>1.001</td>
<td>0.37</td>
</tr>
<tr>
<td>UK</td>
<td>0.9 (2)</td>
<td>1.594</td>
<td>0.41</td>
</tr>
</tbody>
</table>

a: summary indicator of strictness of employment protection, OECD, 1999. Ranking of all OECD countries between parentheses. All rankings increase with the strictness of employment protection.
b: estimated by Berthold, Fehn and Thode (1999). Indicator is the effect of a wage-push shock on unemployment (using SVAR).
c: estimated by Roeger and in’t Veld (1999).

The impact and timing of monetary policy actions can differ across industries, because of varying interest sensitivities in the demand for products. Durable manufactured goods, such as houses and cars are expected to be more responsive to interest rates than non-durable goods and services. Carlino and Defina (1998) find for the US that states with a higher share of manufacturing and a higher share of construction are more sensitive to a monetary policy shock. We also find in chapter 5 that industries producing durable goods respond significantly more to a monetary policy shock.
For the EMU, the share of manufacturing and construction in total GDP is comparable across the member countries (Table 1.2). The exceptions are Germany, with a higher share, and the Netherlands with a lower share than average. Asymmetrical responses of these countries are possible. The expectations about the influence of the monetary union on industrial structure are mixed. The European Commission (1997) argues that the European integration will promote intra-industry trade, leading to less cross-country differences in industrial structure. On the other hand, Krugman (1993) claims that EMU is likely to increase regional specialisation in Europe, implying divergence in industrial structure. So, if the introduction of the euro leads to concentration of the manufacturing and construction sectors in some countries, these countries will be more vulnerable to monetary policy shocks.

Table 1.2
Industrial structure in European countries

<table>
<thead>
<tr>
<th></th>
<th>Share of manufacturing and construction in total GDP (a)</th>
<th>Gross fixed capital formation as a % of GDP (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>0.366</td>
<td>21.4</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.236</td>
<td>19.7</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.265</td>
<td>17.9</td>
</tr>
<tr>
<td>France</td>
<td>0.271</td>
<td>18.4</td>
</tr>
<tr>
<td>Spain</td>
<td>0.321</td>
<td>20.9</td>
</tr>
<tr>
<td>Italy</td>
<td>0.298</td>
<td>17.6</td>
</tr>
<tr>
<td>Austria</td>
<td>0.294</td>
<td>23.8</td>
</tr>
<tr>
<td>Finland</td>
<td>0.299</td>
<td>17.1</td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td>16.8</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.329</td>
<td>24.6</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>15.2</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td>15.6</td>
</tr>
</tbody>
</table>

\(a\): Carlino and Defina (1998).

Capital-intensive industries, which need more investment, are also expected to be affected more strongly than less capital-intensive industries (the cost-of-capital channel is more potent for the former). This is confirmed for the euro area by the evidence provided in chapter 5. Industries with higher investment intensity are more vulnerable to area-wide monetary policy shocks. In chapter 2, we find econometric evidence for the euro area that investment, which is likely to be much more sensitive to a change in the cost of capital, responds stronger to a monetary policy shock than consumption. The response of investment is three times as large as the response of total GDP, while the response of consumption is less than GDP. This is illustrated in Graph 1.2, obtained from chapter 2. A comparison of the euro area and the US (Table 1.3) tells us that gross fixed capital formation is similar in both economies. However, the last column of Table 1.2 shows that there is a considerable difference across countries. Capital-intensity is high for Portugal,
Austria, and Germany, and rather low for Sweden and the UK. The other countries are more in between.

**Graph 1.2**

*Impulse response of GDP, investment and consumption to a monetary policy shock*

*(Estimation period: 1980-1998)*

![Graph showing impulse response of GDP, investment, and consumption to a monetary policy shock.](image)

**Table 1.3**

*Key characteristics of the euro area and the United States*

*(percentages of GDP in 1999)*

<table>
<thead>
<tr>
<th>GDP components</th>
<th>Euro area</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private consumption</td>
<td>56.8</td>
<td>67.6</td>
</tr>
<tr>
<td>Government consumption</td>
<td>20.1</td>
<td>14.4</td>
</tr>
<tr>
<td>Gross fixed capital formation</td>
<td>20.7</td>
<td>20.3</td>
</tr>
<tr>
<td>Exports</td>
<td>16.9</td>
<td>10.8</td>
</tr>
<tr>
<td>Imports</td>
<td>15.4</td>
<td>13.5</td>
</tr>
</tbody>
</table>

**Financial markets**

| Stock market capitalisation     | 90.2      | 179.8         |
| Debt securities                 | 98.8      | 166.2⁺         |
| Of which issued by:             |           |               |
| Government                      | 54.9      | 48.4          |
| Banks                           | 36.4      | 46.8          |
| Corporate sector                | 7.4       | 29.0          |
| Bank assets                     | 175.4     | 96.8          |
| Of which:                       |           |               |
| Loans to government             | 13.5      | ...           |
| Loans to the corporate sector   | 45.2      | 12.6          |
| Loans for house purchase        | 27.8      | 24.6          |
| Other loans to households       | 16.7      | 8.6           |


⁺ This figure includes debt securities issued by government-sponsored enterprises and federally related mortgage pools (42% of GDP).
With respect to the influence of monetary policy, a difference should be made between households, the government and firms, because the euro area is characterised by net creditor households, while the public and corporate sectors are net debtors (ECB, 2000). On the one hand, an increase of the interest rate modifies the cost of capital leading to a change in investment by firms and durable consumption by households, and an increase of the burden of the government deficits. The latter is a very important borrower on the financial markets. Due to the Stability and Growth Pact, this will entail a cut in government expenditures and hampers the working of the automatic stabilisers. In that case, the fiscal policy reaction to a contractionary monetary policy shock will be more restrictive in Belgium and Italy, with their large stocks of government debt (first column of Table 1.4). Table 1.4 provides also an overview of credit to firms and households. Next to Germany and the Netherlands, credit is twice as important in Sweden and the UK (the potential members) than in Italy.

Table 1.4
Composition of credit

<table>
<thead>
<tr>
<th></th>
<th>Gross nom. consolidated debt of the government (1998) a</th>
<th>Credit to the non-government sector as a % of GDP</th>
<th>Share hous./firms in total credit</th>
<th>Net. interest received by hous. / tot. liab b</th>
<th>Hous. fin. liab. / disposable income b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Hous.</td>
<td>Firms</td>
<td>Total</td>
<td>Hous.</td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td>61.2</td>
<td>125</td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
<td></td>
<td></td>
<td>70.0</td>
<td>115</td>
</tr>
<tr>
<td>Belgium</td>
<td></td>
<td></td>
<td></td>
<td>118.1</td>
<td>86</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td>58.1</td>
<td>90</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td></td>
<td></td>
<td>67.4</td>
<td>79</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td>118.1</td>
<td>64</td>
</tr>
<tr>
<td>Austria</td>
<td></td>
<td></td>
<td></td>
<td>64.7</td>
<td>88</td>
</tr>
<tr>
<td>Finland</td>
<td></td>
<td></td>
<td></td>
<td>49.6</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td></td>
<td></td>
<td>59.5</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td></td>
<td></td>
<td>60.0</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td>74.1</td>
<td>143</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td>52.3</td>
<td>117</td>
</tr>
</tbody>
</table>

Note: all figures are calculated from Borio (1996).

a: As a percentage of GDP, European Economy (1998).
c: The UK number includes dividend income.

On the other hand, the impact on non-durable consumption of households goes through income and substitution effects (Favero and Giavazzi, 1999). The substitution effect reduces consumption when there is a rise in the real interest rate because it is more profitable to save. The income effect will depend on the net credit position of the consumer. An increase in interest rates raises disposable income primarily in Italy and the Netherlands (Table 1.4) while wealth decreases in Sweden. The share of financial liabilities in disposable income is also low in Italy.
and very high in Sweden and the UK, making the negative consumption effect of the latter two stronger.

The figures and potential asymmetric effects should, however, be interpreted by making a distinction depending on the maturity of households’ and firms’ debt. As explained in the previous subsection, a shift in the stance of monetary policy is immediately transmitted to short-term money market rates and floating rates linked to short-term rates. The impact on longer-term rates, however, is more difficult to assess. Graph 1.3 shows the response of the short, and long-term interest rate to a monetary policy shock in the euro area (see chapter 2 for a description of the VAR). The short rate increases with 30 basis points, while the long rate increase is only 8 basis points. Since a large proportion of households’ interest income comes from assets at a long term rate, the income effect is likely to be rather small and will adjust only gradually to changes in the interest rate (ECB, 2000).

**Graph 1.3**

*Impulse response of short and long-term interest rate to a monetary policy shock*

(Estimation period: 1980-1998)

![Graph showing impulse response of short and long-term interest rate to a monetary policy shock](image)

The share of credit at short-term or adjustable medium and long-term rates is very different across European countries (Table 1.5). Italy, Austria and the UK are very short-term oriented, whereas credit in the Netherlands is mainly at fixed rates. However, when we relate these figures to the countries’ GDP, only the UK, and to a lesser extent Austria, is significantly more sensitive to a change in short-term interest rates, because mortgage debt of households in the UK is primarily related to the short-term interest rate. Although the share of adjustable interest rates is very large in Italy, the proportion to total GDP lies close to the EU-average, because the

---

11 Note that we do not find a negative correlation between the short and long-term interest rate after a monetary policy shock, as we did in the German case (see appendix 1.1).
total volume of non-government credit is very low in Italy (specifically the households credit). The government’s need to finance large budget deficits can be a reason for preventing the growth of the consumer-debt industry in Italy (Favero and Giavazzi, 1999). The Netherlands still remain weakly sensitive to changes in short-term interest rates, despite their large ratio of credit to GDP from Table 1.4.

One can argue that the shift to EMU can significantly change the composition of Italian credit towards less adjustable forms. The reason is that, in the past, Italy was characterised by high and variable inflation rates. The shift to a more credible ECB lowers the uncertainty about future inflation, making long-term credit more attractive. More generally, the single monetary policy in Euroland may lead to less divergence of the credit structure across members.

Table 1.5
The term structure of credit to the private sector

<table>
<thead>
<tr>
<th>Country</th>
<th>S.T. + Adj. M.T. &amp; L.T. / Total credit</th>
<th>Short term + adjust. medium and long term credit as a % of GDP</th>
<th>Effect on the lending rate of changes in money market rate a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Households</td>
<td>Firms</td>
</tr>
<tr>
<td>Germany</td>
<td>0.39</td>
<td>49</td>
<td>25</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.25</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.44</td>
<td>38</td>
<td>8</td>
</tr>
<tr>
<td>France</td>
<td>0.44</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Spain</td>
<td>0.64</td>
<td>51</td>
<td>4</td>
</tr>
<tr>
<td>Italy</td>
<td>0.73</td>
<td>47</td>
<td>11/13</td>
</tr>
<tr>
<td>Austria</td>
<td>0.74</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>0.35</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>0.73</td>
<td>85</td>
<td>62</td>
</tr>
</tbody>
</table>

Note: all figures are calculated from Borio (1996).


The reaction of the economies to a monetary policy impulse could be different due to discrepancies in the response, both in magnitude and timing, of bank lending rates to a change in the interest rate controlled by the monetary authority. Banks with a close relationship with their customers will (temporarily) absorb a part of the interest rate change. Competition in the banking sector is also an important factor of the pass-through from market rates to retail bank interest rates. Cottarelli and Kourelis (1994) find that the adjustment of the bank lending rates is instantaneous and complete in the Netherlands and the UK. The response is significantly slower in Italy, France and Finland. For the latter two, the response is even incomplete in the long run (see the last two columns in Table 1.5). They also find that the ‘degree
of stickiness' is higher when competition in the banking sector is lower for a larger sample of countries.

We can conclude that the interest rate channel is a very important channel for monetary policy transmission in the euro area. The strength of this channel will persist after the introduction of the euro. Table 1.6 provides an overview of the main determinants of this channel across the individual countries based on the discussion in this section. We assigned each individual country a grade from A to E for each determinant. Grade A means very sensitive to monetary policy compared to the other countries and E means less sensitive to monetary policy. An overall grade based on a subjective weighting of the individual grades is provided in section 1.2.5, when we compare all individual transmission channels. The real wage rigidity measure from Table 1.1 is considered as the most important determinant of price rigidities, unless there is a strong deviation of the other price flexibility indicators. The grade of households' consumption is based on total credit to households, corrected for the adjustability of households' credit and the net interest received. A similar correction for the adjustability of credit and the effect of monetary policy on lending rates is done for firms. A first inspection of the table suggests that it is likely that many differences across countries offset each other. We expect, however, a stronger than average interest rate channel for Germany, Spain and Austria and a weaker than average interest rate channel for the Netherlands.12

Table 1.6
Overview of the interest rate channel

<table>
<thead>
<tr>
<th>Country</th>
<th>Price rigidities</th>
<th>Industrial structure</th>
<th>Government debt</th>
<th>Households consumption</th>
<th>Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Netherlands</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Belgium</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>France</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Spain</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Italy</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>E</td>
<td>B</td>
</tr>
<tr>
<td>Austria</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Finland</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>C</td>
<td>D</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>UK</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

Note: 'A' and 'B' indicate a higher than average sensitivity of the country to a monetary policy shock, 'C' an average and, 'D' and 'E' a lower than average sensitivity.

---

12 See also section 1.2.5 for a more extensive discussion of the subjective weighting of the individual determinants and a comparison of the different channels across countries.
1.2.2.2. THE ASSET PRICES CHANNEL

Overview

Whenever a central bank alters the interest rate, it simultaneously alters the attractiveness of the own currency. An increase means that foreign investors shift part of their investment to financial assets denominated in this currency. As a result, the currency appreciates and lowers the competitiveness of the domestic industry (step 4 of Graph 1.1). The lowering of the competitiveness results in a deterioration of net exports (step 5). Monetary contraction thus decreases national output through an additional channel (step 6). In sum, monetary policy is more potent because it involves the exchange rate. This channel is often called the exchange rate channel. A change in the exchange rate has also a direct effect on inflation through the change in import prices (step 7).

Changes in the monetary policy stance also affect the market value of securities, such as bonds and equities (step 8). The price of bonds is inversely related to the interest rate, so a rise in interest rates lowers bond prices, and vice versa for a fall in interest rates. Higher interest rates also lower other securities prices, such as equities and houses. This is because expected future returns are discounted by a larger factor, so the present value of any given future income falls. On the one hand, the fall in the prices of those assets reduces consumption expenditure through wealth effects (step 11 and 12). On the other hand, the fall in the prices lowers Tobin's q (defined as the market value of firms divided by the replacement cost of physical capital). The crucial point of this discussion is that there exists a link between Tobin's q and investment spending (Tobin, 1969). When q is low, the firm will invest less because the market value of the firm is low relative to the cost of capital. If companies want to acquire capital when q is low, they can buy another firm more cheaply. So, investment spending and output will be lower (step 10).

Implications for EMU

The members of the euro area are all open economies. It is, however, only the extra-EMU trade of goods and services that is important, because an alteration of the euro doesn't affect intra-EMU trade. We can consider the euro area as a large closed economy with a weak exchange rate channel, comparable to the US (see Table

---

13 For the theoretical models underpinning this exchange rate channel, we refer to Obstfeld and Rogoff (1995, 1996) and Wickens (1985).

14 A more Keynesian view comes to a similar conclusion because it supposes that a rise in the interest rate makes bonds more attractive relative to equities, thereby causing the price of equities to decrease (Mishkin, 1996).
Total exports outside the area constitute only 16.9 percent of GDP. The first panel in Graph 1.4 plots the response of the real effective exchange rate to a monetary policy shock of 30 basis points (see chapter 2). The real effective exchange rate appreciates immediately after a monetary tightening, leading to a reduction of competitiveness. Although the impact of the exchange rate on total area output is probably limited, this channel can cause differential effects across members because the openness of EMU countries is very different. The share of extra-EU15 exports in GDP is illustrated in Table 1.7. These figures indicate that Ireland and Belgium could be more vulnerable to a rising euro exchange rate and Spain and Portugal less.

**Graph 1.4**

Impulse response of exchange rate, stock markets and housing prices to a monetary policy shock

(Estimation period: 1980-1998, 10% confidence bands)

Note: left panel: exchange rate, middle panel: stock market, right panel: housing prices.

The response of a European stock market index and housing prices to a monetary policy shock is plotted in respectively the middle and right panel of Graph 1.4. Clearly, both variables react as expected. Stock market prices fall immediately after a monetary tightening (reaching a peak of 3 percentage points after a policy shock in the interest rate of 30 basis points), and there is a gradual decrease of housing prices. Lower stock prices reduce investment of the firms, and have a wealth effect on households. The fall in housing prices has also a wealth effect on households. The impact of the former is smaller in the euro area than in the US (Table 1.3). Stock market capitalisation was in 1999 only 90.2 percent of GDP, while it was 179.8

---

15 This does not necessarily mean that the impact of the exchange rate on prices is not important in the euro area. A depreciation of the euro has a direct effect on import prices and, hence, on the consumer price index (ECB, 2000).

16 See MacDonald (2000) for an overview of the empirical evidence regarding the impact of a shift in the real exchange rate on economic growth. Most studies find a significant impact of the real exchange rate on growth.

17 A number of studies show that changes in household net worth explain a substantial part of the growth in US aggregate economic activity through a 'wealth effect' channel (Poterba, 2000).
percent in the US. Moreover, stock ownership is not as widespread. We can, however, expect that the importance of this channel will grow over time, since people are investing more and more in stocks. Housing wealth accounts for over half of household net wealth in many European countries and is less concentrated than equities. (Maclennan et al, 1999). So, one might expect substantial interest rate effects on consumer expenditure via housing wealth. The marginal propensity to consume out of changes in house price fluctuations is, however, expected to be smaller than stock market fluctuations. When house prices rise, the implicit user cost of living in a house also rises, which can offset the positive wealth effect. Empirical work suggests at best a weak link between house price changes and consumption (Poterba, 2000).

Table 1.7

<table>
<thead>
<tr>
<th>Variables influencing the asset prices channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra EU15 Export/GDP (1996) a</td>
</tr>
<tr>
<td>Financial market capitalisation as a % of GDP (1995-96) b</td>
</tr>
<tr>
<td>Dom. debt securities</td>
</tr>
<tr>
<td>Germany 10.4</td>
</tr>
<tr>
<td>Netherlands 15.6</td>
</tr>
<tr>
<td>Belgium 19.9</td>
</tr>
<tr>
<td>France 8.9</td>
</tr>
<tr>
<td>Spain 7.1</td>
</tr>
<tr>
<td>Italy 12.2</td>
</tr>
<tr>
<td>Austria 17.6</td>
</tr>
<tr>
<td>Finland 18.1</td>
</tr>
<tr>
<td>Ireland 24.4</td>
</tr>
<tr>
<td>Portugal 6.0</td>
</tr>
<tr>
<td>Sweden 17.6</td>
</tr>
<tr>
<td>UK 12.7</td>
</tr>
</tbody>
</table>

b: Maclennan et al. (1999).

Table 1.7 also gives data to assess the differences in the transmission process across countries via both asset prices. The market capitalisation to GDP ratio of bonds and equities may differ from the financial assets held by the households of a country because foreign ownership patterns differ across countries. Nevertheless, the correlation is probably very high due to the home country bias. The high ratios of debt securities for Belgium and Italy must be interpreted very carefully because in these countries the high government debts are mainly owned by their households. In that case, an increase or decrease of the value of this debt doesn't necessarily influence net wealth because the high debt has opposite implications for future disposable income (Barro, 1974). Equity-to-income ratios are very different across countries. Germany, Spain, Italy, Austria and Portugal have only small values of stock market capitalisation ratios. The contrary is true for the Netherlands, UK and
Sweden. These countries, with more extensive funded pension systems, have highly developed capital markets. These countries are expected to have large interest rate effects through this channel. The figures of Table 1.7 may also predict a larger impact of housing wealth on consumption in the high owner-occupation countries Spain and Ireland and less impact in Sweden and Germany. However, countries with high transaction costs (for example Spain) on houses should experience relatively small house price effects on consumption.

This section suggests that the importance of the asset prices channel in the euro area is expected to be rather small. The impact of small changes in net exports on total aggregate demand should not be overstated. The area is a rather closed economy with a limited impact through the exchange rate channel. Stock ownership is very concentrated and total market capitalization is smaller than in the US. Housing wealth is a more important component of total wealth, but the marginal propensity to consume is much lower. We expect, however, that the importance of this channel will grow over time because people are investing more and more in stocks. Although we expect a limited impact of the exchange rate channel for the area as a whole, the distributional effects could be large due to differences in openness across individual countries. Table 1.8 provides an overview of the relative grades for each country. We make a distinction between the exchange rate channel and other asset prices channel.

<table>
<thead>
<tr>
<th>Country</th>
<th>Exchange rate</th>
<th>Other asset prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Netherlands</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Belgium</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>France</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Spain</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Italy</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Austria</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Finland</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Ireland</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Portugal</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Sweden</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>UK</td>
<td>C</td>
<td>A</td>
</tr>
</tbody>
</table>

Note: 'A' and 'B' indicate a higher than average sensitivity of the country to a monetary policy shock, 'C' an average and, 'D' and 'E' a lower than average sensitivity.
1.2.3. THE CREDIT CHANNELS

So far, we have discussed the traditional money channels of monetary policy transmission. A large literature in recent years has focused on credit markets as playing a crucial role in the transmission process that does not operate through the traditional channels. There are two such credit channels which are highly interlinked: the bank lending channel and the broad credit channel, also called the balance sheet channel or the financial accelerator. Both channels are briefly explained in the next two subsections. In section 1.2.3.3, we discuss the main empirical evidence regarding the credit channels. The implications for EMU are discussed in section 1.2.3.4.

1.2.3.1. Bank lending channel

In the bank lending view of monetary transmission, there are three kinds of assets: money, bonds, and loans. The bank lending channel is based on the view that banks play a particular role in the transmission of monetary policy to the real economy and that bank loans and bonds are imperfect substitutes in the balance sheets of banks. Following a monetary contraction, bank reserves and bank deposits decrease (step 13 in Graph 1.1). Since loans and bonds are not perfect substitutes, the quantity of bank loans decreases (step 14). This decrease in bank loans will cause investment to decline (step 15). The latter is only possible when there are firms without an alternative source of investment funds through stock and bond markets. The strength of this channel also depends on the access of banks to close bank deposit substitutes, and the dependence of banks on the central bank.

1.2.3.2. Balance sheet channel - Financial accelerator

The second aspect of the credit channel is the broad credit channel, also called the balance sheet channel or the financial accelerator. This channel is not restricted to the bank lending channel. Credit-market imperfections may characterise all credit markets. Because of asymmetric information problems in the credit market, external financing is difficult to obtain and more costly than internal financing. The cost difference is called the 'external finance premium'. The external finance premium of a borrower is determined by its net worth. Lower net worth means that borrowers have less collateral for their loans. Monetary policy can affect borrowers' net worth in different ways. A restrictive monetary policy raises the interest rates

---

18 See e.g. Bernanke and Blinder (1988) and Stein (1995) for a formal model.


20 For theoretical underpinnings, we refer to Diamond (1984), Jaffee and Russell (1976), Stiglitz and Weiss (1981), and Williamson (1986, 1987a and 1987b).
and thereby reduces the cash flows of firms (step 16). Also, as mentioned before, house, equity and other asset prices decline. Both factors bring down the borrowers’ net asset value and the value of their collateral (step 17 and 18), leading to an increase of the external finance premium (step 19). The consequence is a further reduction in loans (step 20) and probably also in investment. In this way, the credit channel can serve to propagate and amplify an initial monetary contraction. An important feature of this channel is that it is the nominal interest rate that affects the cash flow of the firm whereas it is the real interest rate that affects investment in the traditional interest rate channel (Mishkin, 1996). Moreover, a rise in interest rates may have a much stronger contractionary impact on the economy if balance sheets are already weak (in a recession), which introduces the possibility of non-linearities in the impact of monetary policy.

1.2.3.3. Empirical evidence: Is there a credit channel of monetary policy transmission?

The early studies that try to test whether there is a distinct bank lending channel of monetary transmission focus on the relative forecasting ability and timing relationships of money and credit. The main methodology is to ask whether measures of credit are informative about future output movements, once money has been taken into account. Romer and Romer (1990) and Ramey (1993) find that monetary aggregates are better predictors of future output than credit aggregates. Bernanke and Blinder (1992) show that money falls by a larger amount and more quickly than loans after a monetary policy shock, and that bank loans ‘lag’ output, indicating that the decrease of credit is driven by changes in the demand for bank loans rather than the supply of bank loans. The problem is that the theories are not rich enough to provide exact predictions about the timing patterns that are critical for drawing conclusions. This is particularly true when behaviour depends on forward-looking expectations (Walsh, 1998). This reflects also the difficulty in identifying both channels. A restrictive monetary policy shock will affect both the asset (loans and securities) and liability side (deposits) of bank balance sheets. With a reduction of both, it is very difficult to know whether the decline of output is driven by a money channel, a lending channel or both.

Kashyap, Stein and Wilcox (1993) also provide evidence based on aggregate timing. They find for the US that when the Fed tightens, the issuance of commercial paper, which can be considered as a bank loan substitute, rises while bank loans decrease. They conclude that the change in this mix indicates that loan supply has shifted inward. Kashyap and Stein (1995) test the bank lending hypothesis using disaggregated data. The result is that, following a monetary tightening, the quantity of loans held by small banks falls, while the quantity of loans held by large banks remains constant. The idea is that the latter group should be able to raise external funds easier, and that small banks are affected by a bank lending channel.
However, Oliner and Rudebusch (1995) show that the aggregate evidence of the 
mix arises not because of loan supply effects, but because of heterogeneity in loan 
demand. Since sales of small firms fluctuate more than large firms, and large firms 
use more commercial paper than small firms, we can find a shift in the aggregate 
mix after a monetary contraction without a bank lending channel. This is what 
Oliner and Rudebusch (1995) find. They show that once firm size is taken into 
account, the mix of financing is unaffected by policy changes, and that the 
movement in the aggregate mix arises because of a general shift of debt away from 
small firms towards large firms. This heterogeneity of loan demand can also 
explain the finding of Kashyap and Stein (1995), because small firms are typically 
connected with small banks and large firms with large banks. This is shown by 
Gertler and Gilchrist (1994).

The evidence of the most recent studies regarding the lending channel is mixed. 
Kashyap and Stein (1999), and Kishan and Opiela (2000) find that respectively 
banks with low liquidity and poorly capitalised banks shrink by more than 
equivalent institutions with higher liquidity and higher capital.\footnote{The latter is also found in a study of Peek and Rosengren (1995).} Favero, Flabbi and 
Giavazzi (1999), King (2000), and de Bondt (1999) find only weak evidence of a 
lending channel in the major European countries. Kakes, Sturm and Maier (1999) 
find that the lending channel is not an important transmission mechanism in 
Germany and the Netherlands.

The empirical evidence of a financial accelerator is more straightforward. Gertler 
and Gilchrist (1994) show that inventory investment and sales of small firms, which 
have more financing problems, are more sensitive to changes induced by monetary 
policy than investment and sales of large firms. Moreover, they also illustrate the 
non-linearity effects of monetary policy. The effects of monetary policy on small 
firm variables are greater when the sector as a whole is growing more slowly. 
Kashyap, Lamont and Stein (1994) also find for the US that the inventory 
investment of firms without access to public bond markets was significantly 
liquidity constraint during the 1981-82 and 1974-75 recessions, in which tight 
money also appears to have played a role. In contrast, such liquidity constraints are 
largely absent during periods of looser monetary policy. Non-linearity is also 
detected by Oliner and Rudebusch (1996), who find that cash flow effects on 
investment are stronger after periods of tight money. Vermeulen (2000) provides 
evidence for the four largest euro area economies that weak balance sheets are more 
important in explaining investment during downturns than during upturns. 
Ehrmann (2000) also confirms the financial accelerator theory for Germany. Small 
firms are affected more strongly by a monetary policy shock.
The problem with these papers is that they show the existence of a credit channel, but not the quantitative importance in the overall context of policy transmission. The fact that small firms react different to a monetary policy shock than large firms does not mean that this is important at the aggregate level. Only Dedola and Lippi (2000) have shown yet that the broad credit channel can account for a substantial component of the ‘overall’ policy transmission mechanism. We also provide in chapter 5 some evidence that balance sheet characteristics are important in explaining the total impact of monetary policy. Moreover, we show that monetary policy has stronger effects on output during recessions than during expansions at the industry level. We find evidence that at least a part of this ‘degree of asymmetry’ can be explained by the balance sheet characteristics of the industry.

1.2.3.4. Implications for EMU

On the one hand, there is more potential for a credit channel in the euro area than in the US, because the role of banks in financial intermediation is much more important in Europe. Total bank assets are almost twice as important in the euro area: 175.4 percent of GDP, compared to 98.8 percent in the US (Table 1.3). In the latter, firms finance themselves more directly on financial markets. As already mentioned, the ratio of stock market capitalisation to GDP is twice as large as in the euro area. Moreover, debt securities issued by the corporate sector are much larger: 29.0 percent of GDP in the US, while only 7.4 percent for the euro area. On the other hand, average banks in the US are typically smaller than average banks in the euro area. The concentration ratio in the banking sector is also much lower in the US (Cecchetti, 1999). Both variables could indicate a higher potential for a bank lending channel in the US, because small banks have more difficulties to find substitutes for bank deposits.

Graph 1.5 plots the response of gross operating profits of firms to a monetary policy shock in the euro area, together with 10% confidence bands (see also chapter 2). There is a strong fall in profits after a monetary tightening, leading to a lower net worth of the firms. The latter is also reflected in the asset prices of the firms (see Graph 1.4). This lower net worth must raise the external finance premium, aggravating the effect of the initial monetary policy shock.

The recent trends in the banking sector and the introduction of the euro have a lot of consequences for the financial structure in Euroland (ECB, 1999). The mergers and acquisitions in the banking sector increase the importance of large banks in the EMU, making them less dependent on monetary authorities. Moreover, securitization has expanded dramatically in the mortgage markets for several decades now, and more recently, it has reached significant levels in various other markets, such as consumer credit, commercial credit and corporate debt. The effect of this securitization is likely to be a weakening of the impact of a given policy
move since securitization provides an effective means for banks to deal with their funding problems. Continuous funding is necessary when banks issue mortgages and hold them on their books. They could generate mortgages now and securitize them immediately, obviating the need for funding those assets on an ongoing basis (Estrella, 2001). On the other hand, the introduction of the euro creates a more competitive environment in EMU, leading to further pressure on banks’ profitability (and on their net worth). Also, the single currency will increase market liquidity, which will encourage the issuance of commercial paper and private bonds. Accompanied by further deregulation and liberalisation of financial markets, this is likely to speed up the process of disintermediation, which will weaken the importance of the credit channel.

**Graph 1.5**

Impulse response of gross operating profits to a monetary policy shock
(Estimation period: 1980-1998, 10% confidence bands)

The ratio of firms’ bank loans to all forms of finance is an important indicator of the potential strength of the credit channel and potential asymmetries in EMU. This ratio is very different across countries in Euroland (Table 1.9), going from very high in Ireland to very low in Finland, Sweden and the UK. This means that bank dependence is lower and alternative financing possibilities are higher in the latter countries, making the credit channel weaker. The strength of the bank lending channel largely depends on the access of banks to close bank deposit substitutes. Large and healthy banks are less sensitive to monetary policy, because they can readily offset the decrease in reserves with alternative forms of finance without reserve requirements (such as certificates of deposits). Column 2 of Table 1.9 shows the average size of banks in each country. Banks are on average large in the Netherlands, UK, Sweden and Belgium, and relatively small in Germany, Italy, Austria, Portugal and Finland. Table 1.9 also reports the concentration ratio of the top five banks. Focusing on this ratio may be appropriate if one believes that the
lack of integration of the banking markets is likely to persist, and if the largest banks in each country are expected to be able to attract funds during a credit squeeze, even if these banks are small in an absolute sense (Guiso et al, 2000). Overall, Germany and the UK have the least concentrated banking systems in Europe. On the contrary, large banks dominate in the Netherlands, Finland, Portugal, Sweden and Belgium. Banks are, however, healthier in Ireland, Sweden and the UK.

Table 1.9
The bank lending channel

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Return on assets</td>
</tr>
<tr>
<td>Germany</td>
<td>55</td>
<td>1.326</td>
<td>18.95</td>
<td>0.44</td>
</tr>
<tr>
<td>Netherlands</td>
<td>53</td>
<td>7.223</td>
<td>82.25</td>
<td>0.75</td>
</tr>
<tr>
<td>Belgium</td>
<td>49</td>
<td>4.691</td>
<td>77.39</td>
<td>0.52</td>
</tr>
<tr>
<td>France</td>
<td>49</td>
<td>2.361</td>
<td>42.70</td>
<td>0.36</td>
</tr>
<tr>
<td>Spain</td>
<td>58</td>
<td>2.086</td>
<td>51.90</td>
<td>0.76</td>
</tr>
<tr>
<td>Italy</td>
<td>50</td>
<td>1.681</td>
<td>48.33</td>
<td>0.33</td>
</tr>
<tr>
<td>Austria</td>
<td>65</td>
<td>0.436</td>
<td>50.39</td>
<td>0.38</td>
</tr>
<tr>
<td>Finland</td>
<td>39</td>
<td>0.321</td>
<td>74.33</td>
<td>0.50</td>
</tr>
<tr>
<td>Ireland</td>
<td>80</td>
<td>2.845</td>
<td>40.79</td>
<td>1.57</td>
</tr>
<tr>
<td>Portugal</td>
<td>62</td>
<td>0.798</td>
<td>72.60</td>
<td>0.91</td>
</tr>
<tr>
<td>Sweden</td>
<td>32</td>
<td>3.453</td>
<td>88.21</td>
<td>1.28</td>
</tr>
<tr>
<td>UK</td>
<td>37</td>
<td>6.743</td>
<td>29.07</td>
<td>1.28</td>
</tr>
</tbody>
</table>

a: Cecchetti (1999).
b: ECB (2000). Total assets, mrd ECU.

The credit channel should be very weak in the UK. Financial markets are well developed, and firms are on average very large and have strong balance sheets. This is shown in Table 1.10. An average firm in the UK has 667 employees. The number of publicly traded firms per capita is also the highest in Europe. Moreover, these firms are on average very healthy: highly solvent, high interest coverage ratio and high return on assets. This indicates that creditworthiness is very high, and it should be easy for these firms to find alternative finance. A similar pattern is found for the Netherlands. The opposite is true for Italy. Firms are on average very small, capital markets are poorly developed and balance sheets are weak. In combination with a banking industry characterised by small banks, this implies that the credit channel should be very strong in Italy. Further, we find that firms are on average small and not so healthy in Belgium. Germany has large firms, but their balance sheets are weak and the capital market is poorly developed. Also Portugal is characterised by large, but not so healthy firms. The other countries lie in between.
Table 1.10
The balance sheet channel

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>393 (95)</td>
<td>8.32</td>
<td>0.6</td>
<td>0.1</td>
<td>36</td>
<td>26.67</td>
<td>1.81</td>
<td>1.45</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>720 (129)</td>
<td>13.97</td>
<td>1.0</td>
<td>10.1</td>
<td>34</td>
<td>29.08</td>
<td>5.30</td>
<td>3.51</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>141 (40)</td>
<td>13.68</td>
<td>3.4</td>
<td>1.6</td>
<td>40</td>
<td>25.44</td>
<td>2.24</td>
<td>1.77</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>259 (79)</td>
<td>11.75</td>
<td>3.6</td>
<td>2.8</td>
<td>31</td>
<td>26.74</td>
<td>3.57</td>
<td>2.47</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>198 (71)</td>
<td>9.09</td>
<td>1.0</td>
<td>2.7</td>
<td>33</td>
<td>30.61</td>
<td>3.80</td>
<td>2.19</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>180 (58)</td>
<td>3.78</td>
<td>1.0</td>
<td>1.6</td>
<td>40</td>
<td>18.05</td>
<td>2.15</td>
<td>1.48</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>201 (83)</td>
<td>13.15</td>
<td>2.8</td>
<td>3.0</td>
<td>31</td>
<td>27.91</td>
<td>2.61</td>
<td>1.55</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>216 (69)</td>
<td>13.87</td>
<td>1.1</td>
<td>3.8</td>
<td>35.78</td>
<td>35.78</td>
<td>6.19</td>
<td>3.92</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>21.59</td>
<td>5.7</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>395 (122)</td>
<td>16.11</td>
<td>3.0</td>
<td>7.0</td>
<td>30.38</td>
<td>30.38</td>
<td>1.85</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>292 (74)</td>
<td>25.90</td>
<td>1.5</td>
<td>3.7</td>
<td>&gt;61</td>
<td>24.94</td>
<td>4.27</td>
<td>3.38</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>667 (139)</td>
<td>41.39</td>
<td>59</td>
<td></td>
<td></td>
<td>29.01</td>
<td>5.21</td>
<td>2.73</td>
<td></td>
</tr>
</tbody>
</table>

b: Cecchetti (1999).
e: median firm size between parenthesis.
f: (shareholders capital/ total assets)*100.
g: cash flow / interest payments

It is often mentioned that the introduction of the euro will lead to a convergence of financial and industrial structures in the euro area, and thereby reduce the potential asymmetries of a credit channel. This is not necessarily the case. Cecchetti (1999) shows that the difference in the financial structure across European countries is a consequence of a difference in the legal structure. As long as the legal system is different across countries, a convergence of the financial system is not possible. Differences in the legal system are then the basis for asymmetries in the impact of monetary policy. He finds that countries with better legal protection for shareholders and debtors (such as in the UK and Ireland), have a financial structure with a lower potential for a credit channel, and have also a lower impact of an interest rate change on output and inflation.

Table 1.11 summarises the potential strength of a credit channel in the individual countries. For both grades, the average size variables are the most important indicators, together with the dependence of firms on banks. The financial position of firms is also important to measure the balance sheet channel. Overall, we expect a very limited effect of the bank lending channel on total impact of monetary policy.

22 Examples are Dornbusch, Favero and Giavazzi (1998) and McCauley and White (1997).
in the euro area. This effect is even expected to diminish over time. The balance sheet channel is more important for the overall transmission process.

Table 1.11
Overview of the credit channel

<table>
<thead>
<tr>
<th>Country</th>
<th>Bank lending</th>
<th>Balance sheets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Netherlands</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Belgium</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>France</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Spain</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Italy</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Austria</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Finland</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Ireland</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Portugal</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Sweden</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>UK</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

Note: ‘A’ and ‘B’ indicate a higher than average sensitivity of the country to a monetary policy shock, ‘C’ an average and, ‘D’ and ‘E’ a lower than average sensitivity.

