Five essays on credibility, monetary policy rules and inflation targeting

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To my parents

Acknowledgments

Contents

An overview of the thesis and some related literature

1 Introduction

During the 1990s a number of countries (e.g. Canada, New Zealand, Sweden, and the United Kingdom) have introduced an inflation target as a cornerstone of their monetary policy.[1] Moreover, by January 1 1999 the European Central Bank took over for the 11 national central banks[2] and at the end of March 2002 the Euro will have replaced the national currencies the participating countries. These events have been part of the motivation for my interest in monetary policy and consequently also for this thesis.

The thesis focuses both on the credibility of the monetary policy target – i.e. on the ability of the monetary policy institution to deliver a nominal anchor for the medium and long run, and on the short run effects of the monetary policy set-up on macroeconomic variables such as the rate of inflation, the rate unemployment and output. Moreover, the thesis discusses the use of monetary policy rules and, in particular, rules related to inflation targeting. Alexander et al. (1997) point out that there is a global consensus of three main elements as far as the choice of monetary target is concerned. The first relates to the need for medium-term

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[1]See e.g. McCallum (1996) for a description of the inflation targeting arrangements in the different countries.

[2]In early January this year Greece also joined the European Monetary Union, which henceforth includes 12 of the 15 countries in the European Union. Denmark, Sweden and the UK have thus far not joined.

objective or nominal anchor; the second relates to the need for commitment; and the third relates to the types of frameworks that can be used to obtain price stability. The latter refers to four different choices of targets for monetary policy, namely a direct inflation target, an indirect monetary target, an exchange rate target, and a nominal income target.

2   Institutions for monetary policy credibility

This line of research was initiated by the path-breaking article of Kydland and Prescott (1977), which has later been popularized and extended by Barro and Gordon (1983a,b). The major implication of this analysis is that there will be a so-called inflationary bias – i.e. the rate of inflation will be higher than the inflation goal of the monetary authorities – while expected output is unaffected. This follows from the fact that the monetary authorities cannot commit themselves to an inflation rule. Once the inflation expectations are formed, the authorities will have an incentive to deviate from the announced policy in order to bring output closer to the goal. The market will foresee this, and expect a higher inflation than the policy goal.[3]

This simple model is extended in the literature in several directions[4], but I concentrate on the literature on building monetary policy institutions. Following Persson and Tabellini (1997:pp32) this literature can be divided into three closely

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[3]Calvo (1978) stresses the importance of market inefficiencies for this results. It is because of market inefficiencies that the monetary authority has a higher goal for output than the natural level.

[4]The extensions include the use of repetition to prove their credibility, see e.g. Barro and Gordon (1983b). The idea is that if the government also cares about subsequent periods, it will weigh the benefit of a surprise inflation today against the cost of a higher expected inflation in the future. Consequently, reputation will reduce average inflation.

A natural extension of this is to include monitoring problems, so that the public cannot be sure if the high inflation is a result of some unobservable shock or a deliberate public policy (see Canzeroni (1985)). This leads to temporary increases in actual and expected inflation.

Another extension is discussed by Backus and Driffill (1985), Barro (1986) and Tabellini (1985, 1987). They assume that the public is uncertain about the policy-maker's type – i.e. about their attitude towards inflation and unemployment.

related branches. The first one is the discussion about fixed exchange rate regimes and escape clauses. The former is related to the idea that a country can borrow credibility from abroad by pegging its currency to a low inflation currency, while the latter is related to the discussion about the use of fixed rules (like the fixed exchange rate) with an explicit or implicit escape clause. The monetary authorities then stick to a fixed rule in normal times when the output is close to the target, but use discretionary policy – i.e. surprise inflation – in exceptional times. Flood and Issard (1988) show that an escape clause is always better than the discretionary outcome; and if the variance of the supply shocks are large enough, it is also better than a simple rule (a completely fixed exchange rate).

The second branch is the discussion about whether to appoint a conservative central banker. This was first suggested by Rogoff (1985), and the idea is to choose a central banker who puts a lower weight on the output goal than the society does. This will reduce the inflationary bias. However, the reduction in the inflation bias only comes at a cost, since the stabilization of shocks will be distorted. Nevertheless, Rogoff (op.cit.) shows that appointing a "slightly" conservative central banker will reduce expected costs, but it will not be optimal to reduce the inflation bias altogether.[5]

Finally, the fourth branch is the discussion about central bank contracts and inflation targets. As far as the former is concerned, Walsh (1995) and Persson and Tabellini (1993) use principal agent theory and argue that it is possible to achieve monetary stability without giving up flexibility. The idea is to appoint an independent CB and give it a performance contract. In their model the optimal contract includes an additional linear cost of inflation in the objective function of the CB, which will remove the inflationary bias, but not affect stabilization.[6]

Svensson (1997b) proposes to interpret inflation targeting as a concept giving

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[5]Lohman (1992) combines a conservative CB with escape clauses. The idea is that a partial independent conservative central banker is chosen to conduct monetary policy, while the authorities keep the option to renege upon the monetary policy chosen by the CB.

[6]Persson and Tabellini(op.cit.) extend the basic model and include the possibility of the CB having private information, and to the situation where the CB does not control the monetary target perfectly.

the CB an explicit inflation target (and an implicit unemployment target and an inflation/unemployment weight) different from the parameter in the social welfare function. In the simple set-up, this will give the same result as the optimal contract suggestion.

In a dynamic setting with employment persistence, Svensson (1997b)[7] demonstrates that a discretionary policy will lead to a fourth-best outcome. In addition to the average inflation bias, there will be a state-contingent inflation bias because inflation will depend on lagged employment; and, besides, there will be a stabilization bias.

One may question the feasibility – and consequently also the relevance – of both the optimal-contract and the explicit-inflation-target suggestion. As far as the former is concerned, McCallum (1995) argues that such a set-up does not solve the problem but merely relocates it. There is no reason to believe that the authorities ex post will punish a monetary policy that is in line with their own preferences. Persson and Tabellini (1997:33) argue that such a contract has to be formed in what they call an "institutional stage", and it must be difficult to change it. However, McCallum (1995) argues, despite the Constitution, the US "has not been on an operative metallic standard for many years – since 1971, at the very least, or arguably since 1961, or 1933, or even earlier". As far as the latter is concerned, Persson and Tabellini (1997:43) note that the inflation target itself will never be met. The arrangement is such that the chosen inflation target plus the inflation bias will be equal to the parameter in the social welfare function.[8] Furthermore, in the case of unemployment persistence, both the optimal CB contract and the optimal explicit inflation target would have to be state-contingent, and the latter would mimic the optimal rule solution only if it is combined with a Rogoff-independent central bank (see Svensson 1997b). This makes both these suggestions much more difficult to implement.

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[7]Svensson (1997b) extends the work of amongst others Lockwood and Phillippopoulos (1994) and Lockwood et al. (1998).

[8]A numerical example may be clarifying. Let the inflation target of the society be 2% and the inflationary bias be 4%. The central banker should then have a target of -2%, which will lead to an average of 2% inflation.

2.1 Essay 1: Escape clauses in monetary policy with employment persistence

The dynamic setting with employment persistence is the starting point for the first essay of the thesis, where I extend the analysis in Svensson (1997b) to include an escape clause. Faced with the difficulties with implementing a state-contingent central bank contract or the state-contingent inflation target, the escape clause might be a promising candidate. The institutional set-up in this essay consists of i) an independent Rogoff-conservative central banker, and ii) an escape clause. Policy is conducted using a simple rule in normal times, i.e. setting inflation equal to the goal, but the rule may be abandoned in the case where large shocks have hit the economy.

In normal times the central bank has no discretionary power and cannot trade off employment variations with variations in inflation. Consequently, compared to discretionary monetary policy, employment will vary more and inflation will vary less. Moreover, the set-up introduces a state-contingent peso-problem in normal times. In the model by Flood and Issard (op.cit) the peso-problem was due to the inflation bias. In exceptional times monetary policy will be biased against too much inflation, while in normal times inflation is equal to the goal. Therefore, in expected value, inflation will be higher than the goal as long as there is a positive probability that the escape clause will be used. As a consequence, by setting inflation equal to the goal in normal times, there will be a surprise deflation. In the model discussed in this essay, the peso-problem will be state-contingent since expected inflation depends on past employment. In a situation with low employment, the expected inflation will be high since the authorities would choose a high rate of inflation if they invoke the escape clause. As a result, the deflation surprise will be large in normal times when inflation is set equal to the goal. The gain of the escape clause is that monetary policy will be more effective when large shocks hit the economy. In addition, employment persistence reduces in these situations.

2.2 Essay 2: The sources of German business cycles: how important are permanent shocks?

The credibility literature is also the starting point of the second essay, where I look at the sources of economic cycles in Germany. The German Bundesbank has often been used as an example of an independent Rogoff-conservative central bank. As pointed out above, choosing a conservative central banker will reduce the inflation bias, but distort stabilization. However, the importance of the latter will depend on what types of disturbances drive the economic cycles. As Svensson (2000) indicates, even supply disturbances may increase the output potential as well as output, so in fact the output gap and the rate of inflation move in the same direction. This will then reduce the potential conflict following such disturbances.

The analysis is carried out using five quarterly variables for the German economy, namely the rate of unemployment, GDP, the real exchange rate, CPI, and a broad measure of nominal money holdings – M3. These variables are chosen since they are normally considered important for the conduct of monetary policy. I assume that these variables are driven by five structural disturbances – four permanent and one transitory, and the analysis is carried out by conducting a structural vector autoregressive (SVAR) analysis. SVAR analysis has come to be a common tool in analyzing business cycles and has proven to give information about the source of fluctuations of macroeconomic variables. The strategy used in this paper to decompose the different shocks follows Shapiro and Watson (1988) to some extent, and the identification is done using long-run restrictions.[9] I have ordered the disturbances as follows: Permanent labour shocks are defined as the only disturbances that have a long-run impact on the rate of unemployment, thus they change the natural rate of unemployment. Permanent output shocks do not have a long-run impact on unemployment, but shifts the production frontier and will thus have a long-run impact on GDP. Permanent real exchange rate shocks do not have a long-run impact on neither unemployment nor on GDP, but may change the composition of GDP via

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[9]This strategy was first used by Blanchard and Quah (1989) in their seminal article on the sources of fluctuations in output and unemployment for the US.

their long-run impact on the real exchange rate. Neither the permanent real money shocks nor the transitory shocks have long-run impact on the unemployment and output. In addition they do not change the real exchange rate in the long run. The transitory shocks – in addition – are assumed not to have a long-run effect on real money holdings. This set of restrictions then identifies the structural disturbances and reveal how they affect the macroeconomic variables both contemporaneously and through time.

The main result is that the disturbances that drive unemployment and output in the long run also seem to be important factors for the business cycles. However, the most important factor for the development of the unemployment and output gaps seems to be disturbances that have permanent effects on the rate of unemployment; and since this disturbance drives the output gap and the price level in the same direction, the potential conflict of monetary policy might be less.

3 Monetary policy rules and inflation targeting

A considerable amount of literature has been devoted to analyzing how different monetary policy rule will work in stylized economic models. Large parts of this literature have concentrated on the effects of inflation targeting. However, following Leitemo (1999) there are two different interpretations of inflation targeting in the literature. Batini and Haldane (1998) and McCallum and Nelson (1997) interpret targeting as a simple rule, or, more precisely, as a forward-looking simple rule where the policy instrument reacts to changes in the targeted variable – usually expected inflation some point in the future. Svensson (see Svensson 1997a, 1999, and 2000) on the other hand, interprets inflation targeting as discretionary optimization by an independent central bank, which is given a certain object function.

There is often drawn a distinction between so-called strict or flexible inflation targeting. The former corresponds to the situation where the Central Bank is only concerned about the rate of inflation. Several studies point out that such policy may lead to high variability in real variables such as output, the rate of unemployment or

employment, and the real exchange rate.[10] The latter refers to a situation where the central bank is also concerned about other variables than the rate of inflation.[11] Such set-ups seems to offer a better trade-off between inflation and output variability.

3.1 Essay 3: Tayloring the Norwegian interest rates

In his celebrated article, Taylor (1993) finds that his rule does a good job in tracking the US short term interest rates. The Taylor-rule has thereafter been used both in academics and practise to give statements about how the stance of monetary policy. However, in the theoretical literature on inflation targeting it is often argued that the central bank should focus on expected inflation.[12] In addition, empirical literature have pointed out that actual central banks focus on expected inflation.[13]

This is the starting point of the third essay in the thesis. The essay starts out by motivating the Taylor rule using a model based on the targeting of expected inflation developed by Svensson (1997a). It is shown that the Taylor rule might serve as an instrument for targeting expected inflation if lagged output gap and inflation serve to predict future inflation. Thereafter I compare the Taylor rule with a forward-looking rule for the Norwegian economy. The main insight is that both rules indicate a significantly different monetary policy than the actual one for large periods. Besides, it seems that – to some extent – the Taylor rule and the forward-looking rule are different over the economic cycles. More precise, it seems that the forward-looking rule increases earlier in economic booms and falls earlier in economic recessions. Consequently, the Taylor rule might give a poor indication

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[10]See e.g. Svensson (2000) for a comprehensive study of inflation targeting in an open economy. Furthermore, the danger of large variations in the real exchange rate is pointed out by – among others – Ball (1998).

[11]Batini and Haldane (1998) stress that the actual monetary policy rule does not need to include other variables than the rate of inflation. However, concern about other variables will influence the choice of horizon for the inflation target.

[12]See e.g. Svensson (1997a) for a theoretical justification for targeting expected inflation.

[13]Clarida and Gertler (1996) points out that the monetary policy strategy of the German Bundesbank corresponds well to a forward-looking rule, and Clarida et al. (1998) report a similar result for the G3-countries – the US, Germany, and Japan.

of monetary policy under inflation targeting when the economy goes in or out of recessions or booms.

3.2 Essay 4: A monetary policy rule in practice: the case of Norway

In the fourth essay of the thesis I estimate a forward-looking rule for the Norwegian economy. The starting point is the articles by Clarida et al. (1998, 2000), where they estimate monetary policy rules using forward-looking variables. In the former, the analysis is done for two sets of countries. First, for the G3 economies -- Germany, Japan, and the US, and second, for three European economies – France, Italy, and the UK. For the European economies the basic model is extended to include the German short-term interest rate due to the fixed exchange rate regime. The latter article discusses monetary policy in the US along the same lines, but the authors also include a theoretical justification of the rule. The main idea is that the rule has to offer a sufficiently aggressive reaction to expected inflation, and more precise, the real interest rate must increase following an increase in expected inflation in order to rule out self-fulfilling prophesies. Interestingly, the authors find that the US monetary policy before the Volcker-Greenspan period implied the possibility of self-fulfilling fluctuations in output and inflation.

The essay looks at the effect of pegging the Norwegian Krone to the European currencies. I estimate a monetary policy rule for the period 1986 till 1992, taking into account that the monetary authorities have followed a fixed exchange rate regime. The main result is that the monetary policy set-up accommodated changes in expected inflation in this period. Consequently, monetary policy did not provide a sufficient anchor for short or medium term expected inflation, which – as in the case for the US before the Volcker period – may have led to self-fulfilling prophecies about the development of the rate of inflation.

3.3 Essay 5: Inflation targeting in a monetary union with non-coordinated fiscal policy

So far I have discussed monetary policy issues without taking into account that in most cases the central bank conducts its policy alongside with the fiscal authorities. However, fiscal policy may influence both how monetary policy is conducted and the extent to which monetary policy goals will and can be achieved. These problems have been analyzed in the literature under the heading "coordination problems between fiscal and monetary policy".[14]

Beetsma and Bovenberg (1999) analyze such a monetary/fiscal game in the case where fiscal policy is conducted by myopic governments. They show that compared to a regime with decentralized monetary policy, a monetary union will increase the accumulation of public debts. Beetsma and Bovenberg (2000) extend this analysis and allow the participating countries to be heterogeneous. The result is that debt target will have to be state-contingent. Andersen and Sørensen (1995) argue that with imperfect competition in both product and labour markets, even balanced fiscal policy may affect unemployment.[15] Consequently, this will imply that a restriction on the size of the public sector is necessary. The starting point of Dixit and Lambertini (2000) is the debate on excessive use of fiscal policy to stabilize business cycles. Their analysis is carried out in a Barro-Gorden model, which is extended to a monetary union. The result is that as long as the central bank and the fiscal authorities have the same goals for output and inflation, the first-best can be achieved irrespective of whether the fiscal authorities move first or second and whether the fiscal authorities cooperate or they do not. Additionally, there is no need for monetary commitment.

The starting point of the last essay in the thesis are two important features of the European Monetary Union. First, monetary policy is conducted by the European Central Bank, which is an independent institution with price stability as its

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[14]See e.g. Nordhaus (1994) for an overview of the literature.

[15]Nonetheless, in the union as a whole unemployment is unaffected and, as a result, the decrease in the rate of unemployment in one country comes about through an increase in unemployment in the rest of the countries.

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main objective. Second, fiscal policy is completely decentralized and is carried out by the fiscal authorities in the participating countries. These factors will lead to a strategic game in two dimensions. On the one hand, it will imply strategic interactions between the fiscal authorities seen as a group and the monetary authorities; and, on the other hand, it will imply strategic interactions between the fiscal authorities themselves. The last essay of the thesis discusses coordination problems in a monetary union, where the central bank targets core inflation. It is shown that lack of coordination between monetary and fiscal policy leads to a state-contingent bias in the sense that the fiscal authorities react to changes in average core inflation. Furthermore, lack of coordination between the fiscal authorities will lead to a stabilization bias. As a result, the fiscal authorities do not react correctly to idiosyncratic shocks. The nature of the stabilization bias will depend on whether the fiscal authorities act as Stackelberg leaders with the central bank or not.

References

Alexander, William E., John H. Green, and Birgir Arnason, "A Monetary Framework for Norway, the Options," in Anne B. Christiansen and Jan F. Qvigstad, eds., *Choosing a Monetary Policy Target*, Scandinavian University Press, 1997, pp. 26–60.

Andersen, Torben M. and Jan Rose Sørensen, "Unemployment and Fiscal Policy in an Economic and Monetary Union," *European Journal of Political Economy*, 1995, *11*, 27–43.

Backus, David and John Driffill, "Inflation and Reputation," *American Economic Review*, 1985, *75*, 530–538.

Ball, Laurence, "Policy Rules for Open Economy," October 1998. NBER Working Paper 6760.

Barro, Robert J., "Reputation in a Model of Monetary Policy with Incomplete Information," *Journal of Monetary Economics*, 1986, *17*, 3–20.

_ **and David B. Gordon**, "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 1983, *91*, 589–610.

_ **and** _ , "Rules, Discretion, and Reputation in a Model of Monetary Policy," *Journal of Monetary Economics*, 1983, *12*, 101–121.

Batini, Nicoletta and Andrew G. Haldane, "Forward-Looking Rules for Monetary Policy," May 1998. NBER Working Paper Series 6543.

Beetsma, Roel M. W. J. and A. Lans Bovenberg, "Does Monetary Unification Lead to Excessive Debt Accumulation?," *Journal of Public Economics*, 1999, *74*, 299–325.

_ **and** _ , "Strategic Debt Accumulation in a Heterogeneous Monetary Union," October 2000. Mimeo, University of Amsterdam/Tilburg University.

Blanchard, Oliver J. and Danny Quah, "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review*, 1989, *79* (4), 655–673.

Calvo, Guillermo A., "On the Time Consistency of Optimal Policy in a Monetary Economy," *Econometrica*, 1978, *46*, 1411–1428.

Canzeroni, Matthew B., "Monetary Policy Games and the Role of Private Information," *American Economic Review*, 1985, *75*, 1056–70.

Clarida, Richard and Mark Gertler, "How the Bundesbank Conducts Monetary Policy," 1996. NBER Working Paper Series 5581.

_ , **Jordi Galí, and Mark Gertler**, "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review*, 1998, *42*, 1033–1067.

_ , _ , **and** _ , "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics*, 2000, *115* (1), 147–180.

Dixit, Avinash and Luisa Lambertini, "Symbiosis of Monetary and Fiscal Policies in a Monetary Union," March 2000. Mimeo, Princeton University/UCLA.

Flood, Robert and Peter Issard, "Monetary Policy Strategies," 1988. NBER Working Paper Series 2770.

Kydland, Finn E. and Edward C. Prescott, "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, 1977, *85*, 473–492.

Leitemo, Kai, "Inflation Targeting Strategies in Small Open Economies," July 1999. Manuscript.

Lockwood, Ben and Aspostolis Phillippopoulos, "Insider Power, Unemployment Dynamics and Multipe Inflation Equilibria," *Economica*, 1994, *61*, 59–77.

— , **Marcus Miller, and Lei Zhang**, "Designing Monetary Policy When Unemployment Persists," *Economica*, 1998, *65*, 259–327.

Lohman, Susanne, "Optimal Commitment in Monetary Policy: Credibility versus Flexibility," *American Economic Review*, 1992, *82* (1), 273–286.

McCallum, Bennett T., "Two Fallacies Concerning Central Bank Independence," 1995. NBER Working Paper Series 5075.

— , "Inflation Targeting in Canada, New Zealand, Sweden, the United Kingdom, and in General," 1996. NBER Working Paper Series 5579.

— **and Edward Nelson**, "An Optimizing IS-LM Framework for Monetary Policy and Business Cycle Analysis," 1997. NBER Working Paper Series 5875.

Nordhaus, William D., "Policy Games: Coordination and Independence in Monetary and Fiscal Policies," *Brookings Papers on Economic Activity*, 1994, *2*, 139–216.

Persson, Torsten and Guido Tabellini, "Designing Institutions for Monetary Stability," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 53–84.

_ **and** _ , "Political Economics and Macroeconomic Policy," December 1997. CEPR Discussion Paper 1759.

Rogoff, Kenneth, "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, 1985, *100*, 1169–1190.

Shapiro, Matthew D. and Mark W. Watson, "Sources of Business Cycle Fluctuations," 1988. NBER Working Paper Series 2589.

Svensson, Lars E. O., "Inflation Forecast Targeting: Implementing and Monotoring Inflation Targets," *European Economic Review*, 1997, *41*, 1111–1146.

_ , "Optimal Inflation Targets, "Conservative" Central Banks, and Linear Inflation Contracts," *American Economic Review*, 1997, *87* (1), 98–114.

_ , "Inflation Targeting as a Monetary Policy Rule," *Journal of Monetary Economics*, 1999, *43*, 607–654.

_ , "Open-Economy Inflation Targeting," *Journal of International Economics*, 2000, *50*, 155–183.

Tabellini, Guido, "Accommodative Monetary Policy and Central Bank Reputation," *Giornale degli Economisti e Annali di Economia*, 1985, *44*, 389–425.

_ , "Reputational Constraints on Monetary Policy. A Comment," *Carnegie-Rochester Conference Series on Public Policy*, 1987, *26*, 183–90.

Taylor, John B., "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 195–214.

Walsh, Carl E., "Optimal Contracts for Central Banks," *American Economic Review*, 1995, *85* (1), 150–167.

ESSAY 1:

Escape clauses in monetary policy with employment persistence*

Abstract

The paper discusses the use of escape clauses in monetary policy when there is employment persistence. The institutional set-up consists of i) an independent conservative central banker, and ii) an escape clause. Policy is conducted using a simple rule in normal times, but the rule may be abandoned in the case where large shocks have hit the economy.

In normal times the central bank has no discretionary power and cannot trade off employment variations with variations in inflation. Furthermore, the set-up introduces a state-contingent peso-problem in normal times since expected inflation depends on past employment. The gain of the escape clause is that monetary policy will be more effective when large shocks hit the economy. In addition, employment persistence reduces in these situations.

1 Introduction

This paper analyses the effects of escape clauses when there is employment persistence. The latter is based on the stylized fact about the European labor market: after a shock to employment, there seems to be little tendency to revert to the previous situation. Given these extensions I describe the development of employment and inflation through time in the situation when the monetary authorities conduct monetary policy in normal times based on a simple rule, but it has the option to abandon the rule in situations where large shocks have hit the economy.

The study of escape clauses has been mostly related to the theoretical description of fixed exchange rate regimes such as the Bretton Woods or the European Monetary System (EMS). This institutional arrangements were characterized by stabilizing the exchange rate in normal times and realignments in exceptional times. In their article "Monetary Policy Strategies" – where escape clause was first analyzed – Flood and Issard (1988) do not limit the relevance to the fixed-exchange-rate set-up, but merely justify the use of an escape clause in monetary policy as a way of solving parts of the credibility problem.

It is interesting to note that studies on actual CB behavior observe that very often the instrument of monetary policy can be well described by rather simple rules, except in extraordinary circumstances. For example, Taylor (1993) notes that there is a significant difference between his rule and the actual US short-term interest rate in 1987 as the Federal Reserve eased monetary policy as a responce to the crash in the stock market. And this is exactly what rules with escape clauses are all about: following some simple rules in normal times, and discretionary policy in exceptional times. In the set-up used in this paper, monetary policy is conducted by an independent central bank which follows a simple rule except in extraordinary circumstances. In such cases the central bank abandons the simple rule and uses its knowledge and – importantly – its own preferences to conduct monetary policy in a discretionary manner.

In addition to the escape clause I assume that the central bank is Rogoff (1985) conservative in the sense that it puts a lower weight on employment stabilization

than the rest of society. The implication of this is that when the simple rule is abandoned, the central banker puts a higher weight on the inflation goal. This can be justified by Alan Blinder's observation from his time in the Federal Reserve: <<Rogoff (1985) observed that one way to offset the inflation bias is to install a quite "conservative" person to lead the central bank... This, I believe, is common practice around the world. Indeed, the noun "central banker" practically cries out for the adjective "conservative">> (Blinder, 1997, 14). The institutional set-up therefore consists of i) an independent conservative central banker and ii) an escape clause. The aim of this paper is thus positive rather than normative since these two factors arguably are important ingredients of how actual monetary policy is conducted.

I assume that the (long-run) natural employment coincides with the employment goal of the monetary authorities. This means that the average inflation bias is ruled out by assumption, which is done out of two reasons: The first is analytical tractability since it makes it easier to concentrate on the effect of employment persistence; and the second is a more questionable one, namely that it may be a better description of how an independent central banker acts. The assumption is hence that the problems with inflation biases are not related to the long term goal of the monetary authorities, but to the short - or medium - term goals for stabilizing output (or employment). Alternatively, letting the goal of employment equal natural employment may be justified by the assumption that the average inflation bias is already taken care of by other institutional arrangements such as the linear central bank contract.

The paper has a dynamic structure like in Svensson (1997)[1], who shows that a discretionary policy will lead to a fourth-best outcome in the case of persistent employment. In addition to the well-known average inflation bias, there will be a state-contingent inflation bias because inflation will depend on lagged employment; and, furthermore, there will be a stabilization bias in that inflation will vary too much and employment too little. The reason for the latter is that the inflation bias

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[1]Svensson (1997) extends the work of amongst others Lockwood and Phillippopoulos (1994) and Lockwood et al. (1998). The latter discusses in detail the delegation of a conservative central banker in the case of (un)employment persistence.

in the future will depend on current employment, which increase the gains from stabilizing employment. Svensson then discusses several institutional set-ups which remove some of these biases. A weight-conservative independent central bank as suggested by Rogoff (1985) will – at best – secure a third-best outcome; a pure inflation target secures a third-best outcome, and will therefore have the same effect as the linear central bank contract as suggested by Persson and Tabellini (1993) and Walsh (1995); and a state-contingent inflation target combined with a weight-conservative central bank or state-contingent central bank contract secure a second-best outcome.

This paper is organized as follows: In the second part the model economy is described, including the preferences of the monetary authorities and how it differs from the preferences of the government or society; and in the third part the escape clause is discussed in the situation where employment persists. The fourth part describes the numerical solution and the last part concludes.

2 The model economy

The analytical framework follows from Svensson (1997) and will thus be a Barro and Gordon (1983) model, but the institutional framework include an escape clause.[2] The short-run expectation augmented Phillips-curve relationship is assumed to be given by

$$l_t = (1 - \rho) l^n + \rho l_{t-1} + \alpha (\pi_t - \pi_t^e) + \varepsilon_t, \tag{1}$$

where ε_t is independently, identically normally distributed with zero mean. l_t is (log of) employment in period t, and l^n is (long-run) natural employment. π_t and π_t^e are the actual and the expected rate of inflation in period t. The third term expresses the idea that only surprise inflation will affect employment. The constant α is the slope of the Phillips-curve and it measures the marginal impact on unemployment of a marginal increase in unexpected inflation. Furthermore, ρ measures employment

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[2]The Barro-Gordon model is a popularization of the seminal paper by Kydland and Prescott (1977).

persistence and $0 \leq \rho \leq 1$. If $\rho = 0$, past employment has no effects on the actual employment, i.e. there is no persistence; if $0 < \rho < 1$, there is persistence depending on the size of ρ; and if $\rho = 1$, there is hysteresis and the actual rate of unemployment will evolve as a random walk. I normalize the natural employment to zero and thus the expectation-augmented Phillips-curve will be given by

$$l_t = \rho l_{t-1} + \alpha \left(\pi_t - \pi_t^e \right) + \varepsilon_t. \tag{2}$$

The chosen employment dynamics will be important for the result. Following Modery (1995: pp. 244) the theories explaining *unemployment* persistence can be divided into five groups: First, unemployment persistence can be due to capital shortage. The idea is that shocks that are adverse to the productivity of the capital stock may lead to persistence in unemployment if capital and labor are complementary factors and if it takes time to build up the stock of capital. These theories support a specification similar to the one which is included in the path-breaking article Barro and Gordon (1983); the natural rate of unemployment itself evolves as a moving average depending on its own past. Second, unemployment persistence can be due to human capital shortage. The idea is that the workers ability to work - or more generally their human capital - will depreciate through time when they stay unemployed. Together with wage-stickiness this may therefore lead to persistence in employment. These theories suggest that unemployment will depend on past unemployment; and the size of unemployment persistence will depend on the degree of wage stickiness and the depreciation of the human capital. Third, unemployment persistence can be due to discouraged workers. The idea is that the workers being unemployed gradually make less effort to look for jobs. These theories also suggest that unemployment will depend on past unemployment; and the size of persistence will depend on how rapid the unemployed gets discouraged to look for jobs and on wage flexibility. Fourth, unemployment persistence can be due to labor-turnover costs. The idea is that the firms may be reluctant to hire workers due the lock-in effect of the hiring and firing costs. These theories again relate to a specification where unemployment is influenced by past unemployment. As far as the size of unemployment persistence, it will depend on wage flexibility. Fifth, unemployment

persistence can be due to insider-outsider behavior in the labor market. This is the set-up discussed by Lockwood and Phillippopoulos (1994), which also is the starting point in Lockwood et al. (1998). The idea is that wages are set in a bargain between a labour union and the employers; where the former is assumed to have both a employment and a wage target and tries to minimize deviations from these goals. The employment goal is a convex combination of members – who were last periods employed – and the labour force. Unemployment persistence will depend on the relative weight put on the employment goal versus the wage target and the weight put on the labour force relative to the union members.