1.2.4. INFLUENCE OF CHANGES IN OUTPUT ON INFLATION

A final aspect of the transmission process of monetary policy is the influence of changes in output on the inflation rate (step 21 in Graph 1.1). We know that in the long run, inflation is always a monetary phenomenon, and that shifts in money supply will be reflected in inflation.\(^\text{23}\) However, the speed with which a change in output translates into inflation depends on the flexibility of prices and wages.\(^\text{24}\) In normal circumstances, if output is above its potential level, inflation increases. This is because the demand for labour increases with the higher output. In combination with a tight labour market, this has an upward pressure on wages. This cost pressure for the firm will be reflected in the inflation rate. In addition, capacity will be used more intensively leading to bottlenecks and thereby upward pressure on prices.

An interesting feature of this mechanism is that monetary policy could have a stronger effect on economic activity, and a weaker effect on prices in a trough than in a peak.\(^\text{25}\) If the economy is near a peak, more firms find it difficult to increase their output. As a result, inflation becomes more sensitive to shifts in aggregate

---

\(^{23}\) Of course, taking into account the growth of potential output and evolutions of velocity of money.

\(^{24}\) This is already largely discussed in section 1.2.2.

\(^{25}\) Remark that the non-linear effect on output is also predicted by the financial accelerator theory of the previous section.
demand at higher rates of capacity utilisation. The effect on output is weaker. The reverse is true in a trough. After a shift of monetary policy, it is easy for firms to adjust the utilisation of their capacity. The pressure on prices and wages is also very low, because labour markets are not so tight. This results in a stronger impact on output and a weaker impact on prices. This is exactly what we find in chapter 4. The impact of monetary policy is more potent in recessions than in expansions at the euro area, individual country and industry level.

In general, most econometric evidence finds that nominal price rigidities are comparable between the euro area and the US. However, the flexibility of real wages is much larger in the US. This implies that the impact on economic activity should be higher in Europe, and the impact on prices should be slower (ECB, 2000).

An implication of the asymmetric effects of monetary policy in recessions versus booms is that the business cycles of the individual countries should be synchronised. Apart from the fact that differences in cyclical situations complicate an efficient monetary policy design, these differences could also cause an asymmetric impact across countries. Although a lot of economists expect that the business cycle in European countries will converge with the introduction of the euro and the single monetary policy, it is interesting to see whether cyclical differences have been an important factor in the pre-EMU period. In chapter 4, we therefore also test whether the members of the euro area did share the business cycle in the past twenty years. Eight countries are included in our investigation: Germany, France, Italy, Spain, Austria, Belgium, the Netherlands and Finland. We cannot reject the hypothesis that the first seven countries shared the same business cycle. The only exception is Finland. We reject the hypothesis of a common cycle for Finland and the other seven countries.

1.2.5. SUMMARY

In this section, we compare the cross-country differences in economic and financial structure that may be important for potential asymmetric effects of monetary policy. Table 1.12 summarises the relative grades for all channels. It is very difficult to measure the overall impact of monetary policy across countries, because we do not know the exact weight of the individual channels, and we use noisy proxies to measure these channels. This implies that these results need to be taken with more than the usual degree of caution and it is not possible to make strong claims about how important cross-country differences are for the monetary transmission process. We believe, however, that these grades provide some interesting information, particularly at the extremes of their respective distributions. An overall grade is provided in the last column based on a subjective weighting of the factors.
A first impression of Table 1.12 is that many countries are characterised by idiosyncrasies with respect to the potential strength of the individual channels and it is likely that many of these differences offset each other. As a result, we do not expect large differences of monetary policy effects across countries. Some channels are, however, more important than others which makes asymmetric effects possible. There is a common acceptance in the literature that the interest rate channel is the most important channel of monetary transmission (with a prominent role for the industrial structure). This is confirmed with empirical evidence in chapter 5. We also expect a strong influence of the balance sheet channel. On the other hand, the impact of the bank lending channel and the asset prices channel is likely to be very weak. An exception could be the exchange rate channel. The subjective weighting of the individual grades is based on these impressions.

Table 1.12
Overview of the channels of monetary transmission in Europe

<table>
<thead>
<tr>
<th></th>
<th>Interest rate channel</th>
<th>Asset price channel</th>
<th>Credit channel</th>
<th>Total impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Netherlands</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Belgium</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>France</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Spain</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Italy</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>E</td>
</tr>
<tr>
<td>Austria</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Finland</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>Ireland</td>
<td>C</td>
<td>D</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Portugal</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td>Sweden</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>UK</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
</tr>
</tbody>
</table>

Note: 'A' and 'B' indicate a higher than average sensitivity of the country to a monetary policy shock, 'C' an average and, 'D' and 'E' a lower than average sensitivity.

The impact of monetary policy is expected to be stronger in Germany. The share of production of durable goods in total output is very high in Germany. Combined with a high share of gross fixed capital formation, this implies a strong effect of the interest rate channel. In addition, the expected impact of the credit channel is also very high. Both factors largely outweigh the weak asset prices channel. The credit channel is even stronger in Italy. Italy is also confronted with a high burden for the government deficit after a monetary tightening, and very adjustable interest rates for the private sector. The consumption effect of households, however, reduces these effects. The expected overall impact of a shift in the stance of monetary policy is also higher than average for Belgium, Spain and Austria. Although the impact of the exchange rate channel on the economy is probably very low for the euro area as
a whole, distributional effects are possible. This is for example the case for Belgium. Extra EU15 export is still 20 percent of GDP, indicating that the exchange rate channel is effective. Belgium is also characterised by a high government debt, and small firms with weak balance sheets. Although the effects of a shift in the euro are limited for Spain, we expect a strong impact of the traditional interest rate channel, and a financial accelerator effect. Both channels are even stronger in Austria.

On the other hand, the overall impact is relatively low for the Netherlands. This country is characterised by a ‘soft’ industrial structure, weak consumption effects and a very weak credit channel. The other member countries (France, Finland, Ireland and Portugal) are in between. The economic and financial structure is somewhat different for the two ‘outsiders’ of the EMU, Sweden and the UK. Both countries have very large firms who can easily find alternative forms of finance, and the industrial structure effects are relatively weak. Therefore, we expect a relatively weak effect of monetary policy in Sweden. The impact in the UK is more difficult to assess. The UK has a stronger asset prices channel, and a very strong effect through household’s consumption. This is because mortgage debt of households in the UK is primarily related to the short-term interest rate. The total impact will depend on the relative importance of both effects.
1.3. EMPIRICAL EVIDENCE FOR THE EURO AREA

In this section, we look at the empirical evidence of the pre-EMU period, to see whether the structural differences of the previous section have been translated into significant differences in the impact of monetary policy on the real economy. We can divide the empirical evidence in large econometric models and small econometric models. These two classes are discussed in the next two subsections.

1.3.1. LARGE ECONOMETRIC MODELS

In a study of the BIS (1995), the simulations of a monetary policy experiment across countries are compared. Two tools are used: the macroeconometric models developed by the National Central Banks (NCB's) and the multi-country model of the Federal Reserve Board. The results are presented in Table 1.13. The experiment was a simulation of the effects of a temporary 100 basis points increase in the policy rate for eight quarters, after which the policy rate would return to baseline. The NCB's models simulations indicate that the size and dynamics of output may differ across countries. The results are not completely comparable because the exchange rate is endogenous for Germany, Spain, Austria and the UK, while in the Dutch, Belgian, French and Italian simulations, it is assumed that the nominal exchange rates between the ERM countries remain fixed (the latter is a better replication of the EMU situation). The UK seems to be the country with the highest impact of monetary policy. The opposite is true for Spain. The impact is also smaller in Belgium, Austria and the Netherlands than in France, Germany and Italy. Comparison among the simulations with fixed intra-ERM exchange rates shows us that the impact is higher in France and Italy than in Belgium and the Netherlands.

Table 1.13
Changes in output following a 1% increase in policy rates during 8 quarters

<table>
<thead>
<tr>
<th></th>
<th>National Central Banks’ models</th>
<th>FRB multi-country model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>year t</td>
<td>t+1</td>
</tr>
<tr>
<td>Germany</td>
<td>-0.15</td>
<td>-0.37</td>
</tr>
<tr>
<td>Netherlands</td>
<td>-0.10</td>
<td>-0.18</td>
</tr>
<tr>
<td>Belgium</td>
<td>-0.03</td>
<td>-0.12</td>
</tr>
<tr>
<td>France</td>
<td>-0.18</td>
<td>-0.36</td>
</tr>
<tr>
<td>Spain</td>
<td>-0.05</td>
<td>-0.01</td>
</tr>
<tr>
<td>Italy</td>
<td>-0.18</td>
<td>-0.44</td>
</tr>
<tr>
<td>Austria</td>
<td>-0.08</td>
<td>-0.14</td>
</tr>
<tr>
<td>UK</td>
<td>-0.35</td>
<td>-0.89</td>
</tr>
</tbody>
</table>


*: intra-ERM exchange rates remain fixed.

The results from the FRB multi-country model appear to suggest that, if one applies similar methodologies across the countries, the differences in the output effects
become less clear. The effect is now larger in the UK and smaller in Italy. The amplitude, however, is very similar across countries. This lack of differences could suggest that the observed differences in the NCB's simulations might be attributed to differences in modelling strategies (Smets, 1995). The multi-country simulations, however, suppose endogenous exchange rates for each country, which is not a good replication of the EMU situation (Favero and Giavazzi, 1999).

1.3.2. SMALL ECONOMETRIC MODELS

The advantage of small econometric models is that these studies use the same model for each country. The problem, however, is that only a limited number of variables are used (reduced form estimation). We focus on evidence from vector autoregressions (VARs), since these have served as a primary tool for investigation of monetary policy effects on the real economy. However, also evidence of other small econometric models is presented. The effects of monetary policy on output are summarised in Table 1.14.

Gerlach and Smets (1995) used a VAR approach with a combination of short run and long run restrictions for the G7-countries. Only three variables are included in their VAR: output, the price level and the interest rate. Table 1.14 reports the effects of monetary policy on output for two variants of their model. The first variant is a one standard deviation, one-period shock (first row) and the second is a 100 basis point, two-year sustained increase of the interest rate (second row). Barran, Coudert and Mojon (1996) estimate a VAR with much more variables (including credit variables) using the recursive Choleski identifying assumptions for nine European countries. Britton and Whitley (1997) simulate a variant of the Mundell-Flemming model to analyse the transmission mechanism in the UK, France and Germany. Ramaswamy and Sloek (1997) estimate a simple three-variable VAR for EU-countries. Ehrmann (1998) estimates a VAR with common trends for thirteen European countries. Dedola and Lippi (2000) estimate the effect of a one-percentage point increase in the short-term interest rate using a SVAR containing industrial production, commodity prices, the price level, the money stock and the short-term interest rate. Dornbusch, Favero and Giavazzi (1998) use a small simultaneous model for output in different countries. The impact of a monetary policy shock on output is simulated with fixed exchange rates within Europe.

In this thesis, we also provide a lot of new empirical evidence for the individual countries. In chapter 6 (appendix 6.1), we estimate the output effects of a German monetary policy shock for six European countries. The emphasis is on the output effects taking into account the interaction effects among the countries due to their trade links. The results are also reported in Table 1.14 (Peersman and Smets, 1999). In chapter 3 (Mojon and Peersman, 2001), a VAR is estimated for the 11 individual countries of the euro area. Three types of slightly different models are estimated.
While these models are fairly similar and comparable, we avoid the implausible uniformity of approaches that characterises most of the other studies. We also avoid the multiplication of models that confuse the cross-country comparison.

Table 1.14
Effect of monetary policy on output using small econometric models

<table>
<thead>
<tr>
<th>Study</th>
<th>DE</th>
<th>FR</th>
<th>IT</th>
<th>ES</th>
<th>FI</th>
<th>BE</th>
<th>NL</th>
<th>AT</th>
<th>IR</th>
<th>PT</th>
<th>UK</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerlach and Smets 1</td>
<td>-0.28</td>
<td>-0.19</td>
<td>-0.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.66</td>
<td></td>
</tr>
<tr>
<td>Gerlach and Smets 2b</td>
<td>-1.00</td>
<td>-0.50</td>
<td>-0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.70</td>
<td></td>
</tr>
<tr>
<td>Barran et al.</td>
<td>-0.65</td>
<td>-0.46</td>
<td>-0.30</td>
<td>-0.55</td>
<td>-0.36</td>
<td></td>
<td>-0.35</td>
<td>-0.48</td>
<td></td>
<td></td>
<td>-0.48</td>
<td></td>
</tr>
<tr>
<td>Britton and Whitley</td>
<td>-0.60</td>
<td>-0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.32</td>
<td></td>
</tr>
<tr>
<td>Ramaswamy and Sloek</td>
<td>-0.75</td>
<td>-0.48</td>
<td>-0.50</td>
<td>-0.28</td>
<td>-0.85</td>
<td>-0.95</td>
<td>-0.60</td>
<td>-0.70</td>
<td>-0.50</td>
<td>-0.75</td>
<td>-0.60</td>
<td></td>
</tr>
<tr>
<td>Ehrman</td>
<td>-0.90</td>
<td>-0.40</td>
<td>-0.42</td>
<td>-0.22</td>
<td>-0.60</td>
<td>-0.36</td>
<td>-0.10</td>
<td>-0.05</td>
<td>-0.30</td>
<td>-0.40</td>
<td>-0.45</td>
<td>-0.32</td>
</tr>
<tr>
<td>Dedola and Lippi</td>
<td>-1.61</td>
<td>-0.66</td>
<td>-1.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.72</td>
<td></td>
</tr>
<tr>
<td>Mojon and Peersman</td>
<td>-0.14</td>
<td>-0.20</td>
<td>-0.12</td>
<td>-0.14</td>
<td>-0.44</td>
<td>-0.17</td>
<td>-0.12</td>
<td>-0.18</td>
<td>-0.32</td>
<td>-0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dornbusch et al.</td>
<td>-1.40</td>
<td>-1.54</td>
<td>-2.14</td>
<td>-1.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.90</td>
<td>-2.36</td>
</tr>
<tr>
<td>Peersman and Smets</td>
<td>-0.87</td>
<td>-1.15</td>
<td>-1.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-1.80</td>
<td>-1.00</td>
<td>-0.93</td>
</tr>
</tbody>
</table>

Note: Maximum impact; data not comparable across studies. DE = Germany, FR = France, IT = Italy, ES = Spain, FI = Finland, BE = Belgium, NL = Netherlands, AT = Austria, IR = Ireland, PT = Portugal, UK = United Kingdom, SE = Sweden.

a: effect of monetary policy on industrial production.
b: effect of a 100 basis point, eight-quarters sustained increase of the interest rate.
c: effect of a 1 percentage point increase in the short-term rate.

From Table 1.14, we can conclude that the studies present different rankings of the potency of monetary policy. Some countries are documented to be more sensitive to a monetary policy shock in one study, but less in another. For example, Barran et al. (1996) find the largest impact in Germany and the weakest impact in Italy, while Peersman and Smets (1999) find that the opposite is true. The problem with these cross-country comparisons is that the size of the estimated monetary policy shock differs across countries. In Mojon and Peersman (2001), for example, a one standard deviation monetary policy shock is a rise in the short-term interest rate of 26 basis points for Germany, while it is 59 basis points for Italy, and 84 basis points for Spain.26 Moreover, this also implies that each individual country has his own monetary policy reaction function. Thus, even if the same initial disturbance is analysed (what is done by Dedola and Lippi, 2000), the monetary policy responses would not be harmonised.27 This is illustrated by the two variants of Gerlach and Smets (1995). In the first case (a one standard deviation monetary policy shock), the response of output looks similar across Germany, France and Italy and higher in the UK, while in the second case (a one percentage point, eight-quarters sustained increase of the interest rate), German GDP moves by almost twice as much as that of France and Italy. The latter is equivalent to hitting the model with a sequence of

26 A monetary policy shock is also typically very large in the UK: 100 basis points in Gerlach and Smets (1995), and 110 basis points in Barran et al. (1996).

27 See also Guiso et al. (2000) for a discussion of this problem.
appropriately chosen shocks. To justify this type of analysis, however, we have to assume that the estimated parameters of the model are invariant to the specification of the policy rule, and we are confronted with the Lucas (1976) critique.

Another problem with these approaches, in the context of EMU, is that there is an important difference between a domestic monetary policy shock and a common monetary policy shock because there are large trade linkages between the member countries. The simulation of a common monetary policy shock could be much more similar across countries than a domestic monetary policy shock due to spill-over effects between countries. These problems can largely be solved by looking at the impact of a common monetary policy shock on each of the individual countries. The advantage of this approach is that we have the same monetary policy shock and reaction function across countries, and that we take into account spill-over effects between countries. In chapter 2, we estimate an area-wide VAR using synthetic euro area data. In chapter 4, we estimate the impact of these common monetary policy shocks on industrial production growth for seven euro-area countries. A distinction is made between the impact in a recession versus an expansion. We can, however, easily calculate the total impact of the common monetary policy shock based on a weighted average of the effects in respectively a recession and an expansion. Moreover, we can also formally test whether there are cross-country differences. The results are presented in the first column of Table 1.15.

Table 1.15
Effects of a common monetary policy shock on output

<table>
<thead>
<tr>
<th></th>
<th>Industrial production growth b</th>
<th>Area-wide VAR variant 1 (max. impact)</th>
<th>Area-wide VAR variant 2 (max. impact)</th>
<th>Ex ante expected grade a</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMU</td>
<td>-0.65 (0.12)</td>
<td>-0.20</td>
<td>-0.20</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>-0.98 (0.19)**</td>
<td>-0.28</td>
<td>-0.25</td>
<td>A</td>
</tr>
<tr>
<td>Netherlands</td>
<td>-0.74 (0.32)</td>
<td>-0.11</td>
<td>-0.14</td>
<td>D</td>
</tr>
<tr>
<td>Belgium</td>
<td>-0.47 (0.27)</td>
<td>-0.18</td>
<td>-0.20</td>
<td>B</td>
</tr>
<tr>
<td>France</td>
<td>-0.41 (0.15)**</td>
<td>-0.19</td>
<td>-0.15</td>
<td>C</td>
</tr>
<tr>
<td>Spain</td>
<td>-0.80 (0.26)</td>
<td>-0.22</td>
<td>-0.17</td>
<td>B</td>
</tr>
<tr>
<td>Italy</td>
<td>-0.55 (0.36)</td>
<td>-0.17</td>
<td>-0.17</td>
<td>B</td>
</tr>
<tr>
<td>Austria</td>
<td>-0.80 (0.19)</td>
<td>-0.17</td>
<td>-0.15</td>
<td>B</td>
</tr>
</tbody>
</table>

a: obtained from Table 1.12.
b: standard errors between parenthesis.
**: significant different from the average of the other countries at the 5% level.

The effect of an area-wide monetary policy shock on industrial production growth is significantly stronger than average in Germany, and significantly weaker than average in France. All the other countries are in between. In columns 2 and 3, we present also some preliminary results of the output effects of an area-wide monetary policy shock obtained from an SVAR (see appendix 1.2). In the appendix,
we estimate a two-block VAR for each individual country. In the first block, we include the area-wide variables from chapter 2. The second block contains domestic GDP, the domestic price level and the domestic short-term nominal interest rate. We assume that there is no feedback from the individual country to the area-wide variables. This assumption ensures that the area-wide shocks are invariant to the individual country chosen. Impulse response functions are presented in the appendix. Table 1.15, variant 1, reports the maximum impact on output. The output responses are very similar across countries. We find the strongest impact of the area-wide monetary policy shock in Germany, and the weakest in the Netherlands. This is also exactly what we expected based on the economic and financial structure variables (the grades are also reported in the table). The output responses of the other countries are very similar. We also report a second variant of the model. In this model, we restrict the response path of the domestic nominal interest rate to be the same as the area-wide nominal interest rate. This replicates more closely the situation of a common monetary policy in EMU. These results need, however, to be taken with a high degree of caution, because we implicitly assume that the estimated effects of the domestic interest rate are invariant to the specification of the domestic policy rule. Impulse response functions are again presented in the appendix, and the maximum impact is reported in the third column of Table 1.15 (variant 2). Remarkable is that there is a convergence of the monetary policy impact and amplitude across countries. The effects are still stronger in Germany and weaker in the Netherlands, but the difference with the other countries is less.

In sum, the empirical evidence regarding cross-country differences of the impact of monetary policy is mixed. Some countries are documented to be more sensitive to a monetary policy shock in one study, but less in another. Most of the papers that investigate the impact of a monetary policy shock use SVAR. The problem with this approach is that the size of the estimated monetary policy shocks and the reaction function differs across countries, making a comparison very difficult. One way to solve this is to estimate the impact of area-wide monetary policy shocks on the individual countries. The results are very similar across countries. We find, however, some evidence of a larger effect in Germany and some weak evidence of a smaller effect in the Netherlands.
1.4. CONCLUSIONS

The European Central Bank uses its monetary policy tools to change the money supply and short-term interest rates in order to achieve its final goals. The primary objective is price stability, but the ECB shall also support the general economic conditions in the area, such as a steady growth in output. Most economists agree that, in the short run, monetary policy can influence the real economy. There is, however, disagreement about how exactly a change in the instruments of monetary policy are transmitted to the real economy, and the monetary transmission mechanism itself is often treated as a 'black box'. In this thesis, we have tried to go into this black box, and investigated how exactly shifts in the stance of monetary policy are transmitted to the real economy. This is one of the most important concerns of the ECB. A good understanding of the different channels of monetary transmission is essential in an environment that has changed much with the introduction of the euro. Moreover, while the ECB conducts monetary policy based on union-wide aggregates, the impact of its policy can have differential effects across the member countries, making the job of the ECB even more complicated and a good knowledge of the transmission process more important. In section 1.4.1, we discuss the main research conclusions of this thesis and the contribution to the literature. The policy implications are discussed in section 1.4.2, and in section 1.4.3, we give some indications for further research.

1.4.1. RESEARCH CONCLUSIONS

There is a large literature that tries to explain the different channels of monetary policy. A brief overview of these channels is provided in the first chapter of this thesis. Among these channels, the traditional interest rate channel is the most important channel for the euro area. The idea is very simple. The real interest rate increases after a contractionary monetary policy shock. The higher real interest rate raises the cost of capital for investment and durable consumption, leading to a fall in output. The importance of the asset prices channels is less straightforward. A move in the interest rate has an influence on the real exchange rate and thereby on the competitiveness of the area. However, the total share of exports to countries outside the EMU is rather limited and comparable to the US. We can consider the euro area as a large closed economy, indicating that the exchange rate channel is not very important for the effects of monetary policy on GDP. The influence of this channel on prices is more important. There is a direct effect of the exchange rate on import prices, and a lot of commodity prices are expressed in foreign currencies. The wealth effects of the asset prices channel are also expected to be limited in Europe. Stock market capitalisation is still very low, and not as widespread as in the US. In addition, the effect on permanent income, and thereby on spending, is rather limited because of the high volatility of stock markets. Wealth effects are more likely to take place through real estate prices. The problem with the latter is
that, on average, transaction costs are high and the effect of changes in house prices on consumption is lower than changes in other wealth components.

While the importance of a bank lending channel in the total impact of monetary policy is probably very important in less developed countries, it is expected to be limited in the euro area. Only a few studies find some weak evidence of a bank lending channel in the euro area. The area is on average characterised by large, rather healthy banks, which are able to find alternative forms of finance. The importance of large banks increases even more with the mergers and acquisitions in the sector, making them less dependent on monetary authorities. Moreover, the share of credit provided by small banks, which are more dependent on the central bank, is insignificantly low. In addition, securitization has expanded dramatically for several decades now making the lending channel even weaker. On the other hand, the balance sheet channel or the financial accelerator is an important channel in the euro area.

In this thesis, we use the VAR methodology to study the macro-economic effects of an unexpected change in monetary policy for the euro area. An area-wide VAR is estimated using synthetic euro area data from 1980 till 1998. We show that using a standard identification scheme delivers plausible effects of monetary policy. An unexpected, temporary rise in the short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output after two quarters. The effect on output reaches a peak after five quarters, to slowly return to baseline after twenty quarters. Prices are more sluggish and only start to fall significantly below zero some quarters after GDP. The effect on prices is also more persistent. We perform a number of robustness checks and it seems that the results are robust to alternative identification schemes. We also investigate the reaction of other macro variables, and the GDP components to a monetary policy shock. As expected, investment reacts more, and private consumption reacts less than GDP. We also find a strong and immediate liquidity effect on M1, and a slow decrease of M3 and other credit aggregates. House prices and gross operating profits of firms decrease after a monetary tightening and there is a fall in stock market prices.

One criticism of the area-wide approach is, of course, that because there was no single monetary policy regime, a model based on synthetic euro area data is likely to be misspecified. In order to check the robustness of the area-wide estimates, we therefore modify the basic euro area model and estimate it for each of the countries in the euro area separately. In doing so, we minimise the changes in the specification. We show that three relatively simple identification schemes, depending on the monetary policy decision process in the ERM, obtain similar and consistent effects for the individual countries as in the area-wide model.
In a next step, we investigate whether the area-wide monetary policy impulses have asymmetric effects on output growth in seven countries of the euro area (Germany, France, Italy, Spain, Belgium, Austria and the Netherlands). In particular, we analyse whether these effects are stronger in recessions than in expansions. Such asymmetric effects could arise in models of the insider-outsider theory or in models in which the financial accelerator propagation mechanism is more potent when the economy is in a recession. First, it is shown that these seven countries share the same business cycle. This is of independent interest because it suggests that in a large part of the euro area cyclical differences have not been an important factor in the last twenty years. Next, strong evidence is presented that the area-wide monetary policy impulses, measured as the contribution of monetary policy shocks to the short-term interest rate, have significantly larger effects on output growth in recessions than in booms. These differences are most pronounced in Germany, France, Italy, Spain and Belgium, while they are much smaller in Austria and the Netherlands. Finally, we analyse whether the monetary policy shocks also affect the probability of going from one state to another. We find weak evidence that a tightening of monetary policy reduces the probability of staying in a boom and no evidence that an expansionary monetary policy increases the probability of going from a recession to a boom.

These results confirm that it may be useful to investigate which factors give rise to these asymmetries. We therefore try to make a first step in that direction by analysing asymmetries across industries in the euro area. We estimate the effects of the area-wide monetary policy shocks for eleven industries of these seven countries. We show that on average the negative output effects of an interest rate tightening are significantly greater in recessions than in booms. There is, however, considerable cross-industry heterogeneity in both the average policy effects and the degree of asymmetry across the two business cycle phases. We then explore which industry characteristics can account for this heterogeneity. We find that differences in the average policy sensitivity over the business cycle can mainly be explained by the durability of the goods produced in the sector, the capital intensity of production and the degree of openness. This can be regarded as evidence for the conventional interest rate/cost-of-capital channel of monetary policy transmission. These effects are also economically important. For example, the difference in average investment intensity between the basic metal and the textile industry of 8 percentage points could account for a difference in the output semi-elasticity with respect to interest rate changes of 0.28 points. However, these interest rate channel characteristics cannot explain why some industries are more affected in recessions relative to booms than others. In contrast, differences in the degree of asymmetry of policy effects seem to be mainly related to differences in financial structure. In particular, we find that a higher proportion of short-term debt over total debt and a greater short-term financing need for working capital are associated with a greater sensitivity to policy changes in a recession. Also these effects are economically
significant. For example, a 10 percentage points increase in the share of short-term debt over total debt increases the output semi-elasticity to an increase in the monetary policy interest rate by about 0.30. This finding suggests that financial accelerator mechanisms can partly explain why some industries are more affected in recessions than others. In contrast to some of the literature, we do not find robust evidence that industries with a larger share of smaller firms are significantly more affected by monetary policy during recessions.

The empirical evidence regarding cross-country differences in the impact of monetary policy is mixed. Only a few studies find an asymmetric effect of a monetary policy shock across countries. Even among those that find a differential effect, there is no robust conclusion. Some countries are documented to be more sensitive to a monetary policy shock in one study, but less in another. Most of the papers that investigate the impact of a monetary policy shock use SVAR. The problem with this approach is that the size of the estimated monetary policy shocks and the monetary policy reaction function differs across countries. Moreover, in the context of the EMU, there is an important difference between a domestic monetary policy shock and a common monetary policy shock because there are large trade linkages between the member countries. The simulation of a common monetary policy shock could be much more similar across countries than a domestic monetary policy shock due to spill-over effects between countries. These problems can largely be solved by looking at the impact of a common monetary policy shock on each of the individual countries. The advantage of this approach is that we have the same monetary policy shock and reaction function across countries, and that we take into account spill-over effects between countries. We estimated the effects of an area-wide monetary policy impulse on the individual countries. The output responses are, in contrast to the empirical findings in some other studies, very similar across countries. We find, however, evidence of a larger effect in Germany and some weak evidence of a smaller effect in the Netherlands.

As an alternative, we can compare cross-country differences in the economic and financial structure to see whether there is a potential for asymmetric effects of monetary policy in the euro area. To do so, we have to compare the most important determinants of the individual channels across countries. The disadvantage of this approach is that we do not know the exact weight of the individual channels in the overall impact of monetary policy, making it very difficult to draw strong conclusions. Based on a subjective weighting of the underlying determinants, the impact of monetary policy is expected to be relatively stronger in Germany and weaker in the Netherlands. The expected overall impact of a shift in the stance of monetary policy is also higher than average for Belgium, Spain and Austria.

In this thesis, we also argue that it may be worth considering a simple guideline like the Taylor rule as a benchmark for analysing monetary policy in the euro area. Our
justification is threefold. First, as the rule explicitly links the current policy rate to the current state of the economy as captured by the current trend inflation rate and the current output gap, it is easy to calculate and understand. This simplicity helps the communication of the central bank. Second, there is increasing evidence that the policy behaviour of successful central banks can be usefully described by variants of the Taylor rule. We present some evidence that also in Europe movements in short-term interest rates can be approximated by such a rule. In part, these two reasons explain why so many private sector economists use a Taylor rule to analyse policy decisions. Third, we show that an optimised Taylor rule performs quite well in stabilising output and inflation in a closed economy model of the euro area. In addition, we show that estimation error in the output gap does not significantly affect the performance of the Taylor rule, although it does reduce the optimal feedback coefficient on the output gap. We also found that the performance of the Taylor rule is robust to small changes in the parameters of the model. Overall, this is consistent with research on simple policy rules using models for the US economy.

1.4.2. POLICY IMPLICATIONS

Monetary policy has become the central tool of macroeconomic stabilisation over recent years, but one that has sometimes unexpected and unwanted consequences. To be successful in conducting monetary policy, the monetary authorities must have an accurate assessment of the effects of their policy on the economy. There is, however, still a lot of uncertainty regarding the impact and timing of shifts in the stance of monetary policy on the real economy. This requires a good understanding of the transmission mechanism through which monetary policy affects the economy. This challenge is even more complicated for the euro area because, while the ECB may conduct monetary policy based on union-wide aggregates, the impact can be different across member countries. Moreover, the creation of the Eurosystem constitutes an enormous regime shift, which can change the transmission mechanism, making the job of the ECB even more difficult.

In this thesis, we discussed the transmission mechanism of monetary policy in the euro area. The conventional interest rate channel is the most important channel of monetary transmission. A necessary condition for the interest rate channel to be operative is that price adjustment does not occur instantaneously. As long as the price level is rigid, the central bank can change the real interest rate and therefore influence the real economic activity. A crucial role for the flexibility of prices is played by the wage setting behaviour in the labour market. If real wages become more flexible over time, the impact of monetary policy will diminish. This should be taken into account by monetary authorities in the conduct of monetary policy. The shift to the EMU could considerably change the working of the labour market. The resistance of policymakers to labour market reforms might decline because they realise that monetary policy is no longer available to accommodate
asymmetric shocks. Moreover, the bargaining power of unions is expected to decline, leading to more flexible labour markets, and thus more flexible wages and prices. However, there is still a considerable disagreement in the literature that this will indeed be the case. We can at least expect that it will take some time before labour market reforms will take place and influence the transmission process.

The impact and timing of monetary policy actions differ across industries because of varying interest sensitivities in the demand for products. Capital-intensive industries, which need more investment, are also expected to be affected more strongly than less capital-intensive industries. We find strong empirical evidence that industries producing durable goods and capital-intensive industries respond significantly more to a monetary policy shock. This difference is even economically very important. Taking this into account, the interest rate channel can be relatively strong in Germany and Portugal, and weaker in the Netherlands, Belgium and Ireland. This also implies that shifts in industrial structure can alter the transmission process. A growing share of services in total output can weaken the impact of monetary policy. A concentration of certain industries in some countries may create potential asymmetric responses in these countries.

We can consider the euro area as a large closed economy comparable to the US. This implies that the impact of the exchange rate channel on output is weak. The euro exchange rate is, however, more important for the effect on prices. There is a direct effect of the exchange rate on import prices and a lot of commodity prices are expressed in foreign currencies. Although the impact of the exchange rate on the total area is probably limited, this channel can cause differential effects across countries because the openness of EMU countries is very different. The share of extra-EU15 exports in GDP is relatively high in Belgium and Ireland and relatively low in Spain and Portugal.

The wealth effects of the asset prices channel are also expected to be limited in Europe. Housing wealth accounts for over half of household net wealth in many European countries, and the effect of changes in house prices on consumption is relatively low. The wealth effect through changes in stock market prices on consumption is higher. Stock market capitalisation is, however, still very low in Europe, and not so widespread as in the US. We can expect, however, that the importance of this channel will grow over time, since people are investing more and more in stocks.

The importance of a bank lending channel in the euro area is low. The area is on average characterised by large, well diversified banks, which are able to find alternative forms of finance. The importance of large banks increases even more with the mergers and acquisitions in the sector, making them less dependent on monetary authorities. Moreover, an expanding securization has made the lending channel even weaker over time.
On the other hand, there is an important role for the balance sheet channel or the financial accelerator in explaining the overall impact of monetary policy. Moreover, our results suggest that financial accelerator mechanisms work mainly during recessions. Asymmetries are economically important. The accelerator should be stronger than average in Germany, Belgium, Italy and Austria, and weaker in the Netherlands.

One could easily argue that it is very difficult to make predictions about differential effects of the single monetary policy across countries since the introduction of the euro itself constitutes an enormous regime shift that can change the transmission mechanism. A lot of economists expect a convergence of the economic and financial structure across countries. Though this is surely the case for certain aspects of the economy, a structural reform from the side of politicians is necessary. In order to have a convergence in terms of price flexibility, labour market reforms are necessary in some individual countries. On the other hand, a co-ordination of the legal systems across countries is necessary. As long as these systems are different across countries, a convergence of the financial system is not possible, and there is potential for asymmetric effects of monetary policy.

A very important policy implication from this thesis is that the impact of monetary policy is different across the business cycle phases. We find strong evidence at the area, individual country and the industry levels that the impact of monetary policy is greater in recessions than in booms. Monetary authorities should keep this in mind while conducting monetary policy. In addition, if the state of the business cycle is different across countries, and the impact of monetary policy is different across business cycle phases, asymmetric effects of monetary policy are possible only because of different cyclical situations. We find evidence that at least Finland did not share the business cycle in the past twenty years.

A common business cycle across countries is not only necessary because monetary policy effects are different over the cycle, but also because differences in cyclical situations complicate an efficient monetary policy design. Only if there is a synchronised business cycle, a single, undifferentiated monetary policy will be acceptable for all member countries of the currency area. Assume that one country is hit by a positive demand shock, while the other countries are still in a recession. The former country expects the central bank to increase interest rates in order to dampen the upswing and inflationary pressures. However, this stance of monetary policy is not acceptable considering the aggregate situation. Moreover, this situation could stimulate a further divergence of the former country. If that country has an expanding economy, the inflation rate will be higher as well. A higher inflation rate, combined with a constant interest rate across countries, means a lower real interest rate for that country. This lower real rate will even stimulate the
economy more, leading to divergence. This implies that policy makers should use other instruments to synchronise business cycle asymmetries.

A final policy implication of this thesis is that a simple Taylor rule – defined as an instrument rule linking the central bank’s policy rate to the current inflation rate and the output gap – is a useful monetary policy benchmark for the European Central Bank. This policy guideline can be useful in two respects. First, it can be used internally as a benchmark to assess policy decisions, which are based on the widest information set available. The availability of a benchmark puts some discipline on the central bank’s staff to explain why its analysis deviates from what the benchmark suggests. Second, when made public, they can also be used as communication device to explain policy decisions to the general public.

1.4.3. FURTHER RESEARCH

Further research on the transmission process is necessary. We already have a common monetary policy for more than two years now. Sufficient data of this new situation should be available soon to do further investigations. When we extend the sample period of our analysis in chapter 2, we do not find a structural break in the models since the introduction of the euro. More research on the relative importance of the different channels of monetary transmission is desirable. Also, the transmission process of potential members should be carefully analysed. We already have some indications that the transmission mechanism is different in Sweden and the UK. Further research about the influence of uncertainty about the transmission mechanism on optimal monetary policy is also necessary.

Another important research topic is the business cycle situation in Europe. According to the traditional ‘optimum currency area’ theory, a key indicator for countries having a monetary union is that they should share similar shocks to their economy. A very important source of shocks is provided by the business cycle. In this thesis, we provide new evidence for the existence of a common cycle in seven European countries. This analysis should be extended to other countries. In future research, we also want to further develop the techniques we use. One of the problems with the common business cycle model, is that we can only use a criterion (Akaike and Schwarz) to determine whether the countries are sharing the same business cycle. We want to develop a formal test for this. This test is of interest in itself because it can also be used in a more general framework to test whether two series are sharing the same cycle. Other extensions of this model are also possible. We assume that the transition probabilities are constant over time and follow a two-state Markov chain. This can be extended to a model with time-varying transition probabilities. This allows us to see whether the European business cycle has synchronised over time. Furthermore, the use of time-varying transition probabilities allows us also to investigate which countries are determining the
common cycle, and which countries are following the common cycle. This is useful information for the monetary authorities.

We also intend to do further research on the asymmetric impact of monetary policy depending on the state of the business cycle. We have already found that the financial accelerator can partly explain the differential impact. By extending the analysis to a Markov-switching VAR, we could test the alternative underlying theories. One of the implications of a convex aggregate supply curve (as an alternative theory) is that also prices should react asymmetrically to a monetary policy impulse. This is not a prediction of the financial accelerator theory. The reaction of prices can also be investigated in a Markov-switching VAR. Another advantage of this methodology is that it is also possible to investigate whether there is a difference between expansionary and restrictive monetary policy, and whether the reaction function of the monetary authorities is asymmetric over the business cycle.