The preferences of the monetary authorities is summarized by a cost function W_t, which is a function of employment and inflation in each period. It is assumed to be of the Barro and Gordon (1983)-type and thus a quadratic cost function, hence

$$W_t = \frac{1}{2} \left[(\pi_t)^2 + \lambda^{cb} (l_t - l^*)^2 \right],$$ (3)

where l^* is the employment target and I have normalized the inflation target to zero. The employment target is assumed constant through time and in general it might be different from the natural rate of employment. This will introduce an average inflationary bias. As shown by Svensson (1997), the average inflationary bias may be ruled out by giving the central bank a target for inflation that is lower than the social target or by a central bank contract, as suggested by Persson and Tabellini (1993) and Walsh (1995). In order to concentrate on the effects of employment persistence, I will let the employment goal be equal to the natural employment level. This assumption might also be a better description of how actual central banks act. Blinder (1997) and McCallum (1995) argue that central bankers do not try to push employment above its natural level. The set-up in this model may therefore be seen as taking a stand in the middle saying that central bankers may not try to push employment above its natural level, but they will be tempted to surprise the market with inflation (deflation) when employment is below (above) its long-run level due to persistence.

The last parameter in the cost function is the weight on the employment goal, λ^{cb}. I follow Rogoff (1985) and assume that the central banker is weight-conservative in

the sense that $\lambda^{cb} < \lambda$, where λ is the employment weight of the society.[3] This means that the central banker cares less about variations in employment than the society does; and as noted in the introduction, this can be justified by the observation of Blinder (1997) from his time in the Federal Reserve, that choosing a conservative central banker is a common practice. The result of this is that whenever the central banker abandons the simple rule, it will inflate less for a given level of unemployment than the government would do.

The monetary authorities – as well as society – are assumed to have an infinite planning horizon and to minimize the discounted sum of per period costs, thus minimize

$$V_t = E_t \left[\sum_{s=0}^{\infty} \beta^{t-s} W_s \right] = E_t \left[\sum_{s=0}^{\infty} \beta^{t-s} \frac{1}{2} \left(\pi_t^2 + \lambda^{cb} l_t^2 \right) \right], \tag{4}$$

where β is the discount factor.

I assume that the central bank controls inflation directly, which may be seen as a reduced form problem of one of the two following set-ups. In the first set-up – which follows from Flood and Issard (1989) – the instrument of the central bank is the monetary base b_t and

$$\pi_t = b_t + v_t. \tag{5}$$

Equation (5) is the relationship between inflation and the growth rate of the monetary base, and v_t is the shock to this relationship. The shock is uncorrelated with the supply shock and it is observed by the central bank before it chooses b_t. The central bank therefore controls inflation by varying the growth rate of the monetary base.

In the second set-up the central bank uses the nominal interest rate to influence aggregate demand. A simple representation of aggregate demand – expressed in terms of labour rather than output[4] – may be written as

$$l_t^d = \rho l_{t-1} - \gamma \left(i_t - \pi_t^e \right) + u_t, \tag{6}$$

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[3]The preferences of the society – or the government – can be represented in the same way as for the central bank; and the only difference is the weight on employment stabilization.

[4]This may be found using an aggregate demand function involving output and Okun's law relating output to employment.

where the superscript d denoted demand, γ is a positive constant and ζ_t is the demand shock.[5] i_t is the nominal interest rate and thus labour demand decreases with the real interest rate. Equating aggregate demand (equation 6) with the expectation-augmented Phillips-curve gives a function relating the rate of inflation to the nominal interest rate:

$$\pi_t = \left(1 - \frac{\gamma}{\alpha}\right)\pi_t^e - \frac{\gamma}{\alpha}i_t + \frac{1}{\alpha}\left(u_t - \varepsilon_t\right).$$

Therefore, in the case the demand shock is observable by the central bank before it chooses the nominal interest rate, the rate of inflation can be controlled setting the corresponding nominal interest rate; and the model can be solved assuming that the central bank controls the rate of inflation directly.

3 A simple escape clause with employment persistence

A monetary policy regime with an escape clause is characterized by some rule in normal times and discretionary policy in exceptional times. The former is defined as the times when the shocks to unemployment fall within a determined interval, thus between ε_1^s and ε_2^s. Exceptional times are defined as the complement of this, thus as the times when the shocks fall outside the interval. Another possibility would be to let the escape clause region be defined over some observable variable; and in this case the rate of employment. There are, however, some drawbacks with such set-ups. First, employment is an endogenous variable, which will make the specification of the escape-clause region difficult. One possibility would be to specify the region in terms of past employment, but this will be foolish in the sense that it will only restrict the central bank in normal times with no gains in exceptional times. Another possibility would be to specify the escape clause on what employment would be if the central bank would have followed the simple rule. This variable would, however, have to be calculated ex post using the "unobservable" employment shock and the

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[5] The demand shock will be a composite of labour demand shocks and aggregate demand shocks.

"unobservable" expected inflation; and, in practice, this would not always be an easy task. The only reasonable set-up would therefore be to let the escape clause be defined over some area in the two-dimensional (ε_t, l_{t-1})-space. This might then be implemented by a fixed cost of abandoning the simple rule.[6] Since the inflation bias will be increasing in lagged employment, the escape clause region will be an increasing function in the (ε_t, l_{t-1})-space. If, in addition to a fixed fee, there is a political cost of sticking to the rule and this cost will be an increasing function in lagged employment,[7] this will tend make the escape-clause region decreasing in lagged employment. The one-dimensional escape-clause region might be interpreted as an approximation to such a set-up.

I follow Flood and Issard (1989) and assume that the interval is symmetric around zero. This implies that the conditional expected value of the shock is zero, which will make the model easier to solve. Lohman (1992) notes that in the case of an escape clause without persistence and where the government has a different employment goal than the natural level, the optimal escape clause region will be symmetric around a positive constant due to the existence of an (average) inflationary bias. This has been shown analytically by Alexius (1999) for the case where the supply shock has a uniform distribution.[8] I have ruled out this bias, however.

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[6]In a fixed exchange rate model, Obstfeld (1997) points out that such implementation might lead to multiple equilibria. The reason is that expected inflation – or expected devaluation in Obstfeld's model – depends on the probability that the simple rule is abandoned. At the same time, the choice of whether or not to abandon the rule depends on expected inflation. An increase in expected inflation will make it more costly to follow the simple rule, which make the probability that the government abandons the rule higher; and a higher expected inflation may therefore become self-fulfilling.

Flood and Marion (1998) discuss Obstfeld's results and note the following: First, recalculating Obstfelds results using the normal distribution instead of the triangular distribution used by Obstfeld, they find that an escape clause performs better than reported by Obstfeld. The reason is that the triangular distribution cuts off the probability large shocks. Second, they point out that the authorities should take the possibility of multiple equilibria into account when they choose the fixed cost; and the loss of doing so is comparably small.

[7]This will be the case if the political pressure to abandon the rule is higher the further away employment is from its natural level.

[8]She also show that in the case of a uniform distribution for the supply shock, there does not

In the original suggestion by Flood and Issard (1989) the monetary authorities set inflation equal to the target – $\pi_t = 0$ – in normal times, and I follow their set-up. Using the base-money or the labour-demand management set-up above, the central bank will then neutralize the v_t-shocks or the u_t-shocks; but the supply shocks are not allowed to influence the rate of inflation.

The Flood and Issard (1989)-model is extended by Lohman (1992) where monetary policy in normal times is conducted by a "weight-conservative" central bank, and the government may renege upon monetary policy. To do so they must pay a political fee, however, which will thus only be done if the shocks to employment are large. The policy rule of the central banker will therefore be kinked. For small shocks the central banker does not take into account the ex-post incentives of the government to renege upon monetary policy; but for shocks that are above a threshold, it will have to take into account the government's incentives, and monetary policy will be closer to that of discretion the larger the shock hitting employment is.[9]

The set-up in this paper differs from the above literature in important ways. First, none of the contributions above consider employment persistence, which is an essential ingredient of this paper. Second, in earlier studies the central bank conducts monetary policy following the preferences of the government in exceptional times, whereas I consider the situation where the central bank follows its own preferences when they abandon the simple rule. Arguably, my set-up will be a better description of some of the inflation-targeting central banks, which have the possibility to abandon the inflation target in special circumstances.[10] Furthermore, it might also be argued that the US Federal Reserve may fit this description. Taylor (1993) notes that the US monetary policy can be well described by his simple rule except in extraordinary circumstances – such as the in 1987 when the Fed eased monetary policy due to the crash in the stock market.

exist multiple equilibria as in Obstfeld's model, where the shock has a triangular distribution..

[9]Interestingly, even largely independent central banks such as the German Bundesbank and the Dutch Central Bank had clauses in their laws providing the government to override monetary policy in certain circumstances. See footnote 17 in Persson and Tabellini (1997).

[10]See e.g. McCallum (1996) for a description of inflation targeting in different countries.

Following Leitemo (1999) there are two different interpretations of inflation targeting in the literature. Batini and Haldane (1998) and McCallum and Nelson (1997) interpret targeting as a simple rule, or, more precisely, as a forward-looking simple rule where the policy instrument reacts to changes in the targeted variable -- usually expected inflation some point in the future. Svensson (see Svensson 1997, 1999, and 2000) on the other hand, interprets inflation targeting as discretionary optimization by an independent central bank, which is given a certain object function. The rule I consider is simple in the sense that the central bank is assumed to set inflation equal to zero in each period; but spelled out as a rule involving the central bank instrument, the rule will be a function of all the state variables. Therefore, the rule will be associated to second interpretation of inflation targeting, where the monetary authorities -- in addition -- have the option to abandon the rule if the shock to employment is large enough. More precise, the rule is associated to the regime known as strict inflation targeting, where the central bank is dictated to care only about the rate of inflation. The intuition of this paper should hold also for simple forward-looking rules, however, since these will also limit the central banker from achieving an optimal trade-off between inflation and employment variability following different shocks.

The optimal rule -- for exceptional times -- can be derived from the Bellman equation:

$$V\left(l_{t-1}\right) = (1-q)\,E_{t-1}^{s}\left[\frac{1}{2}\left(\lambda^{cb}l_{t}^{2}\right) + \beta V\left(l_{t}\right)\right] \qquad (7)$$

$$+ q\min_{\pi_{t}^{cb}} E_{t-1}^{cb}\left[\frac{1}{2}\left(\left(\pi_{t}^{cb}\right)^{2} + \lambda^{cb}l_{t}^{2}\right) + \beta V\left(l_{t}\right)\right],$$

where $V\left(l_{t-1}\right)$ is the value function, thus the discounted expected future costs. Furthermore, q is the probability that the shock falls outside the symmetric interval $[-\varepsilon^{s}, \varepsilon^{s}]$, and E^{s} and E^{cb} are the expectation operator over normal and exceptional times, respectively. The minimization is done given the evolution of the labour market, but the monetary authorities do not internalize the effect on expected in-

flation.[11] The first order condition will then be given by:

$$\pi_t^{cb} + \alpha \lambda^{cb} l_t + \alpha \beta V_l(l_t) = 0, \tag{8}$$

which can be interpreted as follows: The first two terms equate the case without persistence (or with zero discount factor) and gives the trade-off between current inflation and employment. The last part takes into account that future employment will be affected because of employment persistence.

Due to the fact that the minimization problem is linear-quadratic and the escape interval is given exogenously[12], the value function will be quadratic;

$$V(l) = \gamma_0 + \gamma_1 l + \frac{1}{2}\gamma_2 l^2, \tag{9}$$

and thus the first-order condition can be written as

$$\pi_t^{cb} + \alpha \lambda^{cb} l_t + \alpha \beta (\gamma_1 + \gamma_2 l_t) = 0. \tag{10}$$

Taking the unconditional expected value of equation (10) gives:

$$E\pi^{cb} + \alpha \lambda^{cb} E l + \alpha \beta (\gamma_1 + \gamma_2 E l) = 0$$

$$E\pi^{cb} = \alpha \beta \gamma_1,$$

since unconditional expected employment is zero. Since I have ruled out the average inflationary bias, unconditional expected inflation will have to be zero, and thus γ_1 will be zero. Therefore, the first order condition reduces to:

$$\pi_t^{cb} + \alpha \left(\lambda^{cb} + \beta \gamma_2 \right) l_t = 0. \tag{11}$$

Assuming rational expectations, the expected inflation in exceptional times will be given by[13]

$$E_{t-1}^{cb} \pi_t^{cb} + \alpha \left(\lambda^{cb} + \beta \gamma_2 \right) \left[\rho l_{t-1} + \alpha \left(E_{t-1}^{cb} \pi_t^{cb} - \pi_t^e \right) \right] = 0$$

$$E_{t-1}^{cb} \pi_t^{cb} \left(1 + \alpha^2 \left(\lambda^{cb} + \beta \gamma_2 \right) \right) = \alpha^2 \left(\lambda^{cb} + \beta \gamma_2 \right) \pi^e - \alpha \left(\lambda^{cb} + \beta \gamma_2 \right) \rho l_{t-1}$$

$$E_{t-1}^{cb} \pi_t^{cb} = \frac{1}{\left(1 + \alpha^2 \left(\lambda^{cb} + \beta \gamma_2 \right) \right)} \alpha \left(\lambda^{cb} + \beta \gamma_2 \right) \left(\alpha \pi^e - \rho l_{t-1} \right). \tag{12}$$

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[11]See Svensson (1997).

[12]If the escape-clause region would be endogenously given by a fixed cost, say, the value function would include a value of waiting.

[13]Since the escape clause interval is symmetric, the expected value of the shock in exceptional times will be zero.

In normal times the central bank sets inflation according to the simple rule

$$\pi_t^s = 0, \tag{13}$$

and, thus, expected inflation – given "normal times" – will be zero.[14] Therefore, the expected inflation will be given by

$$\pi_t^e = qE_{t-1}^{cb}\pi_t^{cb} = \frac{q}{\left(1 + \alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)\right)}\alpha \left(\lambda^{cb} + \beta\gamma_2\right)\left(\alpha\pi^e - \rho l_{t-1}\right)$$

$$\pi_t^e = -\frac{q\alpha \left(\lambda^{cb} + \beta\gamma_2\right)}{1 + (1 - q)\alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)}\rho l_{t-1}. \tag{14}$$

Expected inflation will hence depend negatively on the probability of exceptional times and on past employment. The reason for the latter is that the central bank – when exceptional times occurs – will choose a higher rate of inflation the lower the employment is.

Using this and the expectation-augmented Phillips curve – equation (2) – employment in normal times can be written as:

$$l_t^s = \left(\frac{1 + \alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)}{1 + (1 - q)\alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)}\right)\rho l_{t-1} + \varepsilon_t. \tag{15}$$

There will be no trading-off between inflation and employment variability, and the employment shock will only affect employment. In addition, employment persistence will increase, since the term in the brackets will be higher than one if $q > 0$. This is due to the fact that expected inflation depends on past employment.

Using the first order condition - equation (11) - and expected inflation from equation (14) gives

$$\pi_t^{cb} = \frac{\alpha \left(\lambda^{cb} + \beta\gamma_2\right)}{1 + \alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)}\left[\left(1 + \frac{q\alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)}{1 + (1 - q)\alpha^2 \left(\lambda^{cb} + \beta\gamma_2\right)}\right)\rho l_{t-1} + \varepsilon_t\right]. \tag{16}$$

Following the notation in Svensson (op.cit.), I can write the decision rule for the monetary authority in exceptional times as

$$\pi_t^{cb} = -b\varepsilon_t - cl_{t-1}, \tag{17}$$

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[14]This follows from the fact that I have assumed a that there is a symmetric escape-clause region.

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where

$$b = \frac{\alpha \left(\lambda^{cb} + \beta\gamma_2 \right)}{\left[1 + \alpha^2 \left(\lambda^{cb} + \beta\gamma_2 \right) \right]}, \text{ and} \tag{18}$$

$$c = \frac{\alpha \left(\lambda^{cb} + \beta\gamma_2 \right)}{1 + (1 - q) \alpha^2 \left(\lambda^{cb} + \beta\gamma_2 \right)} \rho. \tag{19}$$

This has the following implications for the policy rule in exceptional times: Compared to the case without an escape clause – which is analyzed by Svensson (op.cit) – the stabilization parameter b is affected by the escape clause only through the fact that γ_2 will depend on the probability parameter q. The reason is that the central bank faces the same trade off between current employment and inflation as in the case without an escape clause. Due to the fact that employment persists, the central banker will also take into account how its choice of inflation will affect future employment, however; and future employment is influenced by the fact that there is an escape clause. As far as the state-contingent bias – the parameter c in the reaction function – is concerned, it is affected by the escape clause in two different ways. First, as for the stabilization parameter, the escape clause influences the parameter through changes in γ_2. Second, the escape clause has a direct effect through the fact that it lowers the expected inflation.

Employment in exceptional times will then be given by:

$$l_t^{cb} = \frac{1}{1 + (1 - q) \alpha^2 \left(\lambda^{cb} + \beta\gamma_2 \right)} \rho l_{t-1} + \frac{1}{\left[1 + \alpha^2 \left(\lambda^{cb} + \beta\gamma_2 \right) \right]} \varepsilon_t. \tag{20}$$

In exceptional times the monetary authorities have discretionary power and will let the employment shock partly feed into employment and partly into inflation. Furthermore employment persistence falls: as long as $q < 1$ the first fraction will be less than one.

The escape-clause thus has the following effects on monetary policy: First, in normal times, the central banker follows the simple rule and thus sets inflation equal to zero. Since expected inflation depends on past employment – see equation (14) – this will result in an inflationary surprise if employment is above the natural level and a deflationary surprise if employment is below the natural level. This is therefore related to the so-called Peso-problem; and since expected inflation depends

on past employment due to employment persistence, there will be a state-contingent Peso-problem. The effect is that employment persistence increases. Second, in exceptional times, the central banker has discretionary power. Since exceptional times only occurs with probability less than one, expected inflation depends less on past employment than in the discretionary set-up. The central banker will choose a higher (dis)inflation the more employment is below (above) the natural level. Therefore, employment persistence will fall in exceptional times.

In order to determine b and c, γ_2 must be found. This is done in the appendix, where I also include an existence condition. Here I turn to a numerical solution of the different parameters in the decision rule and look at how they depend on the probability parameter q – hence on the size of the escape clause region, on how conservative the central banker is (λ^{cb}) and on employment persistence ρ; and in addition I look at how employment persistence in normal and exceptional times will depend on q and λ^{cb}. The aim of the next section is thus to characterize some general features of the decision rule.

4 The numerical solution

The result of the numerical solution is shown in figures 1, 2 and 3.[15] Figure 1 shows how the parameter b – the reaction to a supply shock in exceptional times – depends on the probability q, the central bankers employment weight (λ^{cb}), and employment persistence (ρ), respectively. It is seen that b increases with both ρ, which is due to the fact that the gain of stabilization increases. The reason is that employment – once it is away from the natural level – will stay away for a longer time period. An increase in persistence, therefore, increases the expected discounted cost of not meeting the employment goal this period. The figure also shows the result of Lockwood et al. (1998) that delegating monetary policy to a conservative central banker reduces stabilization. And since stabilization is too high if the government conducts monetary policy itself (in a discretionary way) – there is a stabilization bias

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[15]To do this I have used the following parameter values:.$\alpha = 0.1$, $\beta = (1 + 0.07/4)^{-1}$, $\rho = 0.9$, $\lambda = 1$, and $\lambda^{cb} = 0.5$.

A   B
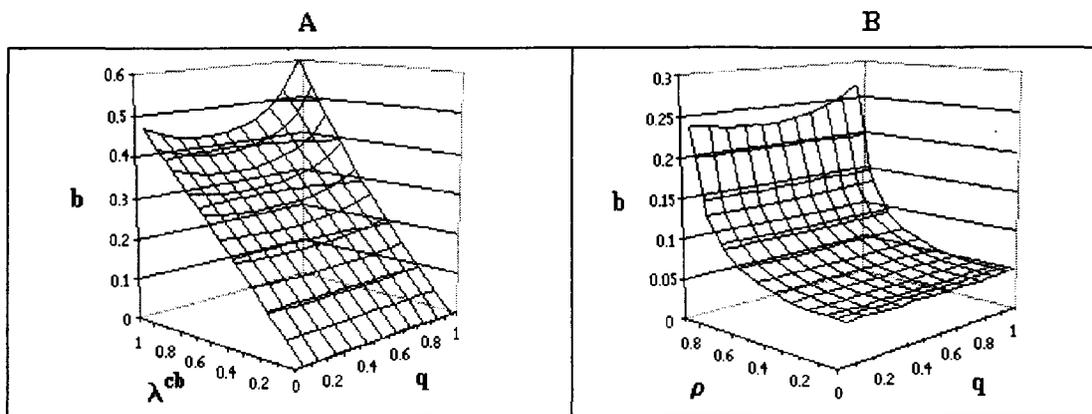
Figure 1: b as a function of q, and λ^{cb} and ρ.

– choosing a central banker with an employment weight below λ will reduce this bias. The optimal response – the so-called commitment equilibrium – is given by $b^* = \lambda\alpha/(1 + \lambda\alpha^2 - \beta\rho^2)$ (see Svensson op.cit). Therefore, lowering λ^{cb} will bring about a gain due to lower stabilization bias as long as $b > b^*$.[16] Furthermore, the figure shows that the parameter b is a U-shaped function of the probability-parameter q,[17] which implies that employment stabilization – in exceptional times – will be reduced by introducing an escape clause; and this will be so both if the starting point is a simple rule or discretionary policy by a conservative central banker.[18] I will return to the explanation for the U-shape below.

Turning to the parameter c – the state-contingent bias – figure 2 shows how this parameter depends on the q, λ^{cb} and ρ. An increase in ρ increases the state-contingent bias since the gain from surprise inflation increases. The figure also show

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[16]It will be optimal to choose even a lower λ^{cb}, even though this introduces a stabilization bias (in the opposite direction) since there still will be a state-contingent bias.

[17]Without employment persistence the parameter b will not be affected by changing the probability-parameter q. The reason is that I have ruled out the average inflation bias, and therefore expected inflation will be zero. The monetary authorities then face the same type of problem if they abandon the simple rule irrespective of the parameter q.

[18]In the case without employment persistence, Flood and Issard (1989) show that the mixed rule (escape clause) always dominates discretion and also dominates the simple rule, if not the variance of the shock hitting the economy is small and the average inflation bias is large.

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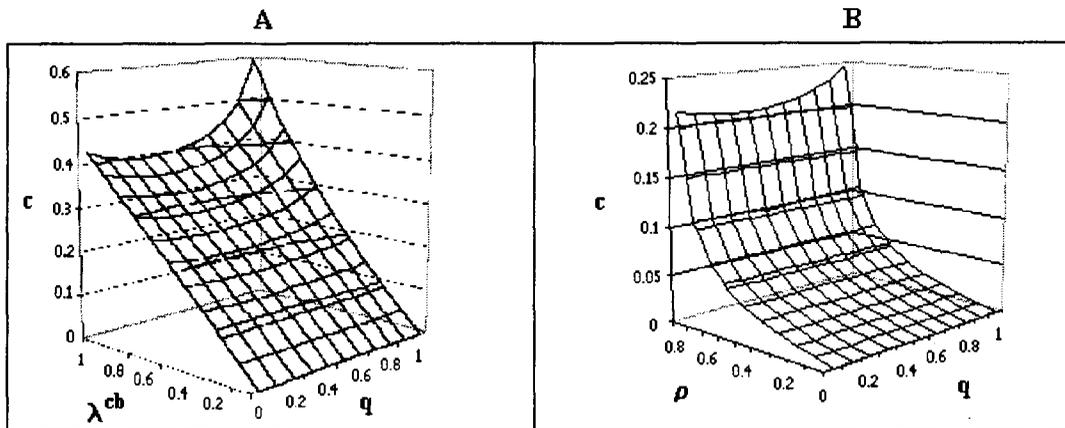
Figure 2: c as a function of q, and λ^{cb} and ρ.

that choosing a conservative central banker decreases the state-contingent bias, as demonstrated by Lockwood et al. (1998). However, in order to remove the this bias altogether the central banker has to put zero weight on the employment goal. Last, also the state-contingent bias is a U-shaped function of the probability parameter q.[19]

The U-shape of b and c as a function of the probability parameter is due to two different factors pulling in opposite directions. The first factor is related to the fact that the monetary authorities will only abandon the simple rule in exceptional times. Since employment persists, the central banker will react more, the more seldom it will act discretionary in the future. This is in order to secure that employment is as close to the goal as possible also in normal times. Hence, the monetary authorities to react more the lower the probability that they will act in the near future, thus the lower q is. The second factor is related to how the probability parameter q influences expected inflation. An increase in the probability of exceptional times will reduce the (absolute) value of expected inflation and make it possible for the authorities to reach a certain level of employment by choosing a lower rate of inflation. This will thus make the reaction lower the lower q is. The first factor will be more important

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[19]To be precise c will only be a U-shaped function of q if there are sufficient employment persistence for given levels of the other parameters. I will return to the reason for this below.

Employment persistence
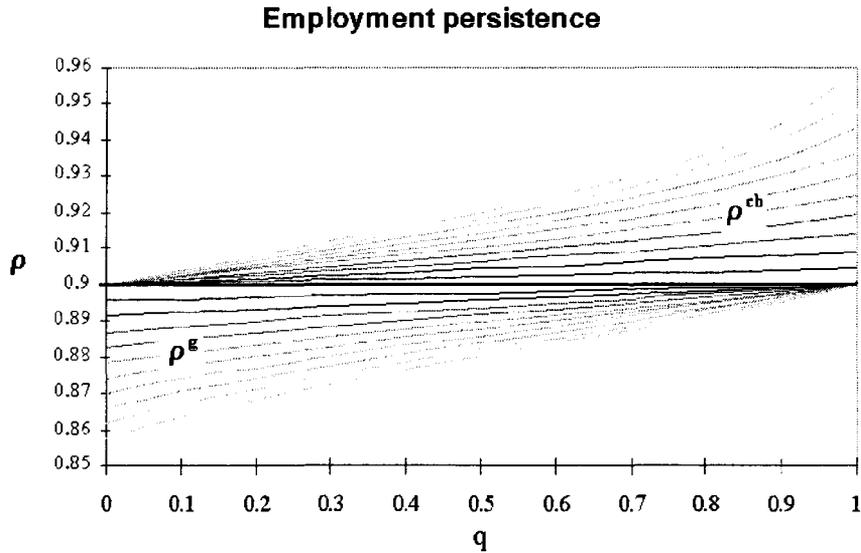
Figure 3: The figure shows how employment persistence – in normal and exceptional times – depends on q and λ.

if q is low; and the second when q is high. In addition, the first factor will be more important the higher the employment persistence is.[20]

Figure 3 shows how employment persistence depends on λ^{cb} and q. The upper part of the figure – values above ρ – shows employment persistence in normal times; and it is seen that increases in the probability q increases the persistence. Since a higher q implies that exceptional times will occur more often, expected inflation will be higher for a given (negative) level of past employment. Therefore, when the central bank sets inflation equal to zero in normal times, this represents a negative inflation surprise and employment persistence will be higher than ρ. As noted above, an escape-clause regime – if there is employment persistence – introduces a state-dependent "Peso-problem". The different lines in figure 3 represent different sizes of λ^{cb}; and higher λ^{cb} pushes the lines upwards in the diagram. Higher λ^{cb} thus increases employment persistence in normal times and the reason is that expected inflation will be higher (for a given negative value of employment). The lower part

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[20]This explains why c is an U-shaped function only if there is sufficient persistence.

of the figure – values below ρ – shows employment persistence in exceptional times; and both q and λ^{cb} will now have opposite effects.

The question that remains to be answered is whether the escape-clause discussed above helps resolve some of the credibility problems in monetary policy. To answer this question, first note that the conservative central banker dominates both discretion and the simple rule. Rogoff (op.cit.) shows that in the one-period case it is optimal to choose a weight on employment variations between zero and that of society. If there is employment persistence, there will be no costs of lowering the weight somewhat below that of society, since stabilization is biased. Furthermore, at $\lambda^{cb} = 0$ – where the conservative central banker mimics the simple rule – the state-contingent bias has disappeared, but there is a stabilization bias. An increase in λ^{cb} will therefore result in an increase of the state-contingent bias of second order, while the stabilization bias will be reduced by first order. Therefore, delegating monetary policy to a conservative central banker will improve welfare.[21]

The next question then is whether the conservative central banker should be dictated further; and the answer is yes. This is due to the fact that the optimal conservative central banker gives the optimal trade off between stabilization and the state-contingent bias. The costs of having such central banker will be higher the higher the realization of the shock is. An escape clause will therefore make it possible for the society to choose a less conservative central banker for the situations when the shocks are large; and a more conservative central banker – someone who puts zero weight on the employment goal – for the situations when the shocks are small.

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[21]This result is shown analytically by Lockwood et al. (1998). They also allow the central banker to have a higher discount factor than the government, thus $\beta^{cb} > \beta$. If persistence ρ is high enough and the discount factor of the central banker is sufficiently higher than β, they show that society may not wish to delegate. I only look at the case where $\beta^{cb} = \beta$.

5 Concluding remarks

This paper extends the discussion about the conduct of monetary policy in the case of employment persistence. The institutional set-up discussed in the paper consists of i) an independent conservative central banker and ii) an escape clause. In normal times the central banker is forced to follow a simple rule of setting inflation equal to zero, but the rule may be abandoned in the case where large shocks have hit the economy. In this cases the central banker carries out monetary policy based on its own preferences, without interference of the government.

It is shown how a simple escape clause works if there is employment persistence. First, as in the case analyzed by Flood and Issard (1989), monetary policy in normal times is reduced to setting inflation equal to the goal; and since expected inflation is non-zero if employment is non-zero, this will represent an inflationary or disinflationary surprise which will influence employment. It is worth noting that in the Flood and Issard (1989)-model the inflationary surprise was due to the average inflation bias, while with employment persistence it will (also) be due to the state-contingent bias. Since expected inflation depends on past inflation so will the inflationary (or disinflationary) surprise, which implies that employment persistence will increase.

In exceptional times monetary policy will be discretionary as in Flood and Issard (1989), though it will be carried out by a conservative central banker. Since expected inflation is lower than it is without the escape clause, monetary policy will be more effective when the rule is abandoned. The result of this is that less inflation surprise is needed to achieve a certain level of employment stabilization. In exceptional times employment persistence will then fall,since the monetary policy surprise will be increasing in past employment.

In the literature escape clauses have been related to fixed exchange rate regimes, where the government keeps a fixed exchange rate in normal times and realigns in exceptional times. This introduces a peso-problem, as the economy will suffer from negative inflation surprises in normal times. If employment persists, the peso problem will be state-contingent, since expected inflation will be higher the lower employment is.

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6 Appendix

To find γ_2 I insert for inflation and employment in normal and exceptional times – equations (13), (15), (16) and (20) – into the Bellman equation (7) and collecting terms. This gives:

$$\gamma_2 = \left(\lambda^{cb} + \beta\gamma_2\right)\rho^2 \left[(1-q)\left(1 - \frac{q\alpha^2\left(\lambda^{cb} + \beta\gamma_2\right)}{1 + (1-q)\,\alpha^2\left(\lambda^{cb} + \beta\gamma_2\right)}\right)^2\right.$$

$$\left. + q\left(\frac{1}{1 + (1-q)\,\alpha^2\left(\lambda^{cb} + \beta\gamma_2\right)}\right)^2\right] +$$

$$q\left(\frac{\alpha\left(\lambda^{cb} + \beta\gamma_2\right)}{1 + (1-q)\,\alpha^2\left(\lambda^{cb} + \beta\gamma_2\right)}\right)^2 \rho^2, \tag{21}$$

and solution to this can be written as:

$$\gamma_2 = \frac{1}{2\left(\rho^2\beta^2\alpha^2 - 4\rho^2\beta^2\alpha^2 q\,(1-q) - \alpha^2\beta\,(1-q)\right)}$$

$$\times \left[1 - \rho^2\beta - 2\rho^2\lambda^{cb}\alpha^2\beta + 8\rho^2\lambda^{cb}\alpha^2\beta q\,(1-q)\right.$$

$$\left. + \alpha^2\lambda^{cb}\,(1-q) \pm \sqrt{A}\right], \tag{22}$$

where

$$A = \left(1 - \rho^2\beta\right)^2 - 4\rho^2\alpha^2\beta\lambda^{cb}$$

$$+ \left[16\rho^2\lambda^{cb}\alpha^2\beta q\,(1-q) + 2\rho^2\lambda^{cb}\alpha^2\beta\,(1-q)\right.$$

$$\left. + 2\alpha^2\lambda^{cb}\,(1-q) + \alpha^4\lambda^{cb2}\,(1-q)^2\right], \tag{23}$$

and the smaller solution is the relevant one. To see this, note that from equation (21) that $\gamma_2 = 0$ if $\rho = 0$, and that $\gamma_2 = \lambda^{cb}\rho^2\frac{1+\alpha^2\lambda^{cb}+4\alpha^2\lambda^{cb}q(q-1)}{1+\alpha^2\lambda^{cb}(1-q)}$ if $\beta = 0$. Considering the limit of the two solutions for γ_2 as $\rho \longrightarrow 0$ and $\beta \longrightarrow 0$ gives

$$\lim_{\rho\to 0}\gamma_2^+ = -\frac{1 + \alpha^2\lambda^{cb}\,(1-q)}{\alpha^2\beta\,(1-q)}, \quad \lim_{\beta\to 0}\gamma_2^+ = \infty, \text{ and}$$

$$\lim_{\rho\to 0}\gamma_2^- = 0, \quad \lim_{\beta\to 0}\gamma_2^- = \lambda^{cb}\rho^2\frac{1 + \alpha^2\lambda^{cb} + 4\alpha^2\lambda^{cb}q\,(q-1)}{1 + \alpha^2\lambda^{cb}\,(1-q)}.$$

Therefore, the smaller root is the relevant one.[22]

A necessary condition for γ_2 to have real solutions is that A is non-negative. It is clear from A that the term in the square brackets reaches its minimum at $q = 1$ (with $0 \leq q \leq 1$). A sufficient condition for the existence of a solution is therefore that

$$\lambda^{cb} \leq \overline{\lambda} = \frac{(1 - \rho^2 \beta)^2}{4 \rho^2 \alpha^2 \beta},$$

that is, the condition for the situation without escape clause will suffice.

References

Alexius, Annika, "Inflation Rules with Consistent Escape Clauses," *European Economic Review*, 1999, *43*, 509–523.

Barro, Robert J. and David B. Gordon, "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 1983, *91*, 589–610.

Batini, Nicoletta and Andrew G. Haldane, "Forward-Looking Rules for Monetary Policy," May 1998. NBER Working Paper Series 6543.

Blinder, Alan S., "What Central Bankers Could Learn from Academics-and Vice Virsa," *Journal of Economic Perspectives*, 1997, *11* (2), 3–19.

Flood, Robert and Nancy Marion, "Perspectives on the Recent Currency Crisis Literature," 1998. NBER Working Paper Series 6380.

_ **and Peter Issard**, "Monetary Policy Strategies," 1988. NBER Working Paper Series 2770.

_ **and** _ , "Simple Rules, Discretion and Monetary Policy," 1989. NBER Working Paper Series 2934.

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[22]See Appendix A in Svensson (1997).

Kydland, Finn E. and Edward C. Prescott, "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, 1977, *85*, 473–492.

Leitemo, Kai, "Inflation Targeting Strategies in Small Open Economies," July 1999. Manuscript.

Lockwood, Ben and Aspostolis Phillippopoulos, "Insider Power, Unemployment Dynamics and Multipe Inflation Equilibria," *Economica*, 1994, *61*, 59–77.

__ , **Marcus Miller, and Lei Zhang**, "Designing Monetary Policy When Unemployment Persists," *Economica*, 1998, *65*, 259–327.

Lohman, Susanne, "Optimal Commitment in Monetary Policy: Credibility versus Flexibility," *American Economic Review*, 1992, *82* (1), 273–286.

McCallum, Bennett T., "Two Fallacies Concerning Central Bank Independence," 1995. NBER Working Paper Series 5075.

__ , "Inflation Targeting in Canada, New Zealand, Sweden, the United Kingdom, and in General," 1996. NBER Working Paper Series 5579.

__ **and Edward Nelson**, "An Optimizing IS-LM Framework for Monetary Policy and Business Cycle Analysis," 1997. NBER Working Paper Series 5875.

Modery, Wolfgang, *Internationale Währunspolitische Arrangements Auf Dem Prüfstand Ökonomischer Effiziens*, Frankfurt am Main: Europäischer Verlag der Wissenschaften, 1995.

Obstfeld, Maurice, "Destabilizing Effects of Exchange-Rate Escape Clauses," *Journal of International Economics*, 1997, *43*, 61–77.

Persson, Torsten and Guido Tabellini, "Designing Institutions for Monetary Stability," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 53–84.

Rogoff, Kenneth, "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, 1985, *100*, 1169–1190.

Svensson, Lars E. O., "Optimal Inflation Targets, "Conservative" Central Banks, and Linear Inflation Contracts," *American Economic Review*, 1997, *87* (1), 98–114.

_ , "Inflation Targeting as a Monetary Policy Rule," *Journal of Monetary Economics*, 1999, *43*, 607–654.

_ , "Open-Economy Inflation Targeting," *Journal of International Economics*, 2000, *50*, 155–183.

Taylor, John B., "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 195–214.

Walsh, Carl E., "Optimal Contracts for Central Banks," *American Economic Review*, 1995, *85* (1), 150–167.

ESSAY 2:

The sources of German business cycles: how important are permanent shocks?*

Abstract

In this paper I analyze the German business cycles by conducting a structural VAR analysis using long-run restrictions. The results are that the disturbances that drive unemployment and output in the long run also seem to be important factors for the business cycles. However, the most important factor for the development of the unemployment and output gaps seems to be disturbances that have permanent effects on the rate of unemployment; and since this disturbance drives the output gap and the price level in the same direction, the potential conflict of monetary policy might be less.

1 Introduction

This paper looks at the sources of variation of key macroeconomic variables in Germany. The motivation to do so is the fact that the Bundesbank is often used as an example of a so-called weight-conservative independent central bank. The origin is the work of Rogoff (1985), who suggested to choose a central banker with a lower weight on the output or unemployment goal than the society has. This reduces the so-called inflationary bias, since the CB has less incentives to inflate. However, it introduces a stabilization bias because the high weight on stable inflation will induce the CB to react less to an unfavorable disturbance to output or unemployment.[1] The importance of this trade-off between reducing the inflationary bias and increase in output/unemployment variation depends on how important different shocks are for the development of output and unemployment. The potential conflict will be higher if these variables are mainly driven by the shocks that have opposite effects on unemployment/output and prices. In the literature these shocks have been related to supply side disturbances. This follows from a text-book AD-AS model: negative

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[1] The paper builds on the credibility literature after the seminal paper by Kydland and Prescott (1977) later popularized by Barro and Gordon (1983a,b). The idea is that the authorities will have incentives to reduce unemployment below the natural level due to market failures giving a too high natural level. Rational agents will, however, know about these incentives of the authorities and will expect a rate of inflation, so that the cost of reducing unemployment by surprise inflation will be high enough to discourage the authorities to do so. This literature has been criticized by several authors, e.g. Blinder (1997), who claim that there is no reason why an independent central bank will have a different goal for unemployment (or output) than the natural level; and if this is so, there is no time-inconsistency problem. It is interesting to note, however, that Blinder is sympathetic to Rogoff's interpretation of an independent central bank: "Indeed, the noun 'central banker' practically cries out for the adjective 'conservative'."

In a recent paper, Clarida et al. (1999) argue that there may be gains from following a rule (rather than discretionary policy) even if the goal of the authorities is the natural level. The reason is that inflation is a forward-looking variable; it depends on - amongst other things - the conduct of monetary policy in the future. Therefore, if the authorities could - in a credible way - commit themselves to react aggressively on future inflation, it would have to decrease activity less today to bring inflation down. An independent weight-conservative central banker may be a credible signal to fight inflation in the future.

aggregate demand shocks (monetary or fiscal) lead to a decrease in GDP and prices, while a negative aggregate supply shocks lead to a decrease in GDP and an increase in prices.

Svensson (2000) argues that some supply shocks will increase the output potential (as well as output), so that the output gap may – in fact – decrease following a positive shock. Thus, following these shocks there will be no conflicts in the traditional sense.[2] The different types of shocks may, however, affect the output gap and inflation differently over time. So even if the output gap and inflation move in the same direction, a conflict of goals may arise.

In order to focus on the source of variation of different variables I conduct a structural vector autoregressive (SVAR) analysis using long-run restrictions. SVAR analysis has come to be a common tool in analyzing business cycles and has proven to give information about the source of fluctuations of macroeconomic variables. The strategy used in this paper to decompose the different shocks follows Shapiro and Watson (1988) to some extent, and the identification is done using long-run restrictions. This was first used by Blanchard and Quah (1989) in their seminal article on the sources of fluctuations in output and unemployment for the US. Long-run restrictions are also utilized by Clarida and Gertler (1996) in their analysis about the source of variations in the real exchange rate. Furthermore, Galí (1992) uses a combination of short-run and long-run in his analysis of the US business cycles.

The analysis is done using five variables: the rate of unemployment, the gross domestic product, the real exchange rate, the consumer price index, and a measure of the nominal money holdings in the economy (M3). The motivation for choosing these variables is that they are normally considered important for the conduct of monetary policy. I assume that these variables are driven by five structural distur-

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[2]This follows if the goal of the monetary authorities should be to limit variations in output and unemployment around their natural levels. In order to change the natural level of these variables other policy measures have to be used, such as structural policy to reduce structural unemployment or tax-policy to increase the well-functioning of the market economy. In this case, the motivation of selecting an independent central bank also disappears. However, one might argue that these supply shocks do not change the market inefficiencies, and therefore the government incentives to use surprise inflation do not change.

bances – four permanent and one transitory. The actual ordering is done as follows: Permanent labour shocks are defined as the only disturbances that have a long-run impact on the rate of unemployment, thus they change the natural rate of unemployment. Permanent output shocks do not have a long-run impact on unemployment, but shifts the production frontier and will thus have a long-run impact on GDP. Permanent real exchange rate shocks do not have a long-run impact on neither unemployment nor on GDP, but may change composition of GDP via their long-run impact on the real exchange rate. Neither the permanent real money shocks nor the transitory shocks have long-run impact on the unemployment and output. In addition they do not change the real exchange rate in the long run. The transitory shocks – in addition – are assumed not to have a long-run effect on real money holdings. This set of restrictions then identifies the structural disturbances and reveal how they affect the macroeconomic variables both contemporaneously and through time.

This analysis will also enable me to look closer on some monetary policy issues. More precise, by looking at the impulse responses following different shocks I try to get "indirect" evidence of how monetary policy was conducted by the German Bundesbank. In particular I ask how the Bundesbank seems to have reacted on the permanent labour and output disturbances; and what seems to have been the target for German monetary policy.

Since the first of January 1999 the European Central Bank (ECB) has been responsible for conducting monetary policy in most of the countries in the European Union. Germany participates in the monetary union and thus this event also ended the era of the German Bundesbank as the responsible monetary policy institution. Understanding how the Bundesbank conducted monetary policy may, however, still give important insights about monetary policy issues. First, the Bundesbank is well known for its inflation record, and thus understanding how this was achieved is certainly an important task. Secondly, the ECB is said to be constructed as a mirror image of the Bundesbank, thus insight about the Bundesbank may – as a by-product – give insights about the future operations of the ECB. If this is so, and since the German economy is important for the development of Euroland – and thereby giving

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correlation between business cycles in Germany and Euroland, analyzing the sources of business cycles development in Germany will also give insights about the possible cost for Germany of having an independent – and conservative – European central bank.

Funke (1997b) analyzes a bivariate SVAR with industrial production and producer prices using a long-run Blanchard-Quah restriction. He finds that demand shocks account for slightly less than 50 per cent of the contemporaneous variations in industrial production; but the effect of the demand disturbances is short-lasting and reaches zero already after three quarters. Therefore, supply shocks are seen to be the most important factor also in the short run, pointing towards a potential monetary policy conflict between inflation and output. Bergman (1996) also conducts a bivariate VAR, but the analysis is done using German real GDP and consumer price inflation. He reports that permanent output disturbances account for around 20 per cent of the contemporaneous variation in output; and that this fraction rises to more than 50 per cent after 20 quarters. These results also square with Karras (1994), who uses unemployment and output and conducts a Blanchard and Quah (1989) analysis.

Weber (1996) conducts a structural VAR analysis using six variables – changes in employment, GDP, the real interest rate, the real wage, the real money holdings and the nominal interest rate. One important finding of his analysis is that aggregate demand shocks seem to be the most important factor driving output in the short run; thus indicating that the costs of a conservative central banker will be limited. To identify the shocks Weber uses a combination of short-run and long-run restrictions, while I exclusively look at long-run restrictions. This is an important difference, since I also explicitly considers the real exchange rate. It might be questioned whether restricting the monetary shocks not to influence output within the quarter – which is done by Weber (1996) – is correct if the exchange rate channel is important.

Clarida and Gertler (1996) rely on short-run restrictions in their analysis of the German economy. Their aim is to describe how the Bundesbank conducted monetary policy, however, and they do not focus on the sources of variations in the

macroeconomic variables.[3] Funke (1997a) also relies on short-run restrictions in his five-variable SVAR. He uses real GDP, the rate of unemployment, the GDP deflator, hourly earnings and M3 to conduct an analysis based on the work of Blanchard (1989). He finds that demand shocks are the most important factor driving output variations in the short run, while supply shocks are more important in the long run. Supply shocks are the most important factor driving variations in unemployment; and demand shocks only play a minor role in the short run. Therefore, if the central bank cares about variations in the rate of unemployment, Funke's analysis indicates that there might be trade-offs in monetary policy between unemployment and inflation.

The rest of this paper is organized as follows: The second part describes the empirical procedure, and the third part the empirical results – how the different variables react to different shocks and what are the sources of variation of the variables. The fourth part concludes.

2 Structural VAR analysis

2.1 Identification

The identification scheme used in this paper is an extension of Shapiro and Watson (1988). I consider a five-variable vector autoregressive (VAR) model for the German economy. The variables are the rate of unemployment, the gross domestic product (GDP), the real exchange rate (RER), the consumer price index (CPI), and the monetary aggregate M3.[4] The variables are denoted u_t, y_t, q_t, p_t, and m_t, respectively, and all variables, except for the rate of unemployment, are in logs.

I assume that the five variables are driven by five serially and mutually indepen-

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[3]To do the analysis they set up an eight variable VAR; and they are able to identify a money demand and a money supply relationship. The latter is then used to analyze the behavior of the German policy instrument, which is assumed to be the day-to-day interest rate.

[4]The data sources are as follows: for GDP, CPI, the real exchange rate, and M3 – Statistiche Bundesamt; the rate of unemployment – OECD before 1992:2 and Statistische Bundesbank thereafter.

dent so-called structural shocks: permanent labour shocks e_t^{ls}, permanent output shocks e_t^{os}, permanent real exchange rate shocks e_t^{qs}, permanent real money shocks e_t^{rms}, and transitory shocks e_t^{ts}. Letting $\mathbf{X}_t = (\Delta u_t, \Delta y_t, \Delta q_t, \Delta p_t, \Delta m_t)'$ be the vector of covariance stationary macroeconomic variables, and $\mathbf{e}_t = \left(e^{ls}, e_t^{os}, e_t^{qs}, e_t^{rms}, e^{ts}\right)'$ the vector containing the structural shocks, it is assumed that the macroeconomic variables can be represented as:

$$\mathbf{X}_t = \Phi\left(L\right)\mathbf{e}_t, \tag{1}$$

where $\Phi\left(L\right) = \left(\Phi_u\left(L\right), \Phi_y\left(L\right), \Phi_q\left(L\right), \Phi_p\left(L\right), \Phi_m\left(L\right)\right)$ is a 5×1 polynomial matrix. I follow the convention and assume that the structural shocks are orthogonal and normalize their variance to unity. These assumptions therefore imply that $E\mathbf{ee}' = \mathbf{I}_5$, where E is the expectation operator.

The reduced-form Wold-moving-average representation of equation (1) is given by:

$$\mathbf{X}_t = \mathbf{B}\left(L\right)\boldsymbol{\varepsilon}_t, \tag{2}$$

where $\boldsymbol{\varepsilon}_t \backsim N\left(0, \Sigma\right)$. Therefore, it is assumed that the reduced form innovations and the structural shocks are related by $\boldsymbol{\varepsilon}_t = \mathbf{C}\mathbf{e}_t$,

$$\mathbf{X}_t = \mathbf{B}\left(L\right)\mathbf{C}\mathbf{e}_t, \tag{3}$$

where $\mathbf{C} = \Phi\left(0\right)$ since $\mathbf{B}\left(0\right) = \mathbf{I}$, and the two polynomial matrixes are related by $\Phi\left(j\right) = \mathbf{B}\left(j\right)\mathbf{C}$ for all j. The reduced form innovations are thus assumed to be linear combinations of the structural shocks. This specification follows Amisano and Giannini (1997), and the model is a so-called C-model after the matrix relating the structural model to the VAR representation. I will estimate the inverted version of this equation, thus

$$\mathbf{A}\left(L\right)\mathbf{X}_t = \boldsymbol{\varepsilon}_t, \tag{4}$$

where $\mathbf{A}\left(L\right) = \mathbf{I} - \mathbf{A}_1 L - ... - \mathbf{A}_p L^p$. This gives estimates of the $\mathbf{A}\left(L\right)$ polynomial matrix and the covariance matrix Σ. Besides, since $\mathbf{A}\left(L\right) = \mathbf{B}\left(L\right)^{-1}$, this also gives estimates of the $\mathbf{B}\left(L\right)$ matrix.

To be able to identify the five types of structural disturbances I need 25 different restrictions. I get $5(5+1)/2 = 15$ restrictions from normality and the orthogonality of the structural shocks: taking expectations on both sides of $\varepsilon_t \varepsilon_t' = \mathbf{C} e_t e_t' \mathbf{C}'$ gives $\mathbf{CC'} = \Sigma$, which is a symmetric matrix and thus contains 15 different elements. Therefore, I need 10 additional restrictions, which I get from the long-run restrictions.[5]

In this paper I limit the identification to recover the structural disturbances $\varepsilon_t = \mathbf{C} e_t$; therefore I leave the structural equations unrestricted in the sense that I do not recover how the different variables interact. A generalization of the C-model in equation (3) is the AB-model given by

$$\mathbf{AA}(L)\mathbf{X}_t = \mathbf{B} e_t,$$

where thus $\mathbf{C} = \mathbf{A}^{-1}\mathbf{B}$ give the simplified model used above. In addition to identifying the shocks the structural relationships between the different variables are also identified. To do this, additional 25 restrictions will have to be put on the system, however. The advantage of the C-model is thus that "few" restrictions will have to be specified; but the disadvantage is that the structural relationships are not identified. This makes the analysis less appropriate for e.g. counterfactual analysis, where tests on parameter stability amongst the structural parameters are important in judging the validity.

The structure of the restrictions used in this paper may be written as

$$
\begin{pmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & -1 & 1 \\
0 & 0 & 0 & 0 & 1
\end{pmatrix}
\Phi(1) =
\begin{pmatrix}
* & 0 & 0 & 0 & 0 \\
* & * & 0 & 0 & 0 \\
* & * & * & 0 & 0 \\
* & * & * & * & 0 \\
* & * & * & * & *
\end{pmatrix},
\tag{5}
$$

where "*" denotes unrestricted elements. Unemployment is therefore driven by the permanent labour shocks in the long run; while output is driven by both permanent labour shocks and permanent output shocks. The idea is consequently that there

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[5]For a critical discussion of the use of long-run restrictions see e.g. Canova et al. (1993).

exist shocks that only affect output, without affecting the rate of unemployment. Furthermore, there are shocks that do not affect neither unemployment nor output, but they affect the real exchange rate. These are shocks that change the composition of GDP, without affecting its level. The last long-run restriction relates to shocks that may change the real money holdings in the long run, but do not change the real exchange rate. This is the restriction used by Clarida and Galí (1994) in their analysis of the sources of real exchange rate variations. They assume that neither money demand nor money supply shocks affect the real exchange rate in the long run. I have labeled this disturbance permanent real money shocks. The last shock – the transitory shock – is not allowed to affect any of the real variables in the long run.

It might be questioned whether the chosen ordering is appropriate. Not at least is the ordering of permanent real exchange rate and real money shocks to some extent arbitrary. The actual ordering says that there might be disturbances that changes the real money balances in the long run, but not the real exchange rate.[6] This paper is mostly concerned about shocks that affect unemployment or output in the long run, however, and the identification of the permanent labour shocks and the permanent output shocks does not depend on the ordering of the permanent real exchange rate and real money shocks.

Notice that the $\mathbf{C}$ matrix might be recovered from the data using the Cholesky decomposition. To see this, note that the right hand side of the equation (5) – from now denoted $\mathbf{P}$ – is lower triangular. Therefore, it is the Cholesky decomposition of the matrix $\mathbf{F}\Phi\left(1\right)\Phi\left(1\right)'\mathbf{F}' = \mathbf{FB}\left(1\right)\mathbf{CC'B}\left(1\right)'\mathbf{F}'$, where $\mathbf{F}$ is the first matrix on the left hand side of equation (5). Here the $\mathbf{C}$ matrix enters, though, which is unobserved, but knowing that $\mathbf{CC'} = \Sigma$ the relationship may be written as

$$\mathbf{PP'} = \mathbf{FB}\left(1\right)\Sigma\mathbf{B}\left(1\right)'\mathbf{F'}. \tag{6}$$

The contemporaneous relationships – the $\mathbf{C}$ matrix – may therefore be found by

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[6]For instance, if money is neutral in the long run, changes in the demand for money will fall into this category. See e.g. Weber (1994) for a discussion about long-run neutrality.

using

$$C = (FB(1))^{-1}P,$$

which follows from equation (5) above.

2.2 Unit-root test and lag structure

In the outline of the structural VAR model above I have assumed that Δu_t, Δy_t, Δq_t, Δp_t, and Δm_t are stationary time series. Here these assumptions are tested using Augmented Dickey-Fuller (ADF) tests, Phillips-Perron (PP) tests, and the Kwiatowski-Phillips-Schmidt-Shin (KPSS) test, thus I look at the unit-root properties for the five series. The former two groups of tests use non-stationarity as the nil hypothesis, while the latter test uses stationarity. The lag length is calculated using the LB-test and the LM-test for autocorrelation. The results are reported in table 1.

The rate of unemployment seem to be integrated; neither the ADF-tests nor the PP-tests can reject the H0 of non-stationarity against stationarity – or trend-stationarity – at any level of significance (up to the 10 per cent level) and the KPSS-test can reject stationarity at the one per cent level of significance.[7] The tests on the first difference of the rate of unemployment can reject non-stationarity (at least at the five per cent level), and the H0 of the stationarity test cannot be rejected at the 2.5 per cent level. Thus, unemployment seems to be I(1) and its first difference I(0). The same results are found for output and nominal money holdings. For the former trend-stationarity can be rejected at the 2.5 per cent level (and none of the non-stationarity tests can be rejected); and the non-stationarity test for the first difference of output can be rejected at the one per cent level for all tests. For the latter trend-stationarity can be rejected at the five per cent level and three of the non-stationarity test do not reject the nil hypothesis (the ADF Z-test reject non-stationarity against trend-stationarity at the 10 per cent level, though): and both the non-stationarity tests are rejected at the one per cent level for the first

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[7]Trend-stationarity is rejected at 2.5 level of significance.

difference. Therefore, both output and nominal money seem to be I(1) with a trend and the first difference hence I(0).

Unfortunately, however, the tests give somewhat unclear results regarding two of the time-series, namely for the real exchange rate and the price level. For the first difference of the real exchange rate the tests uniformly reject non-stationarity at the one per cent level, and stationarity cannot be rejected at any level of significance. This indicates that the first difference is indeed I(0). However, the tests are unclear regarding the level of the variable. First, stationarity and trend-stationarity can be rejected at the ten and one per cent level of significance, respectively. Secondly, the ADF-tests reject non-stationarity at the one per cent level of significance for the t-test (also when a trend is included) and at the 2.5 per cent level for the Z-test (and at the ten per cent level when a trend is included). The PP-tests, however, fail to reject non-stationarity, except for the t-test without a trend, where unit-root may be rejected at the 10 per cent level. Despite of the unclear results, I will keep the initial assumptions and treat the real exchange rate as a non-stationary time series, and its first difference as stationary.

For the price level the tests suggest that the series are at least I(1) with a trend since none of the non-stationarity tests can be rejected at any level of significance and the trend-stationary test can be rejected at the five per cent level. The test on the first difference of the series give less clear results, though. Both PP-tests reject the non-stationarity at the one per cent level, but only the ADF Z-test rejects non-stationarity – and only at the 10 per cent level. Moreover, stationarity is – in fact – rejected at the five per cent level of significance. However, considering the unit-root property of nominal money, it seems natural to assume that the price level is also I(1) with trend and that its first difference is stationary.

All in all the tests suggest the following unit-root property for the series:

$$u \to I(1), \qquad \Delta u \to I(0)$$
$$y \to I(1) + trend, \quad \Delta y \to I(0)$$
$$q \to I(1) + trend, \quad \Delta q \to I(0) \tag{7}$$
$$p \to I(1) + trend, \quad \Delta p \to I(0)$$
$$m \to I(1) + trend, \quad \Delta m \to I(0).$$

Table 1: Unit-root properties of the time-series

			Test statistic[1]		
x	# lags LB/LM	DC[2]	t-test ADF/PP	Z-test AD/PP	KPSS
u	3/1	C	-2.3479/-1.2389	-6.1693/-2.0414	1.3317^{iv}
		T	-2.7289/-1.6225	-13.8966/-4.7205	0.2118^{iii}
Δu	2/0	C	$-3.0410^{iv}/-3.6481^{iv}$	$-25.419^{iv}/-24.8196^{iv}$	0.1885
y	4/1	T	-2.0527/-2.1712	-7.3715/-6.3685	0.1905^{iii}
Δy	3/0	C	$-3.8960^{iv}/-8.0839^{iv}$	$-49.0059^{iv}/-81.8087^{iv}$	0.2403
q	2/1	C	$-3.8066^{iv}/-2.6538^{i}$	$-19.3614^{iii}/-9.5808$	0.3547^{i}
		T	$-4.2130^{iv}/-2.7499$	$-19.6443^{i}/-9.6968$	0.3155^{iv}
Δq	1/0	C	$-4.4038^{iv}/-5.8854^{iv}$	$-38.3595^{iv}/-47.8120^{iv}$	0.2486
p	3/1	T	-2.4990/-2.1964	-12.3932/-5.8930	0.1604^{ii}
Δp	2/0	C	$-2.5044/-4.9705^{iv}$	$-12.6130^{i}/-34.6408^{iv}$	0.4769^{ii}
		T	$-2.54965/-5.17750^{iv}$	$-13.65403/-38.53750^{iv}$	0.2674^{iv}
m	1/1	T	-2.9631/-2.7131	$-17.9804^{i}/-14.1275$	0.1714^{ii}
Δm	0/0	C	-7.2455^{iv}	-62.1073^{iv}	0.0593

[1]The superscript i,ii, iii, and iv indicate that the test statistic is significant at the 10, 5, 2.5 and 1 per cent level. If the test includes a constant, the critical values are -2.58, -2.89, -3.17 and -3.51 for the t-tests; and -11.0, -13.7, -16.3, and -19.8 for the Z-tests. If the test includes both a constant and a trend, they are -3.15, -3.45, -3.73 and -4.04 for the t-tests; and -17.5, -20.7, -23.6, and -27.4 for the Z-test. The critical values for the KPSS-test are 0.347, 0.463, 0.574, and 0.739 for stationarity and 0.119, 0.146, 0.176, and 0.216 for trend-stationarity.