In spite of the generally favourable results concerning the stabilisation properties of a Taylor rule in a relatively closed economy, there remain a number of issues that need to be resolved. First, questions remain about the appropriate choice of the feedback coefficients in the Taylor rule, in particular on the output gap. Second, most empirical studies of central bank behaviour reveal that central banks smooth interest rates and only gradually move towards the policy suggested by a Taylor rule. The reasons for interest rate smoothing need to be better understood. Third, implementing the Taylor rule requires an estimate of the equilibrium real interest rate. The implications of considerable uncertainty about its level need to be examined.
1.5. APPENDIX

APPENDIX 1.1. MONETARY POLICY AND LONG TERM RATES IN GERMANY

In this appendix, we provide some new empirical evidence of the influence of a monetary policy shock on long term interest rates in Germany. We try to test empirically the results of the model of Ellingsen and Söderström (2001). They presume that a change in monetary policy can come for two reasons: either the monetary authorities respond to new information about the economy, such as a supply or demand shock, or there is a shift in the preferences of the central bank (which is a monetary policy shock). In the first case, policy is essentially endogenous, reflecting new input into a given objective function. In the second case, policy is exogenous, in the sense that the input is the same but the objective function has changed. After an endogenous policy action, their model predicts that interest rates of all maturities move in the same direction as the policy innovation. On the other hand, after an exogenous policy action, short and long interest rates should move in the opposite directions. If the central bank becomes more averse of inflation, the weight of inflation in the objective function increases and there is a positive exogenous monetary policy shock. This results in an unexpected upward shift in the short-term interest rate. However, because the preference of the monetary authority has changed, economic agents have to adjust their inflation expectations downward. The latter results in a decrease of sufficiently long-term interest rates. On the other hand, if the economy is hit by a positive demand shock, the central bank reacts to this shock by increasing the short-term interest rate. However, also economic agents have to adjust their inflation expectations upwards, resulting in a higher long-term interest rate.\footnote{The analysis of the consequences of a supply shock is similar.} In the former case, there is a negative correlation between the move in short and long-term interest rates, in the latter case a positive correlation.

This theory is tested by using SVAR for Germany. A similar methodology is used in chapter 2 (section 2.4). Specifically, let $Y_t$ be a vector of macroeconomic variables at time $t$. The monetary policy instrument is also an element of $Y_t$. Let $R^j_t$ denote an interest rate of maturity $j$ months. The following SVAR is estimated:

$$
[A.1.1.1] \begin{bmatrix} a & b \\ c & 1 \end{bmatrix} \begin{bmatrix} Y_t \\ R^j_t \end{bmatrix} = \begin{bmatrix} A(L) & B(L) \\ C(L) & D(L) \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ R^j_{t-1} \end{bmatrix} + \sigma \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^R \end{bmatrix}
$$

where $a$ is a square matrix with ones on the diagonal, $b$ is a scalar, $c$ is a row vector, $A(L)$ is a matrix polynomial in the lag operator $L$, $C(L)$ is a row vector polynomial,
and $B(L)$ and $D(L)$ are scalar polynomials. Throughout our analysis, we maintain the assumptions that $b = 0$ and $B(L) = 0$. That is, neither contemporaneous nor lagged values of the long-term interest rates enter the other equations in the system. These assumptions ensure that the shocks are invariant to bond maturity $j$.

For the basic block of endogenous variables and the identification scheme for Germany, we follow Smets (1996). The advantage of this approach is that he uses a mixture of short and long-run identification restrictions (as in Gali, 1992). This is necessary to disentangle supply and demand shocks. The latter is not possible when we only use short-term restrictions. The vector of endogenous variables is:

$$[A.1.1.2] Y_t = [\Delta y_t, \Delta p_t, s_t, \Delta x_t]$$

with $\Delta y_t$ denoting output growth, $\Delta p_t$ the rate of inflation, $s_t$ the German overnight interest rate, and $x_t$ the real effective exchange rate. The vector of structural shocks is:

$$[A.1.1.3] \epsilon_t = [\epsilon^s_t, \epsilon^d_t, \epsilon^p_t, \epsilon^x_t]$$

With respectively a supply, demand, monetary policy, and an exchange rate shock. In order to identify the supply shock, we assume that there is no long-run impact of demand, monetary policy and exchange rate shocks on output. Furthermore, we assume that there is no contemporaneous influence of monetary policy and exchange rate shocks on output. In order to disentangle the latter two shocks, we follow the same strategy as in chapter 3, where there is a simultaneous impact of a monetary policy shock on the exchange rate and vice versa. We solve this simultaneity problem by estimating the reaction coefficient on the exchange rate using the Japanese interest rate and US dollar/Yen exchange rate as instruments.29

To do the estimation, we use monthly data for the period 1979:1-1998:12. Graph A.1.1 plots the response of respectively output, prices, the interest rate and the exchange rate to supply, demand, monetary policy and exchange rate shocks, together with 10% confidence bands. The results are as expected and similar to the ones obtained by Smets (1996). As the textbook predicts, a supply shock has a positive influence on output and a negative influence on prices. After a demand shock, output initially increases to fall back to baseline after a while. There is a permanent effect on prices. There is a temporary effect of a monetary policy shock on output, and prices decrease. The effect of an exchange rate shock is probably misspecified. These shocks are associated with a large shock to the price level. This

---

may be due to the fact that exchange rate developments are associated with monetary policy shocks (Smets, 1996).

**Graph A.1.1**

*Estimated impulse response functions for Germany*


<table>
<thead>
<tr>
<th>Output</th>
<th>Prices</th>
<th>Interest rate</th>
<th>Exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply shock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand shock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monetary policy shock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exchange rate shock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph A.1.2 presents the responses of respectively the overnight (from the basic VAR), the 1, 3, 6 and 12 month interest rates (swap rates), and the 2, 5, 7 and 10 year government bond yields to the supply, demand, monetary policy and exchange rate shocks. These results confirm the theory of Ellingsen and Söderström (2001). After supply and demand shocks, short and long-term interest rates move in the same direction. However, after a monetary policy shock, short and sufficiently long-term interest rates move in the opposite direction. These results are very robust to other specifications. If we construct a VAR like Bagliano and Favero (1998), or Clarida and Gertler (1997), we also find a negative correlation between the short and long-run interest rates. With the latter two models and identification
strategies, however, we cannot make a distinction between supply and demand shocks since they only use restrictions on the contemporaneous impact matrix.

**Graph A.1.2**

Estimated impulse response functions for Germany
APPENDIX 1.2. SOME MORE EVIDENCE ON THE TRANSMISSION MECHANISM IN THE EURO AREA

In this appendix, we provide some additional evidence on the monetary policy transmission mechanism in seven countries of the euro area: Germany, France, Italy, Spain, Belgium, Austria and the Netherlands. The pre-EMU empirical evidence regarding the cross-country differences on the effects of monetary policy are mixed. Some countries are documented to be more sensitive to a monetary policy shock in one study, but less in another. There are two important problems with most of these studies. A first problem is that the size of the estimated monetary policy shock and the reaction function differ across countries making a comparison very difficult. Another problem, in the context of EMU, is that there is an important difference between a domestic monetary policy shock and a common monetary policy shock because there are large trade linkages between the member countries. The simulation of a common monetary policy shock could be much more similar across countries than a domestic monetary policy shock due to spill-over effects between countries.

These problems can largely be solved by estimating the impact of an area-wide monetary policy shock on each of the individual countries. The advantage of this approach is that we have the same monetary policy shock and reaction function across countries, and that we take into account spill-over effects between countries. We estimate a VAR, based on our area-wide model of chapter 2, with the following representation:

\[
[X_t] = [A(L) 0 0] [X_{t+1}] + \begin{bmatrix} a & 0 & 0 \end{bmatrix} [\epsilon_t^x] \\
[Y_t] = [B(L) C(L) 0] [Y_{t+1}] + \begin{bmatrix} b & c & 0 \end{bmatrix} [\epsilon_t^y] \\
[Z_t] = [D(L) E(L) F(L)] [Z_{t+1}] + \begin{bmatrix} d & e & f \end{bmatrix} [\epsilon_t^z]
\]

\[X_t\] is a block of exogenous variables and contains a world commodity price index, US real GDP, and the US short-term nominal interest rate. There is no effect of the other variables of the model on these variables. \(Y_t\) is an endogenous block of area-wide variables. \(Y_t\) consists of area-wide real GDP, consumer prices, the money stock, the nominal short-term interest rate and the real effective exchange rate. The common monetary policy shock is identified through a standard Choleski-decomposition with the variables ordered as mentioned above.\(^{30}\) Let \(Z_t\) be a block of variables of the individual country. We include GDP, the price level and the short-term nominal interest rate. We suppose that there is no impact of the variables of the individual country on the other variables of the system. This

\(^{30}\) See also chapter 2 for a more extensive discussion.
assumption ensures that the shocks are invariant to the individual country chosen, in order to make a comparison across countries possible. We also estimated the VARs with a feedback of the individual country to the area-wide variables and the results are very similar. Graph A.2.1 plots the response of output in the individual country to a common monetary policy shock. The output responses are very similar across countries. We find the strongest impact in Germany and the weakest in the Netherlands. The response of the other countries is in between.

Graph A.2.1
Response of output to an area-wide monetary policy shock

As an alternative, we also report the results of a variant of the model. In this model, we restrict the response path of the domestic nominal interest rate to be the same as the area-wide nominal interest rate. This replicates more closely the situation of a common monetary policy in EMU. These results need, however, to be taken with a high degree of caution, because we implicitly assume that the estimated effects of the domestic interest rate are invariant to the specification of the domestic policy rule. Impulse responses are presented in Graph A.2.2. Remarkably is that there is a convergence of the monetary policy impact and amplitude across countries. The effects are still stronger in Germany and weaker in the Netherlands, but the difference with the other countries is negligible.
Graph A.2.2
Response of output to an area-wide monetary policy shock

Note: standard error bands are not reported for reasons of legibility.
1.6. REFERENCES


European Central Bank (1999), “Possible effects of EMU on the EU banking systems in the medium to long term”, February, 28 p ;


European Economy (1998)


**Kakes J, Sturm J. and P. Maier (1999)**, “Monetary transmission and bank lending in Germany”, mimeo.


CHAPTER 2

THE MONETARY TRANSMISSION MECHANISM IN THE EURO AREA: MORE EVIDENCE FROM VAR ANALYSIS*

Overview

In this chapter, we use the VAR methodology to study the macro-economic effects of an unexpected change in monetary policy for the euro area. The focus is on the area-wide monetary transmission. An area-wide VAR is estimated using synthetic euro area data from 1980 till 1998. We perform a number of robustness checks with alternative identification schemes, and we examine how the various money, credit, and GDP components respond to an area-wide monetary policy impulse.

* This chapter is joint work with Frank Smets.
2.1. INTRODUCTION

A good understanding of the monetary transmission mechanism in the euro area is essential for an efficient implementation of the ECB’s single monetary policy. There is a large literature that has used the VAR methodology to study the macroeconomic effects of an unexpected change in policy-controlled interest rates in the euro area countries. The use of VARs for the analysis of monetary policy started with the seminal work of Sims (1980). Recently, Leeper, Sims and Zha (1998) and Christiano, Eichenbaum and Evans (1998) have reviewed what one has learned from this extensive literature regarding the monetary transmission mechanism in the United States.

In this chapter, we want to focus on the euro area and present some new evidence using area-wide data. A large part of the literature on the euro area has focused on trying to identify cross-country differences. In these studies, VARs are estimated for the individual countries of the euro area, and the impulse responses of the main macroeconomic variables to a monetary policy shock are compared. In this chapter, our focus is instead on what we have learned regarding the area-wide monetary transmission. In the next section, we therefore start with the discussion of an area-wide VAR estimated on synthetic euro area data from 1980 till 1998. We show that using a standard identification scheme as in Christiano, Eichenbaum and Evans (1998) and Eichenbaum and Evans (1995) delivers plausible effects of monetary policy in the euro area. An unexpected, temporary rise in the short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output after two quarters. The effect on output reaches a peak after 5 quarters, to slowly return to baseline after 20 quarters. Prices are more sluggish and only start to fall significantly below zero some quarters after GDP. The effect on prices is also more persistent. We perform a number of robustness checks in section 2.3. It seems that the results are robust to alternative identification schemes, such as in Gali (1992), and Sims and Zha (1998). Also, a model with the money stock included as a variable performs very well. In section 2.4, we use this VAR to examine how the various money, credit and GDP components respond to an area-wide monetary policy impulse, as well as some labour market variables. Finally, in Section 2.5 we discuss the conclusions.

One criticism of the area-wide approach is, of course, that because there was no single monetary policy regime, a model based on synthetic euro area data is likely to be misspecified. In the next chapter, we therefore modify the basic euro area model and estimate it for each of the countries in the euro area separately. In doing so, we minimise the changes in the specification. The purpose is twofold. First, this analysis allows us to check the robustness of the area-wide results in each of the countries. Second, this analysis also gives us measures of exogenous country-specific monetary policy shocks which can be used in further research.
2.2. A VAR-MODEL FOR THE EURO AREA

2.2.1. THE SPECIFICATION OF THE BENCHMARK MODEL

In this section we describe the benchmark VAR-model we use to analyse the effects of a monetary policy shock in the euro area. The benchmark VAR has the following representation:

\[
\begin{bmatrix}
Y_t \\
X_t \\
\end{bmatrix} = \begin{bmatrix}
A(L) & B(L) \\
C(L) & D(L) \\
\end{bmatrix} \begin{bmatrix}
X_{t-1} \\
Y_{t-1} \\
\end{bmatrix} + \begin{bmatrix}
a & b \\
c & d \\
\end{bmatrix} \epsilon^y_t + \epsilon^x_t
\]

The variables included in the basic model can be divided into two groups. The first group of variables, \(X_t\), contains a world commodity price index \((c_{pt})\), US real GDP \((y^{US}_t)\), and the US short-term nominal interest rate \((s^{US}_t)\). These variables are included to control for changes in world demand and inflation. Moreover, the inclusion of these variables helps to solve the so-called price puzzle (i.e. the empirical finding in the VAR literature that prices rise following an interest rate tightening). In all of the results reported below, we assume that this group of variables is exogenous to the rest of the VAR-model. In other words, these variables influence the other variables of the model, \(Y_t\), but there is no feedback from the other variables to these variables. Further, we also allow for a contemporaneous impact of the exogenous variables on the endogenous variables. In sum: \(b = 0\) and \(B(L) = 0\) in equation [2.1], and:

\[
X_t = \begin{bmatrix}
c_{pt} & y^{US}_t & s^{US}_t \\
\end{bmatrix}
\]

The endogenous variables of the benchmark model, \(Y_t\), consist of real GDP \((y_t)\), consumer prices \((p_t)\), the domestic nominal short-term interest rate \((s_t)\) and the real effective exchange rate \((x_t)\):

\[
Y_t = \begin{bmatrix}
y_t & p_t & s_t & x_t \\
\end{bmatrix}
\]

The policy shock for the euro area is identified through a standard Choleski-decomposition with the variables ordered as mentioned above. The underlying assumption is that policy shocks have no contemporaneous impact on output and prices, but may affect the exchange rate immediately. However, the policy interest

---

1 Each of the VAR models contains also a constant and a linear trend.
2 For example Sims (1992).
rate does not respond to contemporaneous changes in the effective exchange rate. The latter assumption is appropriate for a large, relatively closed, economy such as the euro area as a whole.\textsuperscript{4} In section 2.3, we provide a robustness analysis for alternative identification strategies.

Unless otherwise mentioned, each of the VAR-models is estimated in levels using quarterly data over the period 1980-1998.\textsuperscript{5} In this chapter we do not perform an explicit analysis of the long run behaviour of the economy. By doing the analysis in levels we allow for implicit cointegrating relationships in the data. A more explicit analysis of the long-run behaviour of the various variables is limited by the relatively short sample available.\textsuperscript{6} The data are seasonally adjusted logs, except the interest rates which are in levels. We use the three-month interest rate as the monetary policy rate as this is the only short-term interest rate that is available for all countries over the whole sample period. Standard likelihood ratio tests are used to determine the lag-order of the VARs, which turns out to be of order three.

In order to test the stability of the VAR we run sequential Chow break tests starting in 1990:1. For the euro area as a whole there is no evidence of instability at the 5% confidence level.

\textbf{2.2.2. BASIC ESTIMATION RESULTS}

The results of the benchmark VAR-model for the euro area are shown in Graph 2.1. This graph gives the effect of a domestic, one-standard deviation, monetary policy shock on domestic real GDP, domestic consumer prices, the exchange rate and the domestic short-term interest rate together with a 90 percent confidence band.\textsuperscript{7}

The impulse response patterns reported in the graph are broadly in line with the existing empirical evidence for the United States and many other countries (Christiano et al, 1998). An unexpected, temporary rise in the short-term interest rate of 30 basis points tends to be followed by a real appreciation of the exchange rate and a temporary fall in output after two quarters. The effect on output reaches a peak after 5 quarters, to slowly return to baseline after 20 quarters. Prices are more sluggish and only start to fall significantly below zero some quarters after GDP. The effect on prices is also more persistent. The maximum impact of the

---

\textsuperscript{4} Eichenbaum and Evans (1995) make the same assumption for the US. One can argue that the euro area as a whole is more like the US in terms of openness than like any of its individual members.

\textsuperscript{5} We took 1980 as a starting date because some of the data series used are only available from that year.

\textsuperscript{6} See Coenen and Vega (1999) for an explicit cointegration analysis of a VAR model for the euro area.

\textsuperscript{7} The confidence band is obtained through a standard bootstrapping procedure.
monetary policy shock on output is about 12 basis points. The size of the monetary policy shock is much larger than the one obtained by Monticelli and Tristani (1999) who use an identification strategy that combines both short-run and long-run restrictions and a longer estimation period. They find that a one standard deviation monetary shock corresponds to a 10 basis points move in the interest rate. The maximum impact of this shock on GDP is 0.4 percent.

**Graph 2.1**  
The effects of a monetary policy shock in the euro area  
(Estimation period: 1980-1998; benchmark model)

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate and S is the 3-month nominal interest rate; 90% confidence bands.

Graph 2.2 shows the contribution of the monetary policy shocks to output, prices, the interest rate and the exchange rate, whereas Table 2.1 provides the contribution of the monetary policy shocks to the variance of the forecast errors at various horizons. From Graph 2.2 it is clear that periods of easy monetary policy in the euro area can be situated at the end of 1984 and 1991. In contrast, monetary policy was on average relatively tight at the beginning of 1990 and again during the ERM crisis.
at the end of 1992 and the beginning of 1993. As expected, the contribution of those monetary policy shocks to output and price developments is relatively limited.

**Graph 2.2**

**Contribution of monetary policy shocks to output, prices, the interest rate and the exchange rate in the euro area**

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate and S is the 3-month nominal interest rate.

**Table 2.1**

**Contribution of a monetary policy shock to the forecast error variance**

<table>
<thead>
<tr>
<th></th>
<th>Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td>Output</td>
<td>4.74</td>
</tr>
<tr>
<td>Prices</td>
<td>0.59</td>
</tr>
<tr>
<td>Interest rate</td>
<td>56.31</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>15.59</td>
</tr>
</tbody>
</table>
2.2.3. A COMPARISON WITH THE UNITED STATES

In this section, we estimate our basic model for the US and apply the same identification strategy in order to compare the impact of a monetary policy shock. The sample period is also 1980:1-1998:4. We have only a block of endogenous variables (no exogenous variables):

\[ Y_t = [c p_t, y_t, p_t, s_t, x_t] \]

Identification is again obtained using a standard Choleski-decomposition. Impulse response functions are presented in Graph 2.3. A typical monetary policy shock is somewhat greater in the US (45 basis points compared to 30 basis points in the euro area). This is reflected in a stronger impact on output and a comparable impact on prices. The impact on output is, however, less persistent, and we find already a significant impact on prices after 3 quarters. A potential explanation for both findings is that prices are more flexible in the US. The impact on the real effective exchange rate is more persistent for the US.

Graph 2.3
The effects of a monetary policy shock in the United States
(Estimation period: 1980-1998)

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate and S is the 3-month nominal interest rate; 90% confidence bands.
2.3. A ROBUSTNESS ANALYSIS

In this section, we analyse the robustness of our results with respect to the specification of the model. First, we extend our basic model with the inclusion of a monetary aggregate into the VAR. In section 2.3.2 and 2.3.3, we use respectively the German interest rate as the indicator of monetary policy instead of an area-wide weighted average of the short term interest rates, and the inflation rate instead of the price level. Section 2.3.4 provides a robustness analysis for alternative identification schemes. Two alternative strategies are investigated: A n identification strategy using long-run restrictions as in Gali (1992), and the Sims and Zha (1997) methodology.

2.3.1. THE INCLUSION OF M3 IN THE VAR

Historically money developments have played an important role in the monetary policy strategies of some of the countries now participating in the monetary union. In this section, we therefore extend our benchmark model for the euro area by including a broad monetary aggregate (M3) \((m_i)\) in the block of endogenous variables. The recursive identification strategy is the same as before. However, we allow for a contemporaneous impact of the monetary aggregate on the exchange rate and the domestic interest rate. In this case, the vector of endogenous variables can thus be written as:

\[
\begin{bmatrix}
Y_i \\
\end{bmatrix} = \begin{bmatrix}
y_i \\
p_i \\
m_i \\
S_i \\
x_i \\
\end{bmatrix}
\]

Graph 2.4 shows that the results are very similar to those of the benchmark model. The inclusion of M3 leads to an immediate decrease of GDP after a monetary tightening, while in the benchmark model, output decreases only after a few quarters. Following a negative impact effect which is consistent with a liquidity effect, M3 briefly rises before falling significantly in line with the fall in output and inflation.
Graph 2.4
The effects of a monetary policy shock in the euro area
(Estimation period: 1980-1998; Benchmark model with M3)

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate and S is the 3-month nominal interest rate; 90% confidence bands.
2.3.2. USING THE GERMAN INTEREST RATE INSTEAD OF THE AREA-WIDE INTEREST RATE

Some economists have argued that it may be more appropriate to use the German interest rate rather than an area-wide average interest rate as the indicator of common monetary policy in the countries that now form a monetary union. The reason is that during a large part of the sample period the German Mark provided an anchor role within the ERM system. As a result, the Bundesbank by and large determined area-wide monetary conditions, whereas some of the other countries geared policy towards keeping a fixed exchange rate with the DM.

Graph 2.5
The effects of a monetary policy shock in the euro area
(Estimation period: 1980-1998; benchmark model with German interest rate instead of average rate)

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate and S is the 3-month nominal interest rate; 90% confidence bands.

---

8 This is also done by Dornbusch et al (1998), and by Peersman and Smets (1999).
Graph 2.5 shows that using the German interest rate rather than an area-wide average results in a perverse effect of a monetary policy tightening on both prices and the exchange rate. Prices rise significantly, while the exchange rate depreciates on impact. One explanation is that historically an unexpected monetary tightening in Germany has given rise to tensions within the ERM system which were then resolved by a devaluation of the bilateral exchange rate of the other currencies against the DM. Such devaluations can explain both the positive effect on prices and the depreciation of the effective exchange rate on impact. A misspecification may also arise from the fact that in this VAR we implicitly assume that area-wide variables enter the German reaction function which may not have been the case.

2.3.3. USING THE INFLATION RATE INSTEAD OF THE PRICE LEVEL

The estimates of the basic model are done in log-levels. By doing the analysis in levels we allow for implicit cointegrating relationships in the data. This is the case when the cointegrating variables are integrated of the same order, i.e. I(1). This could be a problem for the price level. One can assume that the inflation rate (i.e. the first difference of the price level) is stationary. In that case, the price level is I(1). However, the sample period, 1980-1998 is typically characterized by a decreasing inflation rate, which could indicate that the price level is I(2) for the sample period. Augmented Dickey-Fuller and Phillips-Perron tests cannot reject the hypothesis of a unit root in the inflation rate at the 5 percent confidence level (the first difference of the inflation rate is stationary). However, these tests are very weak in small samples. Therefore, to see whether the results are robust to this problem, we re-estimate the VAR with the inflation rate instead of the price level. The block of the endogenous variables is then:

\[
Y_t = \begin{bmatrix} y_t & \Delta p_t & s_t & x_t \end{bmatrix}
\]

The results of this estimation are presented in Graph 2.6, and are very similar to the ones obtained from the basic model. Moreover, the slight (insignificant) price-puzzle disappears leading to a more rapid decrease of prices. The total impact on prices however remains the same.

---

2.3.4. ALTERNATIVE IDENTIFICATION SCHEMES

It is well-known that impulse response functions in VAR analysis can be sensitive to alternative identification schemes. In this Section we apply two alternative identification schemes. The first is due to Sims and Zha (1998) and allows for a contemporaneous interaction between the short-term interest rate, the exchange rate and the money aggregate. The second is based on Gali (1992) and uses a mixture of long and short-run restrictions to identify monetary policy.
2.3.4.1. An interaction between short-term interest rate, exchange rate and the money aggregate

Until now, we have used a recursive identification strategy on the contemporaneous structural parameters, that is a Wold-causal chain of the variables. Two alternatives to this strategy are imposing long-run restrictions on the impact of the shocks (applied in the next subsection) or using a more generalized method, suggested by Bernanke (1986), Sims (1986), Sims and Zha (1998), and Kim and Roubini (1997), in which a non-recursive identification strategy is allowed while still giving only restrictions on the contemporaneous parameters. If \( \mu^y_t \) are the residuals from the reduced form estimation of equation [2.1], after taking into account the contemporaneous impact of the exogenous variables, then the structural disturbances and the reduced form residuals are related by:

\[
\mu^y_t = d \varepsilon^y_t
\]

In our basic, recursive identification strategy, \( d \) is a lower triangular matrix. Following Sims and Zha (1998), and Kim and Roubini (1997), we impose now the following restrictions on the contemporaneous structural parameters for the model with money:

\[
\begin{bmatrix}
\mu^y_t \\
\mu^p_t \\
\mu^m_t \\
\mu^x_t
\end{bmatrix} =
\begin{bmatrix}
d_{21} & 1 & 0 & 0 & 0 \\
0 & d_{32} & 1 & d_{34} & 0 \\
0 & 0 & d_{43} & 1 & d_{45} \\
d_{51} & d_{52} & d_{53} & d_{54} & 1
\end{bmatrix}
\begin{bmatrix}
\varepsilon^y_t \\
\varepsilon^p_t \\
\varepsilon^m_t \\
\varepsilon^x_t
\end{bmatrix}
\]

The first two equations represent the sluggish reaction of the real sector to shocks in the other variables. There is no contemporaneous impact of a monetary policy, a money demand, and an exchange rate shock on output and prices. The third equation is a money demand equation. The money demand is contemporaneously reacting to shocks in output, prices and the interest rate. The fourth row represents the monetary policy reaction function. The monetary authority sets the interest rate after observing the current money stock and the exchange rate, and cannot respond contemporaneously to disturbances in output and the price level. The argument for this restriction is that the policy decision has to be made without any contemporaneous information about these variables. Finally, the exchange rate reacts immediately to all the other shocks. The results of this estimation are presented in the first column of Graph 2.7. The second column of this graph contains the same identification strategy for the basic model without the money stock. Equation [2.8] is then:
Finally, the last column presents the impulse responses of the last model, but we allow an instant response of the monetary authority to the price level \((d_{42} \neq 0)\). The reason is that this information is more rapidly available than information about output.

Graph 2.7

The effects of a monetary policy shock in the euro area

(Estimation period: 1980-1998; Sims-Zha identification)

<table>
<thead>
<tr>
<th>with money</th>
<th>basic</th>
<th>cont. prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate, S is the 3-month nominal interest rate and M is the money stock (M3); 90% confidence bands.

Again, the results are very robust to this identification strategy. The impulse response patterns of the main macroeconomic variables are very similar to the basic model’s. We also avoid the small price puzzle of our basic estimation. However,
when we allow for a contemporaneous impact of the price level (column 3) in the monetary policy rule, the response is somewhat different. There is an immediate significant impact of the monetary policy shock on the price level. The strength of this effect, and the effect on the exchange rate are also double the initial effect of the basic model. At the same time, the magnitude of a typical monetary policy shock is much smaller: 10 basis points compared to 30 basis points in the basic model.

2.3.4.2. A mixture of short and long-run restrictions

Another identification strategy is the combination of short and long-run restrictions as in Gali (1992), and Gerlach and Smets (1995). The vector of the endogenous variables is:

\[ Y_t = [\Delta y_t, \Delta p_t, s_t, \Delta x_t] \]

and the vector of the structural disturbances:

\[ \epsilon_t^Y = [\epsilon_t^s, \epsilon_t^d, \epsilon_t^p, \epsilon_t^x] \]

with \( \epsilon_t^s \) denoting a supply shock, \( \epsilon_t^d \) a demand shock, \( \epsilon_t^p \) a monetary policy shock, and \( \epsilon_t^x \) an exchange rate shock. A typical restriction consistent with most macroeconomic models is that in the long-run demand, monetary policy and exchange rate shocks have zero impact on output (Blanchard and Quah, 1989). Supply shocks are thus associated with the permanent shocks to output. In order to discriminate between the aggregate demand shocks and the two other shocks, we use the restrictions that the latter two have no contemporaneous impact on output. To distinguish between a monetary policy shock and the exchange rate shock we assume, as in the basic model, that the interest rate is not contemporaneously affected by disturbances in the exchange rate. The results are reported in Graph 2.8. In the first row, we find the responses of output, prices, interest rate and the exchange rate to a supply shock. As the textbook model predicts, a supply shock has a positive influence on output and a negative influence on prices. Both variables reach a peak about three years after the shock and stabilize at that level subsequently. Also the nominal interest rate decreases after a supply shock because of the lower inflation. In the second row, we find the reaction to an aggregate demand shock. The effect of a demand shock on output will completely dampen out after 4 to 5 years. This shock also leads to a rise in inflation and the interest rate. The impact of a monetary policy shock on output is again comparable with the previous results. The impact on prices however is much stronger than in the basic model. A typical monetary policy shock reduces the price level by 60 basis points. These results are broadly consistent with the findings of previous studies using this identification strategy as in Gali (1992), Gerlach and Smets (1995), and Smets (1997).
Graph 2.8
Estimated impulse response functions for the euro area
(Estimation period: 1980-1998; short and long-run restrictions)

Note: Y is real GDP; P is consumer prices; X is the real effective exchange rate and S is the 3-month nominal interest rate; 90% confidence bands.

Table 2.2 reports the correlations of the monetary policy shocks of the alternative identification strategies. Overall, the correlation of these shocks is very high between the basic model, the model with money, with inflation instead of the price level, and the models where we allow a contemporaneous interaction between money, the interest rate, and the exchange rate. Not surprisingly, the correlation with the model where we use the German interest rate instead of the area-wide interest rate is very low. On the other hand, the correlation is also weak with the model using both short-run and long-run identification restrictions, and the less restricted model with a contemporaneous interaction between interest rate and exchange rate. The correlation between the latter two is however high. The low correlation with the latter two is mainly situated at the end of the sample period. Graph 2.9 plots the contribution of the monetary policy shocks to the short-term interest rate of the basic model, and the model with the long-run restrictions. According to the model with long-run restrictions, monetary policy was restrictive during the mid nineties, whereas monetary policy was more neutral in the basic model.
Table 2.2  
Correlations of shocks with alternative identification strategies

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic model</td>
<td>1.00</td>
<td>0.88</td>
<td>0.94</td>
<td>0.47</td>
<td>0.98</td>
<td>0.81</td>
<td>0.33</td>
<td>0.41</td>
</tr>
<tr>
<td>2. Basic model + money</td>
<td>1.00</td>
<td>0.85</td>
<td>0.42</td>
<td>0.87</td>
<td>0.98</td>
<td>0.32</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>3. Δp instead of p</td>
<td>1.00</td>
<td>0.50</td>
<td>0.91</td>
<td>0.79</td>
<td>0.32</td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. German rate instead of area-wide interest rate</td>
<td>1.00</td>
<td>0.40</td>
<td>0.42</td>
<td>-0.09</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. interaction M, S, and X</td>
<td>1.00</td>
<td>0.80</td>
<td>0.50</td>
<td>0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. interaction S and X</td>
<td>1.00</td>
<td>0.30</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. idem 6, but less restrictive</td>
<td>1.00</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. short and long-run restrictions</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph 2.9  
Contribution of the monetary policy shock to the interest rate

Note: full line is basic model, and dotted line is model using both short-run and long-run restrictions.
2.4. THE EFFECT OF MONETARY POLICY ON OTHER MACRO VARIABLES

2.4.1. THE EXTENDED MODEL

In this section, we discuss the influence of a monetary policy shock on other macroeconomic variables that are not included in the basic model. We have done this by estimating the following equation:

\[
\begin{bmatrix}
X_t \\
Y_t \\
Z_t
\end{bmatrix} = \begin{bmatrix} A(L) & B(L) & C(L) \\
D(L) & E(L) & F(L) \\
G(L) & H(L) & I(L)
\end{bmatrix} \begin{bmatrix} X_{t-1} \\
Y_{t-1} \\
Z_{t-1}
\end{bmatrix} + \begin{bmatrix} a & b & c \\
d & e & f \\
g & h & 1
\end{bmatrix} \begin{bmatrix} \xi_t^X \\
\xi_t^Y \\
\xi_t^Z
\end{bmatrix}
\]

Equation [2.12] is very similar to equation [2.1]. \( X_t \) is still the block of exogenous variables and \( Y_t \) the endogenous block. Let \( Z_t \) be another macroeconomic variable (for example investment). Again, we suppose that neither contemporaneous nor lagged values of the endogenous variables have an influence on the exogenous block. This is also the case for our variable under interest, i.e. \( b = c = 0 \) and \( B(L) = C(L) = 0 \). However, we suppose the same for our macroeconomic variable, \( Z_t \), with respect to our endogenous block of variables, \( Y_t \). This means that also \( f = 0 \) and \( F(L) = 0 \), i.e. there is no impact of the variable under investigation on the other variables in the system. This assumption ensures that the shocks are invariant to the macroeconomic variable chosen.\(^{10}\)

2.4.2. THE RESULTS

Graph 2.10 shows the effects of an area-wide monetary policy shock on the various components of GDP (total real GDP, total investment, private consumption and government consumption). The impulse response pattern of total investment is similar to the response of real GDP. However, the magnitude of investment is three times as large as the magnitude of GDP. After a typical monetary tightening of 30 basis points, GDP falls by 18 basis points, while the effect on investment reaches a maximum of 63 basis points. On the other hand, the response of private consumption is weaker and slower. Consumption starts decreasing after two quarters and has a maximum impact of 17 basis points after five quarters. Finally, government spending only slightly decreases after a long period of time (eight quarters).

---

\(^{10}\) We have also estimated alternative VARs where the additional macroeconomic variable is included in the endogenous block of the model. In that case, this variable is ordered as the last one in the recursive structure (\( F(L) \neq 0 \)). The results are very similar.
Graph 2.10
The effects of a monetary policy shock on components of GDP
(Estimation period: 1980-1998)

The influence on total manufacturing and respectively investment goods and consumption goods in manufacturing is shown in Graph 2.11. As expected, the response of total manufacturing is larger than the response of real GDP (a peak of 50 basis points after a monetary tightening of 30 basis points). Again, we find a stronger impact on investment goods than on consumption goods.
The impulse response functions of monetary and financial indicators to a contractionary monetary policy shock are presented in Graph 2.12. The upper two rows show the response of M3, total credit, M1 and M3-M1. We find a strong and immediate liquidity effect on M1, which appears to be robust to alternative identification schemes. The slow response of M3 is clearly due to the initial increase in the other components of M3. An interest rate rise gives rise to substitution effects from money components that bear no or regulated interest to time deposits and money market funds. This finding is consistent with the literature about money demand.\footnote{For example, Fase and Winder (1992) find a negative relationship between M1 and the short-term interest rate, while the relation between M3 and the short-term interest rate is positive.} The response of total credit is in line with M3. In the last row, we plot the reaction of the short-term and the long-term interest rate. The response of the long-term interest rate is positively correlated with the short-term rate. An increase of the short rate of 30 basis points is followed by a smaller increase of the long rate.
by 8 basis points. This is what one would expect based on the term-structure theory of monetary policy, and is often found in the empirical literature.  

\[\text{Cook and Hahn (1989), and Buttiglione et al (1997). However, one can argue that this positive movement in the long rate is inconsistent with standard monetary theory, because an increase in short rates should reduce inflation, and hence reduce the level of sufficiently long rates (Romer and Romer, 1996).}\]

Finally, Graph 2.13 plots the response of employment, unemployment, labour productivity, real wages, unit labour cost, gross operating profits, house prices and stock market prices to a monetary policy shock. The pattern of employment is very similar to the output pattern. However, the magnitude of the former is less, resulting in a pro-cyclical movement of labour productivity. The unemployment
rate is reacting somewhat slower. A monetary policy shock of 30 basis points has a maximum impact on unemployment of 8 basis points. Because of nominal wage rigidity, real wages increase initially to fall after two quarters. The same pattern is found for unit labour costs. The magnitude of gross operating profits is larger than the response of output: a peak of 32 basis points after four quarters. As expected, stock markets fall immediately after a monetary policy shock, and there is a gradual decrease of house prices, indicating that part of the output response could be caused by a wealth effect.

**Graph 2.13**

The effects of a policy shock on other variables

(Estimation period: 1980-1998)

*Note: 90% confidence bands*
2.5. CONCLUDING REMARKS

In this chapter, we have used the VAR methodology to study the macroeconomic effects of an unexpected change in monetary policy for the euro area. An area-wide VAR is estimated using synthetic euro area data from 1980 till 1998. Using several standard identification schemes, we find plausible effects of monetary policy in the euro area. An unexpected, temporary rise in the short-term interest rate tends to be followed by a real appreciation of the exchange rate and a temporary fall in output. Prices are more sluggish and only start to fall significantly below zero some quarters after GDP. The effect on prices is also more persistent. We also investigated the reaction of other macro variables, and the GDP components to a monetary policy shock. The response of output is mainly due to a decrease in investment, with a magnitude three times as large as GDP, and to a lesser extent in private consumption. We find a strong and immediate liquidity effect on M1, and a slow decrease of M3 and other credit aggregates. The reaction of the long-term interest rate is positively correlated with the short-term interest rate. However, the magnitude of the change in the former is less.