[2]This column indicates which deterministic variables are included in the regression. "C" de-

notes a constant and "T" a trend, and the latter include both a deterministic constant and a trend.

Before testing for the appropriate lag length, a ratio test was used to test whether or not to include a dummy for the German reunification, i.e. a dummy for the first quarter of 1991. The test rejected the exclusion of this dummy at the five per cent level of significance using different lag lengths.[8] The lag length for the reduced form VAR was then calculated using a ratio tests paring down the lag length starting with eight lags (see e.g. Enders 1995: 312-314). These tests indicate the use of four lags.[9]

3 The sources of German business cycles

3.1 Impulse response functions

The impulse response functions show the impact on variable x_i in period $t + s$ from a one-unit increase in shock e_j in period t. Since the shocks are orthogonal by construction, this gives information about how the four variables react over time to the different disturbances. Figure (1) and (2) show the impulse response functions of a one-standard deviation shock for unemployment, output, the real exchange rate, prices, and nominal and real money balances following (permanent) labour, (permanent) output, (permanent) real exchange rate, (permanent) real money (RM), and transitory shocks. The figures also include a 10 % confidence bands: so with 90 % probability, the shocks will have effects that fall within the bands.

A positive labour shock decreases the rate of unemployment and increases output. Since a natural interpretation of labour shocks are disturbances that – all other things equal – decrease labour costs, the effects are therefore as expected. A decrease in the wage demand from labour unions decreases unemployment and increases

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[8]The levels of significanse were 0.00499880, 0.00000001, 0.00000001, 0.00000002, and 0.00000000, for the tests using 2,...,6 lags, respectively.

[9]The significance levels were 0.76668105, 0.41086736, 0.16099151, 0.52192216, and 0.00025340 for the test of seven versus eight lags, six versus seven, etc.

Impulse Response Functions
10% confidence bands
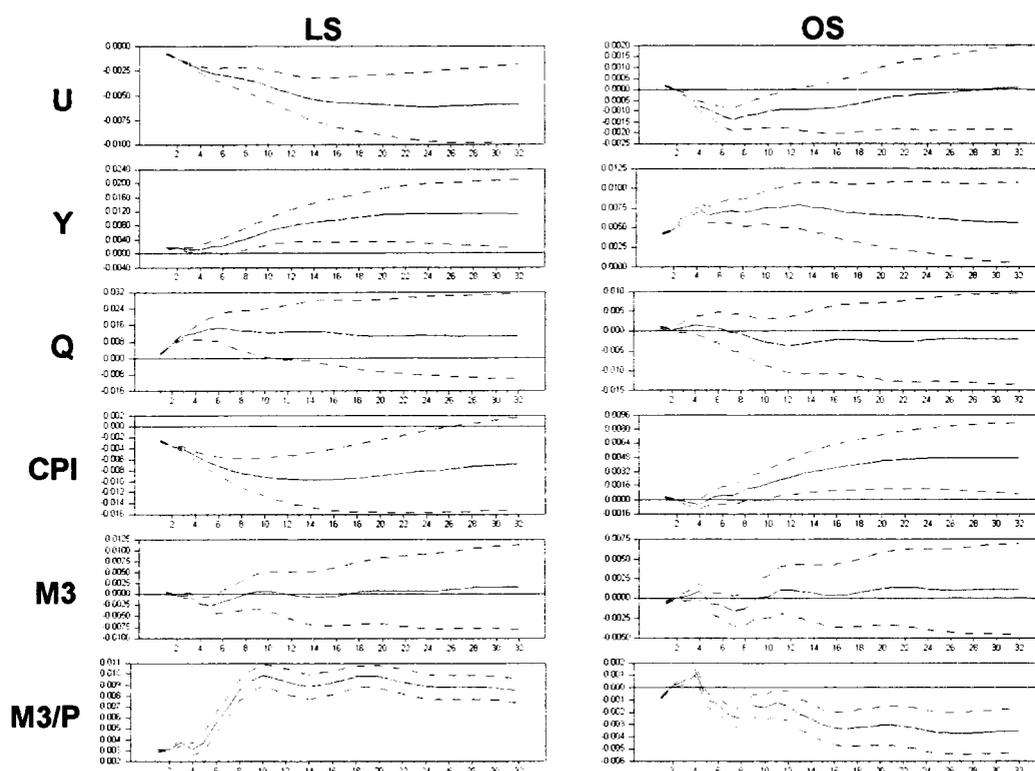
Figure 1: Permanent labour and output shocks.

output by shifting the technology frontier. Notice that unemployment decreases steadily after the initial effect and settles on a higher level after some 16 quarters. Output, however, hardly reacts the first 4-6 quarters after the initial disturbance. Eventually, though, output starts increasing and settles on a higher level after about 20 quarters. As a result, the response of output seem to have a one-year long delay compared to that of the rate of unemployment. One possible explanation to this finding is a simple Keynesian demand story. An exogenous increase in wage demand from labour unions – i.e. a negative labour shock – will have two effects on output.[10] First, there is the direct effect of increased costs of production which should decrease

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[10]This effect will, however, be reduced to some degree due to open-economy effects: there will be a real apreciation, which will increase exports and shift demand from imported towards domestically produced goods.

output. Secondly, there is the indirect effect of increased demand due to higher real wages. A possible explanation of the delayed effect is consequently that, in the short run, the indirect effect more or less cancels out the direct effect. Eventually increased demand feeds into higher prices and output starts to fall. Unemployment increases also in the short run, though, due to substitution in production away from labour.

The real exchange rate increases following a positive labour shock, while the price level decreases. The increase in domestic production reduces the demand for foreign currency – therefore the nominal exchange rate increases. Furthermore, the domestic price level falls, which also will increase the real exchange rate. Some of the effect on the price level is, however, reversed. This would be the case with slow adjustment of nominal wages and mark-up pricing: when wages start to grow due to low unemployment, prices will then increase. This may then also explain the overshooting of the real exchange rate. Since the price level decreases following a labour market shock, this means that this shock has opposite effects on output and prices. For that reason, there exists a possible trade-off of monetary policy following such shocks: the interest rate should be reduced in order to increase output and decrease unemployment, while it should be raised to decrease inflation.

As far as the effect on the monetary aggregates are concerned, the nominal money holdings hardly change, while the real money holdings increase due to the fall in the price level. The former may be seen as an indication that the Bundesbank has not reacted to labour market shocks: it has accommodated the changes in the different variables following this shock.

The permanent output shocks – which increase output – decrease unemployment temporarily. Furthermore, prices seem to increase. The effect on the real exchange rate is small and not significantly different from zero shortly after the disturbance occurred.

One possible explanation for the sign of the effect on prices is that the identification picks up fiscal shocks with small permanent effects. Changes in aggregate demand would then have effects both on prices and output in the short run, while most of the effect would translate into higher prices in the long run. This could also

Impulse Response Functions
10% confidence bands
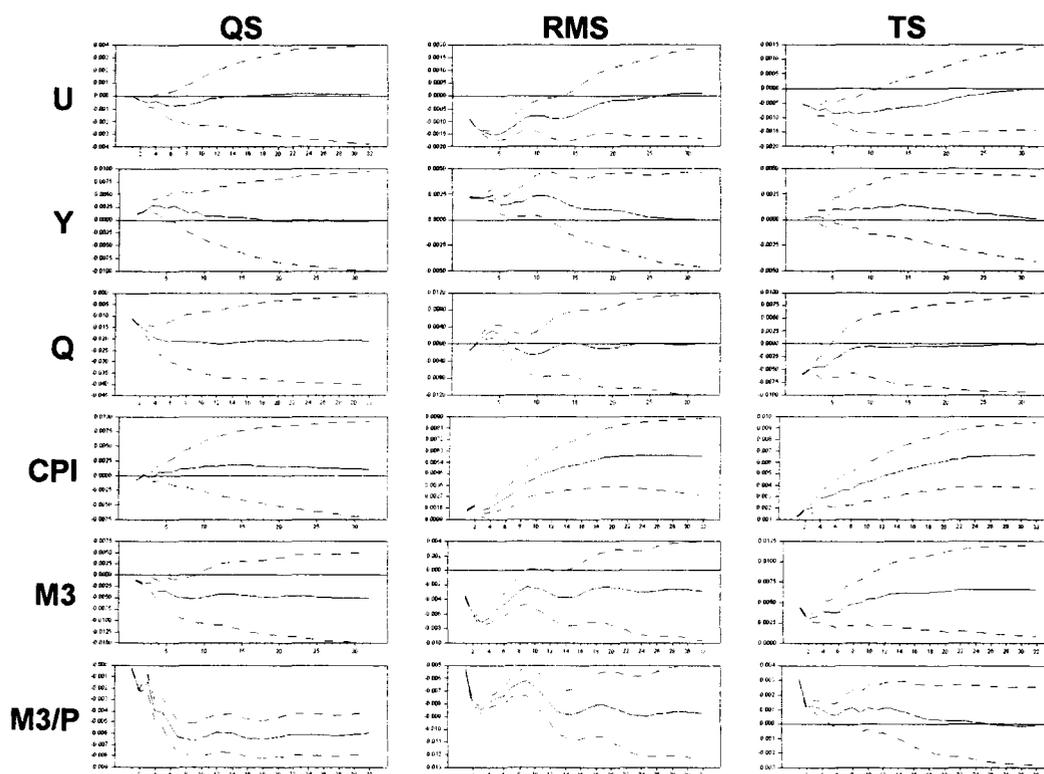
Figure 2: Permanent real exchange rate shocks; permanent real money shocks; and transitory shocks.

explain the hump-shaped impulse response of output, since most of the effect of a aggregate demand shock dies out.

As far as the effect on nominal and real money holdings are concerned, the former hardly change and the latter fall due to the increase in prices. Thus the Bundesbank does not seem to have reacted to permanent output shocks either.

Permanent real exchange rate shocks lead to a temporary decrease in the rate of unemployment and a temporary increase in output. Besides, there is an increase in prices — even though the initial effect is negative — and the real exchange rate decreases. Except from the initial effect on the price level, the effects are then in accordance to a standard text-book macro model: the shocks move the investment-

supply curve. If this is so, the effects on the nominal and real money holdings are counter intuitive. The reason is that they both seem to decrease, while a IS-LM model predicts that money holdings would increase if the nominal interest rate is held unchanged. One possible explanation is that the Bundesbank has reacted to expansionary fiscal policy (or changes in demand due to changes in consumer preferences) by contractionary monetary policy. This may thus give support to claims of some politicians that the Bundesbank has counteracted the fiscal authorities by their concern about inflation.

Turning to the effects of permanent real money shocks, the rate of unemployment decreases and output increases following a shock that decreases the real money shock. This seems reasonable since, for a given level of the nominal interest rate, output must increase to ensure equilibrium in the money market. In addition, the price level increases and the nominal money holdings decrease. These shock therefore drive output and prices in the same direction: output increases temporarily due to some stickiness, but over time the price level rises more and more and the effect on output (and unemployment) dies. However, both the effect on unemployment and output is quite persistent, lasting about 26 quarters.

The effects on the real exchange rate are unclear. Initially the effect is negative, then the impact is reversed in the second quarter and stays positive until the sixth quarter. The effect is small, however, and not significantly different from zero at the ten per cent level of significance already after four quarters.

Looking at the effect on the nominal money holdings, this may be an indication that the Bundesbank has tried to meet a decrease in the demand for real money by reducing the supply of nominal money. However, since the Bundesbank can not control the M3 money measure perfectly, the change in nominal money may also be a change in the creation of money in the banking system. The shape of the impulse response does indicate some action of the Bundesbank, though, namely a temporary contractionary policy. In this way the large effect in the second quarter may be explained and also the fact that some of the effects are reversed before it settles in the eighth quarter.

The transitory shock increases output and prices, while unemployment is de-

creased. Consequently, there are no inflation-output trade-off following these disturbances. However, both the impact on unemployment and output are quite persistent, lasting about 30 quarters, that is between seven and eight years. It is furthermore worth noting that while the largest impact on unemployment occurs some 7 quarters after the shock, the impact on output has a longer delay reaching the peak in the 14th quarter. Furthermore, the impact on output – especially the first four quarters – is quite modest and except from the initial effect, the 10 per cent band does in fact include zero in all periods.

A positive transitory shock leads to a temporary fall in the real exchange rate, that is to say to a real appreciation. As far as the effect on nominal and real money balances are concerned, a positive transitory shock increases nominal money balances and due to some price stickiness also real money holdings increase temporarily. Over time, the increase in the supply of money is met one-to-one by an increase in the price level, leaving the real money holdings unchanged in the long run.

Before looking closer at the source of variation of the variables, I take a brief look at the unemployment and output gap. The motivation for doing this is the assumption that the monetary authorities should stabilize unemployment and output around their natural level. This is based on the assumption of monetary long-run neutrality: and thus changing the natural level of output or unemployment should not be the object of monetary policy. Using the output gap as the aim for monetary policy, Svensson (2000) noted that there is not necessarily a trade-off between inflation and output even following a supply shock. The reason is that permanent supply shocks may increase both output and the output potential; and thus the output gap may in fact decrease. This will be so if rigidities on the demand side restrict the economy from fully taking advantage of the increase in capacity.

The gaps are defined as the difference between the permanent effect of a disturbance and the impulse response, thus as

$$\mathbf{X}_{t+s}^{gap} \equiv \left(\sum_{l=0}^{s} \Phi_l - \Phi(1) \right) d\mathbf{e}_t. \tag{8}$$

For the disturbances that do not have long-run impact on unemployment or output,

The effect of the U gap over time

The effect of the Y gap over time

The effect of the U gap over time

The effect of the Y gap over time
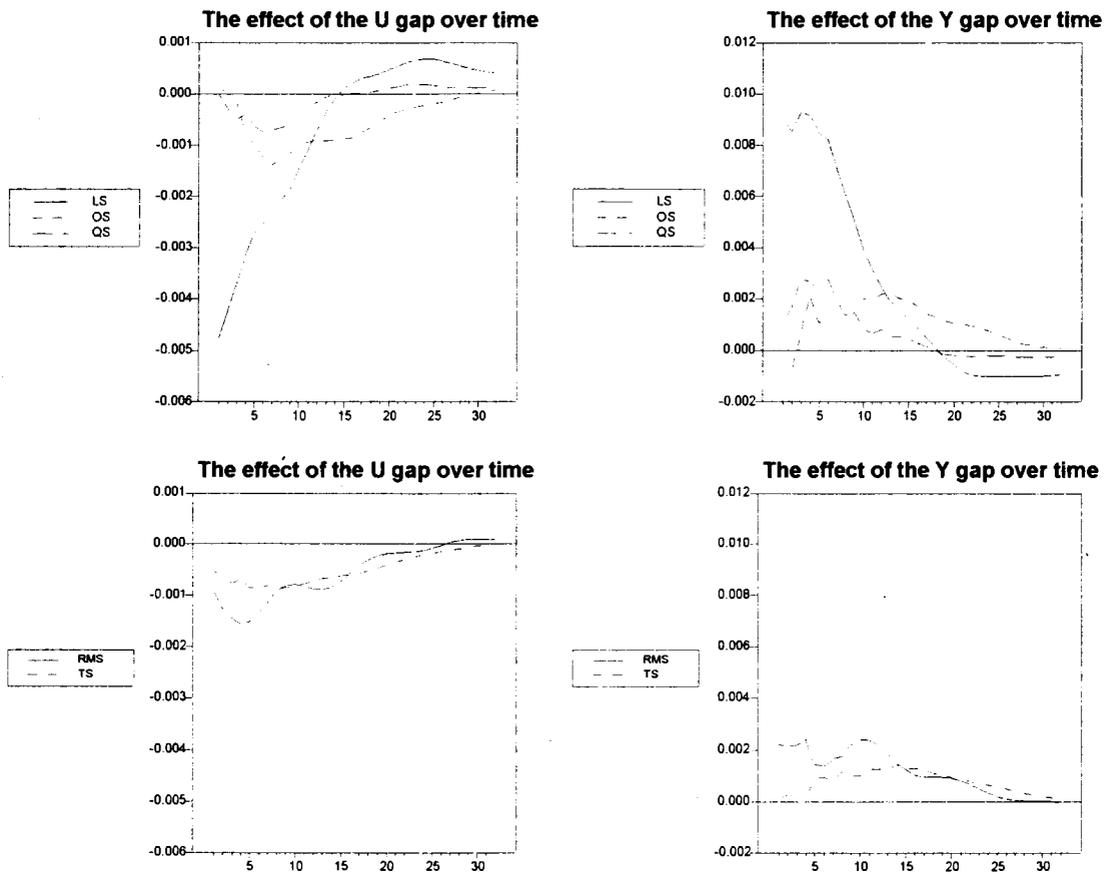
Figure 3: Unemployment and Output Gaps

the gap will thus simply be the impulse response.

As far as the source of changes in the unemployment is concerned, labour shocks stood out; and this is also so for the unemployment gap. The disturbance drive – by definition – long-run unemployment, but due to the long adjustment period it also seem to be the most important shock describing the unemployment gap.

The two important disturbances describing development of output were the permanent labour and output shocks; but for the output gap, labour shocks are by far the most important. Hence, labour shocks induce a long adjustment period in output as well, and for this reason, there are no traditional inflation-output/unemployment trade-offs following this disturbance. A negative labour shock decreases the unemployment gap, it increases the output gap, and it increases prices; and the appro-

priate monetary policy would be a contractionary in order to decrease output and increase unemployment further. As noted above, it seems to be the case that the monetary authorities have accommodated both shocks that have permanent impact on output. This may seem unnecessary, since the permanent labour shocks do not appear to give any inflation-output/unemployment trade-off. However, this disregards the political difficulties – even for an independent central bank – in reducing unemployment further by contractionary monetary policy arguing that unemployment is above the natural level.

As far as the permanent output shocks are concerned, there is also no traditional output/inflation trade-off. A positive output shock *increases* unemployment temporarily, though, so if the authorities do care about unemployment variations, there will be a trade-off.

Before turning to variance decomposition, I also look at the rate of inflation. This is done since inflation – and not the price level – has been the objective for the German monetary policy.[11] The distinction between inflation and price level targeting is, however, beyond the aim of this paper.[12]

Figure (4) shows the impulse response functions for the rate of inflation following the five structural disturbances. The rate of inflation seems to be driven by all of the five shocks, even though the least important shock appears to be the permanent output disturbance. Besides, most of the disturbances seem to bring about considerable variations in the inflation rate in addition to the temporary effect on the level.

3.2   The sources of variation: FEVD analysis

Further information about the sources of variation of the variables can be found by doing a so called forward error variance decomposition. This tells how much of the variation of the variables are due to the different shocks. The mean squared error

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[11] In fact *price-stability* has been the aim of monetary policy, but price stability has been associated with a positive rate of inflation; and no attempts have been made to bring the price level back to the trend-growth if the inflation target has not been met.

[12] For a theoretical consideration see e.g. Svensson (1999).

The effect of inflation over time
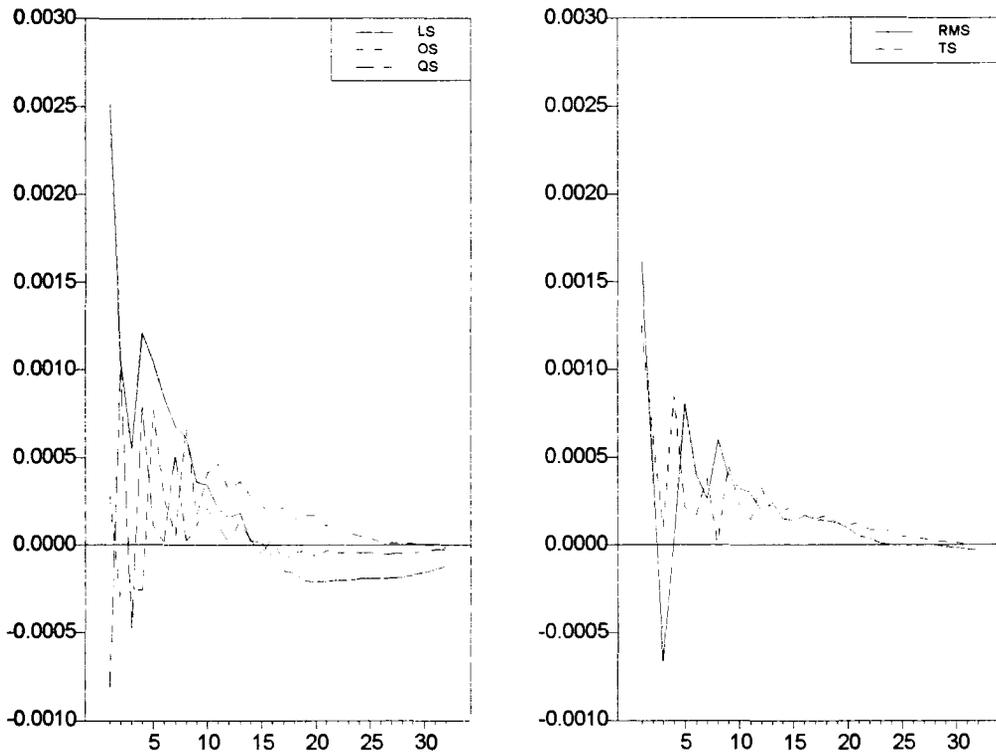
Figure 4: Impulse responces for the rate of inflation

of a s-periods forecast of the variable z – i.e. u, y, q, p, and m – can be written as
(see e.g. Hamilton 1994: 323-324)[13]:

$$MSE\left(\widehat{z}_{t+s|t}\right) = \left(z_{t+s} - \widehat{z}_{t+s|t}\right)^2 \tag{9}$$

$$= \sum_{j=1}^{4}\left[\left(\frac{\partial z_t}{\partial e_t^j}\right)^2 + \left(\frac{\partial z_{t+1}}{\partial e_t^j}\right)^2 + ... + \left(\frac{\partial z_{t+s}}{\partial e_t^j}\right)^2\right],$$

where e^j, for $j = 1,..,5$, denote the five shocks. The term $z_{t+s} - \widehat{z}_{t+s|t}$ gives the
error in forecasting the value of z in period $t + s$, given the information in period t.
Consequently, equation (9) gives the variance of the forecasted error. The proportion

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[13]The formula takes into account that $E\mathbf{ee'} = \mathbf{I}_5$, and as a result the variance term in equation
[11.5.6] in Hamilton (1994) disappears.
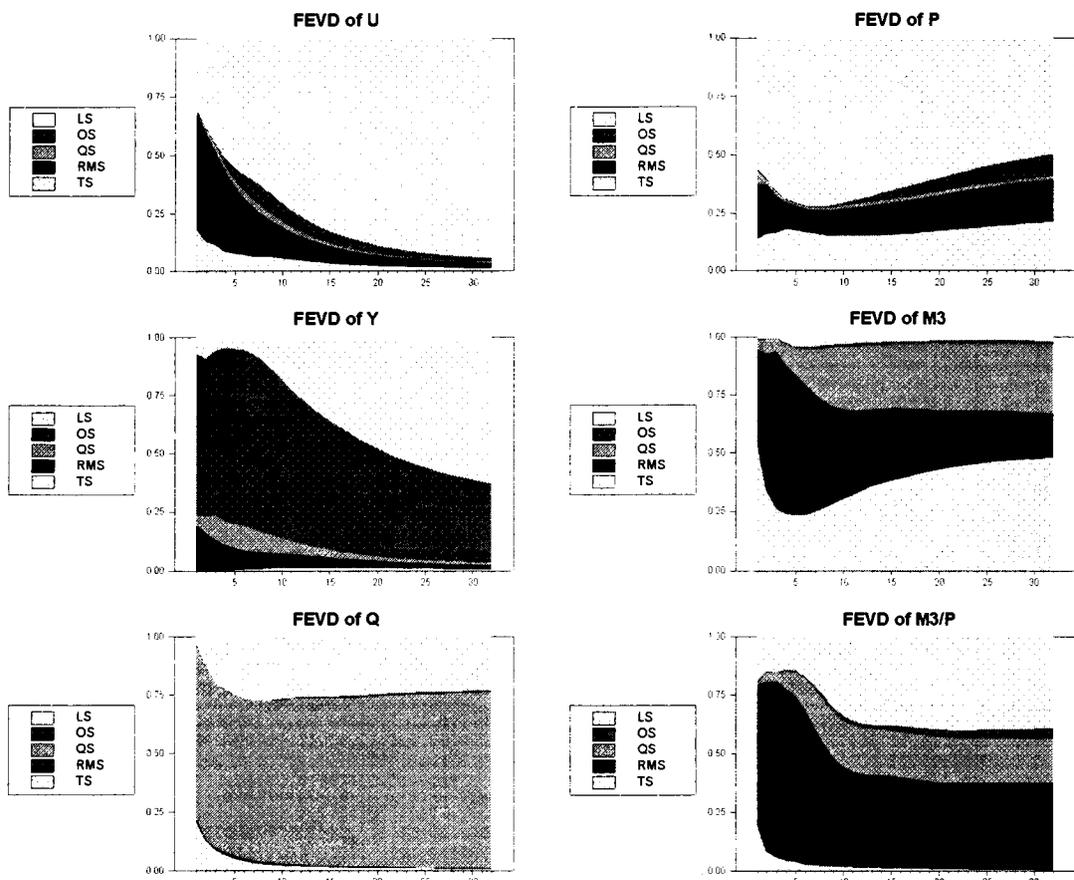
Figure 5: FEVD

due to shock e^j will hence be given by:

$$\frac{\left(\frac{\partial z_t}{\partial e_t^j}\right)^2 + \left(\frac{\partial z_{t+1}}{\partial e_t^j}\right)^2 + \dots + \left(\frac{\partial z_{t+s}}{\partial e_t^j}\right)^2}{MSE\left(\widehat{z}_{t+s|t}\right)}. \tag{10}$$

Figure (5) plots the variance decomposition for the six variables, while the tables 2 to 4 give more specific information about the variance decomposition at certain points in time. The variance decomposition of real money is calculated from the impulse responses of nominal money and prices. Several features stand out.

The permanent labour and output disturbances are important both for unemployment and output, also in the short run. The two shocks account for from 32 to 55 per cent of the changes in unemployment even in the short run, with most of the changes being generated by labour shocks (about 30 and 50 per cent in the

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first and fourth quarter, respectively). Afterwards this percentage rises steadily: in the eighth quarter to about 70 per cent; in the 12th quarter to about 80 per cent; and finally in the 32nd quarter to about 95 per cent. Furthermore, the permanent output shock explains about 9 per cent in the eighth quarter, and thereafter its influence gradually diminishes. As far as the permanent real money shocks and the transitory shocks are concerned, they both have important short-run impacts, while the permanent real exchange rate shock only have a minor influence. Most remarkable is the effect of the real money shock, which explain between 30 and 50 per cent of the variation of rate of unemployment in the first four quarters. This is especially interesting in Germany due to the announced money targeting. The reason is that this shock changes long-run real money holdings; and since it has no impact on unemployment, outpur or the real exchange rate, it is natural to link the disturbance to the demand for real money balances. I will return to this below.

The permanent labour and output shocks explain even a larger part of a forecast in output, where they explain more than 70 per cent over all horizons. In the short run, permanent labour shocks are most important, while labour shocks are more important in the longer run. More precise, the output shocks explain between 68 (contemporaneously) and 75 per cent of the variation up to the eighth quarter; but thereafter its importance gradually diminishes. In an eight-quarter forecast, labour shocks account for about 10 per cent of the variance; and this percentage grows steadily to about 25 per cent in the 12th quarter, to close to 50 per cent in the 20th quarter and finally to above 60 per cent in the 32nd quarter.

Except from labour and output shocks, the most important factors are the real exchange rate and the real money shocks. The former accounts for between five and 10 per cent the first four quarters; but thereafter its importance vanishes. The latter explains close to 20 per cent of the variation of output contemporarily, about 10 per cent in the fourth quarter and thereafter its influence continues to decrease.

Table 2: FEVD of unemployment and output

	Unemployment					Output				
Qrt	LS	OS	QS	RMS	TS	LS	OS	QS	RMS	TS
1	30.5	1.8	0.0	49.6	18.1	7.1	68.6	5.1	19.2	0.0
2	38.4	0.6	1.8	46.2	13.0	8.8	68.0	6.9	16.2	0.1
4	51.7	3.2	2.3	34.3	8.5	4.3	74.5	10.3	10.8	0.1
8	63.9	8.8	3.2	17.8	6.3	10.1	73.7	8.6	6.7	0.9
12	76.3	6.8	1.9	10.3	4.7	26.0	62.5	4.7	5.8	1.0
20	88.8	3.6	0.7	4.5	2.4	47.8	46.1	2.1	3.0	1.0
32	94.4	1.8	0.4	2.2	1.2	62.6	34.1	1.1	1.6	0.6
∞	100	0.0	0.0	0.0	0.0	78.0	22.0	0.0	0.0	0.0

The real exchange rate is mostly driven by the permanent REER shock; and actually this disturbance accounts for more than two thirds of variations over all horizons. Except from this, both the temporary labour shock and the transitory shock have some influence on REER variability. The former explains some three per cent contemporaneously, and thereafter its influence rises to more than one fourth in the eighth quarter, before it reduces and settles around 20 per cent in the long run; the latter explains more than 20 per cent contemporaneously, but this fraction quickly vanishes through time. As far as the permanent output and real money shocks are concerned, neither of them have important effects on the real exchange rate.

The permanent labour shocks are the most important disturbance driving consumer prices in the short to medium run. In fact these shocks explain as much as between 50 and 75 per cent of variation of consumer prices up to the 32nd quarter (and it approaches about one third in the long run). Furthermore, both the permanent real money shock and the transitory shock have important impacts on the development of consumer prices. The former accounts for about one fourth of contemporaneous variation in consumer prices; in the medium term this fraction drops down to about 10 per cent in the eighth quarter; thereafter it increases to close to 20 per cent in the long run. The latter accounts for close to 15 per cent of the

variation of prices contemporaneously, and this fraction steadily increases through time approaching close to one third in the long run.

Table 3: FEVD of REER and CPI

	REER					CPI				
Qrt	LS	OS	QS	RMS	TS	LS	OS	QS	RMS	TS
1	3.0	0.5	74.0	1.3	21.2	56.2	0.7	5.9	23.2	13.9
2	12.4	0.2	74.0	0.5	12.9	60.1	0.3	2.2	21.3	16.1
4	22.3	0.2	69.6	1.1	6.8	68.8	0.5	1.1	11.3	18.3
8	27.5	0.1	68.9	0.6	2.9	72.2	0.6	1.2	10.5	15.5
12	26.0	0.6	71.0	0.6	1.8	68.7	2.1	1.5	12.6	15.1
20	24.8	0.8	73.0	0.4	1.0	60.0	5.7	1.7	15.4	17.2
32	23.1	0.8	75.2	0.2	0.7	49.7	9.3	1.4	18.3	21.3
∞	21.2	0.6	78.2	0.0	0.0	32.1	14.0	0.7	22.8	30.4

The most important factor driving nominal money holdings are the transitory disturbances. More than 50 per cent of contemporaneous variation in nominal money is caused by these shocks. The fraction drops to one fourth in the fourth quarter, but thereafter it rises again approaching more than 50 per cent in the long run. Except from the transitory shocks, both the permanent real exchange rate and the real money shocks have important effects on variations in nominal money. The former accounts for between 40 (contemporaneously) and 65 (fourth quarter) per cent in the very short run; but over time the influence drops towards one tenth in the long run. The latter shock only has a minor short-run influence – between 3 and 10 per cent the first four quarters, but already in the eighth quarter close to 20 per cent of the variation is due to fiscal disturbances. Thereafter the influence increases, approaching one third in the long run. Finally, neither of the shocks that have long-run effects on output have important influence on variation in nominal money.

Contemporaneously, about 20 per cent of the variation in the real money holdings are caused by transitory disturbances. This fraction quickly diminishes, though,

and already in the fourth quarter less than five per cent is due to changes in money supply. In the short run, labour and the real money shocks are the most important disturbances – in addition to the transitory shock. The former accounts for between 18 and 27 per cent of the variation in real money holdings the first two years; and the latter accounts for more than 50 per cent – reaching a peak of close to 75 per cent in the fourth quarter. In the medium to long run the importance of money demand shocks decreases slightly – accounting for around 40 per cent in the long run, and the influence of labour shocks increases to around 35 per cent. Furthermore, the permanent real exchange rate shocks play a more important role in the long run, accounting for about 20 per cent of the variation.

Table 4: FEVD of real and nominal money

Qrt	M3					M3/P				
	LS	OS	QS	RMS	TS	LS	OS	QS	RMS	TS
1	0.7	0.9	3.5	40.5	54.4	18.9	1.5	0.2	59.8	19.6
2	0.6	0.4	6.3	58.4	34.3	14.8	0.6	3.9	72.1	8.6
4	2.5	0.5	9.0	63.7	24.3	13.9	1.0	7.4	73.3	4.4
8	3.4	1.5	22.6	45.8	26.7	25.6	2.2	18.2	52.0	2.0
12	2.4	1.3	27.9	34.4	34.0	37.1	1.7	19.9	40.0	1.3
20	1.6	1.1	29.0	25.3	43.0	39.7	3.1	19.5	37.0	0.7
32	1.7	1.4	29.7	19.0	48.2	39.1	4.4	19.0	37.1	0.4
∞	3.4	0.9	32.0	12.2	51.5	35.3	6.4	19.1	39.2	0.0

Both Weber (1996) and Funke (1997a) use different time series in their analyses, so it is difficult to make direct comparisons with their work. Some similarities and differences are worth noting, however. First, both analysis point towards labour shocks being the most important factor driving hours worked or unemployment: both report that labour shocks account for close to or more than 80 per cent of the variation in hours worked or unemployment. To some extent, this is confirmed in my analysis, even though permanent real money shocks seem to be important in the short run. As far as output is concerned, the two analysis diverge. Weber reports that aggregate supply shocks explain close to 20 per cent of the contemporaneous

variations in output, but this fraction quickly rises, and reaches 80 per cent already in the fourth quarter. My result – namely that permanent shocks are important also for the business cycle – is thus in line with his findings. Funke reports, however, that demand disturbances account for as much as 80 per cent in the eighth quarter and still 60 per cent in the 24th quarter. As far as the development of consumer prices are concerned, Funke finds that these are driven by so-called price-disturbances in the short run (explaining as much as 96 per cent contemporaneously), while aggregate demand shocks are the most important factor in the long run (86 per cent after 24 quarters). Furthermore, the former disturbance does not seem to have a significant effect on the other variables. Weber does not report variance decomposition of the price level, but only looks at the rate of inflation. This points towards labour demand and labour supply shocks as the most important disturbances, where the former is the most important. Consequently, my analysis confirms Weber's results to a certain amount. Last, Weber reports that variations in real money balances mostly are due to disturbances that have permanent effects on output but not on hours worked. My analysis also points towards the labour shocks, but the most important factor is the real money disturbance.[14] Furthermore, following Weber, less of the variations in real money balances are due to money supply shocks than in my analysis.[15] Funke does not report variance decomposition for real money, but his results for the price level and nominal money point towards price-setting and money disturbances, where the latter includes both money supply and demand shocks.[16]

3.3 Money or inflation targeting

One of the cornerstones of the official German monetary policy was money targeting. This official stand has been questioned by a number of researchers, however.

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[14]The real money disturbance in this paper is comparable to the money demand shock in Weber. Therefore, it is worth noting that the demand shock explains up to 24 per cent of the variations in real money in Weber's analysis.

[15]The money supply shocks are comparable to the transitory shocks in my analysis.

[16]Aggregate demand shocks also play an important role both for the price level and for nominal money; but a visual examination of the impulse responses suggests that the effects on real money are limited.

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Bernanke and Mihov (1997) test whether forecasts of inflation and money growth Granger-cause the Bundesbank instrument – which is assumed to be the Lombard rate[17]. The idea behind the test is as follows: If the Bundesbank was a money targeter, it should have reacted to expected changes in the growth rate of money even if the excepted inflation is on the target. If this was not so, it can be taken as an evidence that the Bundesbank was an inflation targeter rather than a money targeter. The results are that both the forecasted rate of inflation and the forecasted rate of money growth Granger-cause the Lombard rate significantly at the five per cent level. However, looking at the decomposition of the forecast variance for the instrument reveals that innovations in expected money growth only play a minor role in explaining the Lombard rate. In the short run, the most important factor for the forecast error of the instrument is its own shocks, pointing at some degree of interest rate smoothing. In the longer run, the most important factor is the rate of inflation, whereas money growth does not play an important role at any horizons. This evidence then led the authors to conclude that "although the Bundesbank uses money growth as an important informational variable and operating guide, and despite its protestations to the contrary, it seems to be better characterized as an inflation targeter than as a money targeter."[18]

Clarida et al. (1998) estimate a policy reaction function for the central bank of a number of different countries, amongst other for Germany. They use a GMM procedure to construct a forward looking policy rule. Their baseline model includes expected inflation and expected output gap, and a term picking up interest rate smoothing. This model seems to describe the behavior of the nominal interest rate rather well; the point estimates are reasonable – have the right sign and magnitude. To the model the authors also add other variables which may enter the policy rule, and specifically they add the gap between the money target and the actual money

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[17]The test is also carried out using the call rate; and a spliced series using the Lombard rate before 1985 and the call rate from 1985 and onwards. These tests give more or less the same results as the base case using the Lombard rate.

[18]This result has been questioned by Brüggermann (1999). She argues that the results in Bernanke and Mihov (1997) are due to the fact that the authors do not consider the asymmetric reactions to positive and negative target deviation.

stock. From this exercise they are able to conclude that their "baseline interest rate reaction function clearly wins. The money aggregate just does not matter, while the other parameter estimates are largely unchanged."

Testing statistically for money versus inflation targeting goes beyond the aim of this paper; and the impulse functions following the real money shocks give mixed results. First, it seems to be the case that a fall in the demand for money has led the Bundebank to reduce money supply even in the short run. This would – to some extent – point towards inflation targeting.[19] However, the fact that the real money shock seems to have important effects on real variables – and that the effects are long-lasting – would point towards monetary targeting. Certainly, even when targeting inflation, money demand changes may spread into the rest of the economy, due to the fact that neither the interbank rate Fibor nor the money stock M3 is perfectly controlled by the central bank. However, the real money shock have long-lasting effects on other variables.

In any case, a necessary condition for money targeting to be successful is that there is a close link between the rate of growth in the monetary aggregate and the rate of inflation. This means that the money demand is stable. If this is so the monetary target will act as an intermediate target; and by smoothing changes in the intermediate target, the final target – the rate of inflation – is also smoothed. The fact that the permanent real money shocks seems so important for the development of the real money balances may be taken as an evidence that the money demand function is not stationary – or trend-stationary: and stationarity is important for the success of monetary targeting.[20]

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[19]The monetary target is set according to a long-run quantity-theory-of-money relationship:

$$\Delta m_t^* = \Delta y_t^* + \pi_t^* + \Delta v_t^*$$

where Δm^* is the targeted change in the monetary aggregate; Δy^* is the changes in potential output; π^* is the inflation target; and Δv^* is the changes in equilibrium or long-run velocity of money.

[20]Cabos et al. (1999) analyze the choice of monetary policy target using the Kalman filter for German data from Bretton Woods until 1997. They find that control problems are likely to be larger for intermediate broad money targets than for direct inflation targets. Moreover, they

4 Concluding remarks

In this paper I have used a structural VAR analysis in order to decompose the German business cycles into different components; and the aim has been to see how important permanent shocks are for the business cycles. The main result is that the most important factor for the development of unemployment seems to be the permanent labour shock, even though real money shocks also seem to play a significant role. The permanent shocks are also important for real GDP; and in this case the shocks that have transitory effects accounts for less than one fourth in the short run.

In addition to examine the different variables, I have also looked at the development of the unemployment and output gaps following the different shocks. The main finding is that labour shocks – which are disturbances that change the long-run natural rate of unemployment – are the most important disturbance for the variation in both the unemployment and the output gap. This is interesting, since a positive labour shock decreases the unemployment gap and increases the output gap and the price level. As a result, the potential conflict of monetary policy should be lower. However, there are certainly political difficulties – even for an independent central bank – in carrying out contractionary monetary policy following a negative labour supply shock, even though it can be argued that the rate of unemployment is higher than the natural level. And it seems that the Bundesbank has accommodated these disturbances. As far as the future operation of the European Central Bank is concerned, it is thus important that the central bank has enough independence. Otherwise, German politicians might be tempted to pressure the central bank to ease monetary policy when the economy is hit by shocks that permanently increase the natural rate of unemployment.

References

Amisano, Gianni and Carlo Giannini, *Topics in Structural VAR Econometrics:*

conclude that broad money dominate narrow money as in intermediate target.

Second, Revised and Enlarged Edition, Springer-Verlag, Berlin, 1997.

Barro, Robert J. and David B. Gordon, "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 1983, *91*, 589–610.

_ **and** _ , "Rules, Discretion, and Reputation in a Model of Monetary Policy," *Journal of Monetary Economics*, 1983, *12*, 101–121.

Bergman, Michael, "International Evidence on the Sources of Macroeconomic Fluctuations," *European Economic Review*, 1996, *40*, 1237–1258.

Bernanke, Ben S. and Ilian Mihov, "What Does the Bundesbank Target?," *European Economic Review*, 1997, *41*, 1025–1053.

Blanchard, Oliver J., "A Traditional Interpretation of Macroeconomic Fluctuations," *American Economic Review*, 1989, *79* (5), 1146–1164.

_ **and Danny Quah**, "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review*, 1989, *79* (4), 655–673.

Blinder, Alan S., "What Central Bankers Could Learn from Academics-and Vice Virsa," *Journal of Economic Perspectives*, 1997, *11* (2), 3–19.

Brüggermann, Imke, "Inflation versus Monetary Targeting in Germany," January 1999. Freie Universität Berlin, Department of Economics.

Cabos, Karen, Michael Funke, and Nikolaus A. Siegfried, "Some Thoughts on Monetary Targeting Vs. Inflation Targeting," 1999. Quantitative Macroeconomics Working Paper Series 8/99,Universität Hamburg.

Canova, Fabio, Jon Faust, and Eric M. Leeper, "Do Long-Run Identifying Restrictions Identify Anything?," 1993. Mimeo, Federal Reserve Board, Washington DC.

Clarida, Richard and Jordi Galí, "Sources of Real Exchange-Rate Fluctuations: How Important are Nominal Shocks?," *Carnegie-Rochester Conference Series on Public Policy*, 1994, *41*, 1–56.

_ **and Mark Gertler**, "How the Bundesbank Conducts Monetary Policy," 1996. NBER Working Paper Series 5581.

_ , **Jordi Galí, and Mark Gertler**, "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review*, 1998, *42*, 1033–1067.

_ , _ , **and** _ , "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature*, 1999, *37* (4), 1661–1707.

Enders, Walter, *Applied Econometric Time Series*, Wiley, New York, 1995.

Funke, Michael, "How Important are Demand and Supply Shocks in Explaining German Business Cycles?: New Evidence on an Old Debate," *Economic Modelling*, 1997, *14*, 11–37.

_ , "Supply Potential and Output Gaps in West German Manufacturing," *International Journal of Forecasting*, 1997, *13*, 211–222.

Galí, Jordi, "How Well Does the IS-LM Model Fit Postwar U.S. Data?," *Quarterly Journal of Economics*, May 1992, *107*, 709–738.

Hamilton, James D., *Time Series Analysis*, Princeton University Press, 1994.

Karras, Georgios, "Sources of Business Cycles in Europe: 1960-1988. Evidence from France, Germany, and the United Kingdom," *European Economic Review*, 1994, *38* (9), 1763–1778.

Kydland, Finn E. and Edward C. Prescott, "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, 1977, *85*, 473–492.

Rogoff, Kenneth, "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, 1985, *100*, 1169–1190.

Shapiro, Matthew D. and Mark W. Watson, "Sources of Business Cycle Fluctuations," 1988. NBER Working Paper Series 2589.

Svensson, Lars E. O., "Price Level Targeting Vs. Inflation Targeting. A Free Lunch," *Journal of Money, Credit and Banking*, 1999, *31*, 277–295.

— , "Open-Economy Inflation Targeting," *Journal of International Economics*, 2000, *50*, 155–183.

Weber, Axel A., "Testing Long-Run Neutrality: Empirical Evidence for G7-Countries with Special Emphasis on Germany," *Carnegie-Rochester Conference Series on Public Policy*, 1994, *41*, 61–117.

— , "Germany Before and After Unification: A Structural VAR Analysis," *Economic Modelling*, 1996, *13*, 575–601.

ESSAY 3:

Tayloring the Norwegian interest rates*

Abstract

This paper looks at the celebrated Taylor rule for the Norwegian economy. This rule is often used as an indication of what the interest rate would have been if the Norwegian Central Bank had aimed at stabilizing the rate of inflation through inflation targeting. However, in the theoretical literature on inflation targeting it is often argued that the central bank should focus on expected inflation. This is the motivation to compare the Taylor rule with a forward-looking rule.

The main conclusion of the paper is that the two rules have a rather similar development through time, and that they both have a significantly different development than the actual short-term interest rate. Furthermore, it seems that – to some extent – the Taylor rule and the foward-looking rule are different over the economic cycles.

1 Introduction

In this paper I consider the celebrated Taylor (1993) rule for Norway. The motivation is that the rule may be seen as an indication of how the Norwegian central bank would have conducted monetary policy if they had followed an independent monetary policy targeting domestic inflation. Taylor finds that his rule does a good job tracking the actual US short term interest rate. As a matter of fact, except from the period around the crack on the stock exchange in 1987, which required extraordinary actions from the Federal Reserve, the difference between the hypothetical interest rate and the actual one is remarkably small. The Taylor rate is also interesting from a theoretical point of view, and in the second section I therefore consider a theoretical model analyzing the targeting of expected inflation developed by Svensson (1997). There he shows that the Taylor rule might in fact serve as an instrument for targeting expected inflation if lagged output gap and inflation serve to predict future inflation. However, Clarida and Gertler (1996) find that monetary policy strategy of the German Bundesbank corresponds well to a forward-looking rule; and better than to the Taylor rule. A similar result is reported by Clarida, Galí and Gertler (1998) for the G3-countries – the US, Germany, and Japan. The first study uses a combination of short-run and long-run restrictions to estimate a structural VAR including amongst others an equation describing the monetary policy rule. The second study estimates the reaction function directly using generalized method of moments. Both analysis indicate that the central banks react to expected deviations from an inflation target and from some GDP target. This is the motivation for calculating a forward-looking Taylor rule for Norway; and it is done using the Norges Banks own estimates of expected inflation which is published in their quarterly journal.

Frøyland and Leitemo (1997) calculated the short term interest rates using the Taylor rule for the period 1985 till 1996. Compared to the development of the actual interest rate, the Taylor-interest rate indicated that the Norwegian monetary policy was to loose around 1987-88, and too tight from around 1989 till about 1994. The third section extend this analysis to include the period before 1985 and after 1994,

and additionally it compares this "backward looking" rule with a forward looking one.

This paper is organized as follows. In the second section I motivate the Taylor rule theoretically and in the third section I calculate the original Taylor rate and a forward-looking rule. The fourth section summarizes the main results.

2   A short motivation for the Taylor rule

To motivate the Taylor (1993)-rule I use a model developed by Svensson (1997). The model builds on two simple equations: the first equation describes an IS-relationship; and the second describes the price-setting behavior in the economy. Let y_t denote the output gap - the percentage deviation of output away from its natural level - and π_t and i_t the rate of inflation and the nominal interest rate - where the latter is the instrument of the monetary authorities. The variable x_t is exogenous factors. I follow Svensson (1997) and let the evolution of inflation and output be given by

$$\pi_{t+1} = \pi_t + \alpha_1 y_t + \alpha_2 x_t + \varepsilon_{t+1} \tag{1}$$

$$
\begin{aligned}
y_{t+1} &= \beta_1 y_t - \beta_2 \left[(i_t - E_t \pi_{t+1}) - r^* \right] + \beta_3 x_t + \eta_{t+1} \\
&= (\beta_1 + \alpha_1 \beta_2) y_t - \beta_2 \left[(i_t - \pi_t) - r^* \right] + (\beta_3 + \beta_2 \alpha_2) x_t + \eta_{t+1}, \tag{2}
\end{aligned}
$$

$$x_{t+1} = \gamma x_t + \theta_{t+1}, \tag{3}$$

where the second equation in (2) follows from inserting for $E_t \pi_{t+1} = \pi_t + \alpha_1 y_t + \alpha_2 x_t$ from (1). This follows from the assumption that ε_t, η_t, and θ_t are i.i.d. shocks that are unknown in period $t - 1$. r^* is the natural level or steady state real interest rate. Furthermore, the coefficients α_1 and β_2 are positive constants, α_2 and β_3 are non-negative, and in addition β_1 and γ are between zero and one. The first equation thus describes the price-setting behavior, where the change in inflation is increasing in lagged values of the output gap. The second equation is the IS-relationship, where the output gap is serially correlated and depends negatively on deviations of the real interest rate r^*. Thus if the real interest rate is equal to the natural level – and the shock is equal to zero – there will be no additional changes in the output gap, and it

will gradually return to zero over time. Last, the exogenous factor $- x_t -$ is assumed to be serially correlated.

It is clear that equation (1) does not satisfy a natural-rate hypothesis, since an ever-increasing rate of inflation will permanently affect output. However, the objective function of the central bank – see equation 4 below – will never make ever increasing rates of inflation optimal policy; and - as noted by Svensson - if the central bank tries to follow such policies, the model breaks down.[1]

Monetary policy is conducted by an independent central bank which has an inflation target equal to the goal of the society π^*. First, I follow Svensson and let controlling the rate of inflation be the sole objective of the central bank. Such regime is often named "strict inflation targeting". Later I shortly comment the case of an additional output stabilization, which often is named flexible inflation targeting.

The central bank is assumed to choose a plan for current and future nominal interest rate to minimize the discounted sum of future period expected losses given by

$$E_t \sum_{s=t}^{\infty} \delta^{s-t} L\left(\pi_s\right) = E_t \sum_{s=t}^{\infty} \delta^{s-t} \frac{1}{2} \left(\pi_s - \pi^*\right)^2 , \tag{4}$$

where $L\left(\pi\right)$ gives the costs in a period of having a rate of inflation equal to π. It is thus assumed that the costs are quadratic in the deviation from the inflation target, and thus the cost function is a special case of a Barro-Gordon[2] cost function where the output gap is not given any weight.

Since the central bank can influence output with one lag, and inflation with two lags, it is instructive to express the rate of inflation in period $t + 2$ as a function of

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[1] The model may be interpreted as an adapting expectations set-up with a NAIRU hypothesis (for the output gap instead of the rate of unemployment). A break-down of the model is then interpreted as a situation where fairly moderate individuals cannot have adaptive expectations.

[2] Barro and Gordon (1983).

the variables in period t and shocks in period $t + 1$ and $t + 2$. This gives

$$
\begin{aligned}
\pi_{t+2} &= \left(\pi_t + \alpha_1 y_t + \alpha_2 x_t + \varepsilon_{t+1} \right) \\
&\quad + \alpha_1 \left\{ \left(\beta_1 + \alpha_1 \beta_2 \right) y_t - \beta_2 \left[(i_t - \pi_t) - r^* \right] + \left(\beta_3 + \beta_2 \alpha_2 \right) x_t + \eta_{t+1} \right\} \\
&\quad + \varepsilon_{t+2} \tag{5} \\
&= \pi_t + \alpha_1 \left(1 + \beta_1 + \alpha_1 \beta_2 \right) y_t - \alpha_1 \beta_2 \left[(i_t - \pi_t) - r^* \right] \\
&\quad + \left[\alpha_2 + \alpha_1 \left(\beta_3 + \beta_2 \alpha_2 \right) \right] x_t + \varepsilon_{t+1} + \varepsilon_{t+2} + \eta_{t+1}. \tag{6}
\end{aligned}
$$

Through changes in the instrument in period t, the central bank can thus influence inflation in period $t + 2, t + 3, \ldots$, but not in period t and $t + 1$. Likewise, changes in the instrument in period $t + 1$, influence inflation in period $t + 3, t + 4, \ldots$, but not in period $t + 1$ and $t + 2$. Due to this simple structure – and since the central bank can reset the instrument next period – this minimization problem may be described as sequence of one-period problems of choosing the instrument to hit an inflation rate two periods later. The problem may thus be described as

$$
E_t \left[\sum_{s=t}^{\infty} \delta^{s-t} \min_{i_s} E_s L \left(\pi_{s+2} \right) \right],
$$

which has the following first order conditions:

$$
\begin{aligned}
\frac{\partial E_t \delta^{s-t} L \left(\pi_{s+2} \right)}{\partial i_s} &= E_t \left[\delta^{s-t} \left(\pi_{s+2} - \pi^* \right) \frac{\partial \pi_{s+2}}{\partial i_s} \right] = 0 \\
\left[\delta^{s-t} \left(E_t \pi_{s+2} - \pi^* \right) \left(1 + \alpha \beta_2 \right) \right] &= 0 \Rightarrow E_t \pi_{s+2} = \pi^*. \tag{7}
\end{aligned}
$$

Thus, the central bank minimizes its costs by setting the instrument such that the *expected* rate of inflation – two periods later – equals the inflation target.

The expected inflation in period $t + 2$ – given the information in period t – will be given by

$$
\begin{aligned}
E_t \pi_{t+2} &= \pi_t + \alpha_1 \left(1 + \beta_1 + \alpha_1 \beta_2 \right) y_t + \left[\alpha_2 + \alpha_1 \left(\beta_3 + \alpha_2 \beta_2 \right) \right] x_t \\
&\quad - \alpha_1 \beta_2 \left[(i_t - \pi_t) - r^* \right]. \tag{8}
\end{aligned}
$$

Consequently, the optimal level of the monetary policy instrument can be written

as

$$\pi^* = \pi_t + \alpha_1 \left(1 + \beta_1 + \alpha_1 \beta_2\right) y_t$$
$$+ \left[\alpha_2 + \alpha_1 \left(\beta_3 + \alpha_2 \beta_2\right)\right] x_t - \alpha_1 \beta_2 \left[(i_t - \pi_t) - r^*\right] \tag{9}$$
$$i_t = \pi_t + \frac{1}{\alpha_1 \beta_2} \left(\pi_t - \pi^*\right) + \frac{1 + \beta_1 + \alpha_1 \beta_2}{\beta_2} y_t + r^*$$
$$+ \frac{\alpha_2 + \alpha_1 \left(\beta_3 + \alpha_2 \beta_2\right)}{\alpha_1 \beta_2} x_t. \tag{10}$$

Equation (10) is nothing else than a kind of Taylor rule for nominal interest rates, though the coefficients in front of the inflation and the output gap $-\frac{1}{\alpha \beta_2}$ and $\frac{1+\beta_1+\alpha\beta_2}{\beta_2}$, respectively – will generally be different from one half. Furthermore, the rule in equation (10) includes the exogenous factor x_t.

If the rate of inflation is on target, and output gap and the exogenous factor are zero, the interest rate equal $i = \pi^* + r^*$. The rule will therefore not be inflationary or deflationary in the long run, but will provide an anchor for inflationary expectations. If either the rate of inflation or the real GDP rises above their targets, the interest rate is increased to dampen the pressure, and opposite if the inflation or real GDP is below their targets. The same happens if the exogenous factor is non-zero: a positive x triggers the central bank to increase interest rate and the opposite for a negative x. Consequently, the rule is active in the short run.

It is important to note that the central bank in this case does not give weight to output fluctuations (or to changes in the exogenous factor x) as such in this case, but it will react to changes in the output gap (or in x) because – all other things equal – it increases future expected inflation. If the central bank also puts a positive weight on the output gap – and thereby has a so-called flexible inflation target – the monetary policy rule will still look like equation (10). There will be one important change, though, namely that the weights in the instrument rule will change. The output gap and the exogenous factor x will then enter in the rule both due to the fact that they predict future inflationary pressure, but also due to the fact that the central bank wishes to smooth out the changes in the output gap. An increase in the output gap will then lead to an increase in the short-term interest rates both since expected inflation increases and since future output gaps increases due to output

persistence.

The Taylor rule will only give a reasonable approximation to the interest rate development under inflation targeting if there are no other factors than past inflation and past output gap that influence the expected inflation and output gap. If this is not the case, the instrument rule will also include these variables. Still, however, it will be the case that the instrument is set so that expected inflation hits the inflation target in the case of strict inflation targeting; and so that a weighted average of the expected rate of inflation and the output gap is zero in the case of flexible inflation targeting.

3 Calculations of interest rate rules

3.1 The Taylor rule

The original Taylor-rule is as follows:

$$i_t = \pi_{t,-4} + \lambda_1 y_{t-1} + \lambda_2 \left(\pi_{t,-4} - \pi_t^* \right) + r^*, \tag{11}$$

where i_t is the short run interest rate and $\pi_{t,-4}$ is the rate of inflation over the pervious four quarters. Thus $\pi_{t,-4} = \sum_{j=1}^4 \Delta p_{t-j}$, with p_t denoting log of the price level. Furthermore, $y_t = 100 \left(Y_t - Y_t^* \right) / Y_t^*$ where Y is real GDP and Y^* is a GDP target. Taylor suggested using a constant growth of 2.2 per cent for the US (calculated from 1984.1 through 1992.3) to calculate the GDP target. I instead follow Frøyland and Leitemo (1997) and use the Hodrick-Prescott filtered trend.[3] By doing so I take into account the possibility that there may be changes in the GDP-trend growth. π^* is the inflation target, and r^* is the real interest rate. As far as the inflation target is concerned, I choose the German inflation target. This is done since the authorities have pegged the Norwegian Krone to European currencies, and therefore it might be argued that they implicitly have chosen the German inflation target. This will then make the hypothetical interest rates more comparable with the actual development

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[3]I have used $\lambda = 16000$ rather than the conventional $\lambda = 1600$ for quarterly data. This is done because of the high variations in the Norwegian time series compared to comparable series for the US.

in the short run interest rate since the differences does not depend on differences in the inflation target. The values are taken from von Hagen (1995).[4]

As far as the real interest rate is concerned I again follow Frøyland and Leitemo (1997) and use 3.5 per cent for the whole period. They justify their choice by citing studies for the UK. With integrated capital markets the real interest rates should then be equalized. Interestingly the choice of 3.5 per cent is also close to the estimated real interest rate for Germany found by Clarida et al. (1998). Last, λ_1 and λ_2 are the weights put on the output and the inflation goal, respectively. I will follow Taylor and use $\lambda_1 = \lambda_2 = 0.5$, which also are the weights chosen by Frøyland and Leitemo.

3.2 Inflation forecast targeting

The calculations of expected inflation will necessarily be somewhat ad hoc. I have chosen the simplest possible procedure, namely to use the forecasts published by the Norges Bank in their quarterly journal 'Penger og Kreditt'. This has the advantage that it only depends on data that surely would have been available for the authorities.[5] From the second quarter of 1994 and onwards new estimates of expected inflation have been published every quarter, while available data before this volume is much more limited. For most estimates of the expected values in the first and the third quarter are not available and I have therefore used the published estimates on quarter in advance. I have calculated a forward-looking rule based on expectations for four periods including the prevailing period. The rule thus looks like the

---

[4]I have used a weighted average of the inflation target for the next four quarters. See the explanation to the calculation of expected inflation below.