This analysis also gives us measures of exogenous area-wide monetary policy shocks which can be used in further research. These shocks are used to investigate asymmetric effects of monetary policy depending on the state of the business cycle in Chapters 4 and 5.

The basic VAR is used as a benchmark for the discussion of the country-specific results of the next chapter. One criticism of the area-wide approach is, of course, that because there was no single monetary policy regime, a model based on synthetic euro area data is likely to be misspecified. In the next chapter, we therefore modify the basic euro area model and estimate it for each of the countries in the euro area separately. This allows us to check the robustness of the results found in this chapter.
2.6. REFERENCES


Fase M. and C. Winder (1993), “The demand for money in the Netherlands and the other EC countries”, De Economist, Jg. 141, No. 4, p 471-495.


Overview

There is a large literature that uses a VAR methodology to study the macroeconomic effects of an unexpected change in monetary policy in the euro area countries. This chapter reviews this literature and presents some new results describing the effects of monetary policy for the 11 individual countries of the euro area. We therefore modify the basic euro area model and estimate it for each of the individual countries separately. The purpose is twofold. First, this analysis allows us to check the robustness of the area-wide results in each of the countries. Second, this analysis also gives us measures of exogenous country-specific monetary policy shocks, which can be used in further research.
3.1. INTRODUCTION

Understanding the transmission mechanism of monetary policy in the euro area is of primary importance for the implementation of the Eurosystem’s monetary policy strategy. Although the Eurosystem targets price stability for the area as a whole, country level evidence should not be neglected for three reasons. First, country level analysis provides additional evidence, which can be used to reduce uncertainty about the transmission of monetary policy. Second, the analysis of the transmission mechanism is usually carried out within models that assume a reaction function of the central bank. This assumption is somewhat artificial when considering the euro area economy before the start of EMU. Therefore estimating central bank reaction functions at the country level seems more appropriate. Third, country specific feature contexts can better be analysed and the evolution of the transmission within each country of the Eurosystem monetary policy can better be assessed.

In this chapter we use VAR models to identify monetary policy in 11 of the countries that now form the euro area. We use VAR models, which is the most widely used empirical methodology to analyse the transmission mechanism. We show that three types of models are enough to describe monetary transmission of the 11 countries. A country falls into one of these three identification schemes, depending on its real and monetary integration with Germany, the nominal anchor of the ERM. The first identification applies to Germany, the second to France, Italy, Spain, Finland, Greece, Portugal, Ireland and Belgium, and the third to the core ERM: Austria and the Netherlands. Since Belgium could also be considered to belong to the latter group, the results of the latter identification scheme are also reported for Belgium.

The contribution of the chapter with respect to the existing VAR literature on the transmission mechanism in euro area countries is threefold. First, we show that three, relatively simple identification schemes, depending on the monetary policy decision process in the ERM, obtain well behaved and qualitatively consistent effects of the monetary policy shocks in all the countries. While our models are fairly similar and comparable, we avoid the implausible uniformity of approaches that characterises most of the VAR literature on international comparisons of the transmission mechanism. We also avoid the multiplication of models that confuse the cross-country comparison. A monetary policy shock is defined as a deviation of

---

1 Luxembourg is not modelled because it formed a monetary union with Belgium, and had no independent monetary policy.

2 See also Clements, Kontomelis and Levy (2001) for a complementary point of view on the role of the ERM in the transmission mechanism. Their study focuses on the effects of the German monetary policy shock on all the other countries of the euro area.
the interest rate from the average reaction function of the central bank for the sample period. It leads to a temporary fall in GDP that peaks between 4 and 6 quarters after the shock and a gradual decrease in the price level. Second, this analysis also gives us measures of exogenous monetary policy shocks at the individual country level, which can be used in further research. Third, the results of the estimations at the country level can be compared with the area-wide results of the previous chapter to check the robustness of the latter.

The chapter is structured as follows. Section 3.2 provides an overview of the literature. Section 3.3 describes first the benchmark model for the euro area, and the three identification schemes chosen for the individual countries. The estimation results are presented in section 3.4. Finally, section 3.5 reports the conclusions.
3.2. THE EFFECTS OF MONETARY POLICY IN THE COUNTRIES OF THE EURO AREA

In this section, we summarise the literature that has used the VAR methodology to study the macroeconomic effects of an unexpected change in policy-controlled interest rates in the euro area countries. We focus on studies that used VARs because it is now the benchmark empirical methodology to simulate the impact of monetary policy. The use of VARs for the analysis of monetary policy started with the seminal work of Sims (1980). Recently, Leeper, Sims and Zha (1998) and Christiano, Eichenbaum and Evans (1998) have reviewed what one has learned from this extensive literature regarding the monetary transmission mechanism in the United States. In Europe, the perspective of EMU led a large part of the literature to focus on cross-country differences in the transmission mechanism. Most studies report that, overall, a majority of countries experience a fall in output (either GDP or industrial production) and in prices after a monetary policy shock. Kieler and Sarenheimo (1998), Peersman (2000) and Guiso et al. (2000) propose synthetic surveys of this literature. For instance, the response of GDP to a “one standard deviation” policy shock after about 4 to 8 quarters range between -0.2 and -0.6 percent. The three surveys stress that the ranking of the countries according to the strength of the effects of monetary policy is not consistent across studies. One should also note that, for any of these studies, the confidence bands around these responses are such that the differences across countries are not significant. In addition, Kieler and Sarenheimo (1998) show that screening the full space of observationally equivalent identifications of monetary policy shocks for Germany, France and the United Kingdom, one can build very similar impulse responses of GDP and prices to monetary policy shocks.

The most straightforward reason why it is difficult to find differences in the effects of monetary policy across countries is that there were no sizeable cross-country differences in the transmission for the sample period. Moreover, admitting that the transmission was different across countries in the period preceding EMU, it is difficult to disentangle whether any observed differences are due to structural differences, which are likely to persist under monetary union, or due to differences in monetary policy regime. How can one model the country-specific monetary policy regimes while preserving comparability of the monetary policy effects?

---

3 Comparisons of VARs and other methodologies that have investigated the transmission in countries of the euro area can be found in Kieler and Sarenheimo (1998), Britton and Whitley (1997) and Guiso et al. (2000). See also Clements, Kontomelis and Levy (2001) for cross-country comparison where the reaction function is constrained to be similar across countries and the intra-EU exchange rates are fixed in the simulation of monetary policy shocks.

On the one hand, imposing the same structure on each of the countries of the euro area, as it was usually done in this literature, is not appropriate. Compare, for example, the estimated effects in Germany where the Bundesbank could follow an independent monetary policy as the de facto anchor of the ERM system and those in a small country like Austria, which had a fixed exchange rate with the German Mark during most of the past 20 years. While one may hope to find reasonable effects of a domestic monetary policy shock in the German case, the effects of such shocks are unlikely to be precisely estimated in the Austrian case where there was hardly any room for an independent monetary policy. We propose instead to estimate for each country a model that accounts for the ERM constraint to which the country was subject during the sample period. This is not a simple thing to do because the ERM has not been a stable monetary policy regime for all countries. Some countries have built their credibility over time while others’ were severely hampered by the ERM crisis in the early nineties. On the other hand, the multiplication of models would hamper the comparison of results across countries. It could also be seen as data mining.

We form groups of countries in order to strike the balance between “one size fits all” and “one model per country”. The criterion to form the groups of the “monetary policy regime-like countries” is the level of their real and monetary integration with Germany. As the anchor of the ERM, Germany is a group of its own for obvious reasons. France, Italy, Spain, Finland, Greece, Portugal, Ireland, and Belgium are modelled as small open economies with a flexible exchange rate vis-à-vis Germany. This means that, although the influence of German monetary policy is taken into account by including the German interest rate in the reaction function of the central bank, the monetary policy shock is a deviation from the reaction function of the domestic interest rate. Austria and the Netherlands form the second group. We model their monetary policy as if they were in a “quasi-fixed” exchange rate regime with respect to Germany. It follows that they do not have autonomous monetary policy shocks. We also report the results for Belgium when we make the same assumption, because Belgium is situated somewhere between the two groups.

Given the criticism of Kieler and Sarenheimo (1998) on the limited power of quantitative comparisons of impulse responses to monetary policy shocks across countries, we just show that using the three above mentioned identification schemes delivers well behaved effects of monetary policy in all the countries. For presentation purposes, we compare the country results to the results of a benchmark VAR model of the euro area proposed by Peersman and Smets (2000). The purpose of this comparison is to check that the area-wide results are, in spite of the artificial nature of the past monetary policy reaction function for the euro area, robust in each of the countries. This analysis also gives us measures of exogenous country-specific monetary policy shocks, which can be used in further research.
3.3. VAR MODELS FOR THE INDIVIDUAL COUNTRIES IN THE EURO AREA

This section first recalls the specification of the benchmark model that has been used by Peersman and Smets (2000). We then discuss how the identification schemes we propose to describe monetary policy in each of the three groups of countries differ from this benchmark. Section 3.3.3 and 3.3.4 present the estimation and the results.

3.3.1. THE SPECIFICATION OF THE BENCHMARK VAR MODEL FOR THE EURO AREA

The benchmark VAR-model from Peersman and Smets (2000) that we use to analyse the effects of a monetary policy shock in the euro area has the following representation:

\[
\begin{bmatrix}
X_t \\
Y_t
\end{bmatrix} = \begin{bmatrix}
A(L) & B(L) \\
C(L) & D(L)
\end{bmatrix} \begin{bmatrix}
X_{t-1} \\
Y_{t-1}
\end{bmatrix} + \begin{bmatrix}
a & b \\
c & d
\end{bmatrix} \begin{bmatrix}
\epsilon^X_t \\
\epsilon^Y_t
\end{bmatrix}
\]

The variables included in the basic model can be divided into two groups. The first group of variables, \(X_t\), contains a world commodity price index (\(c_{tp}\)), US real GDP (\(y^{US}_t\)), and the US short-term nominal interest rate (\(s^{US}_t\)). These variables are included to control for changes in world demand and inflation. Moreover, the inclusion of these variables helps to solve the so-called price puzzle (i.e. the empirical finding in the VAR literature that prices rise following an interest rate tightening). In all of the results reported below, we assume that this group of variables is exogenous to the rest of the VAR-model. In other words, these variables influence the other variables of the model, \(Y_t\), but there is no feedback from the other variables to these variables. Further, we also allow for a contemporaneous impact of the exogenous variables on the endogenous variables. In sum: \(b = 0\) and \(B(L) = 0\) in equation [3.1], and:

\[
\begin{bmatrix}
X'_t \\
Y'_t
\end{bmatrix} = \begin{bmatrix}
cp_t & y^{US}_t & s^{US}_t
\end{bmatrix}
\]

The endogenous variables of the benchmark model, \(Y_t\), consist of real GDP (\(y_t\)), consumer prices (\(p_t\)), the domestic short-term nominal interest rate (\(s_t\)) and the real effective exchange rate (\(x_t\)).

\[^{5}\] Each of the VAR models contains also a constant and a linear trend.

\[^{6}\] For example Sims (1992).
[3.3] \[ Y_t = [y_t, p_t, s_t, x_t] \]

The policy shock for the euro area is identified through a standard Choleski-decomposition with the variables ordered as mentioned above.\(^7\) The underlying assumption is that policy shocks have no contemporaneous impact on output and prices, but may affect the exchange rate immediately. However, the policy interest rate does not respond to contemporaneous changes in the effective exchange rate. The latter assumption is appropriate for a large, relatively closed, economy such as the euro area as a whole.\(^8\)

### 3.3.2. VAR MODELS FOR THE INDIVIDUAL COUNTRIES IN THE EURO AREA

In this Section we present VAR models for all euro area countries except Luxembourg. We discuss the modifications to the benchmark model that are necessary to fit the individual country experiences. In doing so, our objective is to keep the model as close as possible to the benchmark model. We distinguish three groups. The first group contains Germany, which played a special role as the de facto anchor within the ERM system. The second group of countries (Finland, France, Greece, Ireland, Italy, Spain, Portugal, and Belgium) can be described by a similar VAR model. Most of these countries have participated in fixed, but adjustable exchange rate regimes during large parts of the sample period, but nevertheless experienced quite large parity changes. With the exception of France, Belgium and Ireland, each of these countries also went through a floating exchange rate period during the sample. The last group consists of Austria and the Netherlands. These countries have maintained their fixed exchange rate parity against the DM during most of the sample period. We also consider Belgium as an exception in this group.

#### 3.3.2.1. Germany

For Germany we estimate the same VAR model as in equations [3.1] to [3.3]. However, the identification of a monetary policy shock is somewhat different in the sense that we also allow for a contemporaneous response of the German interest rate to the real effective exchange rate. Assuming that there is no contemporaneous reaction of the central bank to an exchange rate shock may be appropriate for relatively closed economies such as the euro area and the US, but is not justifiable

---

\(^7\) As in Sims (1980) and Christiano et al (1998).

\(^8\) Eichenbaum and Evans (1995) make the same assumption for the US. One can argue that the euro area as a whole is more like the US in terms of openness than like any of its individual members.
for an open economy such as Germany. For example, both Bernanke and Mihov (1997) and Clarida and Gertler (1997) have found a significant contemporaneous response of German interest rates to changes in the exchange rate. Similarly, Smets and Wouters (1999) show that allowing for such a response is necessary to avoid a price puzzle. Following Smets and Wouters (1999), we solve the simultaneity problem by estimating the reaction coefficient on the exchange rate using the Japanese interest rate and US dollar/Yen exchange rate as instruments.9

### 3.3.2.2. France, Italy, Spain, Finland, Ireland, Portugal and Belgium

For France, Italy, Spain, Finland, Ireland, Portugal and Belgium, we modify the benchmark model in two respects. First, we include the German short-term interest rate in the block of endogenous variables. Second, we replace the real effective exchange rate with the nominal bilateral DM exchange rate given its prominence in the ERM.10 This leads to the following set of endogenous variables:

\[
[3.4] \quad Y_i' = [y_i, p_i, s_{iDE}, x_i, s_i]
\]

The German interest rate is included in addition to the bilateral DM exchange rate in order to describe the role of Germany as an anchor of the ERM. The domestic interest rate may respond to the German one without any impact on the exchange rate, as it would be the case in a fixed exchange rate regime. This can turn out to be important when estimating a model at a quarterly frequency, while exchange rates and interest rate interact continuously. Basically, we assume that domestic monetary policy shocks are defined as deviations of the domestic interest rate from the German interest rate11. In other words, we describe the effects of monetary shocks that were taken in the process of nominal convergence, which took place before EMU. We obtain that the estimated domestic policy shocks led to a decrease in prices, as if monetary policy had contributed to the nominal convergence with Germany that characterises the sample period. It is interesting to note that not including the German interest rate in the model results in a price puzzle for many of these countries. The reason is that if one does not control for increases in the domestic interest rate that are a response to increases in the German rate, such changes may be associated with a depreciation of the exchange rate. This in turn puts upward pressure on prices.

---

9 See Smets and Wouters (1999) for an explanation of this two-step methodology. The alternative approach yielding similar results would be to include the Japanese interest rate and the US dollar/Yen exchange rate in the VAR and make the identifying assumption that the contemporaneous innovations in these variables only affect the domestic interest rate through their effect on the effective exchange rate.

10 Using an effective exchange rate does not change the results in any significant way.

11 The macroeconometric model of the Banque de France also defines the reaction function in terms of deviations from the German interest rate.
As before, the domestic policy shock is identified using a standard recursive identification scheme, which corresponds to the ordering of the variables in [3.4]. This means that there is a contemporaneous impact of all the endogenous variables on the monetary policy variable. On the other hand, there is no immediate impact of a monetary policy shock on the other variables. The ordering of the bilateral DM exchange rate before the domestic interest rate is plausible since there was a fixed exchange rate regime during most of the estimation period. However, the results are robust with respect to a reverse ordering of the domestic interest rate and the bilateral DM exchange rate. Also allowing for a two-way interaction between the exchange rate and the domestic interest rate did not significantly affect the results.

In the case of Portugal and Ireland, the set of exogenous variables includes respectively the Spanish interest rate and the UK interest rate instead of the US interest rate. This slight modification of the model is meant to account for the integration of Portugal with Spain and of Ireland with the UK. It alleviates a GDP puzzle in the case of Ireland and a price puzzle in the case of Portugal.

3.3.2.2. Austria, the Netherlands (and Belgium)

During most of the sample period Austria, the Netherlands, and to a much lesser extent Belgium, have maintained a fixed central exchange rate parity vis-à-vis the Deutsche Mark. This implies that in these countries the scope for an independent monetary policy was extremely limited and that it is unlikely that we are able to get precise estimates of the effects of domestic monetary policy shocks (with the exception of Belgium). Instead, most of the policy shocks are likely to be driven by policy innovations in the German interest rate. Moreover, these countries are relatively small neighbours of Germany and strongly influenced by economic conditions in Germany. In this case, we therefore modify the benchmark model by including German output, prices, real effective exchange rate and short-term interest rate in the list of endogenous variables and replacing the effective exchange rate with the bilateral rate versus the DM. In addition, we assume that there is no feedback from the smaller country to Germany. The monetary policy shock is identified as the shock to the German interest rate. We can represent this as follows:

\[
\begin{bmatrix}
X_t \\
Y_t^{DE} \\
Y_t^{j}
\end{bmatrix} = 
\begin{bmatrix}
A(L) & 0 & 0 \\
D(L) & E(L) & 0 \\
G(L) & H(L) & I(L)
\end{bmatrix}
\begin{bmatrix}
X_{t-1} \\
Y_{t-1}^{DE} \\
Y_{t-1}^{j}
\end{bmatrix}
+ 
\begin{bmatrix}
a & 0 & 0 \\
d & e & 0 \\
g & h & i
\end{bmatrix}
\begin{bmatrix}
\epsilon_t^{X} \\
\epsilon_t^{DE} \\
\epsilon_t^{j}
\end{bmatrix}
\]

with

\[ Y_t^{DE} = \begin{bmatrix} y_t^{DE} & p_t^{DE} & s_t^{DE} & x_t^{DE} \end{bmatrix} \]

\[ Y_t^j = \begin{bmatrix} y_t^j & p_t^j & x_t^j & s_t^j \end{bmatrix} \quad j = AT, NL \text{ or } BE \]

This implies that we estimate the same monetary policy shocks as in the German case. The response of the German variables to this monetary policy shock is also unchanged.
3.4. ESTIMATION RESULTS

Unless otherwise mentioned, each of the VAR-models is estimated in levels over the period 1980-1998. In this paper we do not perform an explicit analysis of the long run behaviour of the economy. By doing the analysis in levels we allow for implicit cointegrating relationships in the data (Chap. 18 in Hamilton, 1994). A more explicit analysis of the long-run behaviour of the various variables is limited by the relatively short sample available. The data are seasonally adjusted logs, except the interest rates, which are in levels. We use the three-month interest rate as the monetary policy rate as this is the only short-term interest rate that is available for all countries over the whole sample period. Standard likelihood ratio tests are used to determine the lag-order of the VARs, which usually turns out to be of order two or three.

Chow break tests did not reject the overall stability of the various VARs at the 5% confidence level. However, in some countries instability was detected in some of the equations of the VAR. This was in particular the case for Italy where overall stability is rejected at the 10% confidence level. Both the Italian output and exchange rate equations appear to be subject to a significant break in the third quarter of 1992 coinciding with the outbreak of the ERM crisis and the floating of the Italian lira. Also in Finland there is some evidence of instability in the exchange rate equation in the early 1990s.

The results of the basic VAR-model for the euro area and each of the individual countries are shown in Graphs 3.1 and 3.2. These graphs summarise for each of the countries the effects of a one-standard deviation monetary policy shock on domestic real GDP, domestic consumer prices, the exchange rate (effective real exchange rate in the case of the euro area and Germany, the bilateral DM exchange rate in the case of the other countries), and the domestic short-term interest rate. We report the OLS estimate based impulse response function together with a 90 percent confidence band.

Graphs 3.1 and 3.2 show that in each of the countries a monetary policy tightening eventually leads to a fall in output and prices. It is remarkable that this fairly simple identification scheme allowed us to compute well-behaved responses of GDP and of prices to a monetary policy shock. However, some additional features are worth noting.

---

13 We took 1980 as a starting date because some of the data series used are only available from that year.

14 See Ehrmann (2000) for an explicit cointegration analysis of VAR models for the countries of the euro area.
Graph 3.1
The effects of monetary policy shocks in Germany, France, Italy, Spain, Finland, Ireland, Greece, Portugal and Belgium

<table>
<thead>
<tr>
<th>Output</th>
<th>Prices</th>
<th>Exchange rate</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: EMU = euro area, DE = Germany, FR = France, IT = Italy, ES = Spain, FI = Finland, IR = Ireland, GR = Greece, PT = Portugal, BE = Belgium; 90% confidence bands.
First, somewhat surprisingly, we find that in Germany in the very short run output rises after a policy tightening. It turns out that this is mainly driven by the fact that the tightening in the early 1990s coincided with a big positive demand shock due to direct government spending and tax incentives following reunification. If we re-estimate the model over a longer sample period (1974-1998) the weight of this episode is reduced and output falls immediately following a policy tightening. Similarly, if we use industrial production rather than real GDP as our measure of output, this puzzle disappears because industrial production is much less affected by the increase in government spending which mostly affected the government sector and construction. This short-run positive output effect in Germany is to some extent also reflected in the output responses in Austria, the Netherlands and Belgium to a German monetary policy shock. In those countries, domestic interest rates rise very significantly in response to the changes in the German interest rate. Not surprisingly, the effects on output and on prices are quite similar as in the euro area and German model.

Graph 3.2
The effects of monetary policy shocks in Austria, the Netherlands and Belgium

<table>
<thead>
<tr>
<th>Output</th>
<th>Prices</th>
<th>Exchange rate</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: EMU = Euro area, DE = Germany, AT = Austria, NL = Netherlands, BE = Belgium

15 However, the correlation between the monetary policy shocks of the model with GDP and the model with industrial production is 0.99.
Second, while the overall pattern for output and prices is quite similar across countries, the effects on the exchange rate are less consistent across countries and generally less significant. For Austria and the Netherlands the lack of response of the exchange rate to the German monetary policy shock reflects the full credibility of the ERM for those countries. In France, Ireland, Greece, Germany and Belgium the monetary policy shock triggers an appreciation of the exchange rate. Finally, in Italy, Spain and Portugal, we find the so-called exchange rate puzzle, i.e. a tightening of the monetary policy stance leads to a (only slightly significant) depreciation of the exchange rate (Grilli and Roubini, 1995). Given the shifts in exchange rate regime in these countries, the finding of erratic exchange rate responses should not be much of a surprise. More interesting is that the different patterns in the exchange rate responses are not reflected in the responses of prices and output. It is likely that the exchange rate response for one country has often coincided with a similar change of the exchange rate of other European countries in a similar direction so that the effective exchange rate of the country was less affected. Moreover, the last two decades were characterised by a negative correlation between the DM exchange rate and the dollar exchange rate of the European currencies. In sum, these results are consistent with the results of the previous chapter.

Table 3.1 reports the correlations of the identified monetary policy shocks, and the first difference of the interest rate, across countries and with the euro area. Graph 3.3 plots the estimated policy shocks and their contribution to the domestic interest rate for each of the countries. In the left panel of each graph, the full line is the first difference of the interest rate, and the bars are the monetary policy shocks. In the right panel, the bars are the contribution of the monetary policy shocks to the (domestic) short-term interest rate, whereas the full line is the contribution of the accumulation of all shocks to the short-term interest rate. The contribution of those shocks to interest rate developments differs across countries. For the euro area as a whole, it is clear that the years 1982, 1987, 1990 and 1992-93 are identified as periods of relatively tight monetary policy, whereas in 1984 and 1991 policy is estimated to be relatively loose. The dominance of Germany, France and Italy in the euro area is very clear from the graphs, as well as from the calculated correlations. The correlation of the domestic monetary policy shock with the area-wide shock is respectively 0.66, 0.49, and 0.51 while the correlations of the first difference of the interest rate are respectively 0.73, 0.79, and 0.71. From the plotted contributions of the monetary policy shocks to the short term interest rates, we can easily see that monetary policy was not to restrictive in Germany during the period 1992-93, while

---

16 While some studies (Smets, 1997; Gaiotti, 1999) have shown that other identification schemes can alleviate this exchange rate puzzle, we prefer to stick to our “simple” model that performs well in terms of GDP and prices, for the sake of comparability with the other countries.
monetary policy was very tight in the other countries. This is reflected in the area-wide estimates. This means that the high interest rate in Germany after the reunification can be explained by the endogenous response of the Bundesbank to a booming economy. However, the stance of monetary policy for the other countries, which kept a fixed exchange rate vis-à-vis Germany, was too restrictive in view of the recession they were in. Another remarkable feature is that the proportion of the monetary policy shocks to the accumulated shocks of all the variables is very low in Germany compared to the other main countries of the Eurosystem. The reaction of monetary policy to price and output shocks was much more important in Germany. On the other hand, this proportion is also very low for Belgium, the Netherlands and Austria. For these countries, the reaction to exchange rate shocks is very important.

### Table 3.1
Correlations of monetary policy shocks and interest rates across countries

#### Domestic monetary policy shocks

<table>
<thead>
<tr>
<th></th>
<th>Euro</th>
<th>De</th>
<th>It</th>
<th>Fr</th>
<th>Es</th>
<th>Fi</th>
<th>Pt</th>
<th>Gr</th>
<th>Ir</th>
<th>Be</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro area</td>
<td>1.00</td>
<td>0.66</td>
<td>0.51</td>
<td>0.49</td>
<td>0.46</td>
<td>0.13</td>
<td>0.08</td>
<td>-0.07</td>
<td>0.30</td>
<td>0.23</td>
</tr>
<tr>
<td>Germany</td>
<td>1.00</td>
<td>0.16</td>
<td>0.21</td>
<td>0.09</td>
<td>0.19</td>
<td>0.22</td>
<td>0.08</td>
<td>0.08</td>
<td>0.14</td>
<td>0.21</td>
</tr>
<tr>
<td>Italy</td>
<td>1.00</td>
<td>0.34</td>
<td>0.30</td>
<td>0.08</td>
<td>0.11</td>
<td>-0.07</td>
<td>0.24</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>1.00</td>
<td>0.21</td>
<td>0.01</td>
<td>-0.12</td>
<td>-0.29</td>
<td>0.27</td>
<td>0.26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>1.00</td>
<td>0.07</td>
<td>-0.03</td>
<td>-0.20</td>
<td>0.29</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>1.00</td>
<td>0.53</td>
<td>-0.15</td>
<td>-0.03</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>1.00</td>
<td>0.06</td>
<td>0.16</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>1.00</td>
<td>-0.27</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>1.00</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Changes in domestic interest rate

<table>
<thead>
<tr>
<th></th>
<th>Euro</th>
<th>De</th>
<th>It</th>
<th>Fr</th>
<th>Es</th>
<th>Fi</th>
<th>Ni</th>
<th>Be</th>
<th>At</th>
<th>Pt</th>
<th>Gr</th>
<th>Ir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro area</td>
<td>1.00</td>
<td>0.73</td>
<td>0.71</td>
<td>0.79</td>
<td>0.42</td>
<td>0.37</td>
<td>0.68</td>
<td>0.57</td>
<td>0.65</td>
<td>0.14</td>
<td>-0.14</td>
<td>0.36</td>
</tr>
<tr>
<td>Germany</td>
<td>1.00</td>
<td>0.29</td>
<td>0.48</td>
<td>0.04</td>
<td>0.22</td>
<td>0.80</td>
<td>0.53</td>
<td>0.70</td>
<td>0.01</td>
<td>-0.07</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>1.00</td>
<td>0.35</td>
<td>0.22</td>
<td>0.40</td>
<td>0.25</td>
<td>0.33</td>
<td>0.42</td>
<td>0.20</td>
<td>-0.01</td>
<td>0.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>1.00</td>
<td>0.23</td>
<td>0.16</td>
<td>0.48</td>
<td>0.61</td>
<td>0.44</td>
<td>-0.02</td>
<td>-0.23</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>1.00</td>
<td>0.04</td>
<td>0.16</td>
<td>-0.19</td>
<td>-0.05</td>
<td>0.13</td>
<td>-0.07</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>1.00</td>
<td>0.26</td>
<td>0.28</td>
<td>0.35</td>
<td>0.25</td>
<td>-0.06</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>1.00</td>
<td>0.36</td>
<td>0.73</td>
<td>0.12</td>
<td>-0.03</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>1.00</td>
<td>0.52</td>
<td>-0.01</td>
<td>-0.19</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>1.00</td>
<td>0.03</td>
<td>0.03</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>1.00</td>
<td>0.22</td>
<td>-0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>1.00</td>
<td>-0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Graph 3.3
Monetary policy shocks and their contribution to the short-term interest rate

Euro area

Germany

France

Italy
Spain

Contribution of policy shock

Finland

Contribution of policy shock

Ireland

Contribution of policy shock

Greece

Contribution of policy shock

Portugal

Contribution of policy shock
3.5. CONCLUSIONS

In this chapter, we have used VAR models to analyse the effects of a monetary policy shock in the individual countries of the euro area. We have therefore modified the basic euro area model of Peersman and Smets (2000) and estimate it for each of the countries in the euro area separately. In doing so, we minimise the changes in the specification. We show that three, relatively simple identification schemes, depending on the monetary policy decision process in the ERM, obtain well behaved and qualitatively consistent effects of the monetary policy shocks in all the countries. It leads to a temporary fall in GDP that peaks between 4 and 6 quarters after the shock and a gradual decrease in the price level. The effect on the exchange rate is somewhat more mixed. For some countries, we are confronted with an exchange rate puzzle. The estimated responses are, in global, consistent with the area-wide estimates of the previous chapter.

It is very difficult to draw conclusions regarding significant cross-country differences in the impact of monetary policy using SVAR, given that the confidence bounds are generally large. Another problem with this approach is that the size of the estimated monetary policy shocks differs across countries. A one standard deviation monetary policy shock is a rise in the short-term interest rate of, for example, 26 basis points for Germany, while it is 59 basis points for Italy, and 84 basis points for Spain. Moreover, this also implies that each individual country has his own monetary policy reaction function, making a comparison even more difficult. Thus, even if the same initial disturbance is analysed, the monetary policy responses would not be harmonised. One way to solve this would be to standardise the monetary policy shock across countries and to use the same reaction function for all countries. However, to justify this type of analysis, we have to assume that the estimated parameters of the model are invariant to the specification of the policy rule, and we are confronted with the Lucas critique.
3.6. REFERENCES


Overview

This chapter investigates whether monetary policy impulses have asymmetric effects on output growth in seven countries of the euro area (Germany, France, Italy, Spain, Austria, Belgium and the Netherlands). First, it is shown that these seven countries share the same business cycle. Next, strong evidence is presented that area-wide monetary policy impulses, measured as the contribution of monetary policy shocks to the short-term interest rate in a simple VAR for the euro area economy, have significantly larger effects on output growth in recessions than in booms. These differences are most pronounced in Germany, France, Italy, Spain, and Belgium, while they are much smaller in Austria and the Netherlands.

* This chapter is joint work with Frank Smets.
4.1. INTRODUCTION

This chapter investigates whether the effects of monetary policy on economic activity in the euro area depend on the state of the economy. There are at least three strands of the literature that predict that monetary policy is more effective in a recession or trough than during a peak or boom.¹ The first class of theories is based on a convex short-run aggregate supply curve. Convexity implies that the slope of the supply curve is steeper at higher levels of capacity utilisation and inflation than at lower levels. As a result, shifts in aggregate demand that are driven by changes in monetary policy will have a stronger effect on output and a weaker effect on inflation in a trough and the reverse in a peak. Several classes of models give rise to a convex short-run aggregate supply curve. A first model is the so-called capacity constraint model, which assumes that as the economy is near a peak, more firms find it difficult to increase their capacity to produce in the short run. As a result inflation becomes more sensitive to shifts in aggregate demand at higher rates of capacity utilisation. This is consistent with the early empirical work on the Phillips curve, including Phillips (1958), which assumed that the relationship was non-linear. A second class of models is based on the presence of menu costs. For example, Ball and Mankiw (1994) show that as the level of inflation rises, and as firms adjust the timing and the size of price changes, aggregate demand shocks will have less effect on output and more effect on the price level. It is important to mention that this theory predicts that there is an asymmetric impact of monetary policy in peaks and troughs, depending on the level of output, and not necessarily in expansions and recessions. In the empirical work below, a recession will be a period of negative or below average growth, while a boom is a period of higher and positive growth.

The second class of theories is based on downwardly rigid wages as in the so-called insider-outsider theory of employment.² In this theory, the insiders possess considerable market power, because of high turnover costs and the need for their cooperation with new recruits, which they use to set their wages above market-clearing levels. The presence of unemployed outsiders will fail to exert downward pressure on wages. In a growing economy, the insiders respond through their unions by driving up their wages. At the new higher wages, the firms will employ fewer workers than they would otherwise have done. As a result, monetary policy shocks have little effect on employment and growth in an expansion. Rather, the impact of monetary policy will be largely dissipated in wage changes. For example, expansionary monetary policy will only result in higher wages. In the case of a restrictive monetary policy shock, wages will increase less than they would otherwise have done. By contrast, in a recession, firms reduce the size of their

¹ See, for example, Kakes (1998).
² Lindbeck and Snower (1986 and 1988).
workforces and unemployment rises, while the insiders keep their wages. Consequently, a shift in the stance of monetary policy has much larger effects on employment and output. Restrictive monetary policy aggravates the negative effect on employment, while expansive monetary policy mitigates the reduction in employment.

A third class of theories that predict that monetary policy will have a stronger effect on economic activity in recessions is based on credit market imperfections. In these models, asymmetric information between borrowers and lenders gives rise to agency costs. These agency costs are reflected in an external finance premium, which typically depends on the net worth of the borrower. A borrower with higher net worth is able to post more collateral and can thereby reduce its cost of external financing. As emphasised by Bernanke and Gertler (1989), the dependence of the external finance premium on the net worth of borrowers creates a "financial accelerator" propagation mechanism. For example, when an economy is hit by a recession, the net worth of firms will typically fall. This leads to an increase in the cost of external financing, which in turn may aggravate the effects of the initial shock. In response to a monetary policy shock, this propagation mechanism is likely to be weaker during expansions than during recessions. During an expansion, firms can largely finance themselves with retained earnings. Moreover, as their balance sheets are strong, the external finance premium is likely to be relatively low. As a result, monetary policy changes have only a limited impact on this premium, because the share of external finance in total finance is relatively low. In contrast, in a recession, when cash flows are low, firms are more dependent on external finance and collateral values are depressed, the external finance premium will be much more sensitive to changes in the interest rate. Monetary policy is therefore likely to have much stronger effects on economic activity.

In this chapter we do not attempt to distinguish between these various theories. Instead, we want to document empirically whether monetary policy in the euro area indeed has different effects in recessions versus booms. To do so, we employ a

---

3 An example is the "financial accelerator" model developed in Bernanke and Gertler (1989).

4 In Peersman and Smets (2000b), we perform a more disaggregated industry analysis, which allows us to potentially distinguish between the various hypotheses. One could also try to distinguish between both sets of theories by analysing the effect on manufacturing prices. The financial accelerator theories say that a given interest rate change has more impact on nominal aggregate demand when output is low than when it is high. The second set of theories predicts that when output is low, a given change in aggregate nominal demand has more impact on real output and less on prices.

5 There is already a large literature on the 'sign' asymmetries of shocks. Following this literature, there is a small effect of positive shocks in nominal demand and much stronger effects of a negative demand shock. A large number of papers have found empirical support for this theory. These include Cover (1992) and Karras (1996).
multivariate extension of Hamilton's (1989) two-state Markov Switching Model (MSM). This methodology allows us to endogenously determine whether the euro area economy is in a boom or a recession and to test whether the effects of policy are significantly different in the two states of the economy. The multivariate MSM methodology has previously been used by Garcia and Schaller (1995), Kakes (1998) and Dolado and Maria-Dolores (1999) to examine similar questions in the United States, a group of five countries including the United States, Germany, the United Kingdom, Belgium, the Netherlands, and Spain respectively. In this paper we apply the methodology to eight countries of the euro area: Germany, France, Italy, Spain, the Netherlands, Belgium, Austria and Finland.6

The novelty of the chapter is that we take a euro area-wide approach. To do so, we proceed in various steps. In the first step (Section 4.2), we test whether there has indeed been a common cycle in those eight countries that now form part of the European Monetary Union (EMU). In other words, we ask whether before the start of EMU their business cycles were sufficiently synchronised, so that we can assume that the underlying state (boom or recession) was identical in each of these economies. In doing so, we do allow for different mean growth rates in each of the economies. In the estimation we use quarterly data on the growth of industrial production from 1978 till 1998. With the exception of Finland, we find that we cannot reject the hypothesis that there was a common business cycle in each of these countries. In the rest of the analysis we therefore exclude Finland. These results confirm the findings of Artis, Krolzig and Toro (1999) who, using both univariate and multivariate MSMs, also find support for a common European cycle.7 This Section is of independent interest because it suggests that at least for a large part of the euro area differences in cyclical situation are not likely to complicate monetary policy.

In Section 4.3 we then extend the multivariate MSM to test whether monetary policy impulses have different effects on euro area industrial activity in booms versus recessions. Rather than using domestic monetary policy impulses in each of the seven countries, we analyse the effects of an area-wide change in monetary policy. We think this is a useful exercise not only because it more closely resembles the current single monetary policy in the euro area, but also because during most of the sample domestic monetary policies in those seven countries were to a large extent coordinated through the participation in the ERM and other fixed exchange

6 Because of data limitations, we did not consider Portugal, Ireland, Luxemburg and Greece, the remaining countries participating in EMU.

7 Artis, Krolzig and Toro (1999) include the United Kingdom and Portugal in their analysis, but not Finland.
In order to avoid the simultaneity bias, which may result from the fact that through the central banks’ reaction function short-term interest rates depend on economic activity, we use an area-wide VAR (based on Peersman and Smets, 2000a) to identify area-wide monetary policy shocks. The VAR is estimated over the same period as the MSM analysis (1978-1998) and includes area-wide real GDP, consumer prices, the real effective exchange rate and a short-term 3-month interest rate as endogenous variables and commodity prices, the US short-term interest rate and US real GDP as exogenous variables. Using a standard Choleski identification scheme, we show that a monetary policy tightening leads to an immediate rise in the short-term interest rate and an appreciation of the exchange rate. Subsequently, this tightening of monetary conditions has a significant negative impact on output and prices.