[5]The disadvantage with this procedure is that it is not sure that these values reflect the true expectations of the authorities, especially in the early period of the sample. Clarida, Galí and Gertler (1999) argue that inflation is a forward-looking variable, and more precise that it depends on expected inflation. If the authorities are able to influence the market expectations when they publish their own expectations, the authorities have an incentive to under-estimate expected inflation to reduce current inflation.

following:

$$i_t = \pi^e_{t,3} + f_1 y_{t-1} + f_2 \left(\pi^e_{t,3} - \pi^*_t \right) + r^*, \tag{12}$$

where $\pi^e_{t,3} = E_{t-1} \sum_{j=0}^{3} \Delta p_{t+j}$. The specification follows from Clarida et al. (1998) who consider a rule of the type:

$$i_t = i^*_t + \gamma y_{t-1} + \beta \left(\pi^e_{t,3} - \pi^*_t \right), \tag{13}$$

where $i^*_t = r^* + \pi^*_t$, thus a long run nominal interest rate. The parameter γ measures the increase in the nominal interest rate following a one percent increase in the output gap for a given level of the expected inflation; and the parameter β measures the increase in the nominal interest rate following a one percentage point increase in expected inflation. Clarida et al. (1998) stress that the latter parameter will have to be larger than one in order to have an anchor for expected inflation. This will secure that an increase in expected inflation will lead to an increase in the real interest rate. Otherwise, if the parameter β is less than one, the real interest rate would decrease and thus monetary policy would accommodate changes in expected inflation.

This rule in equation (13) can be written as:

$$\begin{aligned} i_t &= r^* + \pi^*_t + \gamma y_{t-1} + \beta \left(\pi^e_{t,3} - \pi^*_t \right) \\ &= \pi^e_{t,3} + \gamma y_{t-1} + (\beta - 1) \left(\pi^e_{t,3} - \pi^*_t \right) + r^*, \end{aligned}$$

which is the rule that I consider with $f_1 = \gamma$ and $f_2 = (\beta - 1)$. I therefore denote the forward-looking rule the Clarida-Galí-Gertler (CGG)-rule.

The expected value is simply calculated as an arithmetic mean of the Central Banks forecasts of inflation for the prevailing and the next year. For instance, the expected inflation in the second quarter in 1989 is calculated as $\pi^e_{2,1989} = 0.75 \pi^e_{1989} + 0.25 \pi^e_{1990}$. The weights are now taken to be $f_1 = 0.44$ and $f_2 = 0.73$: the change in the weights is based on two factors. The first is the fact that output serves as a proxy for expected inflation (together with current inflation) *and* output stabilization in the Taylor rule. In this case of the CGG-rule, however, γ ideally only is the weight put on output stabilization. The second is the fact that an average rate of inflation the last four quarters equal to $\pi_{t,-4}$ will imply an expected rate of average inflation

the next four quarters of $\pi^e_{t,3} = \alpha\pi_{t,-4}$, where the factor α will normally be between zero and one.

The actual choice is based on some back-of-the-envelope calculations in order to make the two rules comparable. I do this by looking at the ability of the two variables which enters the Taylor rule to forecast expected inflation, thus I run the following regression:

$$\pi^e_{t,3} - \pi^*_t = a_1 y_{t-1} + a_2 \left(\pi_{t,-4} - \pi^*_t\right) + e_t. \tag{14}$$

This gave $a_1 = 0.03$ and $a_2 = 0.87$. Inserting (14) for expected inflation into equation (13) gives

$$
\begin{aligned}
i_t &= r^* + \pi^*_t + \gamma y_{t-1} + \beta\left(a_1 y_{t-1} + a_2\left(\pi_{t,-4} - \pi^*_t\right)\right) \tag{15}\\
&= i^*_t + \left[\gamma + \beta a_1\right] y_{t-1} + \beta a_2\left(\pi_{t-1} - \pi^*_t\right).
\end{aligned}
$$

Thus $\gamma + \beta a_1 = \frac{1}{2}$ and $\beta a_2 = \frac{3}{2}$, so that $\gamma = \frac{1}{2}\left(1 - \frac{3a_1}{a_2}\right) = 0.44$ and $\beta = \frac{3}{2a_2} = 1.73$, which are the weights given in the text above.

3.3 The development of short-term interest rates

Figure 1 shows the development of the two hypothetical interest rates rules; the Taylor rule and the forward-looking rule.[6] They are both compared to the development of the three-month interest rate NIBOR. The grids mark periods with changes in the fixed exchange rates. The Norwegian Krone was devalued with 3 per cent on June 9 1982, with 2 per cent on February 7 1984, and with as much as 9.2 per cent on May 5 1986 (see e.g. Alexander et al. 1997). Another two important events were the linking and de-linking of the Krone to ECU on October 2 1990 and December 10 1992. The shaded areas show the periods where the NIBOR is lower than the rate indicated by the rule.

A general feature that stands out is that the two hypothetical rules indicate a rather similar interest rate for most of the time period. However, in some periods

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[6]The data sources are as follows: GDP – Kvarts database, Statistics Norway, CPI – International Financial Statistics, expected inflation – Bank of Norway,.and German CPI – Statistische Bundesamt.
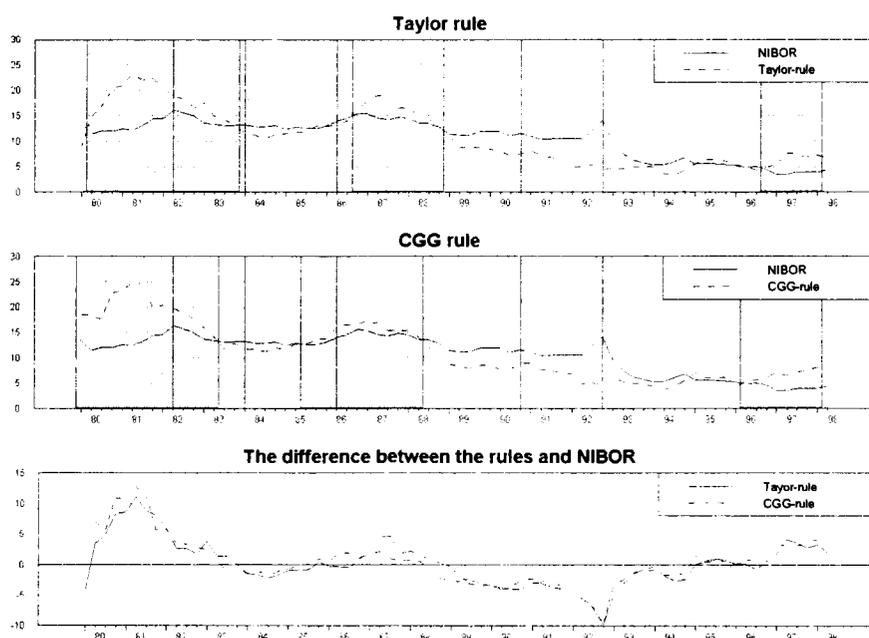
Figure 1: Interest Rate Development

the two rules provide different answers on the question whether the actual monetary policy was too contractionary or too expantionary. I will return to this below.

Both rules indicate first that monetary policy was too loose in the beginning of the sampling period until some point in 1983; and more precise, the Taylor rule indicates a too loose monetary policy until the third quarter and the forward-looking rule until the second quarter.[7] The reason for this is seen in figure 2, where I have plotted the output gap and the inflation gap.[8] This period experienced a sharp increase in the rate of inflation, where the annual rate increased from 4-5 per cent at the end of 1979 to 13-14 per cent at the end of 1980. As far as the output gap was

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[7] It must be stressed that the interbank rate does not necessarily give an accurate picture of the stance of monetary policy in this period. The reason is the financial regulations, which were not abandoned until 1987. First, the interest rates were regulated so that monetary policy was looser than it looks by looking at NIBOR. And, second, there was credit rationing.

[8] As the rate of inflation I have used the inflation measure used in the calculating the Taylor rule, thus the average-price-increase over the past four quarters. The inflation gap is thus the difference between this inflation measure and the target in that specific quarter.

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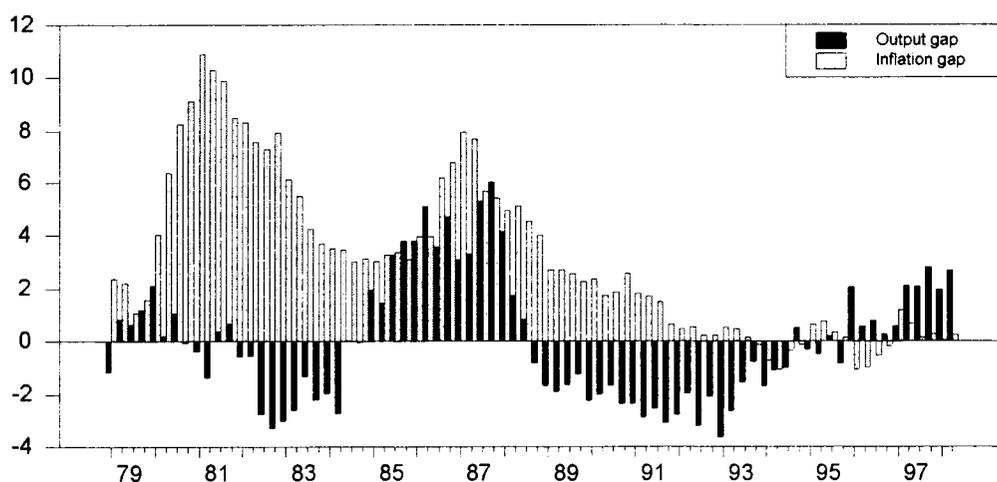
Figure 2: Output and Inflation Gaps

concerned, the changes were moderate, which indicate that the increase in consumer prices were mainly supply driven; and more specific the price increases are related to the second oil price shock which occurred during 1979. This second oil price shock caused an international recession, and since Norway was not an "oil country" yet, the output gap turned negative and the Norwegian economy experienced a deep recession starting in the end of 1981. The sharp increase in the hypothetical interest rates thus result from the increases in the rate of inflation. After this period, the rules indicate a slightly too tight monetary policy. The inflation came down from 11 per cent at the end of 1982 reaching 6 per cent in mid 1984. At the same time - as noted above - the output gap turned negative at the end of 1981 and stayed negative until the end of 1984.

Whereas the cycle in the early 1980's may be described as a supply-side distur- bance, the strong positive cycle around 1985 has every feature of being demand- driven. It coincides with the final deregulation of the Norwegian credit market, which led to a loan-financed consumer boom and ended with the crash in the stock market in the autumn 1987. Inflation rose by more than 4 percentage points from the first quarter of 1985 till the first quarter in 1987; and at the same time the output gap went from negative figures in the fourth quarter of 1984, reaching a peak of remarkable 4.6 per cent in the second quarter of 1986.

Both interest rate rules indicate a too loose monetary policy in this period, which also corresponds to the finding in Frøyland and Leitemo (1997).[9] Interestingly, the forward looking rule seems to indicate a somewhat earlier turning point, where the difference with the actual rate goes from positive to negative figures between the second and the third quarter of 1985. The difference with the actual interest rate then rises quickly and stays between 100 and 200 basis points untill it reaches its maximum in the first quarter of 1986, when the difference rises to slightly more than 200 basis points. Thereafter the difference falls more or less gradually untill the third quarter of 1988, where the CGG-rule indicates a lower interest rate than the actual one. As far as the backward-looking rule is concerned, it indicates a too loose monetary policy from the fourth quarter of 1986 – where the difference between the Taylor rule and the actual interest rate is about 100 basis points. This is five quarters later than the forward-looking rule: and, in fact, the difference of the two rules is close to 250 basis points in the second and third quarter of 1986. Later in the cycle this picture is reversed and the Taylor rule stays considerably above the CGG-rule until the first quarter of 1989. It is interesting to note that the output gap in Germany over the same time period showed negative figures (von Hagen 1995), which probably led to the low interest rates during the boom. Furthermore the Norwegian Krone was devalued in with close to 10 per cent in May 1986, which most probably fed into the boom.

After the boom that took place around 1986 the Norwegian economy sunk into a deep recession. Again figure 2 indicates that the recession was demand-driven since both the rate of inflation and the output gap fell considerably. The forward-looking rule indicates that monetary policy was too tight from the second quarter of 1988 till the fourth quarter of 1994; and the Taylor rule indicates a too tight monetary policy two quarters later. If we look at the actual three-month interest rate over this time period there was a modest decrease until the second quarter of 1992: between 1989:1

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[9]Compared to their results, I find an interest rate indicated by the Taylor rule that is slightly higher arround 1987. This is due to two facts: first, they have assumed an inflation target of 2.5 per cent, while I have a target of 2 per cent in this period; second, the output gap is somewhat higher in my calculations since I use $\lambda = 16000$ when I do the HP-filtering.
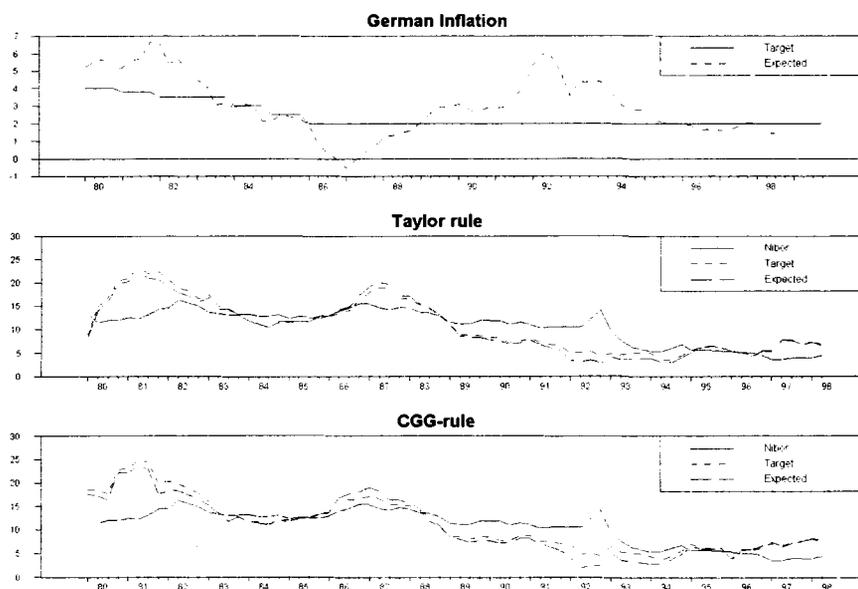
Figure 3: The interest rate rules using expected inflation instead of the German inflation target.

and 1992:2 the interest rate falls from 11.4 to 10.4. During autumn, the three-month rate increases due to the defence of the Krone in European exchange rate; but after the Krone is de-linked from ECU on December 10, 1992, the three month rate falls considerably during the first part of 1993. Actually, from the peak in the fourth quarter in 1992 the actual rate falls from above 14 per cent till less than six per cent a year later. This is then also the turning point of the recession, and from the beginning of 1995 till some point in 1996 the actual interest rate thereafter keeps more or less track of the two hypothetical rules. During 1996 the hypothetical rules start increasing –first the forward-looking rule in the second quarter and then the Taylor rule in the fourth quarter – and they continue to rise throughout 1997. In fact, at the same time the actual rate falls with more than 150 basis points between the third quarter of 1996 and the first quarter of 1997. Thereafter the differences fall considerably as the Norwegian authorities have to increase interest rate to defend the Krone during the summer and autumn of 1998.

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It might be argued that using the German inflation goal will overestimate the hypothetical rules. This is due to the fact that also German inflation overshot the inflation target in most of the period. One reason for using actual inflation rather than the inflation target is that the Norwegian authorities have traditionally aimed at having the same wage and price-development as their main trading partners; and therefore, they would aim at the German rate of inflation rather than the German inflation target. In figure 3 I have plotted a measure for the expected German rate of inflation[10] along with the German inflation target. Furthermore I have plotted the Taylor rule and the CGG-rule when I use the expected German inflation instead of the German inflation target as the aim of monetary policy. It is thus clear from the figure that using the German expected inflation would have led to a not so tight monetary policy in the early 1980's as the German rate of inflation was expected to overshoot the German target. Around 1986 monetary policy would have been tightened even more, however. In this period the Norwegian economy was in an expansion – with high rates of inflation – while the German economy was in a recession – with low rates of inflation. Last, German inflation went up considerably around the unification and at the same time the Norwegian economy was in a recession with low rates of inflation. Targeting the German expected inflation would therefore have implied an even looser monetary policy in this period.

In the calculation of the forward-looking rule above I have followed Clarida et al. (1998) and let the target horizon for expected inflation be one year. However, th choice of time horizon will depend on how fast changes in the instrument will affect the targeted variable (here: the rate of inflation). And compared to the US-economy – which is analyzed by Clarida et al. (1998) – small open economies like the Norwegian tend to have a shorter transmission period. This, therefore, might favor a somewhat shorter time-horizon than I have chosen. However, as argued by Ball (1998), a short horizon for the inflation goal increases the danger of a volatile exchange rate since the exchange rate channel will be the most important for short

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[10]To find a measure for expected inflation I have represented the German inflation as an AR(4) model. Expected inflation is then found by predicting the rate of inflation four periods in a loop procedure.

horizons. And a stable exchange rate has traditionally been an aim of the Norwegian authorities, which might favor an even longer time horizon.

4 Concluding remarks

In this paper I have calculated and compared the Taylor rule and a forward-looking rule. The former is often used as an indication on how the short-term interest rate would have been if the exchange rate target would have been abandoned and central bank had targeted the rate of inflation. However, the Taylor rule will only then give a reasonable indication if past inflation and past output gaps – the two variables in the rule – are good proxies for expected inflation. Therefore, I have calculated a forward-looking rule, which uses expected inflation directly.

The main insight is that both rules indicate a significantly different monetary policy than the actual one for large periods. Furthermore, it seems that the forward-looking rule has evolved somewhat differently than the Taylor rule over the economic cycles. More precise, it seems that the rule increases earlier in economic booms and falls earlier in economic recessions. In the theoretical literature on inflation targeting it is often argued that expected inflation should be the intermediate target for monetary policy. Therefore, the Taylor rule might give a poor indication of monetary policy under inflation targeting when the economy goes in or out of recessions or booms.

References

Alexander, William E., John H. Green, and Birgir Arnason, "A Monetary Framework for Norway, the Options," in Anne B. Christiansen and Jan F. Qvigstad, eds., *Choosing a Monetary Policy Target*, Scandinavian University Press, 1997, pp. 26–60.

Ball, Laurence, "Policy Rules for Open Economy," October 1998. NBER Working Paper 6760.

Barro, Robert J. and David B. Gordon, "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 1983, *91*, 589–610.

Clarida, Richard and Mark Gertler, "How the Bundesbank Conducts Monetary Policy," 1996. NBER Working Paper Series 5581.

_ , **Jordi Galí, and Mark Gertler**, "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review*, 1998, *42*, 1033–1067.

_ , _ , **and** _ , "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature*, 1999, *37* (4), 1661–1707.

Frøyland, Espen and Kai Leitemo, "Pengepolitisk Stabilisering Ved Hjelp Av Taylors Regel," *Sosialøkonomen*, October 1997, *51* (8), 10–15.

Svensson, Lars E. O., "Inflation Forecast Targeting: Implementing and Monotoring Inflation Targets," *European Economic Review*, 1997, *41*, 1111–1146.

Taylor, John B., "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 195–214.

ESSAY 4:

A monetary policy rule in practice: the case of Norway*

Abstract

In this paper I look at the effect on monetary policy of pegging the Norwegian Krone to the European currencies. I estimate a monetary policy rule for the period 1986 till 1992, and I take into account that the monetary authorities have followed a fixed exchange rate regime. The result is that the monetary policy set-up accommodated changes in expected inflation in this period.

1 Introduction

In this paper I look at the effect on monetary policy of pegging the Norwegian Krone to the European currencies. The paper follows the work of Clarida, Galí and Gertler (1998, 2000) and estimate a monetary policy rule; but I take into account the fact that the monetary authorities have followed a fixed exchange rate regime. This is done by estimating a policy rule based on macroeconomic variables, namely the rate of inflation and the output gap. Furthermore, I add a foreign interest rate due to the fixed exchange rate regime. I choose the German short term interest rate since the German Mark can be considered the anchor currency in the European exchange rate regime. In addition I follow Holden and Vikøren (1996) and take into account the fact that the Norwegian Krone was devalued on several occasions preceding the starting point of the analysis. The common view is that the devaluations reduced the credibility of the fixed exchange rate, which in turn led to higher interest rate differentials. I restrict the analysis to the time-period from December 1986 to August 1992 where the monetary policy rule is expected to be stable.

Frøyland and Leitemo (1997) calculate the short term interest rates using the traditional Taylor (1993)-rule for the period 1985 till 1996. Compared to the development of the actual interest rate, the Taylor-rule indicate that the Norwegian monetary policy was to loose around 1987-88, and too tight from 1989 till about 1994. The first part of this paper differs from Frøyland and Leitemo (1997) in three important ways. First, I *estimate* the weights on the rate of inflation and the output gap implied by the actual development of the short term interest rate rather than calculating an interest rate rule using the weights suggested by Taylor. Second, I focus on forward looking variables, and thus I will be able to estimate the weights on the expected rate of inflation and output gap. In the traditional Taylor-rule the output gap enters both due to a weight on stabilizing output and due to its ability to forecast future inflation. Thus the monetary authorities might include the output gap in the operational rule even if they are not concerned about output fluctuations

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as such.[1] Third, this analysis take the fixed exchange rate into account and ask how monetary policy reacted to changes in the foreign interest rate.

Holden and Vikøren (1996) split the interest rate differential into two different parts – temptation and reputation. The temptation part has similarities with the monetary policy rule that I consider, but Holden and Vikøren consider past variables while I look at forward-looking variables. Furthermore, the reputation term is added to the interest rate differential in their model, while it enters multiplicatively in the model I consider.

This paper is organized as follows: The econometric approach and the extensions of the simple rule are described in section two; and the results are discussed in the third part. The last part summarizes.

2 The econometric approach

The estimation procedure follows the work of Clarida et al. (1998, 2000) and estimates a monetary policy rule for Norway using generalized method of moments (GMM). This is done using the 3-month Norwegian interbank rate (NIBOR) as a proxy for the monetary policy instruments. Furthermore, I use monthly data to gain degrees of freedom. The estimation is done for the specific time period December 1986 till the break down of the ERM late 1992. I quit the estimation period in August 1992 which is before the rapid rise in the short term interest rate in late 1992. The estimation period thus goes from 86:12 till 92:7. The motivation for choosing this particular time period is twofold. First, the period is interesting due to the choice of monetary policy set-up, namely a fixed exchange rate regime. Secondly, the monetary policy arrangement was stable over the time period and the weight put on achieving the monetary policy goal was high.

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[1]Svensson (1997) develops a model where the operational rule of the monetary authorities will be a Taylor-type rule both in the case of strict and flexible inflation targeting; but the weights put on the rate of inflation and the output gap will generally differ in the two cases.

2.1 The simple rule

The starting point for the estimation is the interest rate rule in Clarida et al. (1998, 2000) given by:

$$i_t^r = \beta \left[E\left(\pi_{t,k} | \Omega_t \right) - \pi^* \right] + \gamma E \left(y_{t,l} | \Omega_t \right) + i_t^*, \tag{1}$$

where superscript "r" denotes rule and i_t^r is therefore the target for the short-term interest rate for the time period t. $\pi_{t,k}$ is the rate of inflation between period t and period $t + k$ and π^* is the inflation target. $y_{t,l}$ is the average output gap in the time period t till $t + l$. The variable Ω_t is the information available to the central bank when it forms its expectations and i^* is the long-run average nominal interest rate. The rule thus calculates a target for the short-term interest rate based on the expected development of the rate of inflation and the output gap. I follow Clarida et al. (2000) and assume that the central bank considers the excepted inflation over the next year and the average output gap the next half year, thus I use $k = 12$ and $l = 6$.

The rule may be interpreted as a forward-looking Taylor-rule. To see this, note that the rule may be written as

$$
\begin{aligned}
i_t^r &= \beta \left[E\left(\pi_{t,k} | \Omega_t \right) - \pi^* \right] + \gamma E \left(y_{t,l} | \Omega_t \right) + r^* + \pi^* \\
&= E\left(\pi_{t,k} | \Omega_t \right) + (\beta - 1) \left[E\left(\pi_{t,k} | \Omega_t \right) - \pi^* \right] + \gamma E \left(y_{t,l} | \Omega_t \right) + r^*,
\end{aligned}
\tag{2}
$$

which is equal to the Taylor-rule except from the fact that instead of past inflation and output gap – as in the Taylor-rule – this rule is based on expected future values of these parameters. A standard justification of the Taylor-rule – see e.g. Svensson (1997) – is that past inflation and output gap serve as indicator for future inflation (and output gap). Due to the fact that monetary policy is expected to influence these variables with a lag, expected inflation and output gap – rather than their current values – should be the aim of monetary policy. The rule considered here hence directly link the interest rate to the targeted variables.

The rule will then work as follows: On average the interest rate implied by the rule will equal i^*, and thus the rule support the inflation target in the long run: the

nominal interest rate will equal an exogenous (i.e. independent of monetary policy) long-run real interest rate plus the inflation target. In the short run, the rule is active: if either the rate of inflation is above the target or the output gap is positive, the interest rate will increase and vice versa.[2]

It is a useful exercise to follow Clarida et al. (1998) and look at the implied real interest rate defined by $r_t^r \equiv i_t^r - E\left(\pi_{t,k}|\Omega_t\right)$.[3] Inserting for i_t^r from the interest rate rule in equation (1) gives:

$$r_t^r = \beta\left[E\left(\pi_{t,k}|\Omega_t\right) - \pi^*\right] + \gamma E\left(y_{t,l}|\Omega_t\right) + r^* + \pi^* - E\left(\pi_{t,k}|\Omega_t\right)$$

$$r_t^r = (\beta - 1)\left[E\left(\pi_{t,k}|\Omega_t\right) - \pi^*\right] + \gamma E\left(y_{t,l}|\Omega_t\right) + r^*. \tag{3}$$

The rule thus depends on the two parameters β and γ in a very specific way. First, already from equation (1) it is clear that an increase in the expected rate of inflation will trigger an increase in the nominal interest rate as long as $\beta > 0$. However, as can be seen from equation (3), a positive parameter β is not enough to increase the real interest following an increase in expected inflation. If β is between zero and one, monetary policy will accommodate an increase in expected inflation and let the real interest rate decrease. This sort of accommodating monetary policy is reported by Clarida et al. (2000) for the US before Volcker took over by the end of the 1970's. If β is larger than one, however, the real interest rate also increases if expected inflation increases. Looking at the value of β thus gives a straightforward method of judging the monetary policy set-up.

One important implication of the sort of accommodating monetary policy implied by having $0 < \beta \leq 1$, is that it *may* result in higher fluctuations in the rate of inflation due to self-fulfilling prophesies. The argument goes as follows: Assume that there is an exogenous increase in expected inflation. The central bank increases the nominal interest rate (β is larger than zero) but the increase in the nominal interest rate is lower than the increase in expected inflation (β is less than one). The real

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[2]A theoretical justification for the forward-looking rule may be found in Clarida, Galí and Gertler (1999).

[3]Following Clarida et al. (1998) I have to interpret the real interest rate as an "approximate" real rate since the maturity of the interest considered - 3 months - is less than the forecast horizon of inflation - 12 months.

interest rate therefore decreases, which leads to an increase in aggregate demand. This increase in demand will in turn increase output and prices; and thus support the initial increase in expected inflation. If, on the other hand, the central bank increases the nominal interest rate so that the real interest rate increases (if β is more than one), demand – and thus output and prices – should decrease, which is incompatible with the initial increase in expected inflation. One important aim of this analysis will thus be to see whether the Norwegian monetary policy regime have established a framework that rules out such self-fulfilling prophesies.

The second important parameter in the analysis is γ, which says something about the weight put on output stabilization. In the literature about inflation targeting a useful distinction is drawn between strict and flexible inflation targeting. By the former it is mostly referred to a regime where the central bank only puts a positive weight on stabilizing the rate of inflation around the target, and by the latter to a regime where the central bank also puts a positive weight on stabilizing other variables – typically the output gap or the rate of unemployment. Also in the case of strict inflation targeting other variables may enter the operating rule – thus a rule relating the instrument to observable variables – if they help forecast inflation. A typical example is here the Taylor-rule which thus relates the short term interest rate to lagged inflation and the output gap. As shown by Svensson (1997) even strict inflation targeting may give rise to a Taylor-type rule, but the output gap then enters only due to its ability of forecasting inflation. Another aim of this estimation will thus be to see how the monetary set-up has reacted to deviations from the natural level of output.

The rule as it stands above lacks two important aspect of monetary policy which will make it perform poorly, however. First, I does not consider the fact that the Norwegian authorities pursued a fixed exchange rate over the time I consider; and, second, it does not take interest rate smoothing into account.

2.2 Modifications of the rule

I now modify the rule in order to take into account the fact that the Norwegian authorities pursued a fixed exchange rate over the time period I consider; and furthermore, I model interest rate smoothing. The former is done by including the German short term interest rate into the monetary policy rule.[4] More precisely, the nominal interest rate (rule) i_t^r is assumed to be a weighted average of a (hypothetical) domestic and a foreign nominal interest rate rule, thus

$$i_t^r = (1 - \tau_t) i_t^{hr} + \tau_t i_t^f, \tag{4}$$

where i_t^{hr} is the domestic interest rate given by the rule in equation (1) above and i_t^f is the foreign interest rate. Last, τ_t is the weight on the foreign nominal interest rate, which may be time-dependent. I will return to the latter below.

There are – at least – two possible interpretations of this equation and both have some appeal. The first follows Clarida et al. (1998) and says that even a fixed exchange rate regime may give the monetary authorities some possibilities to follow domestic objectives.[5] The parameter τ thus gives the weight which the authorities have to put on the external events due to the fixed exchange rate obligation.[6]

The second interpretation follows from looking at the uncovered interest rate parity, which states that

$$i_t = i_t^f + E_t \left(\Delta e_{t+1} \right) + \phi_t, \tag{5}$$

where i_t^f is the foreign nominal interest rate, e_t is the nominal exchange in period t and thus $E_t \left(\Delta e_{t+1} \right)$ is the expected change in the nominal exchange rate between period t and $t + 1$. The variable ϕ_t is the risk premium. Since the Norwegian authorities have aimed at a fixed exchange rate, the expected change in the exchange

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[4]Lagged values of the German short-term interest rate FIBOR – eight lags ordered as the other variables above – are then added to the list of instruments.