In Section 4.3.2, we then use the contribution of these policy shocks to the euro area interest rate as our measure of monetary policy impulses and estimate the effects of a policy tightening in the two states of the economy. Like Garcia and Schaller (1995), Kakes (1999) and Dolado and Maria-Dolores (1999), we find that, in the euro area too, monetary policy has considerably larger effects on activity when the economy is in a recession. These results are robust to using the change in the average euro area short-term interest rate as a measure of monetary policy.

In Section 4.4, we examine whether these asymmetries in the effects of monetary policy are similar across countries. We find that the asymmetries are most pronounced in Germany, France, Spain, Italy and Belgium. We also find that the effects of the monetary policy shock are much larger in Germany than in the other countries. To some extent this may be due to the large weight of the German economy in our estimates of the common monetary policy shock. Finally, in Section 4.5, we ask whether monetary policy shocks also affect the probability of switching from a boom to a recession and conversely. We find only weak evidence that a tightening of monetary policy reduces the probability of staying in a boom and no evidence that an expansive monetary policy increases the probability of going from a recession to a boom. We conclude with some final remarks in Section 4.6.

---

8 This is definitely the case for Germany, France, Austria, Belgium and the Netherlands. It is less clear-cut for Italy and Spain who went through various periods of floating exchange rate regimes during the sample. However, even in this case a large component of monetary policy innovations is likely to be common with the other countries.
4.2. IS THERE A COMMON CYCLE IN THE EURO AREA?

In order to test whether monetary policy in the euro area has different effects in booms versus recessions it is necessary to determine the likely timing of switches in the state of the euro area business cycle. Hamilton’s (1989) MSM approach provides a natural framework to use in this context, because it allows to endogenously determine the most likely switching dates between the two regimes. One option is to estimate Hamilton’s MSM model on synthetic euro area output growth data and test whether there are indeed two regimes, one with a low or negative growth rate and one with a high growth rate. There are two problems with this euro area-wide approach. First, because of data availability the sample of quarterly observations is relatively small. As a result, the limited degrees of freedom make it quite difficult to distinguish empirically between the two regimes. Second, by using the synthetic euro area data one implicitly assumes that the state of the economy is identical in each of the countries participating in EMU. If this is not the case, the results may be biased against finding two different regimes. A second option is to estimate the MSM model jointly for each of the countries participating in EMU. Joint estimation has the advantage that because of the higher degrees of freedom the estimates are likely to be more precise. In addition, it allows us to test whether the countries indeed share the same business cycle.

In this chapter we therefore follow the second approach. For each country \( i \), out of \( n \) countries, we estimate the following equation:

\[
\Delta y_{i,t} - \mu_{i,s_t} = \phi_1 (\Delta y_{i,t-1} - \mu_{i,s_{t-1}}) + \phi_2 (\Delta y_{i,t-2} - \mu_{i,s_{t-2}}) + \varepsilon_{i,t},
\]

where

\[
\begin{bmatrix}
\varepsilon_{1,t} \\
\vdots \\
\varepsilon_{n,t}
\end{bmatrix} \sim i.i.d. N\left(\begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1n} \\ \vdots & \ddots & \vdots \\ \sigma_{nn} & \cdots & \sigma_{nn} \end{bmatrix}\right) = N(0, \Omega).
\]

\( \Delta y_{i,t} \) is the quarterly growth rate of industrial production in country \( i \). \( \mu_{i,s_t} \) is the mean growth rate conditional on country \( i \) being in state \( s_t \). In this model, we assume that the state of the economy is identical in each of the \( n \) countries.

---

9. One reason for using industrial production indices rather than GDP figures is that the former show a stronger cyclical pattern, making it easier to identify the state of the business cycle.

10. See Hamilton and Perez-Quiros (1996) for an application of such a joint MSM model to different leading indicators.
Following Hamilton (1989), we assume that the autoregressive parameters \((\phi_1, \phi_2)\) are independent of the state and the country. \(^{11}\) \(s_t\) is assumed to follow a two-state Markov chain with the following transition probability matrix:\(^{12}\)

\[
P = \begin{bmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{bmatrix}
\]

where

\[
p_y = \Pr[s_t = j \mid s_{t-1} = i], \quad \text{with} \quad \sum_{j=0}^{1} p_y = 1 \quad \text{for all} \quad i.
\]

We assume that these transition probabilities are constant over time and take the following logistic form:

\[
p_{00} = \Pr[s_t = 0 \mid s_{t-1} = 0] = \frac{\exp(\theta_0)}{1 + \exp(\theta_0)}
\]

\[
p_{11} = \Pr[s_t = 1 \mid s_{t-1} = 1] = \frac{\exp(\theta_1)}{1 + \exp(\theta_1)}
\]

For \(Y_t = [\Delta y_{1t}, \cdots, \Delta y_{nt}]^\prime\), the vector of observations on output growth, this model implies that the conditional density takes the form:

\[
f(Y_t \mid Y_{t-1}, \ldots, Y_1, s_t) = (2\pi)^{-nt/2} |\Omega|^{-1/2} \exp \left[ -\frac{1}{2} (Y_t - \mu_{s_t})^\prime \Omega^{-1} (Y_t - \mu_{s_t}) \right]
\]

where

\(^{11}\) An alternative model would be \(\Delta y_{1t} = \mu_{t,s_t} + \phi_1 \Delta y_{1,t-1} + \phi_2 \Delta y_{1,t-2} + \epsilon_{1t}\), in which case the shift in mean affects the growth rate immediately. We follow Hamilton (1989) and the previous literature by assuming a gradual adjustment to the new mean in equation [4.1]. In principle one could test whether the autoregressive parameters are different across states and across countries. However, the limited degrees of freedom prevented us from estimating such an alternative model. Finally, we restricted the model to two lags, because further lags turned out to be insignificant.

\(^{12}\) In accordance with the usual typology of the business cycle in booms and recessions, we assume that there are only two states. Due to limited degrees of freedom we can not test whether more than two states would be appropriate.
With these assumptions, we also obtain a sequence of joint conditional probabilities

\[ \Pr(s_t = i, \ldots, s_{t-r} = j \mid \Phi_t) \]

which are the probabilities that the series is in state \( i \) or \( j \) at times \( t, t-1, \ldots, t-r \) respectively, conditional upon the information available at time \( t \). By summing these joint probabilities, we can obtain the filtered probabilities, which are the probabilities of being in state 0 or 1 at time \( t \), given the information available at time \( t \):

\[ \Pr(s_t = j \mid \Phi_t) = \sum_{i=0}^{1} \sum_{k=0}^{1} \Pr(s_t = i, s_{t-1} = i, \ldots, s_{t-r} = k \mid \Phi_t) \quad i, j, \ldots, k = 0,1 \]

These probabilities provide information about the regime in which the series is most likely to have been at every point in the sample.

We estimate the model given by equations [4.1] to [4.9] using quarter-to-quarter growth rates of deseasonalised industrial production in eight of the eleven euro area countries: Germany, France, Italy, Spain, Austria, Belgium, the Netherlands and Finland. Graph 4.1 shows (de-trended) industrial production for each of these countries.

To test whether these eight countries indeed share the same business cycle, we estimate the joint model for seven of the eight countries and the eighth country separately. A comparison of the sum of the log likelihoods with the log likelihood of the eight-country model, can then be used to assess whether that country indeed has the same business cycle as the other seven. In Table 4.1 we report the log likelihoods as well as the corresponding Schwarz and Akaike statistics. Based on a visual inspection of Graph 4.1, we started with Finland as the country that was most likely not to share the same business cycle with the other countries. Column 2 of Table 4.1 shows indeed that the sum of the log likelihood of the Finnish model and the common model for the other seven countries is higher than the log likelihood of the common model for the eight countries (bottom row), so that we can reject the hypothesis that Finland is sharing the same business cycle with the other countries. The same exercise is then done for the other individual countries in column 3. The log likelihood of the individual country models and the common model for the remaining seven countries. For these seven countries, we cannot reject the
hypothesis that they share the same business cycle. In the rest of the analysis we proceed with these seven countries.

Graph 4.1
De-trended industrial production in eight euro-area countries

---

13 A border case is the Netherlands, where the Schwartz criterium of the six-plus-one model is marginally below the joint business cycle model.
Table 4.1
Tests for a common business cycle in the euro area

| Countries | 7+1 countries | | | 6+1 countries | | |
|-----------|---------------|---|---|---------------|---|
| Log lik   | Schwarz       | Akaike | Log lik | Schwarz | Akaike |
| DE        | -622.83       | -718.75 | -666.83 |
| FR        | -625.71       | -721.63 | -669.71 |
| IT        | -627.87       | -723.79 | -671.87 |
| ES        | -623.62       | -719.54 | -667.62 |
| AT        | -632.43       | -728.35 | -676.43 |
| BE        | -619.55       | -715.47 | -663.55 |
| NL        | -617.31       | -713.23 | -661.31 |
| FI        | -699.36 -814.90 -752.36 |

DE,FR,IT,ES,AT, BE,NL,FI -702.09 -824.17 -758.09
DE,FR,IT,ES,AT, BE,NL -613.32 -713.60 -659.32

Note: The constant term involving $2\pi$ has been omitted from all calculations.

The results of the estimation of our common model are reported in the first column of Table 4.2. A number of features are noteworthy. In each of the seven countries the mean growth rate in the first state ($\mu_0$) is negative, ranging from $-0.50$ percent in Germany to $-0.03$ percent in the Netherlands. This state therefore corresponds to a euro area recession. Only in Germany, France and Belgium the growth rate in a recession is significantly different from zero. The probability of staying in a recession is relatively high at 0.85, which implies that the mean duration of a recession is about 6 to 7 quarters. In each of the seven countries, the mean growth rate in the second state ($\mu_1$) is significantly positive, ranging from 0.66 percent in the Netherlands to 1.5 percent in Austria. This state therefore corresponds to a euro area expansion. The average duration of an expansion is longer than that of a recession at about 10 quarters.
### Table 4.2
The cyclical effects of monetary policy

<table>
<thead>
<tr>
<th>Country</th>
<th>Common model</th>
<th>Common model + MP (s-1)</th>
<th>Common model + MP (s)</th>
<th>Common model + Δi (s-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>μ₀</td>
<td>-0.50 (0.24)</td>
<td>-1.00 (0.16)</td>
<td>-0.97 (0.17)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>1.03 (0.17)</td>
<td>1.15 (0.12)</td>
<td>1.16 (0.12)</td>
</tr>
<tr>
<td>France</td>
<td>μ₀</td>
<td>-0.35 (0.14)</td>
<td>-0.58 (0.14)</td>
<td>-0.55 (0.14)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>0.87 (0.13)</td>
<td>0.86 (0.10)</td>
<td>0.86 (0.11)</td>
</tr>
<tr>
<td>Italy</td>
<td>μ₀</td>
<td>-0.28 (0.30)</td>
<td>-0.25 (0.29)</td>
<td>-0.22 (0.30)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>1.00 (0.24)</td>
<td>0.84 (0.21)</td>
<td>0.85 (0.22)</td>
</tr>
<tr>
<td>Spain</td>
<td>μ₀</td>
<td>-0.28 (0.22)</td>
<td>-0.34 (0.21)</td>
<td>-0.31 (0.22)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>0.98 (0.17)</td>
<td>0.86 (0.15)</td>
<td>0.87 (0.16)</td>
</tr>
<tr>
<td>Austria</td>
<td>μ₀</td>
<td>-0.24 (0.19)</td>
<td>-0.53 (0.16)</td>
<td>-0.50 (0.16)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>1.50 (0.15)</td>
<td>1.47 (0.11)</td>
<td>1.48 (0.11)</td>
</tr>
<tr>
<td>Belgium</td>
<td>μ₀</td>
<td>-0.44 (0.22)</td>
<td>-0.57 (0.23)</td>
<td>-0.54 (0.23)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>1.02 (0.18)</td>
<td>0.93 (0.16)</td>
<td>0.93 (0.17)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>μ₀</td>
<td>-0.03 (0.32)</td>
<td>-0.42 (0.26)</td>
<td>-0.38 (0.27)</td>
</tr>
<tr>
<td></td>
<td>μ₁</td>
<td>0.66 (0.23)</td>
<td>0.80 (0.19)</td>
<td>0.81 (0.19)</td>
</tr>
<tr>
<td>Common coefficients</td>
<td>φ₁</td>
<td>-0.24 (0.04)</td>
<td>-0.28 (0.04)</td>
<td>-0.28 (0.04)</td>
</tr>
<tr>
<td></td>
<td>φ₂</td>
<td>-0.07 (0.04)</td>
<td>-0.08 (0.04)</td>
<td>-0.08 (0.04)</td>
</tr>
<tr>
<td></td>
<td>p₀₀</td>
<td>0.85 (0.07)</td>
<td>0.78 (0.08)</td>
<td>0.78 (0.08)</td>
</tr>
<tr>
<td></td>
<td>p₁₁</td>
<td>0.90 (0.05)</td>
<td>0.89 (0.04)</td>
<td>0.88 (0.05)</td>
</tr>
<tr>
<td></td>
<td>β₀</td>
<td>-0.89 (0.14)</td>
<td>-0.75 (0.14)</td>
<td>-0.73 (0.34)</td>
</tr>
<tr>
<td></td>
<td>β₁</td>
<td>-0.52 (0.15)</td>
<td>-0.66 (0.16)</td>
<td>-0.20 (0.19)</td>
</tr>
<tr>
<td></td>
<td>β₁-β₀</td>
<td>0.37 (0.03)</td>
<td>0.08 (0.04)</td>
<td>0.52 (0.12)</td>
</tr>
</tbody>
</table>

Note: standard errors in parenthesis

The smoothed probabilities of being in a recession, together with the de-trended output level (respectively together with the output growth) are plotted in Graph 4.2 (respectively Graph 4.3). The shaded area is the smoothed probability of being in a recession. The main recessionary periods are from 1980 till 1982 and from 1990 till 1993. Somewhat more surprisingly also in 1986 and in the second half of 1995 the probability of being in a recession is relatively high.
Graph 4.2
De-trended industrial production and the probability of being in a recession

Note: Right axis: de-trended industrial production. The shaded areas denote the probability of being in a recession (Left axis)
Graph 4.3
Industrial production growth and the probability of being in a recession

Note: Right axis: industrial production growth. The shaded areas denote the probability of being in a recession (Left axis)
4.3. THE ASYMMETRIC EFFECTS OF AREA-WIDE MONETARY POLICY SHOCKS

In this Section we test whether monetary policy in the euro area has different effects on output when the economy is in a recession or an expansion. As our measure of the monetary policy stance in the euro area we take a weighted average of the three-month interest rate in each of the eleven countries participating in EMU. However, in order to avoid the simultaneity bias, which may result from the fact that short-term interest rates depend on economic activity through the central banks’ reaction function, we use monetary policy innovations derived from an identified VAR.14 Section 4.3.1. presents the VAR results. In Section 4.3.2, we then extend the multivariate MSM model of Section 4.2 to include the effects of those monetary policy shocks.

4.3.1. A MONETARY POLICY VAR FOR THE EURO AREA

To derive the euro area-wide monetary policy shocks we follow Peersman and Smets (2000a). They estimate the following block-recursive VAR model over the period 1978-1998:

\[
\begin{bmatrix}
X_t \\
Y_t
\end{bmatrix} = \begin{bmatrix}
A(L) & 0 \\
B(L) & C(L)
\end{bmatrix} \begin{bmatrix}
X_{t-1} \\
Y_{t-1}
\end{bmatrix} + \begin{bmatrix}
a \\
b
\end{bmatrix} e_{X,t} + \begin{bmatrix}
c \\
0
\end{bmatrix} e_{Y,t},
\]

where \(X_t\) is a vector of exogenous variables comprising a world commodity price index, the US nominal short-term interest rate and US real GDP and \(Y_t\) is a vector of endogenous euro area data including real GDP, consumer prices, the nominal 3-month short-term interest rate and a real effective exchange rate. The monetary policy shocks are identified through a recursive Choleski decomposition with the variables ordered as mentioned above.15 The identifying assumptions are thus that monetary policy shocks do not have a contemporaneous impact on output and prices. A monetary policy shock does have an immediate impact on the exchange rate, but the central bank does not respond to changes in the exchange rate within the quarter.

The results of the VAR analysis are shown in Graph 4.4. This Graph summarises the effect of a one-standard deviation monetary policy shock on real GDP, consumer prices, the real effective exchange rate and the short-term interest rate

---

14 More correctly, we will use the historical contribution to the interest rate of the monetary policy shocks as our benchmark measure. See Section 4.3.1. below.

15 These identifying assumptions are similar to the ones used by Eichenbaum and Evans (1995) for the United States.
together with a 90 percent confidence band. From the Graph it is clear that a typical monetary policy tightening in the euro area gives rise to a temporary increase of the nominal interest rate and a temporary appreciation of the real exchange rate. This tightening of monetary conditions leads to a significant, temporary fall in output after about two quarters. Prices respond more sluggishly and fall significantly below zero after about two years.

**Graph 4.4**

**Impulse responses to a monetary policy shock in the euro area**

Notes: Y is real GDP, S is the short-term nominal interest rate, P is the consumer price level and X is the real effective exchange rate.

In the next Section we will use the historical contribution of the monetary policy shocks to the euro area interest rate, as depicted in Graph 4.5, as our benchmark.
measure of monetary policy impulses in the extended MSM model. The advantage of using the historical contribution to the interest rate rather than the monetary policy shocks themselves is that fewer lags need to be used in the MSM, as the historical contribution is itself a moving average of the monetary policy shocks. From Graph 4.5, which plots the historical contribution of the monetary policy shocks together with the short-term interest rate, it is clear that the years 1982, 1987, 1990 and 1992-93 are identified as periods of relatively tight monetary policy, whereas in 1984 and 1991 policy is estimated to be relatively loose.

**Graph 4.5**

*Contribution of the monetary policy shock to the short-term interest rate*

![Graph 4.5](image_url)

Notes: The shaded area is the contribution of the monetary policy shocks to the short-term interest rate (left axis); the solid line is the short-term interest rate itself (right axis).

---

16 The historical contribution of the monetary policy shock to the short-term interest rate consists of the cumulated effects of current and past monetary policy shocks on the interest rate.

17 As the identification of monetary policy shocks is a controversial matter, we will also use the change in the short-term interest rate as an alternative monetary policy indicator in Section 4.3.2.
4.3.2. MONETARY POLICY SHOCKS IN THE MULTIVARIATE MSM MODEL

In order to test whether there are asymmetric effects of monetary policy on output growth depending on the state of the business cycle at the moment the monetary policy stance changes, we extend the basic model of Section 4.2 as follows:

\[ \Delta y_{i,t} - \mu_{i,s_t} = \phi_1 (\Delta y_{i,t-1} - \mu_{i,s_{t-1}}) + \phi_2 (\Delta y_{i,t-2} - \mu_{i,s_{t-2}}) + \beta_{s_t} MP_{t-1} + \varepsilon_{i,t}, \]

where \( \beta_{s_t} \) is the coefficient on the monetary policy indicator \( MP_t \) in a recession \( (s_t = 0) \) or an expansion \( (s_t = 1) \). In this specification we assume that the \( \beta \)-coefficients are identical across countries. The other variables are the same as in equation [4.1].

The results are reported in the second column of Table 4.2. It is clear that a tightening of monetary policy has a significant negative impact on output in both states of the euro area economy. However, as expected, the effects on economic activity are significantly larger in a recession compared to those in an expansion. Graph 4.6 (upper panel) plots the impulse response function of output to a one-standard deviation monetary policy shock in respectively a recession (full line) and an expansion (dotted line). As in the VAR the maximum impact is after 3 to 4 quarters, but while in a recession the maximum impact on output is more than 50 basis points, the impact in an expansion is only about 30 basis points.

In order to test the robustness of our results, we re-estimate the model assuming that the effects of a monetary policy action on output growth depend on the current state of the economy. In this case, the following model is estimated:

\[ \Delta y_{i,t} - \mu_{i,s_t} = \phi_1 (\Delta y_{i,t-1} - \mu_{i,s_{t-1}}) + \phi_2 (\Delta y_{i,t-2} - \mu_{i,s_{t-2}}) + \beta_{s_t} MP_{t-1} + \varepsilon_{i,t}, \]

These results are reported in the third column of Table 4.2. In this case the difference between the monetary policy effects in a recession and an expansion are smaller, though still significant. This is also reflected in the middle panel of Graph 4.6. Finally, the fourth column of Table 4.2 reports the results when we use the first difference of the interest rate as our monetary policy indicator. Again, we find a significantly larger effect of monetary policy in a recession versus an expansion. The bottom panel of Graph 4.6 plots the impulse response functions to a monetary policy shock in both regimes.
Graph 4.6
Impulse responses to a monetary policy shock

Influence shock dependent on the state at the moment of the shock

Influence shock dependent on the current state

First difference of the interest rate

Notes: Solid line is the effect on production in a recession; dashed line is the effect in a boom
4.4. ARE THE MONETARY POLICY EFFECTS DIFFERENT ACROSS COUNTRIES?

In Section 4.3 we have assumed that the effects of the euro area-wide monetary policy shocks were different across states of the economy, but identical across countries. In order to test whether this is indeed the case, we allow the $\beta$-coefficients in equation [4.11] to vary across countries. Table 4.3 reports the results of this exercise. The upper and middle panel reports the estimates of $\beta_0$ and $\beta_1$ for each of the countries as well as the differences across countries. The lower panel reports the estimates of the difference between $\beta_0$ and $\beta_1$.

Several results are noteworthy. First, in all cases the effect of monetary policy on output growth is negative. In a recession the effect varies from -0.60 in the Netherlands to -1.44 in Germany and (with the exception of the Netherlands) is always significant. This compares with an average effect of -0.89 in the restricted model of Section 4.3. The effect on output during downturns is significantly larger in Germany than in the other countries. In an expansion, the effect ranges from -0.21 in France to -0.76 in Austria, compared to -0.52 in the restricted model of Section 4.3. This effect is significantly larger than average in Austria and weaker than average in France.

Second, with the exception of the Netherlands, the effect of policy is always greater in downturns than in booms. The difference is high and significant in Germany, France, Spain and Belgium and high, but less significant in Italy. There is little evidence of asymmetries in Austria and the Netherlands. In the latter case, this may be due to the fact that the Dutch business cycle was not completely in line with the euro area one. Overall, there appears little evidence of significant differences in asymmetries across countries. The degree of asymmetry is only significantly higher in Germany than in France, Austria and the Netherlands.

These results are confirmed in the impulse response analysis presented in Graph 4.7.
### Table 4.3
The cyclical effects of monetary policy in the individual countries

<table>
<thead>
<tr>
<th></th>
<th>$\beta_0$</th>
<th>NL</th>
<th>AT</th>
<th>BE</th>
<th>DE</th>
<th>ES</th>
<th>FR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>-0.60</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>-0.89</td>
<td>-0.28</td>
<td>0.22</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td>-0.72</td>
<td>-0.12</td>
<td>0.16</td>
<td>0.24</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>-1.44</td>
<td>-0.84</td>
<td>-0.55</td>
<td>-0.71</td>
<td>0.23</td>
<td>0.19</td>
<td>0.10</td>
</tr>
<tr>
<td>ES</td>
<td>-0.99</td>
<td>-0.39</td>
<td>-0.10</td>
<td>-0.27</td>
<td>0.44</td>
<td>0.32</td>
<td>0.23</td>
</tr>
<tr>
<td>FR</td>
<td>-0.65</td>
<td>-0.04</td>
<td>0.23</td>
<td>0.07</td>
<td>0.79</td>
<td>0.34</td>
<td>0.20</td>
</tr>
<tr>
<td>IT</td>
<td>-0.88</td>
<td>-0.28</td>
<td>0.00</td>
<td>-0.15</td>
<td>0.55</td>
<td>0.11</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.43</td>
<td>0.28</td>
<td>0.21</td>
<td>0.24</td>
<td>0.20</td>
<td>0.19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1$</th>
<th>NL</th>
<th>AT</th>
<th>BE</th>
<th>DE</th>
<th>ES</th>
<th>FR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>-0.74</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>-0.76</td>
<td>-0.01</td>
<td>0.25</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td>-0.28</td>
<td>0.46</td>
<td>0.47</td>
<td>0.36</td>
<td>0.30</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>-0.65</td>
<td>0.08</td>
<td>0.10</td>
<td>-0.37</td>
<td>0.25</td>
<td>0.22</td>
<td>0.13</td>
</tr>
<tr>
<td>ES</td>
<td>-0.44</td>
<td>0.30</td>
<td>0.31</td>
<td>-0.15</td>
<td>0.21</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>FR</td>
<td>-0.21</td>
<td>0.53</td>
<td>0.54</td>
<td>0.07</td>
<td>0.44</td>
<td>0.23</td>
<td>0.22</td>
</tr>
<tr>
<td>IT</td>
<td>-0.24</td>
<td>0.50</td>
<td>0.52</td>
<td>0.04</td>
<td>0.41</td>
<td>0.20</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.47</td>
<td>0.34</td>
<td>0.26</td>
<td>0.31</td>
<td>0.25</td>
<td>0.24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1 - \beta_0$</th>
<th>NL</th>
<th>AT</th>
<th>BE</th>
<th>DE</th>
<th>ES</th>
<th>FR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>-0.14</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>0.12</td>
<td>0.27</td>
<td>0.11</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE</td>
<td>0.43</td>
<td>0.58</td>
<td>0.31</td>
<td>0.24</td>
<td>0.58</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>DE</td>
<td>0.78</td>
<td>0.92</td>
<td>0.65</td>
<td>0.34</td>
<td>0.11</td>
<td>0.44</td>
<td>0.24</td>
</tr>
<tr>
<td>ES</td>
<td>0.55</td>
<td>0.69</td>
<td>0.42</td>
<td>0.11</td>
<td>-0.23</td>
<td>0.23</td>
<td>0.54</td>
</tr>
<tr>
<td>FR</td>
<td>0.43</td>
<td>0.58</td>
<td>0.31</td>
<td>-0.00</td>
<td>-0.34</td>
<td>-0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>IT</td>
<td>0.64</td>
<td>0.78</td>
<td>0.51</td>
<td>0.20</td>
<td>-0.14</td>
<td>0.09</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Note: standard errors in italics.
Graph 4.7
Impulse response to a monetary policy shock: individual countries

Notes: Solid line is the effect on production in a recession; dashed line is the effect in a boom
4.5. DOES MONETARY POLICY CHANGE THE LIKELIHOOD OF A RECESSION?

In this final Section we follow Garcia and Schaller (1995) and Dolado and Maria-Dolores (1999) in testing whether changes in monetary policy also affect the transition probabilities of going from one state to the other. In the MSM models of Sections 4.2 and 4.3 these probabilities were assumed to be constant. To do so, we modify the logit functions [4.5] and [4.6] determining the transition probabilities as follows:

\[ p_{00} = \Pr[s_t = 0 \mid s_{t-1} = 0] = \frac{\exp(\theta_{00} + \theta_{01 MP_t})}{1 + \exp(\theta_{00} + \theta_{01 MP_t})} \]

\[ p_{11} = \Pr[s_t = 1 \mid s_{t-1} = 1] = \frac{\exp(\theta_{10} + \theta_{11 MP_t})}{1 + \exp(\theta_{10} + \theta_{11 MP_t})} \]

Moreover, in order to isolate the effect of the shocks on the transition probabilities from the linear effect examined above, we constrain the \( \beta \)-coefficients to be equal to zero as in equation [4.1]. Based on equations [4.14] and [4.15], we would expect \( \theta_{01} \) to be positive as a monetary policy tightening is likely to increase the probability of staying in a recession. In contrast, \( \theta_{11} \) is expected to be negative as a monetary policy tightening is expected to reduce the probability of staying in an expansion.

Table 4.4 reports the results when we use both the monetary policy shock and the first difference of the interest rate as our measures of change in the monetary policy stance. From these results, it is clear that \( \theta_{01} \) is insignificant, suggesting that monetary policy shocks have no effect on the probability of staying in a recession. We do find that \( \theta_{11} \) is negative, but it is only significantly different from zero at the 10% confidence level.
Table 4.4
The effects of monetary policy on state switches

<table>
<thead>
<tr>
<th>Country</th>
<th>MP-shock µ₀</th>
<th>MP-shock µ₁</th>
<th>ΔI µ₀</th>
<th>ΔI µ₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>0.53 (0.22)</td>
<td>1.05 (0.17)</td>
<td>0.75 (0.23)</td>
<td>1.04 (0.15)</td>
</tr>
<tr>
<td>France</td>
<td>0.36 (0.14)</td>
<td>0.87 (0.12)</td>
<td>0.38 (0.15)</td>
<td>0.77 (0.12)</td>
</tr>
<tr>
<td>Italy</td>
<td>0.39 (0.27)</td>
<td>1.07 (0.23)</td>
<td>0.30 (0.31)</td>
<td>0.89 (0.22)</td>
</tr>
<tr>
<td>Spain</td>
<td>0.28 (0.22)</td>
<td>0.97 (0.17)</td>
<td>0.37 (0.23)</td>
<td>0.91 (0.16)</td>
</tr>
<tr>
<td>Austria</td>
<td>0.31 (0.17)</td>
<td>1.54 (0.15)</td>
<td>0.40 (0.18)</td>
<td>1.43 (0.13)</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.49 (0.21)</td>
<td>1.05 (0.18)</td>
<td>0.49 (0.23)</td>
<td>0.91 (0.17)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>-0.04 (0.26)</td>
<td>0.66 (0.23)</td>
<td>-0.19 (0.29)</td>
<td>0.69 (0.21)</td>
</tr>
</tbody>
</table>

Common coefficients

| φ₁ | 0.24 (0.04) | -0.24 (0.04) |
| φ₂ | -0.07 (0.04) | 0.06 (0.04) |
| θ₀₀ | 1.72 (0.57) | 2.56 (1.00) |
| θ₁₀ | 0.75 (0.66) | 1.86 (1.28) |
| θ₁₁ | 2.10 (0.61) | 2.66 (0.71) |
| θ₉₁ | 1.81 (1.06) | 1.60 (0.99) |

Note: standard errors in parenthesis
4.6. CONCLUSIONS

In this chapter we have investigated whether monetary policy impulses have asymmetric effects on the growth rate of industrial production in seven countries of the euro area (Germany, France, Italy, Spain, Austria, Belgium and the Netherlands). In particular, we have analysed whether these effects are stronger in recessions than in expansions. Such asymmetric effects could arise in models of the insider-outsider theory or in models in which the financial accelerator propagation mechanism is more potent when the economy is in a recession.

We have first shown that one cannot reject the hypothesis that these seven countries share the same business cycle. This result is of interest in itself because it suggests that in a large part of the euro area cyclical differences have not been an important factor in the past twenty years. Next, we have found strong evidence that area-wide monetary policy impulses, measured as the contribution of monetary policy shocks to the short-term interest rate in a simple VAR for the euro area economy, have significantly larger effects on output growth in recessions than in booms. Impulse response functions show that on average the maximum impact of a standardised monetary policy shock on output is about 20 basis points larger in a recession than in a boom. These differences are most pronounced in Germany, France, Spain, Italy and Belgium, but are not significant in Austria and the Netherlands. Finally, we have analysed whether monetary policy shocks also affect the probability of going from one state to another. We do not find strong evidence that this is indeed the case.

The results in this chapter confirm that it may be useful to investigate in future research which factors give rise to these asymmetries. In Peersman and Smets (2000b) we try to make a first step in that direction by analysing asymmetries across industries in the euro area. Differences in asymmetries in the impact of monetary policy across industries can then be related to industry-specific factors such as financial and economic structure, which may give important insights in which factors drive those asymmetries.
4.7. REFERENCES


Peersman G. and F. Smets (2000a), “The monetary transmission mechanism in the euro area: more evidence from VAR analysis”, mimeo, ECB.

CHAPTER 5

THE INDUSTRY EFFECTS OF MONETARY POLICY IN THE EURO AREA*

Overview

This chapter first estimates the effects of an euro area-wide monetary policy change on output growth in eleven industries of seven euro area countries over the period 1978-1998. On average the negative effect of an interest rate tightening on output is significantly greater in recessions than in booms. There is, however, considerable cross-industry heterogeneity in both the overall policy effects and the degree of asymmetry across the two business cycle phases. The chapter then explores which industry characteristics can account for this cross-industry heterogeneity. Differences in the overall policy effects can mainly be explained by the durability of the goods produced in the sector, the capital intensity of production and the degree of openness. This can be regarded as evidence for the conventional interest rate/cost-of-capital channel. In contrast, differences in the degree of asymmetry of policy effects seem to be related to differences in financial structure, in particular the maturity structure of debt and the need for working capital. This suggests that financial accelerator mechanisms can partly explain cross-industry differences in asymmetry.

* This chapter is joint work with Frank Smets
5.1. INTRODUCTION

There is a large literature that compares the macroeconomic effects of a change in monetary policy in the various euro area countries. Much less comparative empirical work has been done based on sectoral or microeconomic evidence. Nevertheless, such evidence is important as it may improve our understanding of why the macroeconomic policy effects are different across countries. For example, Carlino and DeFina (1998) have argued that differences in the regional effects of monetary policy in the United States are related to the industry composition of the various US states. Similarly, it has been argued that differences in financial structure could lead to asymmetries in the transmission process as some countries are more affected by financial accelerator mechanisms than others. Typically, such transmission channels imply that monetary policy has distributional effects, which can most easily be detected using dis-aggregated data.

In this chapter we analyse the effects of a common monetary policy shock in eleven manufacturing industries in seven countries of the euro area (Austria, Belgium, France, Germany, the Netherlands, Italy and Spain). First, we document the cross-industry heterogeneity of the output effects of an area-wide monetary policy innovation. Following recent research on cyclical asymmetries in the effects of monetary policy, we also show that most industries are more strongly affected in cyclical downturns than in booms. Also in this case, there are, however, considerable cross-industry differences in the degree of asymmetry across business cycle phases.

Second, we try to explain the cross-industry heterogeneity on the basis of individual industry characteristics. Following Dedola and Lippi (2000), it is useful to distinguish between two broad channels: the interest rate channel and the broad credit channel. As proxies for the determinants of the interest rate channel, we use an industry dummy for the durability of the goods produced by the sector, industry measures of investment intensity and the degree of openness to capture exchange rate sensitivity. As the traditional interest rate channel is expected to be operative both in booms and recessions, one should not expect significantly different explanatory power of these industry characteristics in different stages of the business cycle.

As proxies for the determinants of the broad credit channel, we construct a number of indicators that may be associated with the strength of financial accelerator effects. These indicators include proxies for the size of the firms in the industry and the financial structure of the industry such as financial leverage, the maturity

2 See, for example, BIS (1995).
structure of debt, the financing need for working capital and the ratio of cash-flow over interest rate payments. In contrast to the traditional interest rate channel, financial accelerator theories typically predict that monetary policy will have larger output effects in a recession than during a boom. The reason is that the external finance premium which depends on the net worth of the borrower will be more sensitive to monetary policy actions during a recession when cash flows are low, firms are more dependent on external finance and collateral values are depressed. In sum, we expect the proxies for the traditional interest rate channel to have a significant influence on the overall impact of policy, but not on the differential effect across booms and recessions. In contrast, the indicators of financial structure are likely to explain why some industries are relatively more sensitive to monetary policy changes in recession versus booms.

This chapter is related to at least three strands of the empirical literature on the monetary transmission mechanism. First, a number of papers such as Ganley and Salmon (1997), Hayo and Uhlenbrock (2000) and Dedola and Lippi (2000) have recently examined the industry effects of monetary policy shocks. All these papers find considerable cross-industry heterogeneity in the impact of monetary policy. Ganley and Salmon (1997) and Hayo and Uhlenbrock (2000) examine the industry effects in respectively the United Kingdom and Germany. Our study follows most closely Dedola and Lippi (2000) who systematically analyse 20 industries in five OECD countries (Germany, France, Italy, the United Kingdom and the United States). They find that the cross-industry distribution of policy effects is similar across countries and that these patterns are systematically related to industry output durability and investment intensity, and to measures of firms' borrowing capacity, size and interest payment burden. In this study we focus on seven countries of the euro area. In addition, we also analyse explicitly business cycle asymmetries in the industry effects of monetary policy.

Second, our study is also related to the literature that examines whether monetary policy has different effects in booms versus recessions (Garcia and Schaller (1995), Kakes (1998), Dolado and Maria-Dolores (1999) and Peersman and Smets (2000b)). In a variety of countries, those studies show that monetary policy has stronger output effects in recessions than in expansions. These studies are, however, not able to distinguish between various explanations for this asymmetry. In particular, it is not clear whether the asymmetries are driven by asymmetric financial accelerator effects or by downwardly rigid wages as in the so-called insider-outsider theory of employment. In the latter theory, the insiders possess considerable market power because of high turnover costs and the need for their cooperation with new recruits. As a result, monetary policy shocks lead to larger wage (and price) changes and

---

3 See, for example, Bernanke and Gertler (1989), Gertler and Hubbard (1988), Azariadis and Smith (1998).
smaller output changes in an expansion than in a recession. Using the cross-industry variation, our study is able to test whether indicators of financial structure and average size can explain the degree of asymmetry.

Finally, our study also sheds light on the empirical literature that tries to test the empirical implications of financial accelerator theories more directly. A number of studies find that investment of small firms, which are assumed to have less access to alternative forms of finance, is more liquidity constraint during downturns. For example, Kashyap, Lamont and Stein (1994) find for the US that the inventory investment of firms without access to public bond markets was significantly liquidity-constraint during the 1981-82 and 1974-75 recessions, in which tight money also appears to have played a role. In contrast, such liquidity constraints are largely absent during periods of looser monetary policy. Gertler and Gilchrist (1994), who examined movements in sales, inventories, and short-term debt for small and large manufacturing firms, confirm that the effects of monetary policy changes on small-firm variables are greater when the sector as a whole is growing more slowly. Non-linearity is also detected by Oliner and Rudebusch (1996), who find that cash flow effects on investment are stronger after periods of tight money. Finally, for the four largest euro area economies, Vermeulen (2000) provides evidence that weak balance sheets are more important in explaining investment during downturns than during upturns.

The rest of the chapter is structured as follows. In Section 5.2, we first discuss our methodology for estimating the industry effects of a euro area-wide monetary policy change (Section 5.2.1). This requires a measure of the euro area wide monetary policy stance. In addition, we also need a business cycle indicator for the euro area to test whether the policy effects are different in booms versus recessions. For both variables we rely on earlier work. We, then, present the estimation results and discuss to what extent the effects of policy vary across countries, sectors and business cycle phases (Section 5.2.2). Next, in Section 5.3 we discuss the industry characteristics that we use (Section 5.3.1) and present the results of the regression analysis (Section 5.3.2). The main conclusions of our analysis can be found in Section 5.4.
5.2. THE INDUSTRY EFFECTS OF MONETARY POLICY

In this Section we estimate and describe the effects of a euro area-wide monetary policy shock on output in eleven manufacturing industries in seven euro area countries (Austria, Belgium, France, Germany, Italy, the Netherlands and Spain). A list of the manufacturing industries considered is provided in the data appendix. We also examine to what extent these effects are different in booms versus recessions.

5.2.1. METHODOLOGY

In order to derive the output effects of monetary policy, we estimate for each individual industry $i$ of country $j$ the following linear regression equation:

\[ \Delta y_{ij,t} = (\alpha_{ij,0} p_{0,t} + \alpha_{ij,1} p_{1,t}) + \phi_{ij,1} \Delta y_{ij,t-1} + \phi_{ij,2} \Delta y_{ij,t-2} + 
\]

\[ (1 - \phi_{ij,1} - \phi_{ij,2}) \left( \beta_{ij,0} P_{0,t-1} MP_{t-1} + \beta_{ij,1} P_{1,t-1} MP_{t-1} \right) + \epsilon_{ij,t} \]

where $\Delta y_{ij,t}$ is the quarterly growth rate of production in industry $i$ of country $j$, $MP_t$ is the monetary policy indicator and $p_{0,t}$ and $p_{1,t}$ are the probabilities of being in respectively a recession or an expansion at time $t$ ($p_{0,t} + p_{1,t} = 1$).

This reduced-form output equation is inspired by the Markov-Switching model estimated in Peersman and Smets (2000b). Peersman and Smets (2000b) show that this model is able to capture the effects of monetary policy innovations on output in the seven euro area countries considered in this study. Compared to the VAR approach used in Ganley and Salmon (1997), Hayo and Uhlenbrock (2000) and Dedola and Lippi (2000), the biggest advantage of this specification is its simplicity. The single equation approach makes it easy to extend the model to distinguish between business cycle phases. The parameters $\beta_0$ and $\beta_1$ give the long-run effects of monetary policy on the industry’s output in a recession and an expansion respectively.

In contrast to Dedola and Lippi (2000) who use domestic monetary policy impulses, we want to analyse the effects of a euro area-wide change in monetary policy on the various industries. We think this is a useful exercise not only because it more closely resembles the current policy regime with a single euro area-wide monetary

\[ 4 \text{ We will treat both the monetary policy innovation and the recession probabilities as exogenous to output growth in the individual industry.} \]

\[ 5 \text{ The single-equation approach will also allow us to do the analysis of the cross-industry heterogeneity of the policy effects in one step using a panel data approach. See Section 5.3.3. below.} \]
policy, but also because during most of the sample period domestic monetary policies in the seven countries considered were to a large extent coordinated through the participation in the ERM and other fixed exchange rate mechanisms.6

In order to avoid the simultaneity bias which may result from the fact that short-term interest rates depend on economic activity through the central banks’ reaction function, we follow Peersman and Smets (2000b) and use the contribution of monetary policy shocks to the euro area interest rate in an identified VAR as our measure of monetary policy impulses.7 The identified VAR we use is described in Peersman and Smets (2000a). Graph 5.1 plots the historical contribution of the monetary policy shocks together with the short-term interest rate. From the graph it is clear that the years 1982, 1987, 1990 and 1992-93 are identified as periods of relatively tight monetary policy, whereas in 1984 and 1991 policy is estimated to be relatively loose.

**Graph 5.1**

**Contribution of the monetary policy shock to the short-term interest rate**

<table>
<thead>
<tr>
<th>Year</th>
<th>Monetary Policy Shock Contribution</th>
<th>Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>-2.7</td>
<td>2</td>
</tr>
<tr>
<td>1982</td>
<td>1.8</td>
<td>4</td>
</tr>
<tr>
<td>1985</td>
<td>-0.9</td>
<td>6</td>
</tr>
<tr>
<td>1988</td>
<td>0.0</td>
<td>8</td>
</tr>
<tr>
<td>1991</td>
<td>-0.9</td>
<td>10</td>
</tr>
<tr>
<td>1994</td>
<td>-1.8</td>
<td>12</td>
</tr>
<tr>
<td>1997</td>
<td>2.7</td>
<td>14</td>
</tr>
</tbody>
</table>

Note: The shaded area is the contribution of the monetary policy shocks to the short-term interest rate (left axis); the solid line is the short-term interest rate itself (right axis).

---

6 This is definitely the case for Germany, France, Austria, Belgium and the Netherlands. It is less clear-cut for Italy and Spain who went through various periods of floating exchange rate regimes during the sample. However, even in this case a large component of monetary policy innovations is likely to be common with the other countries.

7 We use the contribution of the shocks to the interest rate rather than the shocks themselves because this allows us to cut down on the number of lags.
In order to distinguish booms from recessions, we again follow an area-wide approach and use the filtered recession probabilities derived in Peersman and Smets (2000b). Peersman and Smets (2000b) estimate a MSM model jointly for each of the seven countries in our analysis and show that those seven countries share the same business cycle. Graph 5.2 plots the smoothed probabilities ($p_{0,t}$ and $p_{1,t}$), together with the de-trended industrial output level in each of the seven countries. The main recessionary periods are from 1980 till 1982 and from 1990 till 1993. Somewhat more surprisingly also in 1986 and in the second half of 1995 the probability of being in a recession is relatively high.

**Graph 5.2**

De-trended industrial production and the probability of being in a recession

Note: Right axis: de-trended industrial production. The shaded areas denote the probability of being in a recession (left axis).
5.2.2. ESTIMATION RESULTS

We individually estimate equation [5.1] for 74 manufacturing industries in the euro area over the period 1978-1998. The quarterly growth rates of industry output are taken from the OECD database “Indicators of Industrial Activity”.\(^8\)

Graph 5.3 plots the distribution of the β-estimates in a boom and a recession, their difference and a weighted average where the weights are based on the unconditional probability of being in a recession versus in a boom (0.40 versus 0.60 respectively).\(^9\) The weighted average is a proxy for the overall policy effect. In a recession, 67 out of 74 industries are negatively affected by a policy tightening, whereas in an expansion 57 industries are negatively affected. While the average difference between the effect in a recession versus a boom is clearly positive at 0.29, there are 23 industries in which the policy effect in a recession is not larger than in an expansion. The correlation between the policy effects in downturns and those in expansions is surprisingly low at 0.09.

\(^8\) Estimations are done for 11 industries from 7 countries. 3 industries (all in Belgium) are excluded because data are only available for a much shorter sample period. See also appendix 1 for a discussion of the data.

\(^9\) The weighted average of the policy effects in booms and recessions is highly correlated with the estimated policy effects in a regression similar to equation [5.1] where we do not take into account different business cycle phases. The correlation coefficient is 0.91.
How different are the policy effects across industries and countries? Table 5.1 provides an estimate of the country and industry effects by regressing the $\beta$-estimates on a set of country and sector dummies.\(^{10}\) We also report the effects on the difference and the weighted average discussed above. The parameters on the country and sector dummies report the deviations from the mean effect. A number of patterns are clear. First, it appears that both in recessions and in booms the average policy multiplier is significantly negative. The average effect over the business cycle is about –0.46. In addition, the degree of asymmetry in booms versus recessions is very significant. This confirms the results of Peersman and Smets (2000b) who find a significant degree of asymmetry using country data.

Second, focusing on the country effects, it appears that the overall output effects of the common monetary policy shock are significantly larger in Germany than in the other countries. In contrast, the overall policy effect is significantly smaller in Belgium. It is important to note that this is the case even though we control for the industry composition.\(^{11}\) With the exception of the Netherlands, countries do not seem to differ significantly from the average degree of asymmetry in the euro area. As discussed in Peersman and Smets (2000b), the a-typical behaviour of the Netherlands where the effects of monetary policy in booms are larger than those in recessions, may partly be due to the fact that in this country the business cycle was least correlated with the euro area business cycle. This will tend to bias the asymmetry results downwards. It is interesting to see that controlling for the industry composition, Germany is no longer a positive outlier, while Austria is no longer a negative outlier in the degree of asymmetry, as was found in Peersman and Smets (2000b).

Third, looking at the industry effects, it is clear that the overall policy effects are small in the food, beverages and tobacco (310) and paper, printing and publishing (340) industries. In contrast, the overall effects are significantly larger in the fabricated metal products (381), machinery (382) and to a lesser extent, the transport equipment (384) sectors. These results are consistent with the findings in Ganley and Salmon (1997), Hayo and Uhlenbrock (2000) and Dedola and Lippi (2000). Overall these studies suggest that the durability of the output produced by the sector is an important determinant of its sensitivity to monetary policy changes. This is mainly because the demand for durable products, such as investment goods, is known to be much more affected by a rise in the interest rate through the usual cost-of-capital channel than the demand for non-durables such as food. For example, Dedola and Lippi (2000) report that an industry dummy which captures the degree of durability is highly significant in explaining cross-industry effects.

\(^{10}\) We estimated the effect of the country and sector dummies on the policy multipliers in booms and recessions jointly using SUR methods.

\(^{11}\) Note that Belgium is the only country for which three of the eleven sectors are missing.
The right-hand-side panel of Table 5.1 shows that also in our data set this durability dummy is highly significant.\footnote{For an explanation of the durability dummy, see the data appendix.}

### Table 5.1

<table>
<thead>
<tr>
<th></th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
<th>$\beta$</th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>-0.63</td>
<td>-0.35</td>
<td>-0.46</td>
<td>-0.39</td>
<td>-0.24</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>(11.6)</td>
<td>(6.45)</td>
<td>(3.66)</td>
<td>(11.8)</td>
<td>(3.79)</td>
<td>(2.39)</td>
</tr>
<tr>
<td>Germany</td>
<td>-0.23</td>
<td>-0.19</td>
<td>-0.21</td>
<td>-0.23</td>
<td>-0.19</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>(1.80)</td>
<td>(1.50)</td>
<td>(2.25)</td>
<td>(1.58)</td>
<td>(1.37)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>France</td>
<td>0.09</td>
<td>0.12</td>
<td>0.11</td>
<td>0.09</td>
<td>0.12</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.69)</td>
<td>(0.92)</td>
<td>(1.15)</td>
<td>(0.62)</td>
<td>(0.85)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>Italy</td>
<td>-0.13</td>
<td>0.17</td>
<td>-0.30</td>
<td>0.05</td>
<td>-0.13</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>(1.00)</td>
<td>(1.34)</td>
<td>(1.66)</td>
<td>(0.56)</td>
<td>(0.87)</td>
<td>(1.24)</td>
</tr>
<tr>
<td>Spain</td>
<td>-0.04</td>
<td>-0.05</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.05</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.29)</td>
<td>(0.37)</td>
<td>(0.06)</td>
<td>(0.47)</td>
<td>(0.25)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Austria</td>
<td>-0.25</td>
<td>-0.04</td>
<td>-0.22</td>
<td>-0.25</td>
<td>-0.24</td>
<td>-0.22</td>
</tr>
<tr>
<td></td>
<td>(1.96)</td>
<td>(0.28)</td>
<td>(1.19)</td>
<td>(1.32)</td>
<td>(1.72)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.38</td>
<td>0.15</td>
<td>0.23</td>
<td>0.37</td>
<td>0.15</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>(2.49)</td>
<td>(0.99)</td>
<td>(1.06)</td>
<td>(2.22)</td>
<td>(2.18)</td>
<td>(0.91)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.19</td>
<td>-0.16</td>
<td>0.35</td>
<td>0.19</td>
<td>-0.16</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>(1.45)</td>
<td>(1.28)</td>
<td>(1.93)</td>
<td>(0.25)</td>
<td>(1.29)</td>
<td>(1.17)</td>
</tr>
<tr>
<td>310</td>
<td>0.55</td>
<td>0.31</td>
<td>0.24</td>
<td>0.41</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(3.32)</td>
<td>(1.87)</td>
<td>(1.03)</td>
<td>(3.41)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>320</td>
<td>0.01</td>
<td>0.07</td>
<td>-0.06</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.42)</td>
<td>(0.26)</td>
<td>(0.38)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>330</td>
<td>0.02</td>
<td>0.10</td>
<td>-0.08</td>
<td>0.07</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.58)</td>
<td>(0.32)</td>
<td>(0.55)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>340</td>
<td>0.28</td>
<td>0.20</td>
<td>0.09</td>
<td>0.23</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1.57)</td>
<td>(1.10)</td>
<td>(0.34)</td>
<td>(1.79)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>350</td>
<td>0.09</td>
<td>-0.16</td>
<td>0.24</td>
<td>-0.06</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.49)</td>
<td>(0.87)</td>
<td>(0.96)</td>
<td>(0.45)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>360</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.22)</td>
<td>(0.19)</td>
<td>(0.16)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>370</td>
<td>0.15</td>
<td>-0.18</td>
<td>0.33</td>
<td>-0.05</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.90)</td>
<td>(1.10)</td>
<td>(1.41)</td>
<td>(0.41)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>381</td>
<td>-0.17</td>
<td>-0.31</td>
<td>0.14</td>
<td>-0.25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1.02)</td>
<td>(1.86)</td>
<td>(0.59)</td>
<td>(2.11)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>382</td>
<td>-0.30</td>
<td>-0.39</td>
<td>0.09</td>
<td>-0.36</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1.82)</td>
<td>(2.35)</td>
<td>(0.37)</td>
<td>(2.97)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>383</td>
<td>0.05</td>
<td>0.14</td>
<td>-0.09</td>
<td>0.11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.29)</td>
<td>(0.81)</td>
<td>(0.36)</td>
<td>(0.84)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>384</td>
<td>-0.67</td>
<td>0.18</td>
<td>-0.86</td>
<td>-0.16</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(4.05)</td>
<td>(1.11)</td>
<td>(3.64)</td>
<td>(1.33)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Durability</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.37</td>
<td>-0.18</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>(2.92)</td>
<td>(1.44)</td>
<td>(1.13)</td>
<td>(2.81)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.38</td>
<td>0.24</td>
<td>0.25</td>
<td>0.35</td>
<td>0.20</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Note: t-statistics in parenthesis. Country and industry coefficients are deviations from overall mean.
Table 5.1 also shows that there is much less evidence that the degree of asymmetry in the policy effects differs systematically across sectors. The only sector which differs significantly from the average is the transport equipment industry which appears to be much more sensitive to monetary policy in recessions than in booms. On the other hand, there is some weak evidence of cyclical asymmetries in the food, beverages and tobacco (310), chemicals (350) and basic metal (370) industries. Table 5.1 also shows that the durability dummy has no significant impact on the degree of asymmetry. This finding is in agreement with our conjecture that this determinant of the strength of the traditional interest rate channel should not have different effects in booms versus recessions.
5.3. INDUSTRY CHARACTERISTICS AND THE MONETARY POLICY EFFECTS

In this section, we analyse whether cross-industry differences in the effects of monetary policy in booms and recessions can be explained by a number of industry characteristics. Section 5.3.1 describes the industry characteristics that we will use. In Section 5.3.2, we discuss the regression specification and the estimation results. Finally, Section 5.3.3 reports the results from a one-step methodology.

5.3.1. INDUSTRY CHARACTERISTICS

In this Section we describe the industry characteristics that we will use to try to explain the cross-industry heterogeneity in policy effects. Since the coefficients $\beta_{g,0}$ and $\beta_{g,1}$ are averages of the industry behaviour over the estimation period, the industry-specific variables are also measured as averages over the available period.\(^{13}\)

5.3.1.1. The conventional interest rate channel

Apart from the durability dummy used in Section 5.2, we use one characteristic, the industry’s investment intensity (INV), to describe the strength of the conventional interest rate/cost of capital channel. This characteristic, measured as the ratio of gross investment over value added, has also been used by Hayo and Uhlenbrock (2000) and Dedola and Lippi (2000). It captures the capital intensity of the industry. Industries that are more capital-intensive are expected to be more sensitive to changes in the user cost of capital, which itself will depend on changes in interest rates. Table 5.2 shows that in our sample the average investment intensity is about 14%. There are, however, considerable differences in investment intensity both across countries and sectors. The investment intensity appears to be particularly low in Spain. It is also lower than average in the textile industry and, more surprisingly in the fabricated metal products and machinery sector. In contrast, investment intensity is relatively high in the basic metal and transport equipment industries.

---

\(^{13}\) This is also done by Dedola and Lippi (2000). The sample period of the estimation is 1978-1998. However, the indicators from BACH are averages over the period 89-96 (the largest ‘common’ sample for all industries). This methodology means that we implicitly assume that the ranking of the industries with respect to these variables is constant over time. A calculation of the rank correlation for the period 1989-1996 gives us values of 0.88, 0.80, and 0.92 for respectively the working capital, the coverage and the leverage ratio. For firm size, we only have data available for all industries for 1996.
## Table 5.2
Industry characteristics: country and industry averages

<table>
<thead>
<tr>
<th>INDV</th>
<th>OPEN</th>
<th>FIN</th>
<th>WOC</th>
<th>COV</th>
<th>LEV</th>
<th>SIVAS</th>
<th>SIVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.14</td>
<td>2.20</td>
<td>0.72</td>
<td>0.73</td>
<td>3.53</td>
<td>1.76</td>
<td>0.12</td>
</tr>
<tr>
<td>(47.98)</td>
<td>(18.63)</td>
<td>(119.47)</td>
<td>(44.34)</td>
<td>(35.68)</td>
<td>(32.30)</td>
<td>(18.99)</td>
<td>(82.23)</td>
</tr>
<tr>
<td>Germany</td>
<td>-0.02</td>
<td>-0.88</td>
<td>0.06</td>
<td>-0.09</td>
<td>-0.30</td>
<td>-0.20</td>
<td>-0.06</td>
</tr>
<tr>
<td>(4.67)</td>
<td>(4.18)</td>
<td>(3.66)</td>
<td>(3.17)</td>
<td>(1.96)</td>
<td>(1.53)</td>
<td>(5.06)</td>
<td>(6.95)</td>
</tr>
<tr>
<td>France</td>
<td>0.00</td>
<td>-0.89</td>
<td>-0.06</td>
<td>0.00</td>
<td>0.65</td>
<td>-0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>(0.33)</td>
<td>(4.58)</td>
<td>(4.46)</td>
<td>(0.03)</td>
<td>(2.99)</td>
<td>(0.50)</td>
<td>(0.35)</td>
<td>(0.38)</td>
</tr>
<tr>
<td>Italy</td>
<td>0.03</td>
<td>-0.99</td>
<td>0.09</td>
<td>0.33</td>
<td>-1.06</td>
<td>0.66</td>
<td>-0.05</td>
</tr>
<tr>
<td>(4.72)</td>
<td>(4.87)</td>
<td>(7.96)</td>
<td>(9.91)</td>
<td>(6.92)</td>
<td>(4.30)</td>
<td>(3.29)</td>
<td>(3.12)</td>
</tr>
<tr>
<td>Spain</td>
<td>-0.06</td>
<td>-1.28</td>
<td>0.06</td>
<td>0.07</td>
<td>-0.99</td>
<td>-0.20</td>
<td>-0.03</td>
</tr>
<tr>
<td>(9.40)</td>
<td>(5.58)</td>
<td>(4.45)</td>
<td>(1.40)</td>
<td>(5.61)</td>
<td>(1.69)</td>
<td>(2.89)</td>
<td>(1.32)</td>
</tr>
<tr>
<td>Austria</td>
<td>0.01</td>
<td>-0.03</td>
<td>-0.01</td>
<td>0.06</td>
<td>1.01</td>
<td>0.33</td>
<td>-0.02</td>
</tr>
<tr>
<td>(1.59)</td>
<td>(0.17)</td>
<td>(0.44)</td>
<td>(1.19)</td>
<td>(3.19)</td>
<td>(2.07)</td>
<td>(1.40)</td>
<td>(2.05)</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.03</td>
<td>2.14</td>
<td>-0.05</td>
<td>-0.20</td>
<td>-0.79</td>
<td>-0.19</td>
<td>0.09</td>
</tr>
<tr>
<td>(2.85)</td>
<td>(4.35)</td>
<td>(4.36)</td>
<td>(6.40)</td>
<td>(3.86)</td>
<td>(1.89)</td>
<td>(4.39)</td>
<td>(3.74)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.02</td>
<td>1.93</td>
<td>-0.10</td>
<td>-0.17</td>
<td>1.49</td>
<td>-0.36</td>
<td>0.07</td>
</tr>
<tr>
<td>(1.85)</td>
<td>(5.10)</td>
<td>(5.40)</td>
<td>(3.95)</td>
<td>(3.96)</td>
<td>(2.11)</td>
<td>(3.02)</td>
<td>(2.07)</td>
</tr>
</tbody>
</table>

| 310 | 0.00 | -0.73 | 0.02 | 0.05 | 0.55 | -0.24 | -0.05 | 0.09 |
| (0.39) | (2.47) | (1.70) | (0.59) | (1.57) | (1.99) | (2.83) | (4.14) |
| 320 | -0.04 | 1.00 | 0.04 | 0.19 | -0.76 | 0.03 | 0.09 | -0.26 |
| (6.22) | (1.91) | (2.81) | (6.26) | (3.70) | (0.30) | (4.80) | (9.93) |
| 330 | -0.02 | -0.86 | -0.06 | -0.14 | 0.10 | 0.01 | 0.07 | -0.12 |
| (1.77) | (3.42) | (2.48) | (3.09) | (0.39) | (0.08) | (3.84) | (3.75) |
| 340 | 0.03 | -1.01 | -0.06 | -0.14 | 0.10 | 0.01 | 0.07 | -0.12 |
| (2.55) | (2.87) | (2.48) | (3.09) | (0.39) | (0.08) | (3.84) | (3.75) |
| 350 | 0.02 | 0.51 | -0.02 | -0.06 | 0.84 | -0.60 | -0.10 | 0.20 |
| (2.00) | (2.63) | (0.93) | (1.11) | (2.62) | (6.81) | (4.35) | (6.92) |
| 360 | 0.03 | -1.15 | -0.07 | -0.12 | 1.16 | -0.58 | 0.00 | -0.04 |
| (5.17) | (4.11) | (6.48) | (4.13) | (3.90) | (4.10) | (0.26) | (2.02) |
| 370 | 0.04 | 0.74 | -0.07 | 0.09 | -0.83 | 0.13 | -0.10 | 0.24 |
| (3.70) | (2.51) | (3.68) | (1.41) | (3.64) | (0.48) | (4.81) | (8.96) |
| 381 | -0.03 | -0.96 | 0.07 | 0.04 | -0.29 | 0.43 | 0.08 | -0.18 |
| (3.37) | (3.46) | (5.55) | (1.19) | (1.09) | (5.09) | (3.16) | (8.64) |
| 382 | -0.05 | 0.72 | 0.07 | 0.04 | -0.29 | 0.43 | 0.08 | -0.18 |
| (5.80) | (3.28) | (5.55) | (1.19) | (1.09) | (5.09) | (3.16) | (8.64) |
| 383 | -0.02 | -0.25 | 0.03 | 0.08 | -0.43 | -0.13 | -0.07 | 0.16 |
| (3.42) | (1.07) | (1.10) | (1.55) | (1.22) | (0.87) | (4.64) | (11.98) |
| 384 | 0.04 | 1.97 | 0.04 | -0.03 | -0.14 | 0.51 | -0.08 | 0.21 |
| (3.96) | (2.79) | (1.49) | (0.38) | (0.26) | (1.55) | (4.60) | (5.81) |

Note: t-statistics in parenthesis. For an explanation of the variables, see the data appendix. Country and industry data are deviations from overall mean.

In addition, we also use, as a proxy for the degree of openness of an industry (OPEN), the ratio of exports and imports over value added. It is not clear what the expected sign is of the effect of this indicator on the strength of the monetary policy effect. On the one hand, a more open sector will be less affected by the slowdown in...
the domestic economy caused by the tightening of monetary policy. On the other hand, a policy tightening will generally lead to an exchange rate appreciation, which reduces the competitiveness of the sector and may have a negative effect on external demand. One important drawback of the indicator used is that it includes both euro area and non-euro area trade. As we are analysing the effect of an area-wide monetary policy innovation, the ideal indicator should only include non-euro area trade. However, we have not yet been able to break down industry trade by country of destination and therefore could not construct such an indicator. As can be seen from Table 5.2, the implication of this drawback is that the openness indicator is on average much larger for the smaller countries (Belgium and the Netherlands) than for the larger countries. It is nevertheless useful to include this indicator in the regression analysis, because the country effects will be picked up by the country dummies that we include in the regression.

As there are no strong a priori reasons why the conventional interest rate channels would work differently in booms versus recessions, we expect both investment intensity and openness to have similar effects over the business cycle.

5.3.1.2. The financial accelerator channel

The financial accelerator theory of the monetary transmission mechanism states that asymmetric information between borrowers and lenders gives rise to an external finance premium, which typically depends on the net worth of the borrower. A borrower with higher net worth is able to post more collateral and can thereby reduce its cost of external financing. As emphasised by Bernanke and Gertler (1989), the dependence of the external finance premium on the net worth of borrowers creates a “financial accelerator” propagation mechanism. A policy tightening, will not only increase the cost of capital through the conventional interest rate channel, it will also lead to a fall in collateral values and cash flow, which will tend to have a positive effect on the external finance premium. Moreover, because collateral values and cash flows are typically low in a recession, the sensitivity of the external finance premium to changes in interest rates will be higher in recessions. Monetary policy is therefore likely to have stronger effects in recessions than in booms.14

In order to test whether differences in agency costs can partly explain the observed cross-industry heterogeneity in policy effects, we use four balance sheet indicators and two indicators capturing the average size of the firms in the industry. The four financial indicators are a leverage ratio, a coverage ratio, an indicator of the

---

14 See, for example, Bernanke and Gertler (1989), Gertler and Hubbard (1988), Azariadis and Smith (1998).
maturity structure of debt and an indicator of the need for working capital. We discuss each of them in turn.

Financial leverage (LEV, i.e. total debt over capital and reserves) is a basic indicator of the balance sheet condition that is commonly used by financial analysts. However, it is not entirely clear what sign to expect in the analysis below. On the one hand, firms with high leverage ratios are likely to face greater difficulties obtaining new, additional funds on the market, especially during recessions. Based on this argument we expect that there is a positive influence of the leverage ratio on the differential impact of monetary policy.\(^\text{15}\) On the other hand, a high leverage ratio may also be an indication of the indebtedness capacity of firms. For example, Dedola and Lippi (2000) interpret the leverage ratio as an indicator of borrowing capacity, consistent with the findings that more leveraged firms tend to get loans at better terms. In that case, highly-leveraged firms could be less sensitive to monetary policy changes.

Our second indicator is the coverage ratio (COV, i.e. gross operating profits over total interest payments), which measures the extent to which cash flow is sufficient to pay for financial costs and is therefore related to credit worthiness. Firms with a higher coverage ratio are therefore expected to be less sensitive to monetary policy changes. However, also in this case high interest payments could be a signal of high borrowing capacity.

The ratio of short-term over total debt (FIN) attempts to measure the extent to which a firm has to finance itself short term rather than long term and is therefore related to its access to long term finance. With imperfect capital markets, we expect the spending of firms with a higher short term debt to be more sensitive to interest rate changes in particular in a recession. Finally, a related indicator is the working capital ratio (WOC), defined as the ratio of working capital (current assets minus creditors payable within one year excluding short-term bank loans) over value added. The working capital ratio captures the extent to which the firm depends on financing for its current assets. As these assets typically can not be used as collateral, this variable proxies the short term financial requirement of the industry. We expect the financial accelerator to be stronger in industries with a higher level of working capital.

The balance sheet data used to calculate the financial ratios discussed above are taken from the European Commission BACH-database. This database is constructed through the aggregation at the industry level of a large number of

\(^{15}\) The ratio of financial leverage that we use is total debt divided by firms' capital and reserves. The coverage ratio is gross operating profits divided by total interest payments. The results are however robust to alternative definitions of both variables.
individual firm data.\textsuperscript{16} An extensive, detailed discussion of the definitions and the sources of all the variables is in the Appendix. Table 5.2 gives an idea of the average value of those indicators and their differences across countries and sectors. It is worth noting that because accounting data are typically not fully harmonised across countries, it may be difficult to compare those ratios across countries. In the analysis below, such systematic differences should be picked up by the country dummies.

Finally, the size of a firm is often used as an indicator for the degree of asymmetric information problems in lending relationships. Agency costs are usually assumed to be smaller for large firms because of the economies of scale in collecting and processing information about their situation. As a result, large firms can more easily finance themselves directly on financial markets and are less dependent on banks. Greater diversification of large firms can also be reflected in a smaller external finance premium. We thus expect that industries with a higher average firm size are likely to do relatively better in downturns and be less exposed to the financial accelerator. In the benchmark model, we use two size indicators. The first indicator gives the share of firms with a turnover of less than 7 million ECU in total industry value added (SIVAS). The second indicator focuses more on the importance of large firms and is given by the share of firms with a turnover in excess of 40 million ECU in total value-added (SIVAL). Of course, both indicators are highly correlated. Table 5.2 shows that on average the share of small firms in total value added is about 12 percent, while that of large firms is 67 percent. On average, the share of small firms appears to be relatively larger in Belgium and the Netherlands than in the other countries. It is quite low in Germany. Regarding the industry composition, the food sector has the largest share of small firms and the lowest share of large firms, while the opposite is the case for the basic metal, electrical machinery and transport equipment industries.

Finally, Table 5.3 gives the correlation matrix of the various industry characteristics discussed above. A number of features are worth mentioning. First, there is a positive correlation between investment intensity and the share of large firms in the industry. Capital intensive industries also feature a smaller share of short-term debt in total debt. Second, there does not appear a strong correlation between the size measures and any of the balance sheet indicators. Finally, as expected, the maturity structure of debt and the working capital ratio are highly correlated. Also the leverage ratio and the coverage ratio are highly correlated.

\textsuperscript{16} This dataset is also used by Vermeulen (2000).
Table 5.3
Industry characteristics: correlations

<table>
<thead>
<tr>
<th></th>
<th>INV</th>
<th>OPEN</th>
<th>SIVAS</th>
<th>SIVAL</th>
<th>FIN</th>
<th>LEV</th>
<th>COV</th>
<th>WOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>INV</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OPEN</td>
<td>0.33</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SIVAS</td>
<td>-0.18</td>
<td>0.16</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SIVAL</td>
<td>0.29</td>
<td>0.11</td>
<td>-0.81</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FIN</td>
<td>-0.45</td>
<td>-0.29</td>
<td>-0.17</td>
<td>-0.07</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LEV</td>
<td>0.06</td>
<td>-0.03</td>
<td>0.00</td>
<td>-0.25</td>
<td>0.17</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>COV</td>
<td>0.17</td>
<td>0.08</td>
<td>0.08</td>
<td>0.14</td>
<td>-0.27</td>
<td>-0.44</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>WOC</td>
<td>-0.11</td>
<td>-0.20</td>
<td>-0.30</td>
<td>-0.05</td>
<td>0.47</td>
<td>0.33</td>
<td>0.42</td>
<td>1.00</td>
</tr>
</tbody>
</table>

5.3.2. SPECIFICATION AND RESULTS

In this Section we analyse more systematically to what extent the industry characteristics discussed above can explain the cross-country heterogeneity in the β-coefficients estimated in Section 5.3.17 To do so, we estimate the following system of two equations using SURE methods to account for the correlation in the residuals:

\[ \beta_{ij,0} = \alpha_0 + \alpha_{i,1}dum_i + \alpha_{j,2}dum_j + \alpha_{k,3}\text{characteristic}_{ij,k} + \eta_{ij,0} \]

\[ \beta_{ij,1} = \alpha_0 + \alpha_{i,1}dum_i + \alpha_{j,2}dum_j + \alpha_{k,3}\text{characteristic}_{ij,k} + \eta_{ij,1} \]

where \( dum_i \) and \( dum_j \) are respectively country and industry-dummies. In all regressions we include country and industry dummies to take into account country-specific and industry-specific effects. This is important because our methodology may give rise to spurious industry and country-specific effects. For example, the monetary policy effects may differ systematically across countries because our area-wide monetary policy shock is more appropriate for some countries than for others.18 Similarly, industry-specific effects are important to

---

17 This two-step methodology is comparable to the one used by Dedola and Lippi (2000). In a first step, they estimate the total impact of monetary policy on individual industries using VARs. In the second step, this impact is regressed on typical balance sheet characteristics of the industries. One difference here is that we estimate the effects on the policy multipliers in booms and recession jointly.

18 For example, it could be argued that to the extent that the common monetary policy shock is dominated by the changes in the German interest rate, such a shock could have been accompanied by a depreciation of the bilateral DM exchange rate of the currencies of some of the other euro area countries. In that case, one would expect a stronger effect in Germany than in those other countries.
control for the possibility that the business cycle of that industry is not fully synchronised with the common cycle.

In addition, we also estimate separately a similar set of equations for the difference between the policy effects in a boom versus a recession and a weighted average of those effects. Obviously, this is just a linear combination of the equations [5.2] and [5.3] above. However, it allows us to directly assess which characteristics have a significant impact on the total effects and which characteristics affect the asymmetry in the policy effects across business cycle phases.

In Table 5.4, we report the results of the estimations when we include the interest rate channel characteristics, the balance sheet indicators and the size variables separately. In each of these regressions also the country and sector dummies are included, but not reported. Several results are worth noting. First, focusing on the interest rate channel characteristics, we find that industries with a higher investment intensity are more sensitive to monetary policy changes. This evidence in favour of the cost-of-capital channel is consistent with the findings of Hayo and Uhlenbrock (2000) and Dedola and Lippi (2000). Moreover, this effect is economically significant. The difference in investment intensity between the most and the least capital intensive industry (Table 5.2) is about 0.08. Such a difference could thus explain a difference of 0.28 in the $\beta$-coefficients, which themselves have a standard deviation of about 0.40.

In contrast to Dedola and Lippi (2000), we also find a significant effect of the degree of openness. Sectors with a higher degree of openness appear to be less affected than more closed sectors. This effect is, however, relatively small. A 10 points percentage increase in openness, measured as exports and imports over value added, reduces the absolute value of the $\beta$-coefficients with only 0.01. To some extent, this small effect may be due to the fact that our measure of openness also includes trade within the euro area, as discussed before.

A Wald test that the coefficients on investment intensity and openness are the same in booms and recessions has a significance level of 0.91. We therefore can not reject our hypothesis that the interest rate channel works similarly whatever the state of the business cycle. Table 5.4 reports the results when we impose this restriction.
Table 5.4
Explaining cross-industry heterogeneity in the effects of monetary policy

<table>
<thead>
<tr>
<th></th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
<th>$\beta_0 \cdot \beta_1$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest rate channel characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INV</td>
<td>-3.35</td>
<td>-3.54</td>
<td>0.18</td>
<td>-3.46</td>
</tr>
<tr>
<td></td>
<td>(1.36)</td>
<td>(1.46)</td>
<td>(0.05)</td>
<td>(2.04)</td>
</tr>
<tr>
<td>OPEN</td>
<td>0.10</td>
<td>0.14</td>
<td>-0.03</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(1.74)</td>
<td>(2.38)</td>
<td>(0.41)</td>
<td>(3.05)</td>
</tr>
<tr>
<td><strong>Interest rate channel characteristics: restricted estimation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INV</td>
<td>-3.45</td>
<td>-3.45</td>
<td>0.00</td>
<td>-3.45</td>
</tr>
<tr>
<td></td>
<td>(2.07)</td>
<td>(2.07)</td>
<td>(0.19)</td>
<td></td>
</tr>
<tr>
<td>OPEN</td>
<td>0.12</td>
<td>0.12</td>
<td>0.00</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(3.03)</td>
<td>(3.03)</td>
<td>(3.03)</td>
<td></td>
</tr>
<tr>
<td><strong>Balance sheet indicators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIN</td>
<td>-3.03</td>
<td>1.67</td>
<td>-4.07</td>
<td>-0.21</td>
</tr>
<tr>
<td></td>
<td>(2.04)</td>
<td>(1.17)</td>
<td>(2.35)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>WOC</td>
<td>-0.97</td>
<td>0.49</td>
<td>-1.46</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>(2.26)</td>
<td>(1.19)</td>
<td>(2.53)</td>
<td>(0.30)</td>
</tr>
<tr>
<td>COV</td>
<td>0.00</td>
<td>-0.20</td>
<td>0.21</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(2.38)</td>
<td>(1.77)</td>
<td>(1.84)</td>
</tr>
<tr>
<td>LEV</td>
<td>-0.13</td>
<td>0.22</td>
<td>-0.36</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.91)</td>
<td>(1.55)</td>
<td>(1.78)</td>
<td>(0.30)</td>
</tr>
<tr>
<td><strong>Various industry size indicators (separate estimations)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIVAS</td>
<td>0.05</td>
<td>1.46</td>
<td>-1.40</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(1.27)</td>
<td>(0.85)</td>
<td>(1.08)</td>
</tr>
<tr>
<td>SIVAL</td>
<td>0.40</td>
<td>-1.54</td>
<td>1.95</td>
<td>-0.76</td>
</tr>
<tr>
<td></td>
<td>(0.45)</td>
<td>(1.75)</td>
<td>(1.55)</td>
<td>(1.18)</td>
</tr>
<tr>
<td>SIEM 50</td>
<td>0.66</td>
<td>-0.51</td>
<td>1.18</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>(3.62)</td>
<td>(2.71)</td>
<td>(4.80)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>SIEM 100</td>
<td>0.28</td>
<td>-0.53</td>
<td>0.82</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>(1.57)</td>
<td>(3.12)</td>
<td>(3.40)</td>
<td>(1.61)</td>
</tr>
<tr>
<td>SIITU 20</td>
<td>0.12</td>
<td>0.17</td>
<td>-0.05</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(0.65)</td>
<td>(0.93)</td>
<td>(0.18)</td>
<td>(1.14)</td>
</tr>
<tr>
<td>SIITU 30</td>
<td>0.30</td>
<td>-0.30</td>
<td>0.61</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>(1.51)</td>
<td>(1.50)</td>
<td>(2.16)</td>
<td>(-0.40)</td>
</tr>
<tr>
<td>SIITU 40</td>
<td>0.15</td>
<td>-0.20</td>
<td>0.35</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>(0.75)</td>
<td>(1.00)</td>
<td>(1.24)</td>
<td>(0.41)</td>
</tr>
</tbody>
</table>

Note: t-statistics in parenthesis

Second, in contrast to the interest rate channel characteristics, we find no significant effect of the balance sheet indicators on the total policy effects. However, consistent with the financial accelerator hypothesis, we do find that weaker balance sheets imply a significantly stronger policy effect during recessions than during booms. The financial variables that seem to work most consistently with the financial accelerator hypothesis are the ratio of short debt over total debt and the working capital ratio. While these variables have no explanatory power during booms, they do explain cross-industry differences during recessions. Moreover, these effects are
economically significant. The difference in ratio between the industry with the highest short term debt and the one with the lowest is about 0.14. According to the estimates reported in Table 5.4 this could account for a difference in the estimated policy effects of about 0.40. This is of the same magnitude as the effects of differences in investment intensity. Differences in the financing need for working capital can explain similar magnitudes.