[5]Clarida et al. (1998) give an interpretation of the policy rule of the UK during the so-called hard ERM along these lines.

[6]In this case, it might seem reasonable to follow Clarida et al. (1998) and let the weight τ be independent of time.

rate should in principle be zero. However, the authorities might change the parity in the fixed exchange rate regime – they could choose to devalue/revalue the currency.

The rule in equation (4) can be written as

$$i_t^r = i_t^{fr} + (1 - \tau_t) \left(i_t^{hr} - i_t^{fr} \right),$$ (6)

and the claim is that the devaluation risk will be related to the difference between the domestic and foreign nominal interest rate rules, thus to $(1 - \tau_t) \left(i_t^{hr} - i_t^{fr} \right)$. A possible interpretation of the domestic interest rate rule – i_t^{hr}, is the interest rate that would have prevailed if the authorities were free to choose the interest rate and did not have any limitations in their monetary policy. The weight τ_t will hence be related to the probability that the monetary authorities will abandon the fixed exchange rate obligation and set the interest rate according to the state of the domestic economy. Furthermore, the domestic interest rate rule i_t^{hr} is a function of the domestic expected inflation and output gap and the foreign rate i_t^{fr} likewise a function of foreign expected inflation and output gap. Therefore, the interest rate differential will be related to the difference between the domestic and foreign expected inflation and output gaps. The devaluation risk will hence be state dependent as it maps from differences in rate of inflation and output gaps in the two countries.

Holden and Vikøren (1996) make the useful distinction between reputation and temptation in a fixed exchange rate regime. The former captures the idea that a weaker government – in the sense that it puts a lower weight on the fixed exchange rate obligation – will have lower credibility since it – other things equal – will use devaluations more frequently; and the latter relates to the assumption that a devaluation is more likely if there are some macroeconomic imbalances. They consider a model where temptation is linked to unemployment; if the unemployment in Norway is high, the interest rate differential with our trading partners will be high, since the government is tempted to devalue in order to lower unemployment. The idea is thus to distinguish between the two effects of a devaluation on future credibility as discussed by Drazen and Masson (1994); a devaluation increase future devaluation risk since the probability that the government is "weak" is higher, but at the same

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time it decreases future devaluation risk since a reduction in the macroeconomic imbalance today will tend to persist (there is autocorrelation in e.g. unemployment and a low unemployment therefore increases the probability of low unemployment in the near future). Therefore, a devaluation may end up increasing credibility.

Holden and Vikøren (1996) estimate their model using a number of different variables to express temptation[7], but a simplified version of their model look like the following:

$$i_t - i_t^f = a_1 \left(\pi_{t,-12}^h - \pi_{t,-12}^f \right) + a_2 u_{t-1}^h + a_3 \left(i_{t-1} - i_{t-1}^f \right) + g_t, \qquad (7)$$

where $\pi_{t,-12}$ is defined as the average inflation the *last* 12 months, u_t is the rate of unemployment in period t, and g_t is reputation in period t. I will return to the latter shortly.

Inserting for i_t^{hr} and i_t^f from equation (1), equation (6) may be written as

$$\begin{aligned} i_t^r &= i_t^f + (1 - \tau_t) \left[\beta^h \left(E_t \pi_{t,k}^h - \pi^* \right) - \beta^f \left(E_t \pi_{t,k}^f - \pi^* \right) \right] \\ &\quad + (1 - \tau_t) \left[\gamma^h E_t y_{t,l}^h - \gamma^f E_t y_{t,l}^f \right]. \end{aligned} \qquad (8)$$

The rule I use is thus similar to the rule proposed by Holden and Vikøren (1996). Compared to the equation (7) above, I focus on expected values of the parameters rather than past observations. Furthermore, the rule I consider assumes that temptation will depend on the difference between inflation and the target for both the domestic and foreign country, and it allows for the monetary authorities in the two countries to put different weights on the inflation goal.[8] Finally, the rule includes a both the domestic and the foreign output gaps, and again it allows for different weights in the two countries.

Estimating the rule in equation (4) will miss one important aspect of monetary policy, namely the fact that the Norwegian monetary authorities devalued the Norwegian Krone on several occasions preceding the time period that I consider, last in

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[7]More precisely they, use the rate of unemployment in period $t - 1$, the inflation differential, changes in the real exchange rate over the last twelve months, the trade balance in $t - 1$, the foreign reserves in period t, and the position of the nominal exchange rate within the band.

[8]If the weights on the inflation goal are equal in the two countries the rule reduces to the sort of specification in equation (7).

May 1986. A common view is that this resulted in low credibility of the fixed exchange rate regime, or actually to low reputation, which in turn led to high interest rate differentials. This is captured by Holden and Vikøren (1996) in their parameter g_t above. They construct this term as

$$g_t = b_1 cum\,(dev)_t + b_2 cum\,\left(dev^2\right)_t + b_3 \left[cum\,(dev)_t\right]^2$$
$$dev_t = \left(i_t - i_t^f\right) - E_t\left[\Delta x_{t+t} \,|\text{no realignment}\right],$$

where $E_t\left[\Delta x_{t+t} \,|\text{nr}\right]$ is the expected change in the nominal exchange rate within the band (given no realignments of the peg) and thus dev is expected devaluation. Holden and Vikøren (1996) argue that reputation will depend on accumulated expected devaluations, which again both will depend on the period since the last devaluation and the size of the devaluation expectation each period. They use the function above, which also will capture non-linearities in the effect of devaluation expectations.

I will use a simplified approach proposed by Chen and Giovannini (1993):

$$g_t = b\ln\left(1 + t - t_d\right),$$

where t_d is the point in time of the last realignment. In the case of a devaluation, reputation will thus be 0 and it will increase gradually as the time period since the last devaluation increases. Holden and Vikøren (1996) estimate the model for the time period 78:12 till 92:12, thus a period involving four devaluations of the Krone. Therefore, it seems reasonable to take the nature of past devaluations into account in the way they suggest. I look at a shorter time period without any devaluations and thus the simplified function should therefore give a reasonable approximation.

Holden and Vikøren (1996) assume that reputation enters additively into the interest rate differential. I will, on the other hand, assume that reputation enters multiplicatively. The argument for doing this is that reputation should only affect the interest rate differential if the monetary authorities would have set a different interest rate than in the foreign country: If the domestic interest rate rule coincides with the foreign interest rate, the domestic monetary authorities do not wish to set a different interest rate even if they were able to, so the interest rate differential

should be zero. I therefore consider the following specification, where reputation enters multiplicatively:

$$i_t^r - i_t^f = \left(1 - b\ln\left(1 + t - t_d\right)\right)\left(i_t^{hr} - i_t^f\right),\tag{9}$$

where thus the term $b\ln\left(1 + t - t_d\right)$ equals the τ_t in equation above. The rule in equation (4) above might therefore be interpreted as follows: the interest rate is a weighted sum of the foreign interest rate and the rate which the authorities would choose if they abandon the fixed exchange rate: and weights are linked to the reputation of the regime.

As noted above, the rule in equation (9) lacks interest smoothing. This is the observation that most central banks are reluctant to change the interest rate rapidly, and instead smooth out the interest rate changes over several periods.[9] Therefore, before turning to the estimation, I will have to take into account the possibility of interest rate smoothing. To do this I follow Holden and Vikøren (1996) and assume that the interest rate differential is given by:

$$i_t - i_t^f = \left(1 - \sum_{m=1}^{m=M} \rho_m\right)\left(i_t^r - i_t^f\right) + \sum_{m=1}^{m=M} \rho_m \left(i_{t-m} - i_{t-m}^f\right) + v_t,\tag{10}$$

where ρ_m measures the weight put on the interest rate differential m months ago, and the sum of the weights is between zero and one. With a one period interest rate smoothing, the interest rate differential will be given by:

$$i_t - i_t^f = \left(1 - \rho\right)\left(i_t^r - i_t^f\right) + \rho\left(i_{t-1} - i_{t-1}^f\right) + v_t.\tag{11}$$

The error term – which is assumed to be i.i.d. – might be considered as unexplained parts of monetary policy. Another possibility is that it comes from the fact that the interbank rates is not directly controlled by the monetary authorities. The Norwegian central bank sets the overnight lending rate and the deposit rate, and the NIBOR will (normally) fluctuate between these.[10]

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[9]Rebelo and Xie (1999) discuss the optimality of interest rate shoothing in cash-in-advance models, while Goodhart (1996) discusses interest smoothing in a more general setting.

[10]The error term v_t will also include a risk premium, which is thus assumed to be stationary. Akram and Frøyland (1997) estimate the relationship between Norwegian and European (Euro) short-term interest rates between 1989:11 and 1996:5 and cannot reject a hypothesis of a stationary risk premium.

Inserting for the interest rate given by the rule in equation (9) into the actual interest rate differential in equation (11) I get:

$$
\begin{aligned}
i_t &= (1 - \rho)(b_0 - b_1 \ln(1 + t - t_d)) \\
&\quad \times \left\{ [\beta (E(\pi_{t,k}|\Omega_t) - \pi^*) + \gamma E(y_{t,l}|\Omega_t) + r^* + \pi^*] - i_t^f \right\} \\
&\quad + \rho \left(i_{t-1} - i_{t-1}^f \right) + v_t,
\end{aligned}
\tag{12}
$$

where the latter equality follows from inserting for i_t^h from equation (1). This equation cannot be estimated directly since the equation depends on unobservable variables; the expected inflation and the expected output gap. To be able to do so, I write the interest rate rule using realized values as follows:

$$
\begin{aligned}
i_t &= (1 - \rho)(b_0 - b_1 \ln(1 + t - t_d)) \left\{ [\beta (\pi_{t,k} - \pi^*) + \gamma y_{t,l} + r^* + \pi^*] - i_t^f \right\} \\
&\quad + \rho \left(i_{t-1} - i_{t-1}^f \right) + \varepsilon_t \\
&= (1 - \rho)(b_0 - b_1 \ln(1 + t - t_d)) \\
&\quad \times \left\{ \alpha + \beta \pi_{t,k} + \gamma y_{t,l} - i_t^f \right\} + \rho \left(i_{t-1} - i_{t-1}^f \right) + \varepsilon_t,
\end{aligned}
\tag{13}
$$

where

$$
\alpha = r^* + (1 - \beta) \pi^* \text{ and}
\tag{14}
$$

$$
\begin{aligned}
\varepsilon_t &\equiv -(1 - \rho)(b_0 - b_1 \ln(1 + t - t_d)) \\
&\quad \times \{ \beta [\pi_{t,k} - E(\pi_{t,k}|\Omega_t)] + \gamma [y_{t,l} - E(y_{t,l}|\Omega_t)] \} + v_t.
\end{aligned}
\tag{15}
$$

The error term is now a linear combination of the disturbance v_t and the errors in forecasting inflation and output given the information set Ω. Following Clarida et al. (2000) the disturbance has a MA$(k - 1)$ representation (since $k > l$).

To estimate (13) I use a set of instruments $\mathbf{u}_t \in \Omega_t$, which are thus assumed to be part of the information set of the central bank and – in addition – orthogonal to the interest rate shock v_t. I use eight lags – ordered 1 to 6, 9 and 12 – of the following variables: the Norwegian and German three month interest rates NIBOR and FIBOR;[11] the changes in the average output gap and inflation;[12] the changes

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[11] For these series only seven lags - ordered 2 to 6, 9 and 12 - are used since their first lag enters the monetary policy rule.

[12] The output gap is calculated using the Hodrick-Prescott filter on *quarterly* data for the main-

in the log of the real exchange rate;[13] the changes in the real oil price.[14][15] I assume rational expectations. Therefore, since the instruments are assumed to be part of the information set of the market participants when they form their expectations about future inflation and output gap, it is thus assumed that $E\left(\varepsilon_t | \mathbf{u}_t\right) = 0$. This therefore give us a set of orthogonality conditions:

$$
\begin{aligned}
0 \;=\; & E\left\{(1 - \rho)\left(b_0 - b_1 \ln\left(1 + t - t_d\right)\right)\left[\alpha + \beta \pi_{t,k} + \gamma y_{t,l} - i_t^f\right] \right. \\
& \left. + \rho\left(i_{t-1} - i_{t-1}^f\right) | \mathbf{u}_t\right\},
\end{aligned}
\tag{16}
$$

thus one for each of the instruments in $\mathbf{u}_t$.

To estimate equation (16) I utilize GMM with instrument variables. This is a two-step procedure (see e.g. Doan, 1996: 5-22 and 5-23). In the first step the non-linear model is estimated using non-linear least squares; and the residuals are used to construct an optimal weighting matrix, whereby taking into account that the residuals have a MA(11) representation. In the second step the model is reestimated – again using non-linear least squares – using the new weighting matrix. The overidentifying restrictions in the estimation is tested using a χ^2-test.
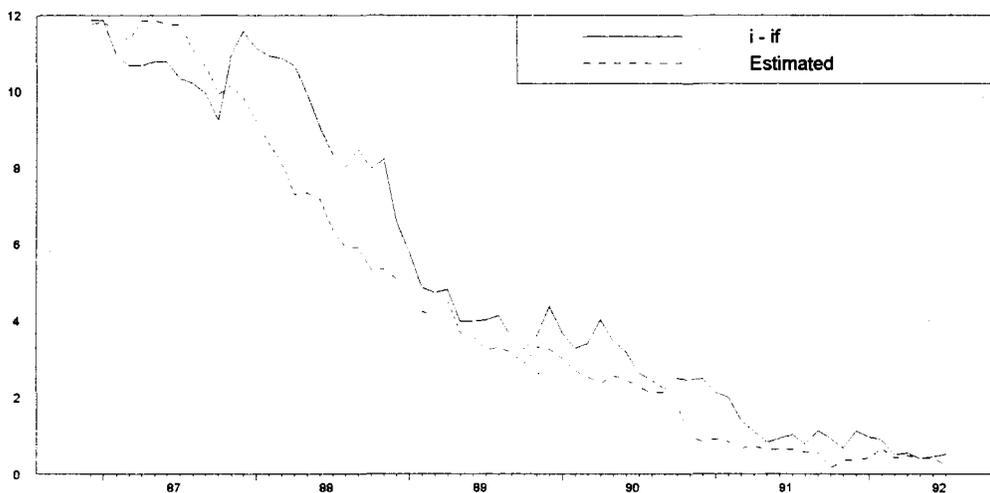
Figure 1: Actual and estimated short-term interest rate.

3 The results

The results of this estimation are given in table 1; and in figure 1 I have plotted the actual three months interest rate NIBOR and the estimated interest rate. The latter is calculated using realized values of the rate of inflation and the output gap. It is clear from the figure that the interest rate rule is able to explain large part

---

land GDP from 1978:1 till 1998:2. I considered using a weighted average of industrial production and construction, but found that it was a poor indicator of mainland GDP. This is probably due to the increase in non-tradables over the time period as the oil sector has become increasingly more important. The monthly "observations" of the six-month – thus two-quarter – average output gap is constructed as a weighted average of quarterly data. For example, the average output gap for the period starting in the February is constructed as a weighted average of the first three quarters: the first quarter has weight two sixth, the second one half, and the third one sixth.

[13] The real exchange rate is defined as $q = e + p^* - p$, where e is the log of the nominal exchange rate (a basket of exchange rate with weights based on trade) and p^* and p are the foreign and domestic price level in logs.

[14] The real oil price is calculated using the price of Brent Blend in dollars, transformed into the Norwegian currency by the spot price and deflated by the producer price index.

[15] Except GDP – which is taken from the Kvarts database, Statistics Norway – the series are taken from International Financial Statistics.

of the development of the actual short term interest rate.[16] The general decreases in the interest rate between 1986:12 and 1989:1 and between 1989:7 and 1991:5 are well explained by the rule. Furthermore, the rule indicates a rather stable interest rate from 1991:6 to the end of the estimation period. Some developments seem hard to explain, however. This is especially true for the rapid increases in interest rates which occurred at the end of 1987, and at the end of 1990. I will return to possible explanations for this below.

Table 1

Variable	Coefficient	Std Erro	T-Stat	Significance
constant	8.1536	0.5265	15.4852	0.00000000
ρ	0.8303	0.0084	98.3031	0.00000000
β	1.4729	0.1173	12.5583	0.00000000
γ	0.4289	0.0881	4.8667	0.00000113
b	0.1114	0.0058	19.1809	0.00000000

Test of overidentifying Restrictions:

$\chi^2(44) = 6.392334$ with significance 0.99999999

The estimation thus implies an interest smoothing of 0.83, which is somewhat lower than reported by Clarida et al. (1998) for the G3 countries: they find 0.91 for Germany, 0.93 for Japan and 0.92 for the US.

The main findings of this paper concern the parameters β and γ in the domestic-based monetary policy rule – the term denoted temptation, which relates the short-term interest rate to the development of expected inflation and expected output gap . Both parameters are significant with t-statistics of 12.6 and 4.9 for β and γ, respectively. As far as the former parameter is concerned the monetary policy authorities wish to increase the nominal interest rates by 147 basis points when expected domestic inflation increased by one percentage point; and thus the real interest rate by 47 basis. Likewise, nominal (and real) interest rates increased by 43 basis points when expected domestic output gap increased by one percentage

---

[16]Notice that I have plotted the interest rate rule and thereby not taken interest rate smoothing into account. By doing so, I would improve the fit.
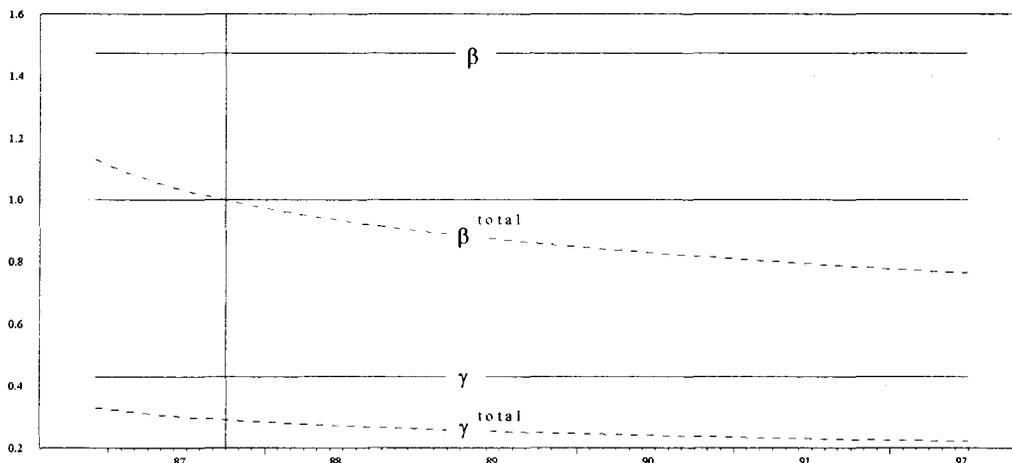
Figure 2: The development of β^{total} and γ^{total} through time.

point. Therefore, this indicates that monetary policy did not want to accommodate either increases in expected inflation or increases in expected output gap. The comparable estimates for the G3 countries reported by Clarida et al. (1998) are 1.31 for Germany, 2.04 for Japan, and 1.79 for the US. The monetary policy rule estimated for the Norwegian authorities thus have the same characteristics as the rule estimated by Clarida et al for the G3 countries.

The monetary authorities in the G3 countries and Norway differ in one important aspect, however, namely the fixed exchange rate obligation. Due to this, the Norwegian central bank was not free to set the short-term interest rate, but it had to set interest rates to defend the exchange rate parity. This is the reason why the foreign interest affects significantly the Norwegian short-term interest rate. To find how an increase in the expected inflation or an increase in the expected output gap affect the interest rate, I have to take into account the development of reputation. This is done in figure 2, where I have plotted the total inflation and employment gap parameters given by $\beta_t^{total} = (1 - \tau_t)\beta$ and $\gamma_t^{total} = (1 - \tau_t)\gamma$, respectively. This indicates that the monetary policy set-up led monetary policy to accommodate changes in expected inflation in most of the time period[17], while output were

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[17] β^{total} falls below unity in period 87:10.

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stabilized. As far as the former is concerned, the monetary policy – due to the fixed exchange rate set-up – thus did not manage to rule out self-fulfilling prophecies about the expected rate of inflation: exogenous increases in expected inflation led to decreases in the real interest rate. This may therefore – in itself – give a possible explanation of some of the variation in short-term interest rates. Since monetary policy supported multiple equilibria in prices, the changes in the short term interest rate may have come about due to self-fulfilling changes in expected (and realized) inflation.

The problem was thus that due to the external the monetary policy set-up did not provide an anchor for expected inflation. This intuition lacks one important aspect of international economics, however, namely the purchasing power parity (PPP).[18] If the PPP holds, this in itself would provide an anchor for expected inflation since the relative PPP states that $\pi_t = \pi_t^f + \Delta e_t + \Delta k_t$, where k_t is the real exchange rate and Δk_t captures real exchange rate changes due to different developments in e.g. domestic and foreign non-tradable productivity. Unfortunately, most empirical tests of the PPP concludes that at most it holds only in the very long run – even when differences in productivity in the non-tradable sector is properly taken into account (see e.g. Obstfeld and Rogoff: Chapter 4.1 and 4.2). Therefore, the domestic rate of inflation may hence wander away from the long-run equilibrium for a considerable time period before the law of one price eventually bites; and hence, there are no guarantees that self-fulfilling prophesies could not appear.[19][20]

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[18] Actually, one reason to peg the nominal exchange rate is to borrow credibility about the inflation target.

[19] The so-called "solidarity alternative" – thus the division of responsibility of Norwegian economic policy that was put in place during 1992 – may, in principle, solve this problem. Monetary policy is responsible for stabilizing exchange rates, fiscal policy for stabilizing output and the largest of the trade unions is responsible for wage-moderation and thus for stabilizing prices (see e.g. Alexander, Green and Arnason (1997)). However, there is little evidence that the solidarity alternative in itself constributed to wage-moderation (Alexander et al) beyond the fact that the high rates of unemployment in the early 1990's gave little preassure on wages.

[20] Note that having a monetary policy rule with $0 \leq \beta < 1$ is not a sufficient condition for self-fulfilling prophesies to appear. In addition, this will depend not only on the PPP, but on the whole structure of the economy.

The estimated constant will be given by

$$
\begin{aligned}
constant &= r^* + \pi^* + [\beta(\bar{\pi} - \pi^*) + \gamma\bar{y}] + \phi_0 \\
&= r^* + (1 - \beta)\pi^* + \beta\bar{\pi} + \gamma\bar{y} + \phi_0,
\end{aligned}
$$

where $\bar{\pi}$ and $\bar{y}$ are average inflation and average output gap, respectively, and ϕ_0 is the average risk premium. The constant thus consists of three parts: The first part is the average (long-run) nominal interest rate i^* – the long-run real interest rate plus the inflation target. The second part – the term in the square brackets in the first equality above – reflects that the average inflation and output gaps have been different from zero over this time period. The last part is a constant risk premium, ϕ_0. Since both i^* and ϕ_0 are unknown, these parameters cannot be estimated. However, by choosing a reasonable real interest rate and assuming that the constant risk premium is zero[21], I can calculate the implied inflation target. This will be given by

$$
\pi^* = \frac{constant - r^* - \beta\bar{\pi} - \gamma\bar{y}}{1 - \beta}.
$$

and letting $r^* = 3.5$ – which is the value chosen by Frøyland and Leitemo (1997) to calculate the Taylor rule for Norway – gives $\pi^* = 2.35$. This corresponds well to the German inflation target, which was equal to 2 percentage points in this period (see e.g. von Hagen 1995).[22]

In figure 3 I have plotted the interest rate differential, temptation, and – using the right hand scale – reputation. The figure shows how the interest rate differential decreases both due to the decrease in temptation and the increase in reputation. The former decreases both because the Norwegian economy went into a recession which eventually brought inflation down; and because the danger of German inflation after the re-union, which led the Bundesbank to increase short-term interest rates. Furthermore, the high interest rate differential in the beginning of the time period

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[21]In fact, Akram and Frøyland (1997) report a zero average risk-premium between Norwegian and Euro 3-month interest rates over the time period 1989 to 1996. Furthemore, Holden and Vikøren (1996) also assume a zero average risk premium in their analysis.

[22]Calculating r^* assuming that the inflation target equals 2 percentage points gives $r^* = 3.34$.
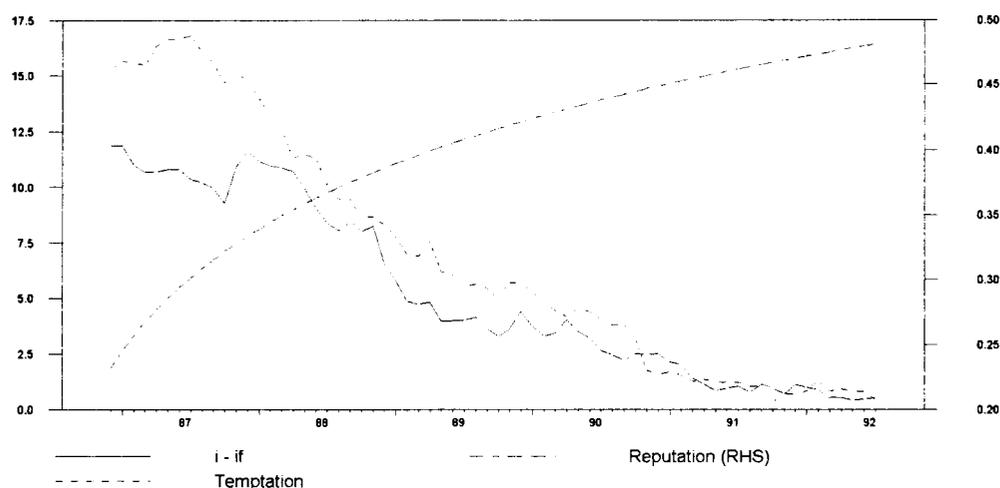
Figure 3: Temptation and reputation compared to the interest rate differential.

was not only lack of reputation; but low reputation combined with the state of the domestic economy.

4 Concluding remarks

In this paper I have estimated a monetary policy rules for Norway, where I explicitly take the fixed exchange rate setting into account. This was done by introducing the German short-term interest rate and by taking into account the development of credibility. The latter was modelled consisting of two parts; reputation and temptation. The estimation period was December 1986 to August 1992 and the main finding was that the monetary policy set-up seems to have accommodated changes in expected inflation. Therefore, monetary policy did not provide a sufficient anchor for short or medium term expected inflation which may have led to self-fulfilling prophecies about the development of the rate of inflation.

References

Akram, Qaisar Farooq and Espen Frøyland, "Empirisk Modellering Av Norske

Pengemarkeds- Og Obligasjonsrenter," *Norsk Økonomisk Tidsskrift*, 1997, *111*, 63–92.

Alexander, William E., John H. Green, and Birgir Arnason, "A Monetary Framework for Norway, the Options," in Anne B. Christiansen and Jan F. Qvigstad, eds., *Choosing a Monetary Policy Target*, Scandinavian University Press, 1997, pp. 26–60.

Chen, Zhaohui and Alberto Giovannini, "The Determinants of Realignments under the EMS: Some Empirical Regularities," 1993. NBER Working Paper Series 4291.

Clarida, Richard, Jordi Galí, and Mark Gertler, "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review*, 1998, *42*, 1033–1067.

_ , _ , **and** _ , "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature*, 1999, *37* (4), 1661–1707.

_ , _ , **and** _ , "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics*, 2000, *115* (1), 147–180.

Doan, Thomas A., *RATS User's Manual Version* Estima 1996.

Drazen, Allan and Paul R. Masson, "Credibility of Policies versus Credibility of Policymakers," *Quarterly Journal of Economics*, 1994, *109*, 735–754.

Frøyland, Espen and Kai Leitemo, "Pengepolitisk Stabilisering Ved Hjelp Av Taylors Regel," *Sosialøkonomen*, October 1997, *51* (8), 10–15.

Goodhart, Charles, "Why Do the Monetary Authorities Smooth Interest Rates?," February 1996. Special Paper No. 81, LSE Financial Markets Group.

Holden, Steinar and Birger Vikøren, "The Credibility of a Fixed Exchange Rate: How Reputation is Gained and Lost," *Scandinavian Journal of Economics*, 1996, *98* (4), 485–502.

Obstfeld, Maurice and Kenneth Rogoff, *Foundation of International Macroeconomics*, MIT Press, Cambridge Massachusetts, 1996.

Rebelo, Sergio and Danyang Xie, "On the Optimality of Interest Rate Smoothing," *Journal of Monetary Economics*, 1999, *43*, 263–282.

Svensson, Lars E. O., "Inflation Forecast Targeting: Implementing and Monotoring Inflation Targets," *European Economic Review*, 1997, *41*, 1111–1146.

Taylor, John B., "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 195–214.

von Hagen, Jürgen, "Inflation and Monetary Targeting in Germany," in Leonardo Leiderman and Lars E.O. Svensson, eds., *Inflation Targets*, Centre for Economic Policy Research, London, 1995.

ESSAY 5:

Inflation targeting in a monetary union with non-coordinated fiscal policy*

Abstract

The paper discusses coordination problems in a monetary union – with an independent central bank. It is shown that lack of coordination between monetary and fiscal policy leads to a state-contingent bias in that the fiscal authorities react to changes in core inflation. Furthermore, lack of coordination between the fiscal authorities will lead to a stabilization bias, in that the fiscal authorities do not react correctly to idiosyncratic shocks. The nature of the stabilization bias will depend on whether the fiscal authorities act as Stackelberg leaders in the game with the central bank.