A lower coverage ratio or a higher leverage ratio also appear to increase the degree of asymmetry between policy effects in a recession versus a boom (although only at the 10 percent significance level). However, in contrast to the other financial indicators, this is mainly a result of a perverse effect on the policy effects during a boom. In particular, industries with a lower coverage ratio (i.e. higher interest payments relative to profits) appear to be less sensitive to monetary policy innovations during a boom. To some extent, these perverse effects may be the result of the fact that high leverage and thus high interest rate payments maybe an indicator of good credit standing and high borrowing capacity as mentioned above.

Finally, the bottom panel of Table 5.4 reports the results of the various size indicators. Here the results are less clear. Our preferred size indicators (SIVAS and SIVAL) fail to have any significant effect, although the size of their effect on the degree of asymmetry has the right sign. This is in contrast to the findings of Dedola and Lippi (2000) who do find a significant effect in their sample on the total effects. In order to check the robustness of these results, Table 5.4 also reports estimations with alternative size indicators. SIEM50 (SIEM100) is a dummy variable which takes on the value of one when the average employment of the firms in the sector is greater than 50 (100). This variable is, however, less reliable than the others because we had to use two different data sets to construct this variable for all countries in our sample (see the data appendix). SITU20 (SITU30, SITU40) is a dummy variable which takes on the value of one when the average turnover of the firms in the sector is greater than 20 (30, 40) million ECU. As one can see from Table 5.4, most of the size variables have the right sign on the degree of asymmetry. However, only three of them are significant. In sum, while there is some indication that industries with firms of a smaller size are more negatively affected by a policy tightening in recessions versus booms, this evidence does not appear to be very robust.

Table 5.5 shows that these results are robust when we include all characteristics in the same regression equation. The first column reports the results when all the characteristics are included. Columns (2) to (4) report the results from various more specific regression specifications when the insignificant characteristics are deleted.
Table 5.5
Explaining cross-industry heterogeneity in policy effects (joint estimation)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta_0$</td>
<td>$\beta_1$</td>
<td>$\beta_0$</td>
<td>$\beta_1$</td>
</tr>
<tr>
<td>INV</td>
<td>0.92</td>
<td>-4.26</td>
<td>0.00</td>
<td>-3.39</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(2.78)</td>
<td>(2.03)</td>
<td>(2.17)</td>
</tr>
<tr>
<td>OPEN</td>
<td>-0.04</td>
<td>0.15</td>
<td>0.00</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(0.51)</td>
<td>(4.05)</td>
<td>(3.09)</td>
<td>(2.89)</td>
</tr>
<tr>
<td>FIN</td>
<td>-4.54</td>
<td>0.02</td>
<td>-3.54</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(2.26)</td>
<td>(0.02)</td>
<td>(1.95)</td>
<td>(2.11)</td>
</tr>
<tr>
<td>WOC</td>
<td>-1.49</td>
<td>-0.24</td>
<td>-1.87</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(2.53)</td>
<td>(0.88)</td>
<td>(3.49)</td>
<td>(2.12)</td>
</tr>
<tr>
<td>COV</td>
<td>0.22</td>
<td>-0.15</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1.80)</td>
<td>(2.65)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEV</td>
<td>-0.35</td>
<td>0.09</td>
<td>-0.41</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(1.75)</td>
<td>(0.99)</td>
<td>(2.15)</td>
<td></td>
</tr>
<tr>
<td>SIVAS</td>
<td>-1.73</td>
<td>1.12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1.14)</td>
<td>(1.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIEM50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.58)</td>
</tr>
<tr>
<td>TU30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.57</td>
</tr>
<tr>
<td>R²</td>
<td>0.41</td>
<td>0.55</td>
<td>0.37</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>0.46</td>
<td>0.42</td>
<td>0.36</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Note: Each regression also includes country and sector dummies. T-statistics in parenthesis.

5.3.3. ONE-STEP ESTIMATION

In the Sections above we have used a two-step methodology whereby in the first step we estimate the policy effects and in the second step we try to explain the cross-industry differences on the basis of industry characteristics. In this Section we check the robustness of this two-step methodology by performing the estimations in one step using standard panel data techniques.

Since $p_{1,t-1} = 1 - p_{0,t-1}$, we can rewrite equation [5.1] as follows:

$$\Delta y_{ij,t} = (\alpha_{y,ij} - \delta_{y,ij})p_{0,t} + \alpha_{y,ij} + \phi_1 \Delta y_{ij,t-1} + \phi_2 \Delta y_{ij,t-2} + (1 - \phi_3) \left[ (\beta_{y,ij} - \delta_{y,ij})p_{0,t-1} + \beta_{y,ij} MP_{i,t-1} + \beta_{y,ij} MP_{i,t-1} + \epsilon_{ij,t} \right]$$

where we also have assumed that the autoregressive parameters are the same across industries. We can now substitute equations [5.2] and [5.3] directly into equation [5.4] and estimate this equation in one step for all industries simultaneously. Table 5.6 reports the results of the fixed-effects (or within)

---

19 In order to have a balanced panel data set, we excluded Belgium from the analysis. This leaves us with 66 industries and 79 periods.
estimator and a more general Feasible GLS estimator which allows for heteroscedasticity and cross-sectional correlation of the residuals. The latter estimator is more appropriate as output growth is likely to be correlated across industries.

Table 5.6 shows that the results obtained above are generally robust. We still find that the interest rate channel characteristics mainly affect cross-industry differences in the overall policy effects, whereas the short-term debt indicators significantly affect the differential policy effect in recessions versus booms. Our preferred size variable remains insignificant. There are two slight differences with the results reported above. First, using the panel data techniques the openness variable becomes insignificant. Second, both the coverage ratio and the leverage ratio have a significant effect on the policy effects in a boom. A higher interest rate burden or higher leverage is associated with a smaller sensitivity to monetary policy shocks in a boom. As discussed above, this may be due to the fact that firms with a high leverage are also firms with a good credit standing. This finding is consistent with the finding of Dedola and Lippi (2000).

Table 5.6
Panel data estimation

<table>
<thead>
<tr>
<th></th>
<th>Within estimator</th>
<th>Feasible GLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta_0$ $\beta_1$</td>
<td>$\beta_1$</td>
</tr>
<tr>
<td>INV</td>
<td>-</td>
<td>-6.21</td>
</tr>
<tr>
<td></td>
<td>(1.81)</td>
<td>(3.21)</td>
</tr>
<tr>
<td>OPEN</td>
<td>-</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(1.51)</td>
<td>(1.22)</td>
</tr>
<tr>
<td>SIVAS</td>
<td>-1.85</td>
<td>2.66</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(1.09)</td>
</tr>
<tr>
<td>FIN</td>
<td>-4.90</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>(1.18)</td>
<td>(0.51)</td>
</tr>
<tr>
<td>WOC</td>
<td>-1.90</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>(1.57)</td>
<td>(0.26)</td>
</tr>
<tr>
<td>COV</td>
<td>0.25</td>
<td>-0.25</td>
</tr>
<tr>
<td></td>
<td>(0.97)</td>
<td>(1.32)</td>
</tr>
<tr>
<td>LEV</td>
<td>-0.31</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>(0.76)</td>
<td>(1.14)</td>
</tr>
</tbody>
</table>

Note: t-statistics in parenthesis
5.4. CONCLUSIONS

In this chapter we have estimated the effects of a euro area-wide monetary policy change on output growth in eleven industries of seven euro area countries over the period 1978-1998. We have shown that on average the negative output effects of an interest rate tightening are significantly greater in recessions than in booms. There is, however, considerable cross-industry heterogeneity in both the average policy effects over the business cycle and the differential impact in recessions versus booms.

This chapter explores which industry characteristics can account for this heterogeneity. We find that differences in the average policy sensitivity over the business cycle can mainly be explained by the durability of the goods produced in the sector, the capital intensity of production and the degree of openness. This can be regarded as evidence for the conventional interest rate/cost of capital channel of monetary policy transmission. These effects are also economically important. For example, the difference in average investment intensity between the basic metal and the textile industry of 8 percentage points could account for a difference in the output semi-elasticity with respect to interest rate changes of 0.28 points. However, these interest rate channel characteristics cannot explain why some industries are more affected in recessions relative to booms than others.

Cross-industry differences in the degree of asymmetry of policy effects over the business cycle seem to be mainly related to differences in financial structure. In particular, we find that a higher proportion of short-term debt over total debt and a greater short-term financing need for working capital are associated with a greater sensitivity to policy changes in recessions. Also these effects are economically significant. For example, a 10 percentage points increase in the share of short-term debt over total debt increases the output semi-elasticity to an increase in the monetary policy interest rate by about 0.30. This finding suggests that financial accelerator mechanisms can partly explain why some industries are more affected in recessions than others. In contrast to some of the literature, we do not find robust evidence that industries with a larger share of smaller firms are significantly more affected by monetary policy during recessions.

Overall, our results are in agreement with those of Dedola and Lippi (2000) who conclude that there is role for both traditional cost-of-capital channels and the broad credit channel in explaining the sectoral effects of monetary policy. Moreover, our results suggest that financial accelerator mechanisms work mainly during recessions. This is consistent with some of the literature reviewed in the introduction.
5.5. APPENDIX

APPENDIX 5.1. DATA SOURCES AND DEFINITIONS

Industrial data are quarterly for the period 1978-1998 from the OECD database: “Indicators of Industrial Activity”. The following industries of each country are included in our analysis:

- Food, beverages and tobacco (310)
- Textile, wearing apparel and leather industries (320)
- Wood and wood products, including furniture (330)
- Paper and paper products; printing; publishing (340)
- Chemicals; chemical, petroleum, coal, rubber and plastic products (350)
- Non-metallic mineral products (360)
- Basic metal (370)
- Fabricated metal products, except machinery & equipment (381)
- Machinery, except electrical (382)
- Electrical machinery, apparatus, appliances & equipment (383)
- Transport equipment (384)

Our estimates concern these eleven industries for the countries Germany, France, Italy, Spain, Austria, Belgium, and the Netherlands, except for the industries 340, 350 and 383 for Belgium because data are only available for a much shorter sample period.

The first explanatory variable is a durability dummy, which is 1 if the industry produce durable goods. This variable is also used by Dedola and Lippi (2000) and is based on the economic destination of production from the national accounts statistics. According to this criterion, the ‘durable’ output industries are 330, 360, 370, 381, 382, 383, and 384.

The investment intensity (INV) and openness (OPEN) ratios are constructed from the STAN-OECD database, which records annual data at the industry level. We use an average for the period 1978-1996. They are:

- INV: gross investment/ value added.
- OPEN: (export + import)/ value added.

Balance sheet data are from the European Commission BACH-database. It contains aggregated balance sheets and profit and loss account information at the industry level. Most of the industries are matching with the OECD dataset, though, there are some exceptions: Industries 330 and 340 are aggregated in the BACH dataset, as well as industries 381 and 382. For these industries, the values from BACH are
assigned to both industries. Balance sheet data are averages over the period 89-96 (the largest ‘common’ sample for all industries). The following definitions are used:

- **Working capital (WOC):** the ratio of working capital to value added. Working capital is defined as the asset item “current assets” minus the liability item “creditors payable within one year” (except short-term bank loans). In BACH, this is: \((D - F + F2) / T\). Results are similar when we exclude cash and current investment from the ratio, or when we include the short-term bank loans in the ratio.

- **Leverage ratio (LEV):** ratio of total debt (short and long run) to capital and reserves: \((F + I) / L\). Similar results are obtained with the ratio of total debt to total assets, though the standard errors are larger.

- **Coverage ratio (COV):** ratio of gross operating profits to total interest payments: \(U / 13\). The results are robust to other specifications of this ratio. Examples are net operating profits or total profits (except depreciations) in the nominator or total debt in the denominator.

- **SIVAS (SIVAL):** The share of small (large) firms in total industry value added. These are firms with a turnover of less than 7 million ECU (more than 40 million ECU).

- **SITU20 (SITU30, SITU40):** is a dummy variable which takes on the value of 1 when the average turnover of the firms in the sector is greater than 20 (30,40) million ECU.

- **SIEM50 (SIEM100):** average employment per firm of the industry. For this ratio, data is only available for the year 1996 for the industries of Germany, France, Belgium, and Italy. These data are completed with data from OECD “Industrial Structure Statistics” for Austria, Spain, and the Netherlands. For the size variable, we constructed a dummy that takes the value 1 for industries with an average size larger than 50 (100).
5.6. REFERENCES


Peersman G. and F. Smets (2000a), “The monetary transmission mechanism in the euro area: more evidence from VAR analysis”, mimeo, ECB.

Peersman G. and F. Smets (2000b), “Are the effects of monetary policy in the euro area greater in recessions than in booms?”, mimeo, ECB.

CHAPTER 6

THE TAYLOR RULE: A USEFUL MONETARY POLICY BENCHMARK FOR THE EURO AREA?*

Overview

This chapter explores the Taylor rule – defined as an instrument rule linking the central bank’s policy rate to the current inflation rate and the output gap – as a benchmark for analysing monetary policy in the euro area. First, it presents evidence that interest rates in Germany and the euro area can be described by a Taylor rule with interest rate smoothing. Second, it analyses the stabilisation properties of the Taylor rule in a closed economy model of the euro area, estimated using aggregate data from five EU countries. An optimised Taylor rule performs quite well compared to the unconstrained optimal feedback rule. Finally, the robustness of these results to estimation error in the output gap and model uncertainty is examined.

* This chapter is joint work with Frank Smets
6.1. INTRODUCTION

In this chapter we explore the usefulness of the Taylor rule -- defined loosely as an instrument rule linking the central bank's instrument (the short-term interest rate) to the current inflation rate and the output gap -- as a benchmark for analysing monetary policy in the euro area. Such instrument rules have the advantage that they are simple and transparent as they explicitly relate the policy instrument to current economic conditions. They have, however, two important disadvantages. First, they may be too restrictive as the number of variables in the feedback list is typically limited. Second, they may not be robust to changes in the structure of the economy. For these two reasons, central banks, including the ECB, would never want to commit to such simple instrument rules. The need to be able to change policies flexibly in response to new information and/or structural changes in the economy puts a premium on central bank discretion. Nevertheless, simple instrument rules like the Taylor rule could be a useful benchmark, provided that their stabilisation properties prove to be reasonably robust to changes in the underlying economy.

To bring some evidence to bear on whether this is the case, we develop three sections. In Section 6.2, we first review some evidence on recent interest rate behaviour in Europe. In particular, following Clarida, Galí and Gertler (1998) (CGG), we analyse whether a Taylor rule can reasonably describe the Bundesbank's interest rate policy in the last two decades. More speculatively, we also analyse whether average interest rates in the euro zone can be described by such a rule. Such an historical analysis is of interest for two reasons. First, the Bundesbank arguably is a model central bank for the ECB. If the Taylor rule is a good description of Bundesbank policy, then it may also be an appropriate benchmark for the ECB. Second, if in the recent past average interest rates in the euro area can be described by a Taylor rule, then using such a rule as a benchmark has the advantage of continuity. By and large we confirm the results of CGG that a forward-looking version of the Taylor rule with interest rate smoothing is able to track German and European short-term interest rates quite well since 1979.

While a historical analysis of interest rate behaviour in Europe may suggest the usefulness of the Taylor rule, it does not answer the normative question whether the Taylor rule is a good benchmark to discuss policy in the newly established

---

1 In December 1998 the ECB Council announced a stability-oriented monetary policy strategy. It consists of a quantitative definition of the price stability objective as "an increase of the area-wide harmonised index of consumer prices of below 2%". In addition, a two-pillar strategy -- a reference value for the growth of a broad money aggregate and a broad-based assessment of the outlook for inflation -- was announced to explain monetary policy decisions. This strategy was designed to communicate the long-run commitment to price stability, while allowing for enough short-run flexibility to face the many uncertainties related to the establishment of the new currency.
single currency area. To make progress on this question, we need to analyse the stabilisation properties of the Taylor rule in a model of the euro area economy. Obviously it is difficult to come up with a convincing aggregate model of the euro area economy when the single currency has just been created. Nevertheless, in Section 6.3.1, we estimate a version of the closed-economy model presented in Rudebusch and Svensson (1998) using a weighted average of output and inflation in five euro countries as a measure of aggregate output and inflation and the real German policy rate as a measure of the common monetary policy.

We argue that this model may approximate the working of monetary policy in the euro area. Part of this justification is given in Appendix 6.1. There we show that once one controls for changes in bilateral exchange rates and interest rate differentials, a rise in the German real interest rate has similar effects on output in each of the five countries. Moreover, the external transmission channel through the DM-dollar exchange rate does not appear to be significant. While these results need to be taken with more than the usual degree of caution, we consider them as supporting the view that, overall, the euro area will function as a relatively closed economy. Moreover, to the extent that differences in the impact effect of the common monetary policy on the other countries are mitigated by the cross-border effects, the effects will be relatively uniform across the whole euro area.

We then use the EU5 model to compare the performance of a simple Taylor rule with various other instrument rules and the optimal feedback rule in Section 6.3.2. Our measure of comparison is a standard loss function which captures the fact that the central bank dislikes output, inflation and interest rate variability. Our results are similar to the ones obtained by Rudebusch and Svensson (1998). We find that a Taylor rule performs quite well compared to the optimal feedback rule, although the feedback on the output gap is larger than suggested by Taylor (1993).

Finally, in section 6.4 we analyse the robustness of the results to various forms of uncertainty. Given the importance of the output gap in the Taylor rule and the fact that typically the confidence band around estimates of the output gap is quite large, we first analyse the impact of estimation error in the output gap on the Taylor rule's stabilisation properties (Section 6.4.1). Consistent with recent research by Aoki (1998), Orphanides (1998), Rudebusch (1998) and Smets (1998), we find that estimation error reduces the optimal feedback coefficient on output in a simple Taylor rule. However, it does not affect its relative performance. In Section 4.2 we ask how sensitive the Taylor rule is to model uncertainty. As in Estrella and Mishkin (1998) and Rudebusch (1998), we find that the estimated parameter uncertainty has only negligible effects on the efficient feedback parameters. Moreover, the stabilisation properties of a simple Taylor rule with coefficients of 1.5 on inflation and 1.0 on output as recently proposed by Taylor (1998a) appear quite robust to changes in the parameters of the estimated economy as long as the basic closed economy structure is maintained.
6.2. TAYLOR RULES FROM THE PAST

In this section we first briefly review the work of CGG. They argue that the Bundesbank’s monetary policy reaction function can be cast in terms of a forward-looking Taylor rule with interest rate smoothing. In addition, we look more broadly at interest rates in the eleven euro zone countries.

CGG argue that central bank behaviour in the G3 countries can be described by a forward-looking version of the Taylor rule with interest rate smoothing as in the following equation:

\[ i_t = (1 - \rho)[\tilde{r} + \beta_i(E[\pi^*_{t+n} | I_t] - \pi) + \beta_z E[z_t | I_t] + \rho i_{t-1} + \mu_t], \]

where \( i_t \) is the central bank’s policy rate, \( \tilde{r} \) is the equilibrium nominal interest rate, \( \pi \) is the inflation target, \( \pi^*_{t+n} \) is the annual inflation rate at time \( t+n \), \( z_t \) is the output gap (the log difference between actual and potential output), and \( \mu_t \) is an i.i.d. disturbance representing exogenous shocks to the short rate. \( E \) is the expectation operator and \( I_t \) is the information available to the central bank at the time it sets the policy interest rate.

The term in square brackets captures the target interest rate of the central bank. In this simple Taylor-like specification the target rate is solely a function of current or expected inflation and the current output gap. For this instrument rule to lead to an effective stabilisation of the inflation rate \( \beta_i \) needs to be greater than one and \( \beta_z \) positive, so that the real policy rate rises whenever inflation is above target and/or output is above potential. The parameter \( \rho \) captures the degree of interest rate smoothing or the speed with which the actual policy rate adjusts to the target rate.

To estimate the parameters of equation [6.1], we rewrite the policy rule in terms of realised variables as follows:

\[ i_t = (1 - \rho)\beta_0 + (1 - \rho)\beta_i \pi^*_{t+n} + (1 - \rho)\beta_z z_t + \rho i_{t-1} + \epsilon_t \]

where \( \beta_0 = \tilde{r} - \beta_i \pi \) and \( \epsilon_t = -(1 - \rho)[\beta_i(\pi^*_{t+n} - E[\pi^*_{t+n} | I_t]) + \beta_z (z_t - E[z_t | I_t])] + \mu_t \).

Suppose \( u_t \) is a vector of variables within the central bank’s information set \( (u_t \in I_t) \), then \( E[\epsilon_t | u_t] = 0 \). These moment conditions can be used to estimate the parameters in [6.2].

Table 6.1 presents the estimation results using monthly data covering the period 1979:1-1997:12. For the baseline specification the horizon of the inflation forecast is one year ahead \((n = 12)\). Several results are worth mentioning. First, although our sample period is somewhat longer and the instrument set larger, our baseline results are close to the baseline results in CGG. The parameters on expected inflation and output are significantly greater than respectively one and zero, but significantly lower than the values of 1.5 and 0.5 postulated by Taylor (1993). The latter result is, however, not robust and depends, for example, on the method used for detrending industrial production (see specification 8 and 9 of Table 6.1).2

Table 6.1
Estimates of a forward-looking Taylor rule

<table>
<thead>
<tr>
<th>Specification</th>
<th>(\beta_0)</th>
<th>(\beta_1)</th>
<th>(\beta_2)</th>
<th>(\beta_3)</th>
<th>(\rho)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany (1979:1-1997:12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Baseline</td>
<td>2.52</td>
<td>1.30</td>
<td>0.28</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.32)</td>
<td>(0.10)</td>
<td>(0.05)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>2. + nominal effective exchange rate</td>
<td>2.57</td>
<td>1.29</td>
<td>0.32</td>
<td>-0.52</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>(0.36)</td>
<td>(0.11)</td>
<td>(0.06)</td>
<td>(0.24)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>3. + real effective exchange rate</td>
<td>2.47</td>
<td>1.29</td>
<td>0.34</td>
<td>-0.77</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.12)</td>
<td>(0.06)</td>
<td>(0.29)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>4. With current inflation</td>
<td>3.24</td>
<td>0.99</td>
<td>0.43</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.06)</td>
<td>(0.03)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>5. With two year ahead inflation</td>
<td>1.19</td>
<td>1.93</td>
<td>0.30</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.99)</td>
<td>(0.33)</td>
<td>(0.09)</td>
<td>(0.005)</td>
<td></td>
</tr>
<tr>
<td>6. + current inflation</td>
<td>2.61</td>
<td>0.69</td>
<td>0.26</td>
<td>0.57</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>(0.26)</td>
<td>(0.12)</td>
<td>(0.03)</td>
<td>(0.09)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>7. + two year ahead inflation</td>
<td>2.80</td>
<td>1.26</td>
<td>0.22</td>
<td>-0.01</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>(0.42)</td>
<td>(0.10)</td>
<td>(0.04)</td>
<td>(0.15)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>8. HP-filter on output</td>
<td>1.74</td>
<td>1.59</td>
<td>0.43</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.37)</td>
<td>(0.11)</td>
<td>(0.10)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>9. Exponential smoothing on output</td>
<td>1.15</td>
<td>1.83</td>
<td>0.49</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.39)</td>
<td>(0.14)</td>
<td>(0.09)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>10. Quarterly data</td>
<td>3.50</td>
<td>0.96</td>
<td>0.54</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.78)</td>
<td>(0.27)</td>
<td>(0.17)</td>
<td>(0.02)</td>
<td></td>
</tr>
<tr>
<td>The euro area (1980:1-1997:4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Quarterly data</td>
<td>3.67</td>
<td>1.20</td>
<td>0.76</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(0.09)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: The estimated equation is given by equation [6.2]. The optimal weighting matrix is obtained from first step two-stage least squares parameter estimates. In the case of Germany the instrument set \(u_t\) includes lagged values of inflation, the output gap, short and long term interest rates, the exchange rate, commodity prices and the money supply. Industrial production is used to capture output developments on a monthly basis. In the baseline case a quadratic trend is used to calculate the output gap. In the case of the euro area, the instrument set includes lagged values of inflation, the output gap, short and long-term interest rates and the money supply. A linear trend is used to calculate the output gap on the basis of GDP data. GDP weights are used to aggregate the national series.

2 The magnitude of the parameters also changes when we estimate the reaction function using quarterly data of GDP instead of industrial production (see specification 10 in Table 6.1).
Second, in contrast to the closed economy Taylor rule in which there is no explicit policy feedback on the exchange rate, the results of the second and third specification in Table 6.1 show that over the sample period the German policy rate rose significantly in response to a depreciation of the trade-weighted exchange rate. This is consistent with previous findings using different methodologies (e.g. Clarida and Gertler (1996) and Bernanke and Mihov (1997)), as well as with a careful reading of the Monthly Reports of the Bundesbank (see, for example, Tsatsaronis (1994)). It is also consistent with the simple theoretical analysis in Gerlach and Smets (1998) and Ball (1998) who emphasise the importance of the exchange rate channel in open economies and its implications for the optimal monetary policy rule.

Third, in contrast to CGG we find that current inflation remains significant when we add it to the baseline specification (specification 6). Instead, two-year-ahead annual inflation is not (specification 7). This sheds some doubt on CGG’s interpretation of [6.2] as an inflation-forecast rule from which the relative weights on inflation versus output stabilisation in the central bank’s preferences can be deduced. As most estimates suggest that central banks affect inflation with a lag that is longer than one year, the forecast horizon should more likely be 2 years ahead. In fact, specification 6 suggests that the policy rate responds to a measure of current trend inflation, with the trend being calculated as a 24-month centred moving average of inflation. This is consistent with the importance many central banks attach to measuring core inflation. Its purpose is to purge purely temporary factors from the current inflation rate as these cannot be influenced anyway.

Finally, Graph 6.1 examines the stability of the Bundesbank’s policy reaction function during the whole post-Bretton Woods period by estimating the parameters of [6.2] with a moving window of 10 years. Although the Bundesbank regained its monetary policy independence and started announcing monetary growth targets immediately following the breakdown of the Bretton Woods system in 1974, there is evidence of instability in the estimated equation between most of the 1970s and the period following 1979. The wide confidence bands during the 1970s suggest a

---

3 In this specification the target rate includes a fourth term, $\beta_i \Delta e_i$, where $\Delta e_i$ is the log difference of a nominal (real) trade-weighted exchange rate in percentage points.

4 See, for example, Svensson (1997) for a derivation of such a rule in a simple theoretical model. CGG argue that the significance of the output gap in the reaction function in spite of the inclusion of the inflation forecast proves that the Bundesbank cares about output stabilisation.

5 See, for example, Black, Macklem and Rose (1997) and Battini and Haldane (1998) for a numerical analysis of the optimal forecast horizon in inflation forecast targeting rules.
misspecification of the equation. In particular the coefficient on inflation is very volatile and even negative in the early period.

Graph 6.1
10-year moving window estimates of the Bundesbank's reaction function
(1975:1-1997:12)

With the adoption of the Maastricht Treaty in the early 1990s the process of monetary convergence in the EU countries accelerated. It may thus make sense to look at average interest rate behaviour in the EU countries in the 1990s as an indicator of the European monetary policy stance. Gerlach and Schnabel (1998) show that a simple Taylor rule applied to a weighted average of the output gap and the inflation rate in the eleven euro countries can explain the fall in the average 3-month interest rate over the period 1990-97 quite well.\(^6\) One exception is the period of exchange market turmoil in late 1992 and early 1993 when interest rates rose

---

\(^6\) To calculate the interest rate that is consistent with a Taylor rule, they assume coefficients of 1.5 and 0.5 on respectively inflation and the output gap, a constant inflation target of 2 percent and a constant equilibrium real interest rate of 3.55%. The latter is derived from a cross-country regression which filters out the effect of changes in the real exchange rate.
quite dramatically in a number of ERM countries to defend the fixed exchange rate parity.

The lower panel of Table 6.1 reports the results of estimating equation [6.2] on quarterly weighted average data for the eleven euro-area countries. Somewhat surprisingly the results are very similar to the results obtained for Germany. Graph 6.2 plots the average three-month interest rate together with the forward-looking target rule.

**Graph 6.2**

*Average interest rates in the euro area and an estimated forward-looking Taylor rule*


In sum, the evidence presented in this Section suggests that a Taylor rule with interest rate smoothing can track short-term interest rates in Germany and the euro area as a whole quite well. While this evidence complements similar evidence for the United States and other relatively large economies, the analysis remains ex post and does not necessarily say much about how well a Taylor rule may work for the future ECB. To this we turn in the next section.
6.3 THE TAYLOR RULE IN AN AGGREGATE MODEL FOR THE EU5

One of the obvious problems with analysing optimal monetary policy in the euro area is that it is difficult to predict how the economy and the transmission mechanism will work under the new monetary regime. Nevertheless, the establishment of the ESCB is not a completely new policy environment as a gradual process of monetary convergence has preceded it. In particular, France and Germany and some of their smaller neighbours have had fixed exchange rates with occasional parity adjustments since the end of the Bretton Woods system. In this section we use a simple model of the transmission process in these countries to analyse more formally the performance of a simple Taylor rule. The model is similar to that estimated by Rudebusch and Svensson (1998) for the United States. As our measures of output and inflation we take a weighted average of real GDP and the CPI in Germany, France, Austria, Belgium and the Netherlands. The monetary policy indicator used to estimate the effects of a change in the common monetary policy stance is the real German day-to-day rate.7

This aggregate EU5 model may be a useful approximation of the working of the euro economy as a whole in a number of respects. First, while two large euro countries, Italy and Spain, are excluded from the aggregate model, the five countries included still account for almost two thirds of GDP in the EMU area. Second, the countries included have had a history of fixed bilateral exchange rates, with the German Bundesbank de facto playing the anchor role.8 As a result, the transmission of the German interest rate on aggregate output and inflation under a fixed exchange rate regime may be as close as one can get to a historical description of the effects of a common monetary policy in EMU.

Third, the model takes into account that in terms of openness the euro area as a whole will be more like the United States than like any of its individual members. The ratio of exports of goods to euro area-wide GDP is about 14% and by and large comparable to that of the United States and Japan. The disaggregated analysis of the transmission mechanism in Appendix 6.1 confirms this hypothesis. Two results from this analysis need to be highlighted. First, we find that once one controls for changes in bilateral exchange rates and interest rate differentials the output effects of a rise in the German real rate are similar in the five countries (with the possible

7 Also Italy has been a long-standing member of the ERM. We decided against including Italy in the estimation of the aggregate model because its inflation behaviour over the estimation period was very different. Other countries participating in EMU are excluded either because of problems with data availability (Ireland) or because they started participating in the ERM only recently (Spain, Portugal, Finland). See also Taylor (1998).
8 See, for example, the references in Gros and Thygesen (1992) and De Grauwe (1997).
exception of Belgium). Second, the external exchange rate approximated by the DM/USdollar exchange rate has only negligible effects on aggregate output. Thus, in contrast to recent estimation results in Dornbusch et al. (1998) we find that the coefficient on the external exchange rate in an implicit Monetary Conditions Index (MCI) for the ECB would be close to zero.

It is nevertheless obvious that the aggregate EU5 model can only be a rough approximation of the transmission process in the euro area. First, while we argue in Appendix 6.1 that the output effects of monetary policy in these five countries are similar, this may not be the case for the other euro area countries. Indeed, in Appendix 6.1 we find some evidence that the impact of a common monetary policy shock on Italian output may be significantly larger than in these countries. Second, the bilateral exchange rates were not completely fixed during the estimation period. The omission of changes in bilateral exchange rates or interest rate differentials may bias the estimation of the aggregate model. Third, it is hard to predict how inflation will respond to the output gap under the new policy regime. Implicitly we assume that the euro area-wide Phillips curve will resemble the one in the EU5 countries over the last two decades. Finally, not only is the monetary regime changing, at the same time many other structural changes are taking place which may have an impact on the transmission process. For all these reasons, the results of this section need to be treated very cautiously.

The rest of this section is structured as follows. In Section 6.3.1 we estimate a simple aggregate model for the EU5 based on Rudebusch and Svensson (1998). In Section 6.3.2 we analyse the performance of various optimal instrument rules in the estimated model.

### 6.3.1. AN ESTIMATED AGGREGATE MODEL FOR THE EU5

In this section we estimate a simple aggregate model for the EU5 along the lines of Rudebusch and Svensson (1998). The main difference with the latter paper is that we simultaneously estimate the model and the output gap using unobservable component techniques.9

The estimated model has the following form:

\[ \pi_{t+1} = \alpha(L)\pi_t + \beta z_t + \varepsilon^\pi_{t+1} \]
\[ z_{t+1} = \varphi_1 z_t + \varphi_2 z_{t-1} + \lambda (i_t - \overline{\pi}_t) + \varepsilon^z_{t+1} \]
\[ y_{p,t}^i = \mu + y^p_t + \varepsilon^y_{t+1} \]

where $\pi_t$ is an EU5 weighted average of quarterly inflation in percentage points at an annual rate; $\pi_t^G$ is four-quarter inflation in Germany; $i_t$ is the quarterly average German day-to-day rate in percentage points at an annual rate; $y_t^p$ is a weighted average of the log of unobserved potential GDP in percentage points and $z_t$ is the unobserved output gap, i.e. the log difference between actual real GDP ($y_t$) and potential GDP in percentage points.

Equation [6.3] can be interpreted as a Phillips-curve which relates inflation to the lagged output gap and to lags in inflation. The second equation is the reduced form of an aggregate demand equation which relates the output gap to its own lags and to a lagged real interest rate, which is approximated by the difference between the nominal day-to-day rate and average inflation over the previous four quarters. Equation [6.5] assumes that potential output follows a random walk process with constant drift. Finally, equation [6.6] is an identity that defines the output gap.

In Appendix 6.2 we show how this model can be written in state space form and estimated using the Kalman filter and maximum likelihood methods. Table 6.2 reports the estimation results with quarterly data over the period 1975:1-1997:4. For comparison we also add the estimation results for the same model estimated for the United States over the same period. As can be seen all the parameters have the expected sign and are significant. It is useful to compare the EU5 estimates with the US ones. While the effect of the real policy rate on the output gap is almost the same in both cases ($\lambda=-0.10$), we estimate the slope of the Phillips-curve to be steeper in EU5 than in the US ($\beta=0.33$ instead of 0.11).

The EU5 output gap is somewhat more persistent than the US one, but does not exhibit the hump-shaped pattern of the US output gap. In contrast, the inflation process is much less persistent in the EU5 than in the US. The sum of the $\alpha$-parameters is 0.74 in the EU5 case versus 0.92 in the US case. One interpretation for the fact that we can easily reject a unit root in the inflation process in the EU5 is that during this period agents in the EU5 put a positive weight on the constant inflation target (which equals the average inflation rate over the sample) in forming their inflation expectations. One important issue for the analysis of optimal Taylor rules is whether this weight will be different in the EMU area. This will in part depend on the reputation of the new central bank. Everything else equal lower anti-inflationary credibility will result in a higher persistence of inflation.\footnote{See, for example, the discussion in McLean (1998).} Implicitly we assume that the ECB will inherit the credibility of the EU5 central banks. If this
turns out not to be the case and, for example, the weight on the ECB’s inflation target is less than implicit in the EU5 model, then one implication for the optimal Taylor rule would be that the central bank will have to lean more against inflation and output (see the results of section 6.4.2).

Table 6.2
Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>EU5 (75:1–97:4)</th>
<th>US (75:1–97:4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varphi_1$</td>
<td>0.84 (0.22)</td>
<td>1.41 (0.15)</td>
</tr>
<tr>
<td>$\varphi_2$</td>
<td>0.10 (0.22)</td>
<td>-0.52 (0.13)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.33 (0.13)</td>
<td>0.11 (0.05)</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>-0.10 (0.04)</td>
<td>-0.12 (0.03)</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>0.45 (0.09)</td>
<td>0.48 (0.09)</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>0.17 (0.11)</td>
<td>0.19 (0.08)</td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td>0.06 (0.10)</td>
<td>0.13 (0.09)</td>
</tr>
<tr>
<td>$\alpha_4$</td>
<td>0.06 (0.09)</td>
<td>0.12 (0.10)</td>
</tr>
<tr>
<td>$\sigma_y^2$</td>
<td>0.19</td>
<td>0.39</td>
</tr>
<tr>
<td>$\sigma_z^2$</td>
<td>0.22</td>
<td>0.14</td>
</tr>
<tr>
<td>$\sigma_{\pi}^2$</td>
<td>0.98</td>
<td>0.74</td>
</tr>
<tr>
<td>Likelihood</td>
<td>129.3</td>
<td>129.5</td>
</tr>
</tbody>
</table>

*Note: Standard errors in parenthesis*

Graph 6.3 compares the effects of a temporary one-percentage point rise in the real policy rate during 8 quarters on the output gap and inflation in the EU5 and the US. Consistent with the discussion above, one can see that the effects on EU5 output are less in magnitude, but more persistent than in the US, while the effects on inflation are stronger. This again suggests that according to these estimates the output cost of reducing inflation is less in Europe than it is in the US. Comparing these results with the results of the disaggregated analysis in Graph A.6.1 and A.6.2 of Appendix 6.1, it is likely that the output effects would be larger if the aggregate data had included Italy.\textsuperscript{11}

\textsuperscript{11} In Section 6.3.4 we analyse the robustness of the stabilisation properties of the Taylor rule to larger output effects of a monetary policy shock.
Turning to the estimates of the variances of the shocks, we find that the variance of the inflation shocks is very similar to that in the US. However, estimated supply shocks are relatively less important, while demand shocks are more important in the EU5 compared to the US. Graph 6.4 plots the one-sided and two-sided estimates of the EU5 output gap together with a two standard-deviations confidence band. Consistent with the findings of Gerlach and Smets (1997) the confidence band around the estimates of the output gap is quite wide, but somewhat less so than for the US (Smets, 1998). Typically, the standard deviation of the output gap is a bit less than one percent. According to these estimates the EU5 was at the end of 1997 still facing a negative output gap of 2% which is marginally significantly different from zero.
6.3.2. HOW WELL DOES THE TAYLOR RULE PERFORM?

6.3.2.1. Instrument rules and the loss function

In order to analyse how well an optimised Taylor rule performs in the EU5 model estimated in the previous section, we consider the following loss function,\(^{12}\)

\[ E(L_t) = \gamma \text{Var}(\pi_t) + (1 - \gamma) \text{Var}(z_t) + \nu \text{Var}(i_t - i_{t-1}). \]

The central bank cares about variability in the deviations of annual inflation from a constant inflation target, variations in the output gap and changes in the short-term interest rate. As all variables are demeaned before the analysis, equation [6.7] implies that the inflation target equals the mean inflation rate over the sample.

In this section we assume that the central bank takes the model estimated in section 6.3.1 as given and observes the current state of the economy, including not only

---

12 This discussion follows Rudebusch and Svensson (1998). They show how this loss function is equivalent to a more standard intertemporal loss function with a discount rate equal to one.
current and past inflation and interest rates, but also the current and past output
gap. The central bank’s task is then to set its policy instrument, $i_t$, in such a way as
to minimise the loss function [6.7] subject to the dynamics of the economy
described by equations [6.3] to [6.6].

We consider seven instrument rules. The benchmark rule is the unrestricted
optimal feedback rule. Given the linear-quadratic nature of the optimal control
problem the optimal rule is linear in each of the seven state variables. In addition,
we consider six restricted instrument rules. The first four of these are all variants of
the popular Taylor rule. The first restricted rule is the simple Taylor rule (T), and
constrains the feedback of the policy rate to the current annual inflation rate and
the current output gap,

\[(T) \quad i_t = g_x \pi_t + g_z z_t.\]

The second restricted rule is a forward-looking Taylor rule (FT). In such a rule the
central bank responds to an inflation forecast rather than to current inflation.
Following RS, we assume the central bank responds to a constant-interest-rate
inflation forecast, i.e. the inflation forecast is calculated under the assumption of a
constant interest rate. The forecast horizon is assumed to be 8 quarters.

\[(FT) \quad i_t = g_x \pi_t + g_z z_t.\]

The third and fourth restricted rules (TS) and (FTS) correspond to the previous two
rules, but allow for interest rate smoothing by including the lagged interest rate in
the feedback list, i.e.

\[(TS) \quad i_t = g_x \pi_t + g_z z_t + g_i i_{t-1}.\]

\[(FTS) \quad i_t = g_x \pi_t + g_z z_t + g_i i_{t-1}.\]

Finally, the last two restricted rules (F) and (FS) are pure inflation-forecast rules
with and without smoothing, i.e.

\[(F) \quad i_t = g_x \pi_t.\]

\[(FS) \quad i_t = g_x \pi_t + g_i i_{t-1}.\]

For each of these rules the feedback parameters are optimised so as to minimise the
unconditional variance of the period loss function in equation [6.7] (see Appendix
6.2. In addition, we also report the performance of the original Taylor rule (OT) and a modified Taylor rule with a somewhat larger response to output (MT), i.e.

\[(OT) \quad i_t = 1.5\hat{\pi}_t + 0.5z_t.\]

\[(MT) \quad i_t = 1.5\hat{\pi}_t + 1.0z_t.\]

### 6.3.2.2. Results

The upper panel of Table 6.3 gives the feedback parameters for each of the nine instrument rules, the corresponding standard deviations of the goal variables, the value of the loss function and the ranking among the rules considered. Following Rudebusch and Svensson (1998), we assume for the benchmark case that the central bank puts equal weight on inflation and output deviations \((\gamma = 0.5)\) and a weight of 0.25 \((\nu = 0.25)\) on the interest rate smoothing component.

<table>
<thead>
<tr>
<th>Rule</th>
<th>(\sigma_{\pi_t})</th>
<th>(\sigma_{z_t})</th>
<th>(\sigma_{i_t-i_{t-1}})</th>
<th>Loss</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without uncertainty</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal</td>
<td>1.12</td>
<td>0.69</td>
<td>0.82</td>
<td>1.03</td>
<td>1</td>
</tr>
<tr>
<td>T ((g_\pi = 1.53, g_z = 1.58))</td>
<td>1.16</td>
<td>0.73</td>
<td>0.96</td>
<td>1.18</td>
<td>4</td>
</tr>
<tr>
<td>MT ((g_\pi = 1.5, g_z = 1.0))</td>
<td>1.23</td>
<td>0.83</td>
<td>0.74</td>
<td>1.25</td>
<td>6</td>
</tr>
<tr>
<td>OT ((g_\pi = 1.5, g_z = 0.5))</td>
<td>1.35</td>
<td>0.97</td>
<td>0.62</td>
<td>1.48</td>
<td>7</td>
</tr>
<tr>
<td>F ((g_\pi = 2.39))</td>
<td>1.42</td>
<td>1.16</td>
<td>0.89</td>
<td>1.89</td>
<td>9</td>
</tr>
<tr>
<td>FT ((g_\pi = 1.89, g_z = 1.54))</td>
<td>1.15</td>
<td>0.73</td>
<td>1.01</td>
<td>1.19</td>
<td>5</td>
</tr>
<tr>
<td>TS ((g_\pi = 0.67, g_z = 1.33, g_i = 0.55))</td>
<td>1.14</td>
<td>0.69</td>
<td>0.82</td>
<td>1.06</td>
<td>3</td>
</tr>
<tr>
<td>FS ((g_\pi = 2.47, g_i = -0.03))</td>
<td>1.42</td>
<td>1.15</td>
<td>0.91</td>
<td>1.89</td>
<td>8</td>
</tr>
<tr>
<td>FTS ((g_\pi = 0.84, g_z = 1.26, g_i = 0.58))</td>
<td>1.13</td>
<td>0.69</td>
<td>0.82</td>
<td>1.05</td>
<td>2</td>
</tr>
<tr>
<td><strong>With estimated output gap uncertainty</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal</td>
<td>1.30</td>
<td>1.03</td>
<td>0.92</td>
<td>1.60</td>
<td>1</td>
</tr>
<tr>
<td>T ((g_\pi = 1.65, g_z = 1.41))</td>
<td>1.32</td>
<td>1.04</td>
<td>0.99</td>
<td>1.67</td>
<td>3</td>
</tr>
<tr>
<td>MT ((g_\pi = 1.50, g_z = 1.00))</td>
<td>1.39</td>
<td>1.07</td>
<td>0.81</td>
<td>1.70</td>
<td>4</td>
</tr>
<tr>
<td>OT ((g_\pi = 1.50, g_z = 0.50))</td>
<td>1.46</td>
<td>1.11</td>
<td>0.69</td>
<td>1.81</td>
<td>5</td>
</tr>
<tr>
<td>TS ((g_\pi = 0.80, g_z = 1.54, g_i = 0.48))</td>
<td>1.31</td>
<td>1.03</td>
<td>0.92</td>
<td>1.61</td>
<td>2</td>
</tr>
<tr>
<td><strong>With estimated model uncertainty</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal</td>
<td>1.15</td>
<td>0.72</td>
<td>0.83</td>
<td>1.11</td>
<td>1</td>
</tr>
<tr>
<td>T ((g_\pi = 1.51, g_z = 1.56))</td>
<td>1.19</td>
<td>0.77</td>
<td>0.98</td>
<td>1.27</td>
<td>3</td>
</tr>
<tr>
<td>TS ((g_\pi = 0.67, g_z = 1.31, g_i = 0.55))</td>
<td>1.17</td>
<td>0.72</td>
<td>0.84</td>
<td>1.13</td>
<td>2</td>
</tr>
</tbody>
</table>
The optimal feedback rule in the estimated EU5 model is given by

\[ i_t = 0.34\pi_t + 0.17\pi_{t-1} + 0.09\pi_{t-2} + 0.05\pi_{t-3} + 1.17z_{t-1} + 0.12z_{t-2} + 0.56i_{t-1}. \]

This rule implies a quite strong response to the current output gap with policy rates increasing more than one for one with increases in the output gap. Not surprisingly, with a weight of 0.25 on the interest rate smoothing component, the optimal feedback rule also implies a significant feedback on the lagged interest rate.

The importance of the output gap is also obvious in the restricted instrument rules. We find that the weight on the output gap in the simple Taylor rule is as large as the weight on inflation and equals about 1.5. In other words, while the weight on inflation is close to the weight proposed by Taylor (1993), the optimal weight on the output gap is three times as large (i.e. 1.5 instead of 0.5). This result is consistent with the findings of Ball (1997) who using a small calibrated model of the US economy argued that an efficient weight on the output gap should be much larger than the 0.5 proposed by Taylor (1993). The third and fourth row in Table 6.3 give an indication of the cost of following a Taylor rule with lower weights on output. Using the original Taylor rule (OT) increases a typical deviation of the output gap by almost 30 percentage points and a typical deviation of inflation from target by about 20 percentage points. Using a weight of 1.0 reduces these losses considerably.\(^{13}\)

Obviously, the optimal feedback coefficients in the Taylor rule will also depend on the weights in the objective function. Graph 6.5 plots the efficient Taylor rule parameters as a function of the weights on output relative to inflation and the weight on the interest rate smoothing component. In this graph the symbol O on the left side of the solid curves stands for strict output targeting, i.e. \(\gamma = 0\), while the symbol I on the right side stands for strict inflation targeting, i.e. \(\gamma = 1\).\(^{14}\) The middle curve corresponds to a weight on interest rate smoothing, \(\nu\), equal to 0.25 as in the benchmark case. The upper and lower curves correspond to respectively a smaller and greater weight on interest rate smoothing in the loss function.

\(^{13}\) In a recent paper John Taylor seems to acknowledge that his original proposal may be inefficient and considers rules with a weight on output of 1.0 (Taylor, 1998). See, for example, also McCallum and Nelson (1998).

\(^{14}\) A weight in between is what Svensson (1997) calls flexible inflation targeting.
A couple of observations are worth making. First, for a given weight on interest rate smoothing it appears that the optimal feedback coefficient on the output gap is not much affected by the relative weight on output versus inflation stabilisation. A higher weight on inflation does increase the response to inflation considerably. Again, this reflects the crucial role of the output gap in attempts at inflation stabilisation in this model. In contrast, the weight on interest rate smoothing does affect the optimal response to output quite significantly. As interest rate smoothing becomes more important the coefficient on the output gap falls quite considerably. Over the sample period the standard deviation of changes in the German policy rate was 0.68. If this is a good indicator of the interest rate smoothing objective of a central bank, it suggests that the implicit weight on interest rate smoothing should lie between the cases of $\nu = 0.25$ and $\nu = 0.5$ depicted in Graph 6.5.

In view of the considerable weight on interest rate smoothing in the objective function, allowing for a response to the lagged interest rate in the restricted instrument rule, improves the performance of the Taylor rule quite considerably. While the long-run feedback on inflation is not much affected, interest rate smoothing allows for an even stronger response to the output gap in the medium-
term. As is clear from Table 6.3, a Taylor rule with interest rate smoothing (TS) comes very close to the optimal feedback rule in this EU5 model.

Allowing the central bank to respond to a constant-interest rate inflation forecast rather than current inflation does not particularly improve the performance of the Taylor rule. While the optimal feedback coefficient on the output gap falls somewhat and that on the inflation forecast rises, the losses are very comparable. The crucial role of the output gap in the transmission mechanism of monetary policy is most obvious when comparing the Taylor rules with the simple inflation forecast rules. The latter perform clearly much worse than the simple Taylor rule. As there are only two shocks in the economy, it is not very surprising that in this economy, one can not improve very much upon a simple Taylor rule by using inflation forecasts rather than current inflation. Obviously, in a more realistic setting filtering out temporary shocks from more permanent ones by using a inflation forecast will be optimal given the considerable lags in the transmission process.15

In sum, if the model estimated for the EU5 in section 6.3.1. is a reasonably good approximation of the way the euro-area economy will work, then the results in this section suggest that a simple Taylor rule with a relatively strong feedback on the output gap would perform quite well in stabilising the economy in the face of macroeconomic shocks. How do these results relate to the existing literature on optimal monetary policy rules? These results on the stabilisation properties of the Taylor rule are quite similar to the findings in Rudebusch and Svensson (1998). One difference with the RS results is that they find a much stronger feedback on inflation. This can be explained by the higher persistence of inflation in the estimated US model. Lower inflation persistence which may be interpreted as higher crediblity of the inflation target implies that the central bank will need to lean relatively less against changes in inflation.

There is more evidence that a simple Taylor rule with a relatively strong feedback on the output gap performs quite well in the US economy. Earlier work include the studies by Henderson and McKibbin (1993) and Levin (1996). More recently Levin et al (1998) examined the performance of a Taylor-like rule in a range of models for the US economy.16 Similarly to our findings they find that such a rule outperforms simple inflation-forecast rules. In addition, they find that not much can be gained from including other information (such as lagged variables, foreign variables or the exchange rate) in the feedback rule.

15 See Battini and Haldane (1998) on a lucid discussion of why forward-looking rules while simple in form may perform very well.

16 One difference with the findings in this paper is that they find that a strong persistence in the policy rate is optimal. This result is in part due to the fact that it is the long-term interest rate that matters in the aggregate demand equation.
The overall positive results that have been found for the US economy contrast with the less favourable results researchers have found for smaller, more open economies. Black, Macklem and Rose (1997) and Battini and Haldane (1998), for example, find that inflation forecast rules have the ability to perform much better than simple Taylor rules in respectively the Bank of Canada’s QPM-model and a calibrated model of the UK economy. Similarly, De Brouwer and O’Regan (1997) find that including the exchange rate and foreign variables improves the performance of the Taylor rule in a model for the Australian economy.

These results are not very surprising. While in closed economies the current output gap and inflation may be close to sufficient statistics to describe the state of the economy, this is unlikely to be the case for more open economies. The most important difference is probably the importance of the exchange rate channel, which is, for example, emphasised in Svensson (1997c) and Battini and Haldane (1998). Indeed, the importance of this channel in relatively open economies is reflected in a significant response to the exchange rate as, for example, illustrated in the estimated reaction function for the Bundesbank in Table 6.1. However, these results do not necessarily turn around the positive results concerning the Taylor rule of this section. As long as the underlying paradigm of a relatively closed economy with the main transmission channel working through the output gap is reasonable for the euro-zone economy, a Taylor rule would appear to be a useful benchmark.
6.4. UNCERTAINTY AND THE ROBUSTNESS OF SIMPLE TAYLOR RULES

6.4.1. THE EFFECT OF ESTIMATION ERROR IN THE OUTPUT GAP

In light of the crucial role of the output gap in the efficient Taylor rules of the previous section, an important question that needs to be addressed concerns the impact of estimation error in the output gap on the efficient feedback parameters and the performance of the Taylor rule. Several authors, including Kuttner (1994), Staiger et al (1996) and Gerlach and Smets (1997) have shown that indicators of capacity utilisation such as the output gap or the NAIRU are estimated with a considerable margin of uncertainty. Given the initial aggregation problems and the lack of reliable historical data, this is likely to be even more true for the measurement of an EMU-wide output gap. One counterargument is that the variability of the EMU-wide output gap will be less than that of the individual countries because some of the idiosyncrasies will be averaged out. In this section, we analyse the effect of estimation error in the output gap on the efficient instrument rules and their performance in the estimated model of section 6.3.1.

To address this question we follow Smets (1998) who argues that estimation error in the output gap may in part explain why the actual central bank response to movements in the output gap is less than optimal control exercises suggest. The loss function and the dynamics of the economy are again given by equations [6.3] to [6.7]. However, now we assume, consistent with the estimated model, that output gaps are not directly observed, but need to be estimated. In other words, two of the state variables, $z_t$ and $z_{t-1}$ are unobserved. Current and past growth rates of real GDP, $\Delta y_t$, are observed, but could be due to either a change in the growth of potential output or a change in the output gap, so that the central bank faces a signal extraction problem. The Kalman filter which was used in section 6.3.1. to estimate the model gives the optimal estimate of the output gap given the observed data and the structure of the economy.

The middle panel of Table 6.3 gives the results of the optimal control exercise when we take the estimated uncertainty of the output gap into account. As emphasised in Estrella and Mishkin (1998) and shown by Chow (1970) estimation errors in the state variables do not affect the optimal unconstrained feedback rule in a linear-quadratic framework. As a result of this certainty equivalence theorem, the only difference between the optimal linear feedback rule in panel 1 and 2 of Table 6.3 is that in the latter case the feedback is on the estimated state variables rather than on

---

17 See Appendix 6.2 for some of the technical details.
However, the loss function is affected as the policy feedback on measurement error in the output gap will filter through into the economy and increase the variability of the goal variables. Indeed, the loss under the optimal feedback rule increases from 1.03 to 1.60.

More interesting are the results concerning the restricted feedback rules. The relative ranking of the different rules is not affected. However, comparing panel 1 and 2 of Table 6.3, it is obvious that in the simple Taylor rule, the weight on output falls from 1.58 to 1.41 and the weight on inflation increases from 1.53 to 1.65. The effect of measurement error is to put less weight on the variable that is measured with error and more on the variable that is perfectly observed. Graph 6.6 plots the Taylor rule coefficients as a function of the uncertainty in the output gap. The optimal response to the output gap in a simple Taylor rule falls at an increasing rate as the standard deviation of the estimation error in the output gap increases, while the optimal response to inflation rises. In both cases the optimal feedback parameter is still relatively high at the estimated standard deviation (around 0.8 percent). However, increasing the standard deviation beyond its estimate results in a rapid drop of the feedback parameter. A standard deviation of 1.13 would in this model be consistent with a coefficient of 0.5 on output, as suggested by Taylor (1993). It becomes optimal not to respond to the output gap when its standard deviation is larger than 1.15 percent.

Graph 6.6
Taylor rule coefficients as function of output gap uncertainty

---

18 This result is sometimes called a separation theorem. See Chow (1970) for a discussion.
Graph 6.5 shows that the negative effect of higher estimation error on the Taylor rule coefficients is robust to various weights in the objective function. The dashed lines give the optimal Taylor rule coefficients for various weights taking the estimated output gap uncertainty into account. In almost all cases the efficient Taylor rule coefficient on output falls, but how much depends on the weights in the objective function. It is worth noting that although the effect of the estimated output gap uncertainty is to move the efficient Taylor rule parameters in the direction of the values suggested by Taylor (1993), it is clear that one needs either larger than estimated output gap uncertainty or a strong interest rate smoothing objective to explain why actually estimated feedback parameters on output are around 0.5. However, from the third and fourth row in the middle panel of Table 6.3 it is obvious that the loss of having a lower feedback parameter on output (0.5 or 1.0) is much less when one takes into account the measurement error in the output gap.

In sum, estimation error in the output gap can partly explain why central banks in practice respond less to the output gap than suggested by optimal control exercises which do not take into account this uncertainty. In the extreme, high uncertainty may result in a zero response to the output gap. With the estimated standard deviation of the EU5 output gap, a quite strong feedback is still optimal. It is an empirical question whether estimates of the EMU-wide output gap are subject to much larger confidence bands. These results correspond with other recent research that has analysed the effects of measurement error in both output gaps and inflation on the optimal feedback coefficients in a Taylor rule. Both Rudebusch (1998) and Orphanides (1998) analyse measurement error in inflation and the output gap in a very similar model for the United States. Both of them document that there are significant revisions in US estimates of inflation and the output gap and show that taking this measurement error into account reduces the efficient feedback parameters and brings them more in line with the original Taylor rule ones. Aoki (1998) performs a theoretical analysis in a simple, but optimising model of the US economy. Consistent with the previous results, he shows that noise contained in the data offers a reason for policy conservatism.

6.4.2. THE EFFECT OF UNCERTAINTY ABOUT THE TRANSMISSION MECHANISM

In Section 6.3 we have argued that a simple model of the transmission mechanism for a relatively closed economy may be a useful starting point for analysing monetary policy in the euro area. However, the uncertainties remain large. In part, this is a generic problem facing central banks. In spite of decades of economic research on this issue, there is still a considerable degree of uncertainty about the
precise effects on output and inflation of changes in the monetary policy stance.\textsuperscript{20} In the case of euro area, the fact that monetary policy may impact the economy of the different nations differently, the associated aggregation problem, the absence of aggregate historical data and the potential for a structural break under the new regime make an analysis of the euro area-wide transmission mechanism even more complicated. In this section, we make a preliminary and necessarily limited attempt at assessing the impact of parameter uncertainty on the optimal policy rules considered in this paper.

Following the original work of Brainard (1967), a number of authors, including Svensson (1997b), Clarida et al (1997b), Cecchetti (1997), Estrella and Mishkin (1998) and Wieland (1997), have recently analysed the effect of parameter uncertainty on optimal monetary policy rules using simple mostly theoretical models of the transmission mechanism.\textsuperscript{21} There is, however, little attempt to quantify the effects of parameter uncertainty in an empirical model. Such quantification is important because only in the special case where none of the parameters are correlated can one unambiguously show that higher uncertainty about the transmission mechanism will result in a more cautious response of the central bank to the economy’s state variables.\textsuperscript{22}

In this section we use two admittedly limited ways of assessing the impact of model uncertainty on optimal policy behaviour and the performance of the Taylor rule in particular. First, following the literature discussed above we analyse the optimal Taylor rule if we take into account the estimated variance-covariance matrix of the parameter estimates as a measure of model uncertainty. The lower panel of Table 6.2 presents the results.\textsuperscript{23} We basically confirm the results of Estrella and Mishkin (1998) and Rudebusch (1998) who show that parameter uncertainty only marginally reduces the efficient feedback parameters in the instrument rules. This is true for both the optimal linear feedback rule and the simple Taylor rule. Moreover, even doubling the estimated standard deviations of the parameters does not significantly change this result. In sum, conventional parameter uncertainty does not seem to matter very much for the efficient instrument rules.

However, the estimated parameter uncertainty of the EU5 model may not take into account the potential for model uncertainty that arises from the fact that the

\textsuperscript{20} For an overview of some of the empirical research on the transmission mechanism in the European context, see Kieler and Saarenheimo (1998).

\textsuperscript{21} See also Blinder (1998). A particularly innovative paper is Wieland (1997). He analyses the trade-off faced by the central bank between caution and experimentation.


\textsuperscript{23} Some of the technical details can again be found in Appendix 6.2.
transmission in the other EMU countries may be different or from structural breaks due to the establishment of the new monetary regime. While a full analysis of the robustness of simple Taylor rules to such model uncertainty deserves a separate paper, Graph 6.7 presents some suggestive evidence. In this graph we plot the efficiency frontier of both the optimal linear feedback rule and the efficient simple Taylor rule (T) for four different versions of the EU5 model. In each case the symbol MT corresponds to the outcome of the Modified Taylor rule with a feedback coefficient of 1.5 on inflation and 1.0 on the output gap. The solid lines correspond to the estimated model.

**Graph 6.7**

**Efficiency frontiers**

The lines indicated by Model 1 correspond to a similar model with a reduced slope of the Phillips curve ($\beta$ is 0.15 instead of 0.33). In other words, compared to the estimated model, the sacrifice ratio is higher and similar to the one estimated for the United States. As noted in Rudebusch (1998), a steeper slope of the Phillips curve will reduce the feedback coefficient on the output gap while increasing the one on inflation. The lines indicated by Model 3 correspond to a model in which the output effects of an interest rate rise are much higher ($\lambda$ is –0.15 instead of –0.10). A higher interest rate sensitivity will generally reduce the feedback coefficients on both output and inflation. Finally, the lines with short dashes (Model 2) correspond
to a model in which the persistence of inflation is greater ($\alpha(1)$ is 0.85 instead of 0.74).

Except in the latter case, the results of Graph 6.7 seem to indicate that the modified Taylor rule does relatively well in stabilising output and inflation compared to the efficiency frontier. The gains from moving to the frontier are typically less than 10 basis points in terms of a reduced standard deviation of inflation and the output gap. More substantial gains can be achieved when inflation is much more persistent than estimated in the EU5 model. In this case an efficient Taylor rule would do much better and could potentially reduce the standard deviation of inflation by more than 20 basis points. The reason for this is that when shocks to inflation are highly persistent it pays for the central bank to be much more aggressive. In this particular case the efficient Taylor rule parameters are 1.9 on inflation and 1.8 on the output gap if the central bank cares equally about output and inflation. Most evidence seems, however, to suggest that inflation persistence has fallen as inflation has come down.

Overall, the evidence presented here suggests that the relatively good performance of a simple Taylor rule with coefficients of 1.5 on inflation and 1.0 on output is robust to small variations in the parameters of the estimated model. This is consistent with tests of the robustness of simple Taylor rules in the US models. Levin et al (1998), for example, find that the Taylor rules they consider are quite robust across the different models of the US economy they analyse. One possible exception that we identified is when the inflation process turns out to be much more persistent than estimated in the EU5 model. In that case optimal Taylor rules are still performing quite well, but the feedback parameters need to be much higher than the ones typically suggested. Of course, the significance of these results is somewhat reduced by the fact that we did not consider radically different models of the euro area economy.
6.5. CONCLUSIONS

The need to be able to change policies flexibly in response to new information and/or structural changes in the economy puts a premium on central bank discretion. Nevertheless, simple policy guidelines can be useful in two respects. First, they can be used internally as a benchmark to assess policy decisions which are based on the widest information set available. The availability of a benchmark puts some discipline on the central bank's staff to explain why its analysis deviates from what the benchmark suggests. Second, when made public they can also be used as a communication device to explain policy decisions to the general public.

In this paper we have argued that it may be worth considering a simple guideline like the one suggested by Taylor (1993) as a benchmark for analysing monetary policy in the euro area. Our justification is basically threefold. First, as the rule explicitly links the current policy rate to the current state of the economy as captured by the current trend inflation rate and the current output gap, it is easy to calculate and understand. This simplicity helps the communication of the central bank. Second, there is increasing evidence that the policy behaviour of successful central banks can be usefully described by variants of the Taylor rule.\(^2\) In Section 6.2 of this paper we present some evidence that also in Europe movements in short-term interest rates can be approximated by such a rule. In part, these two reasons explain why so many private sector economists use a Taylor rule to analyse policy decisions.

Third, the benefits of having a benchmark rule will, of course, depend on how robust the ability of the rule to stabilise inflation and output is to changes in the structure of the economy. Obviously, if optimal policy deviates frequently and persistently from the benchmark and/or the rule needs to be revised frequently, the advantages of having such a benchmark will quickly disappear.\(^2\) In section 6.3 of the paper we argue that to a first degree the euro area economy can be modelled as a relatively closed economy along the lines of Rudebusch and Svensson (1998). Using this estimated model we show that simple Taylor rules do a rather good job in stabilising output and inflation. In Section 6.4 we show, in addition, that estimation error in the output gap does not significantly affect the performance of the Taylor rule, although it does reduce the optimal feedback coefficient on the output gap. We also find that the performance of the Taylor rule is robust to small changes in the parameters of the model. Overall, this is consistent with research on simple policy rules using models for the US economy.

\(^2\) For an interesting historical analysis of US monetary policy through the lenses of the Taylor rule, see Taylor (1998).

\(^2\) The importance of robustness in the design of monetary policy rules has often been stressed by Ben McCallum (See, e.g. McCallum (1997)).
In spite of the generally favourable results concerning the stabilisation properties of a Taylor rule in a relatively closed economy, there remain a number of issues which need to be resolved. First, questions remain about the appropriate choice of the feedback coefficients in the Taylor rule, in particular on the output gap. Second, most empirical studies of central bank behaviour reveal that central banks smooth interest rates and only gradually move towards the policy suggested by a Taylor rule. The reasons for interest rate smoothing need to be better understood. In an innovative study, Sack (1998) finds that in a situation where the central bank learns about the policy multiplier by observing the reaction of the economy to recent interest rate changes, it may be optimal to move gradually over time. Third, implementing the Taylor rule requires an estimate of the equilibrium real interest rate. The implications of considerable uncertainty about its level need to be examined.
In this appendix we provide some additional evidence on the monetary policy transmission mechanism in six European countries, Austria, Belgium, France, Germany, Italy, and the Netherlands. The emphasis is on the output effects of a common monetary policy shock taking into account the interaction effects among the EU countries due to their trade links. The effects of such a shock will most closely replicate the effects of a common monetary policy under EMU. The immediate goal of the exercise is to provide some suggestive evidence that, first, a common monetary policy shock has quite similar effects on output in the five EU countries that we use in the aggregate model and, secondly, that the external (dollar) exchange rate has negligible effects on output.

To do so, we estimate for each country $i$ the following output equation:

$$y_t^i = \sum_{j=1}^{k} A_j^i y_{t-j}^i + \sum_{j=1}^{k} B_j^i y_{t-j}^i + \sum_{j=1}^{k} C_{ij}^i r_{t-j}^{DM} + \sum_{j=1}^{k} D_{ij}^i (r_{t-j} - r_{t-j}^{DM}) + \sum_{j=1}^{k} E_j^i x_{US/DM} + \sum_{j=1}^{k} F_{ij}^i x_{i/DM} + \epsilon_t^i$$

where $y_t^i$ is output growth in country $i$, $r^{DM}$ is the real German interest rate, $r_t$ the real rate of country $i$, $x_{US/DM}$ the US/DM exchange rate and $x_{i/DM}$ the exchange rate of country $i$ in DM. We include the German real rate and $x_{US/DM}$, the DM/dollar exchange rate as measures of the common monetary policy stance in Europe. In addition, we add the real interest rate differential and the DM exchange rate of each European currency to control for deviations of the domestic policy stance from the common monetary policy stance.

Equations [A.6.1.1] can be seen as the output equations of a VAR, which also includes real interest rates and exchange rates. We estimate this system for the six EU-countries mentioned above using SUR estimation and quarterly data over the...
period 1978:1-1995:4. The common lag length of two quarters was derived using a sequence of (likelihood ratio) exclusion tests. With this system, we simulate the effect of a 1 percentage point increase in the German real interest rate and the effect of a 1 percent appreciation of the DM/US dollar exchange rate during 8 quarters on GDP in each of the six countries, as well as on a weighted average.

Graph A.6.1
Transmission channels in EU6

Graphs A.6.1 and A.6.2 highlight the main results of the analysis. Graph A.6.1 shows the effect of a one percentage point increase in the interest rate and a one percent appreciation of the dollar exchange rate on a weighted average of GDP in the six countries together with a two standard deviations confidence band. It is immediately clear that while there is a strong interest rate channel, in contrast to Dornbusch et al (1997), we do not find a systematic negative effect of an appreciation of the dollar on output in these six countries. Only in France we find a significant negative effect (See lower panel of Graph A.6.2). However, even there the implicit weight on the exchange rate in a Monetary Conditions Index is small. While we find these estimates more plausible than the ones suggested by Dornbusch et al (1998), our results need to be taken with more than the usual degree of caution. In estimating the system, we assumed the real interest rate and the exchange rate to be pre-determined. While this may be a reasonable assumption for the real interest rate, it is much less clear for the real exchange rate. In particular,

---

28 We also estimated the system excluding Italy over the period (1975:1-1995:4) with very similar results. The six EU countries represent about 84% of PPP-adjusted real GDP of the EMU area in 1990. Without Italy this share falls to 62% of EMU GDP. While it would be interesting to include Spain and the other smaller EMU countries Ireland, Finland, Portugal and Luxembourg, data limitations prevented us from doing so.
if the exchange rate appreciates in response to forecasts of stronger growth, a simultaneous equations bias may reduce the estimated output effects of such an appreciation. In future research we intend to address this problem by using instrumental variables in the estimation.

**Graph A.6.2**

Transmission channels in six EU countries:
Differences from the average output effect on EU6
Graph A.6.2 suggests that there are significant differences in the strength of the interest rate channel across the six countries. The graph shows the difference in output effects between each country and the EU6 (i.e. a weighted average of the six EU countries) together with a 95 percent confidence band. An interest rate shock has very similar effects on output in Austria, France, Germany and the Netherlands, but considerably larger effects in Belgium and Italy. In view of the high government debt in both countries one possible explanation is that higher interest rates increase the government debt burden and lead to a procyclical tightening of fiscal policy. The fact that monetary policy may have larger effects in Italy than in the rest of the EMU area has also been noted in other studies (for example, BIS (1995) or Dornbusch et al (1998)). One explanation emphasised in these studies is that the share of the private debt incurred at adjustable interest rates is larger in Italy than in the other EMU countries. This implies that a rise in interest rates has a more direct effect on the interest rate burden of the private sector.

APPENDIX 6.2. ESTIMATION AND OPTIMAL CONTROL OF THE EU5 MODEL

A.6.2.1. Estimation of the EU5 model

In order to estimate model [6.3] to [6.6] using the Kalman filter and maximum likelihood methods, we write the model in state space form. The measurement equations are given by:

\[
\begin{bmatrix}
\Delta y_t \\
p_t
\end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 0 & \beta \end{bmatrix} \begin{bmatrix} z_t \\ z_{t-1}
\end{bmatrix} + \begin{bmatrix} \mu \\ \alpha(L)p_{t-1}
\end{bmatrix} + \begin{bmatrix} \epsilon_t^y \\ \epsilon_t^p
\end{bmatrix}
\]

The corresponding state equation is:

\[
\begin{bmatrix}
z_{t+1} \\
z_t
\end{bmatrix} = \begin{bmatrix} \phi_1 & \phi_2 \\ 1 & 0
\end{bmatrix} \begin{bmatrix} z_t \\ z_{t-1}
\end{bmatrix} + \begin{bmatrix} \lambda(i_{t-1} - p_{t-1}) \\ 0
\end{bmatrix} + \begin{bmatrix} \epsilon_t^z \\ 0
\end{bmatrix}
\]

Assuming that each of the three shocks are independently normally distributed with the following variance-covariance matrix,

\[
\Sigma_{\epsilon} = \begin{bmatrix}
\sigma_y^2 & 0 & 0 \\
0 & \sigma_p^2 & 0 \\
0 & 0 & \sigma_z^2
\end{bmatrix}
\]
one can form the likelihood function using the Kalman filter and derive the estimates of the model using maximum likelihood estimation. The results are presented in Table 6.2.

### A.6.2.2. Optimal control of the EU5 model

In order to derive the optimal feedback parameters of the different instrument rules, we write the EU5 model in its companion form. The state-space representation of the economy is then given by,

\[ X_{t+1} = AX_t + Bi_t + \nu_t, \]

where the vector \( X_t \) of state variables, the matrix \( A \), the column vector \( B \), and the disturbance vector \( \nu_t \) are given by

\[
A = \begin{bmatrix}
\beta & 0 & 0 & 0 & 0 & 0 \\
\alpha_1 & \alpha_2 & 0 & 0 & 0 & 0 \\
\alpha_3 & \alpha_4 & \alpha_5 & \alpha_6 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix},

\[
B = \begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix},

\[
\nu_t = \begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix}.
\]

The vector \( Y_t \) of goal variables fulfills

\[ Y_t = C_X X_t + C_i i_t, \]

where

\[
Y_t = \begin{bmatrix}
\pi_t \\
z_t \\
i_t - i_{t-1}
\end{bmatrix},

\[
C_X = \begin{bmatrix}
0 & 1/4 & 0 & 1/4 & 1/4 & 1/4 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & -1
\end{bmatrix},

\[
i_t = \begin{bmatrix}
0 \\
0 \\
0
\end{bmatrix}.
\]

The period loss function can then be written as

\[ E[L_t] = E[Y_t^\prime KY_t], \]

where \( K \) is a 3x3 diagonal matrix with \( (\gamma, 1-\gamma, \nu) \) on the diagonal.
The loss function when the model and the state variables are known

If one assumes that both the parameters of the model in (A.6.2.1) and the state variables are known, then each of the restricted rules can be written as a linear function of the vector of state variables (say $i_t = gX_t$). The dynamics of the model and the goal variables for a given rule are then given by

\[ X_{t+1} = MX_t + \nu_{t+1}, \]

\[ Y_t = CX_t, \]

where $M = A + Bg$ and $C = C_X + C_i g$.

The optimal feedback parameters in each of the restricted instrument rules can than be calculated by minimising the unconditional loss:

\[ E[L_t] = E[Y_t, KY_t] = \text{trace}(K\Sigma_\gamma), \]

where $\Sigma_\gamma$ is the unconditional covariance matrix of the goal variables and is given by:

\[ \Sigma_\gamma = C\Sigma_X C', \]

and $\Sigma_X$ is the covariance matrix of the state variables and is in turn related to the covariance matrix of the disturbances by the following equation,

\[ \text{vec}(\Sigma_X) = \left[ I - (M \otimes M) \right]^{-1} \text{vec}(\Sigma_\gamma). \]

The loss function with measurement error in the output gap

In matrix notation the observation equation equivalent to equation [A.6.2.1] is given by:

\[ W_t = DX_t + \eta_t, \]

where the vector of observables $W_t$, the matrix $D$, and the vector $\eta_t$ are given by

---

29 See Rudebusch and Svensson (1998) for a discussion of how the constant-interest rate forecast can be calculated.
The central bank’s estimate of the current state of the economy is then given by 

\[ E[X_t] = E[X_t | W_t] \]

In this case the objective function is still given by equation [A.6.2.9]. However, with measurement errors in the output gap the covariance matrix of the goal variables and the state variables need to be modified to include the effect of measurement error. This results into the following expressions:

\[ \Sigma_y = C \Sigma_x A' + C \Sigma_x \Sigma_y \Sigma_x ' \], and

\[ \text{vec}(\Sigma_x) = \left[ I - (M \otimes M) \right]^{-1} \left[ \text{vec}(\Sigma_y) + [(A \otimes A) - I] \text{vec}(\Sigma_x) \right], \]

where \( \Sigma_y \) is the covariance matrix of the measurement errors in the vector of state variables and can be derived separately from the Kalman filter used in A.6.2.1. (See Chow (1970))

**The loss function under model uncertainty**

If the state variables are observed, but the parameters of the estimated model in equation [A.6.2.4] are subject to uncertainty, then equations [A.6.2.9] and [A.6.2.10] again describe the loss function and the covariance matrix of the goal variables, but in this case the covariance matrix of the state variables is given by the following equation:

\[ \text{vec}(\Sigma_x) = \left[ I - E[(A + Bf) \otimes (A + Bf)] \right]^{-1} \text{vec}(\Sigma_x). \]

In order to calculate the expectation in [A.6.2.15] we use the estimated covariance matrix of the parameters.
6.7. REFERENCES