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1 Introduction

Since the first of January 1999 the European Central Bank (ECB) has been responsible for conducting monetary policy in most of the countries in the European Union.[1] This implies that the national central banks no longer have the responsibility to conduct monetary policy, but only to supply money to meet the demand given the interest rates set by the ECB. Moreover, the principal goal of the ECB is to ensure price stability; and they are only supposed to foster the general economic development in the union when this does not compromise with the principal goal.[2]

The major drawback with the European Monetary Union (EMU) is that the participating countries can no longer use countercyclical monetary policy when their economies are hit by an idiosyncratic shock.[3] Furthermore, the loss of monetary policy sovereignty implies that fiscal policy has become more important, since it is still conducted by the individual countries.[4]

In this paper I focus on the countercyclical function of fiscal policy in a monetary union. There is a common central bank, which is assumed to be independent from the fiscal authorities. Besides, there are fiscal authorities in each country deciding upon fiscal policy. In such a set-up, the paper discusses strategic interactions in two dimensions. The first dimension is the interaction between the fiscal authorities – seen as a group – and the central bank. In one set of cases the game between the monetary and fiscal authorities is modelled as a simultaneous Cournot game. This situation is thus intended to describe the situation in which either the fiscal authorities have no information about the action of the central bank, or in which the fiscal authorities cannot commit to a level of fiscal spending and will change it

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[1] The European Monetary Union includes all the countries in the European Union except the United Kingdom, Sweden and Denmark.

[2] For a thoroughly discussion of monetary policy and institutions in the European monetary union see von Hagen (1997).

[3] In any case, it might be argued that the advantage with the EMU is that the ECB will look at the general economic development in the whole area, whereas the Bundesbank conducted monetary policy based only on the economic situation in Germany.

[4] Only a small fraction of GDP in each of the countries is canalized to a union-wide fiscal authority.

after the monetary authorities have set the real interest rate. In the other set, fiscal authorities act as a Stackelberg leader. The second dimension is the interaction between the two fiscal authorities themselves; and here I also discuss two types of situations. In the first the authorities act independently and take each others actions as given, and in the second the authorities coordinate. In total this gives four possible strategic interactions.

There already exists literature on the coordination between fiscal and monetary policy.[5] Andersen and Schneider (1986) look at the problem of coordination in the cases where both the monetary and the fiscal authorities cares about variations in output and inflation, but they are allowed to have different output and inflation goals and to put different weights on achieving the two goals. Their main result is that – within a Keynesian framework – fiscal policy is too expansionary and monetary policy is too contractionary. Both Nordhaus (1994) and Agell et al. (1996) are concerned with fiscal deficits and inflation. The former discusses the problems of debt reduction in the case of non-coordinated monetary and fiscal policy; and the latter deals with time-inconsistency problems and the choice of exchange rate regime. Tornell and Velasco (1995) also focus on the choice of exchange rate regime, but their aim is to discuss fiscal discipline. Alesina and Tabellini (1987) discuss non-coordinated monetary and fiscal policy with credibility problems, but as opposed to the case discussed by Agell et al. (1996), only monetary policy is subject to the time-inconsistency problem. Last, Leitemo (1999) discusses the coordination problem in an open economy when monetary policy is tied to an inflation target and the fiscal authority is concerned about a broad set of macroeconomic variables. I adopt the set-up discussed by Leitemo (1999). The model is extended, however, to include a monetary union.

In a monetary union set-up, Beetsma and Bovenberg (1998) discuss the interaction between a union central bank and national fiscal authorities, where the aim of fiscal policy is to provide public goods. Beetsma and Bovenberg (1999) analyze the fiscal policy by myopic governments and argue that a monetary unification increases the accumulation of public debts. Therefore, debt ceilings may play an important

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[5]See e.g. Nordhaus (1994) for an overview of the literature.

role in reducing the accumulation of debt and allow the central bank to focus on the goal of price stability. In addition, if the economies are hit by supply shocks debt targets that limit countercyclical policy may help to reduce debt variability. This analysis is extended in Beetsma and Bovenberg (2000) to allow for a heterogeneous union. In such case the debt target will have to be state-contingent. However, Andersen and Sørensen (1995) construct a general equilibrium model with imperfect competition in both product and labour markets and show that even balanced fiscal policy may affect unemployment.[6] Consequently, a debt or deficit rule may not be enough and a restriction on the size of the public sector would be necessary. Van Arle and Garretsen (2000) discuss how national fiscal policy can be used as demand management in different asymmetric settings. This paper also discusses fiscal stabilization, but as opposed to van Aarle and Garretsen (2000) the main objective is to discuss different strategic interactions between the central bank and the fiscal authorities. In this respect, the paper bears similarities with Dixit and Lambertini (2000). Their starting point is the debate about excessive use of fiscal policy to stabilize business cycles. They construct a Barro-Gorden model extended to a monetary union and reason that as long as the central bank and the fiscal authorities have the same goals for output and inflation, the first-best can be achieved irrespective of whether the fiscal authorities move first or second and whether the fiscal authorities cooperate or they do not. Additionally, there is no need for monetary commitment. This paper differs from Dixit and Lambertini (2000) in one important way, however, namely that the central bank is tied up to an inflation target. Consequently, the central bank has a different goal from the fiscal authorities.

The rest of the paper is organized as follows: In the second part the model economy is described, including the objective and the behavior of the common central bank and the objective of the fiscal authorities. The third part contains the discussion about four different strategic interactions between the central bank and the fiscal authorities. Moreover, the fourth part extends the basic set-up and considers

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[6]Nonetheless, in the union as a whole, unemployment is unaffected and as a result the decrease in the rate of unemployment in one country comes about through an increase in unemployment in the rest of the countries.

the case when the fiscal authorities are concerned about real echange rate variability, and the fifht part concludes.

2 The model

The analytical framework follows Leitemo (1999) and will thus be a Ball (1998) model, but it is extended to include two countries with a common independent central bank. The model is Keynesian and both monetary and fiscal policy are able to influence output in the short run, but a positive output gap induces inflationary pressure, which will reduce the output gap over time. The fiscal authorities use government spending to pursue a set of goals, whereas the central bank only has one goal and will use the real interest rate in order to bring the expected rate of inflation in line with the inflationary target.

The real exchange rate plays a crucial role in the model. It is linked to the central bank instrument and influences both output and the rate of inflation. The former is affected by the real exchange rate in a standard way: an increase in the real exchange rate – a real depreciation – will increase the demand for domestically produced goods. The latter is affected by an increase in the real exchange rate through two different channels: first, the (consumer price) inflation is increased by increasing prices of imported goods; and, second, inflation is increased over time due to the increase in demand for domestically produced goods.

I let all the variables below be measured as a deviation from the long-run or steady-state values. The short-run supply side of each of the two economies is given by a wage curve

$$\Delta w_{jt+1} = \pi_{jt}^c + \gamma y_{jt} + \varepsilon_{jt+1}, \quad j = 1, 2 \tag{1}$$

where Δ is the difference operator, and for each of the two countries w is the nominal wage, π^c is consumer price inflation, and y the output gap – the percentage deviation from steady state production. ε_j is an idiosyncratic supply shock in country j, which independently identically distributed with zero mean and $cov\left(\varepsilon_{1t}, \varepsilon_{2t}\right) = 0$. Consequently, the supply shocks of the two countries are independent of each other.

Equation (1) implies that wage-earners are compensated for past consumer price inflation and that the wage rate depends on the state of the economy represented by the output gap. This can be rationalized by the assumption that wage-setters have adaptive expectations about the consumer price inflation.

The domestic producers operate under monopolistic competition and set prices as a mark-up over unit-cost, which is assumed to be given by the wage rate. Therefore, if the mark-up is normalized to zero[7], the relationship between the wage rates and the domestic price levels will given by

$$p_{jt} = w_{jt}. \tag{2}$$

The producers in both countries are price-takers internationally. It is assumed that the prices of imported goods – denoted p_t^i – are equal in the two countries, and they are given by

$$p_t^i = s_t + p_t^*, \tag{3}$$

where s_t is the nominal exchange rate and p^* is the price level outside the monetary union. This implicitly assumes that there is a direct pass-through from foreign prices. Consequently, I assume the law of one price for the imported goods.

The real exchange rate is defined as $e_{jt} \equiv s_t + p_t^* - p_{jt}$, and imported prices may therefore be written as

$$p_t^i = e_{jt} + p_{jt}. \tag{4}$$

The consumer price is a weighted average of imported prices and the two domestic price levels in the two countries in the monetary union. It is assumed to be given by:[8]

$$p_{jt}^c = \phi p_t^i + \mu p_{jt} + (1 - \phi - \mu) p_{it} \text{ for } j, i = 1, 2 \text{ and } j \neq i, \tag{5}$$

---

[7]This is done for analytical convenience, since imperfect competition does not play any significant role in this analysis.

[8]This can be justified by a Cobb-Douglas utility function of the form:

$$u_j = \left(x_j^*\right)^\phi x_{jj}^\mu x_{ji}^{1-\phi-\mu},$$

where x_j^* is the consumption of imported goods consumed in country j, and x_{ji} is the consumption of goods in country j which are produced in country i. The ideal consumer price-index is found

where ϕ is the proportion of "foreign" goods in the consumption bundle, and μ is the proportion of domestic goods. The consumer price inflation will therefore be given by

$$
\begin{aligned}
\pi^c_{jt} &= \phi\pi^i_t + \mu\pi_{jt} + \left(1 - \phi - \mu\right)\pi_{it} \\
&= \phi\left(\Delta e_{jt} + \pi_{jt}\right) + \mu\pi_{jt} + \left(1 - \phi - \mu\right)\pi_{it} \\
&= \left(\phi + \mu\right)\pi_{jt} + \phi\Delta e_{jt} + \left(1 - \phi - \mu\right)\pi_{it},
\end{aligned}
\tag{6}
$$

where the second equality follows from using the first difference of equation (4).

To find the equation describing the evolution of the domestic inflation, I take first difference and lead equation (2), and thereafter I insert for the change in the wage rate from equation (1) and for consumer price inflation from equation (6). This gives the domestic inflation in each of the two countries as

$$
\begin{aligned}
\pi_{jt+1} &= \pi^c_{jt} + \gamma y_{jt} + \varepsilon_{jt+1} \\
&= \left(\phi + \mu\right)\pi_{jt} + \left(1 - \phi - \mu\right)\pi_{it} + \phi\Delta e_{jt} + \gamma y_{jt} + \varepsilon_{jt+1}.
\end{aligned}
\tag{7}
$$

The demand side of the economies is described by an aggregate demand rela-

---

by maximizing the utility function subject to a budget constraint. If W_j denotes wealth used on consumption, this will result in the following levels on consumption (dropping country-subscript for simplicity):

$$
x^* = \phi\frac{W}{P^*}, x_1 = \mu\frac{W}{P_1}, x_2 = \left(1 - \phi - \mu\right)\frac{W}{P_2},
$$

where P^* and P_j are the prices of goods produced abroad and in country j. Inserting this into the utility function, the ideal consumer price index can be calculated as $P^c = \frac{u}{W}$, thus as:

$$
P^c = \frac{W}{W\left(\frac{\phi}{P^*}\right)^\phi\left(\frac{\mu}{P_1}\right)^\mu\left(\frac{1-\phi-\mu}{P_2}\right)^{1-\phi-\mu}} = \frac{P^{*\phi}P_1^\mu P_2^{1-\phi-\mu}}{\phi^\phi\mu^\mu\left(1 - \phi - \mu\right)^{1-\phi-\mu}}
$$

$$
\log P^c = \phi\log P^* + \mu\log P_1 + \left(1 - \phi - \mu\right)\log P_2 - K,
$$

and thus with small letters indicating the log of the variable and by choosing an appropriate numerator, the price index can be normalized to

$$
p^c = \phi p^* + \mu p_1 + \left(1 - \phi - \mu\right)p_2
$$

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tionship

$$y_{jt} = \mu \left(\beta e_{jt} + \kappa g_{jt} + u_{jt} \right) + (1 - \mu) \left(\beta e_{it} + \kappa g_{it} + u_{it} \right) \quad \text{for } j, i = 1, 2 \text{ and } j \neq i,$$

$$(8)$$

where e_{jt} the real exchange rate in country j, g_{jt} government spending in country j, and u_{jt} is an idiosyncratic i.i.d. demand shock in country j.[9] The parts in the two brackets are the demand from inhabitants in country j and i, respectively. Therefore, the aggregate demand in country j is a weighted average of the demand from the inhabitants in the monetary union, where the weight on own inhabitants is given by μ.[10] As a result, demand increases with the country-specific real exchange rate, and increases with domestic spending.

Turning to the union-wide development of the different price indicators and aggregate demand, it is assumed that the two countries have equal size. Accordingly, for each of the variables, the union-wide average will be given by

$$x_t = \frac{1}{2} \left(x_{1t} + x_{2t} \right).$$

For that reason the average consumer price will be given by

$$
\begin{aligned}
p_t^c &= \frac{1}{2} \left(\phi p_t^i + \mu p_{1t} + (1 - \phi - \mu) p_{2t} + \phi p_t^i + \mu p_{2t} + (1 - \phi - \mu) p_{1t} \right) \\
&= \phi p_t^i + \frac{1}{2} \left((1 - \phi) p_{2t} + (1 - \phi) p_{1t} \right) \\
&= \phi p_t^i + (1 - \phi) p_t = p_t + \phi e_t,
\end{aligned}
$$

$$(9)$$

since

$$e_t = s_t + p_t^* - p_t.$$

$$(10)$$

Therefore, average consumer price inflation will be given by

$$\pi_t^c = \pi_t + \phi \Delta e_t,$$

$$(11)$$

---

[9]The demand shocks in the two countries are independent of each other.

[10]An obvious short-coming with this is that the demand does not depend on the real interest rate. A more satisfying specification would be to let the demand from the inhabitants in the two countries depend on their respective country-specific real interest rate given by $i_t - E_t \pi_{jt+1}$. This will, however, complicate the algebra considerably, and I will abstract from this here.

and domestic price inflation within the union will evolve as

$$
\begin{aligned}
\pi_{t+1} &= \frac{1}{2}\left[(\phi+\mu)\pi_{1t} + \phi\Delta e_{1t} + (1-\phi-\mu)\pi_{2t} + \gamma y_{1t} + \varepsilon_{1t+1}\right.\\
&\quad + \left.(\phi+\mu)\pi_{2t} + \phi\Delta e_{2t} + (1-\phi-\mu)\pi_{1t} + \gamma y_{2t} + \varepsilon_{2t+1}\right]\\
&= \pi_t + \phi\Delta e_t + \gamma y_t + \varepsilon_{t+1}.
\end{aligned}
\tag{12}
$$

Furthermore, average aggregate demand in the union is given by

$$
y_t = \beta e_t + \kappa g_t + u_t,
\tag{13}
$$

and last, the uncovered interest rate parity holds

$$
E_t e_{t+1} - e_t = r_t - r_t^*,
$$

where r and r^* are the average and foreign real interest rate. For simplicity, it is assumed that $E_t r_{t+1}^* = 0$, hence the foreign real interest rate is not auto-correlated (and therefore the expected future value is zero since the variable is measured as a deviation from the steady-state value). This implies that the union-wide model reduces to the set-up used by Leitemo (op.cit.) except from the important fact that government spending will not average the same function as in the single-country.

The central bank targets average core inflation, which is defined as

$$
\hat{\pi}_t \equiv \pi_t - \phi e_{t-1}.
\tag{14}
$$

By leading (14) and replacing domestic inflation from equation (12), I get a process for core inflation

$$
\begin{aligned}
\hat{\pi}_{t+1} &= \pi_t + \phi\left(e_t - e_{t-1}\right) + \gamma y_t + \varepsilon_{t+1} - \phi e_t\\
&= \hat{\pi}_t + \gamma y_t + \varepsilon_{t+1}.
\end{aligned}
\tag{15}
$$

The central bank sets the average real interest rate so that

$$
E_t \hat{\pi}_{t+1} = 0,
\tag{16}
$$

which implies that

$$
\hat{\pi}_t = -\gamma y_t.
\tag{17}
$$

Inserting from equation (17) into the union-wide aggregate demand function (equation 13) and solving for the average real exchange rate, gives

$$-\frac{1}{\gamma}\widehat{\pi}_t = \beta e_t + \kappa g_t + u_t$$

$$e_t = -\frac{1}{\beta}\left(\frac{1}{\gamma}\widehat{\pi}_t + \kappa g_t + u_t\right). \tag{18}$$

In order to find a function for the real interest rate, I have to find the fundamental solution for the real exchange rate, which is a forward-looking variable due to the interest rate parity. As noted above the union-wide model can be described exclusively by union-wide aggregates, thus by the aggregate demand function, the uncovered interest rate parity, the supply function, and the monetary policy function, equations (13), (10), (15), and (16), respectively. Therefore, since there is no auto-correlation in the variables describing the union as a whole – due to the set-up of the model and the assumption of symmetric and equal sized countries – it must be that $E_t e_{t+1} = 0$.[11] This implies

$$e_t = r_t^* - r_t \tag{19}$$

$$r_t = \frac{1}{\beta}\left(\frac{1}{\gamma}\widehat{\pi}_t + \kappa g_t + \beta r_t^* + u_t\right). \tag{20}$$

Therefore, the central bank increases real interest rates if current core inflation is above target in order to reduce future core inflation via lower aggregate demand. Further, it will react contractionary both to an increase in government spending and to a positive demand shock. This is due to the fact that a higher aggregate demand increases future core inflation. Last, the central bank reacts positively on increases in foreign real interest rates, which lead to a real depreciation and thus to higher aggregate demand.

The fiscal authorities are concerned about variations in the output gap and government spending and they are assumed to minimize the following quadratic

---

[11]So far I have not discussed the actions of the two governments. The spending of the individual countries might be auto-correlated in itself or the average government might depend on the distribution between the two countries due to convexities. The discussion below makes clear, however, that there is no auto-correlation in average government spending either.

cost function:[12]

$$L_{jt} = \frac{1}{2} \left\{ \eta_y \left(y_{jt}\right)^2 + \eta_g \left(g_{jt}\right)^2 \right\},$$ (21)

where parameter η_y is related to the costs of having a fluctuating output gap (and thereby fluctuating employment), and η_g measures the costs of changing government spending according to the economic situation.

An obvious short-coming of this specification (except the points made in the footnote above), is that I have not included a rate of inflation. In the single-country model described by Leitemo, this may be rationalized by some division of responsibility, since politicians may not be concerned about fluctuations in the rate of inflation if it is a well-known fact in the public that the central bank is responsible for controlling inflation. In my model, on the other hand, the central bank only cares about the union-wide rate of inflation. Therefore, one might argue that the fiscal authorities would – or even should – consider their individual rate of inflation. However, as a convenient simplification, I will assume that the fiscal authorities are not concerned about variations in the rate of inflation. Moreover, this will not affect the main results of the analysis.

Note that from the definition of the real exchange rate and the relationship between the average real exchange rate and the real interest rate, the country specific real exchange rate can be written as[13]

$$\begin{aligned}
e_{jt} &= s_t + p_t^* - p_{jt} = e_t + p_t - p_{jt} \\
&= e_t - \left(\pi_{jt} - \pi_t\right).
\end{aligned}$$ (22)

Inserting this into equation (8) for the country specific real exchange rate, and then substituting the average real exchange rate from equation (18), I can write a

---

[12]This differs from the cost function discussed by Leitemo (op.cit.) in that I do not include the real interest rate and the real exchange rate. The former is a natural consequence of ruling out the real interest rate from the aggregate demand function. As far as the latter is concerned, I will turn to this case below. Nevertheless, to simplify the model initially, I will first consider the case where the fiscal authorities do not care about real exchange rate variations.

[13]The latter equality follows from normalizing the price indexes so that $p_{jt-1} = p_{t-1}$.

reduced-form equation for the output gap as follows:

$$
\begin{aligned}
y_{jt} &= -\left(\frac{1}{\gamma}\widehat{\pi}_t + \kappa g_t + u_t\right) + \beta\pi_t \\
&\quad + \mu\left(\kappa g_{jt} + u_{jt} - \beta\pi_{jt}\right) + (1 - \mu)\left(\kappa g_{it} + u_{it} - \beta\pi_{it}\right) \\
&= -\frac{1}{\gamma}\widehat{\pi}_t + \left(\mu - \frac{1}{2}\right)\left[\kappa\left(g_{jt} - g_{it}\right) + u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right] \quad\quad (23) \\
&= y_t + 2\left(\mu - \frac{1}{2}\right)\left[\kappa\left(g_{jt} - g_t\right) + u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right], \quad\quad (24)
\end{aligned}
$$

where the two latter equalities follow from the definitions of average government spending and demand shock. These equations therefore show how fiscal spending in one country will affect the output gap in the other country both through demand spill-overs and through changes in monetary policy. It is noteworthy, though, that with $\mu > \frac{1}{2}$ – thus the normal case where government spending has the largest impact in the domestic economy – an increase in government spending in country i will decrease the output gap in country j. The reason why the monetary policy channel dominates the demand-spill-over-channel is due to the monetary policy target. Following an exogenous increase in g_{jt}, the monetary authorities will increase real interest rates so that the average output gap remains constant. Therefore, since the increase in g_{it} influences y_{it} more than y_{jt}, y_{jt} will have to fall in order for the average output gap to stay constant. If $\mu = \frac{1}{2}$ – thus if the effects government spending in country j will be equally distributed between the two countries – the output gap in country j will be equal to the union-average. The reason is that the fiscal authorities no longer have the possibility of local demand management.

3   The strategic set-ups

I focus on four different strategic interactions between the fiscal authorities and the monetary authority. I start with the case where the two fiscal authorities coordinate – or cooperate – and they act as Stackelberg leaders in the game with the central bank. In the second case, the two fiscal authorities do not coordinate, and they play a Cournot game with the central bank. In order for the fiscal authorities to be able to act as Stackelberg leaders with the central bank they, first, must know about the

reaction function of the central bank and, second, be able to commit to a level of fiscal spending.

The third and fourth cases are hybrids of the first two. In the third case the governments do not coordinate, but each of the governments act as a Stackelberg leader in the game with the central bank; and in the last case, the two fiscal authorities coordinate, but they play a Cournot game with the monetary authorities.

3.1 The coordinated Stackelberg equilibrium

In this case, the governments coordinate their fiscal policy in order to minimize[14]

$$L_t^{CS} = \frac{1}{2} \sum_{j=1}^{2} \left\{ \eta_y \left(y_{jt} \right)^2 + \eta_g \left(g_{jt} \right)^2 \right\},$$ (25)

subject to the constraint (23), and they thus take into account how monetary policy will react to changes in government spending.

The first order condition is given by:

$$0 = \eta_y \left(\mu - \frac{1}{2} \right) \kappa \left(y_{jt} - y_{it} \right) + \eta_g g_{jt}$$ (26)

$$g_{jt} = -\frac{\eta_y}{\eta_g} \left(\mu - \frac{1}{2} \right) \kappa \left(y_{jt} - y_{it} \right).$$ (27)

As a result, the fiscal authorities in country j will take both its own and the other countries' output gap into account. Government spending will decrease when the output gap in country j is higher than in country i, and at the same time, fiscal authorities in country i will increase spending. Both things will decrease the output gap in country j; the latter through the fact that an increase in government spending in country i will trigger the central bank to increase real interest rates, which will decrease the output gap in country j. The size of the fiscal reaction will depend on how effective fiscal policy is, which is measured by the factor $\left(\mu - \frac{1}{2} \right) \kappa$. The effect of fiscal policy is reduced by the demand-spill-over $- (1 - \mu) -$ and the monetary policy

---

[14] I concentrate on this symmetric solution since giving the two countries unequal weights will make the average government spending and real interest rate depend on the individual parameters and not only on their union-wide averages.

reaction, which eliminates half of the fiscal effect. The size of fiscal spending will also depend on the relative weight on fluctuations in government spending relative to the fluctuations in the output gap, thus the fraction $\frac{\eta_y}{\eta_g}$. Fiscal spending will be higher (lower) the higher (lower) the aversion is against fluctuations in the output gap (government spending).

Taking union-wide average of the first order condition gives average government spending and real interest rate equal to

$$g_t^{cs} = 0 \tag{28}$$

$$r_t^{cs} = \frac{1}{\beta}\left(\frac{1}{\gamma}\widehat{\pi}_t + \beta r_t^* + u_t\right), \tag{29}$$

where the latter equation follows from equations (20) and (28). The average government spending is thus zero, which – of course – follows from the fact that the fiscal authorities have taken into account that the average output gap is pinned down by the central bank objective (see equation 17). Thus if the average government spending were e.g. above zero, these would only result in a higher average real interest rate without any effect on the average output gap. Therefore, since the governments wish to minimize the fluctuations in government spending around zero, they will set the average government spending equal to zero.

Government spending and the output gap for country j are given by:[15]

$$g_{jt}^{cs} = g_t^{cs} - \frac{4\left(\mu - \frac{1}{2}\right)^2\kappa}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right] \tag{30}$$

$$y_{jt}^{cs} = y_t + 2\left(\mu - \frac{1}{2}\right)\frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right]. \tag{31}$$

Equations (30) and (31) demonstrate how fiscal spending and the output gap, respectively, react to changes in the state variables in equilibrium. The first part of each equations shows the average response. Since average output gap is pinned down by the monetary policy rule, changing average fiscal policy will only lead to a different mix of government spending and real interest rate and will not change the output gap. Knowing this, the two fiscal authorities coordinate so that the average

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[15]The calculations are given in the appendix.
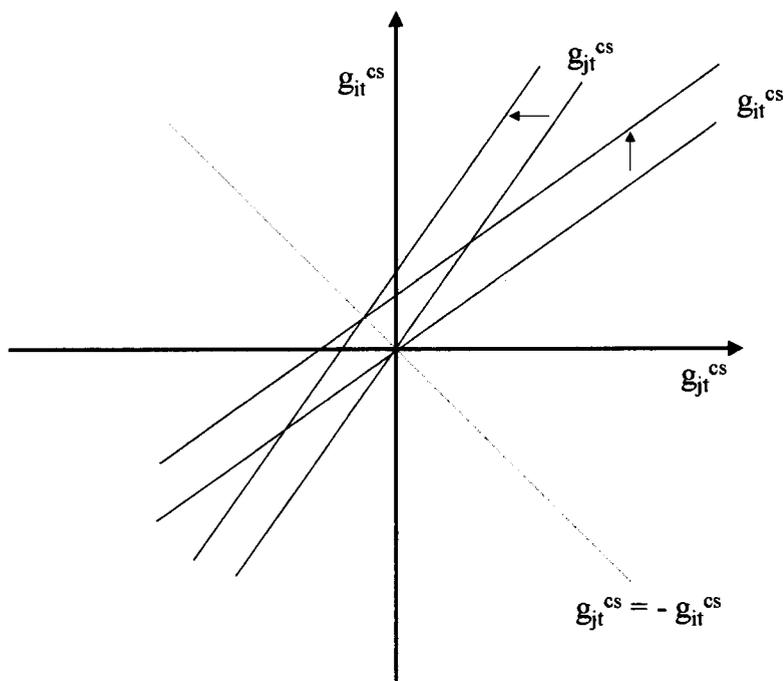
Figure 1: Coordinated Stackelberg Equilibrium

fiscal policy is zero. The second parts of equations (30) and (31) show the response to country-specific changes (measured as deviations from the union average).

The equilibrium is shown in figure 1,[16] which also plots the reaction to a positive demand shock in country j (or a negative shock in country i). The fiscal authorities will thus use government spending to reduce the effect on the output gap of idiosyncratic shocks. As seen from the figure, the fiscal spendings sum to zero, and the equilibria will be on the dotted line denoted $g_{jt}^{cs} = -g_{it}^{cs}$.

---

[16]The reaction functions are of "reduced form" in the sense that I have eliminated the last stage of the game, and simply described the model as a game between the two fiscal authorities. The reaction functions are found inserting the output gap difference from equation (24) into the first order condition and solving for fiscal spending. This gives:

$$g_{jt} = \frac{2\left(\mu - \frac{1}{2}\right)^2 \kappa^2}{\frac{\eta_g}{\eta_v} + 2\left(\mu - \frac{1}{2}\right)^2 \kappa^2} g_{it} - \frac{4\left(\mu - \frac{1}{2}\right)^2 \kappa}{\frac{\eta_g}{\eta_v} + 2\left(\mu - \frac{1}{2}\right)^2 \kappa^2} \left(u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right)$$

3.2 The uncoordinated Cournot equilibrium

In this case, the fiscal authorities not only take the action of the other fiscal authority as given, but they also take the real interest rate – and thereby the country-specific real exchange rate – as given when they set their fiscal spending. Minimizing the government cost function (equation 21) subject to the aggregate demand function – equation (8) – gives the first order condition

$$0 = \eta_y y_{jt} \mu \kappa + \eta_g g_{jt} \tag{32}$$

$$g_{jt} = -\mu \frac{\eta_y}{\eta_g} \kappa y_{jt}. \tag{33}$$

Obviously, the government now does not take into account the effects of fiscal spending on the output gap in the other country in the monetary union. Besides, comparing equation (33) with equation (27) makes clear that, since the fiscal authorities do not take the central bank reaction into account in the uncoordinated Cournot game, they will react more aggressively than in the coordinated Stackelberg game to an increase in the output gap. The reason is that fiscal policy seems more efficient than it really is.

The average reaction function for the fiscal authorities is by:

$$g_t = \frac{\mu \kappa}{\frac{\eta_g}{\eta_y} + \mu \kappa^2} \left(\beta r_t - \beta r_t^* - u_t \right). \tag{34}$$

Together with the monetary policy reaction function – equation (20) – this therefore shows that there is a conflict of interest between the central bank and the fiscal authorities. First, if the fiscal authorities wish to increase government spending to spur activity, the central bank will react by increasing real interest rates. Second, and likewise, if the central bank wishes to reduce real interest rates to increase activity, the fiscal authorities will react by decreasing government spending. In the literature, this is referred to as the "battle over the output gap".

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Average government spending and the real interest rate are given by:

$$0 = -\eta_y \mu \kappa \frac{1}{\gamma} \widehat{\pi}_t + \eta_g g_t$$

$$g_t^{uc} = \mu \frac{\kappa \, \eta_y}{\gamma \, \eta_g} \widehat{\pi}_t \tag{35}$$

$$r_t^{uc} = \frac{1}{\beta} \left[\left(1 + \mu \kappa^2 \frac{\eta_y}{\eta_g} \widehat{\pi}_t \right) \frac{1}{\gamma} \widehat{\pi}_t + \beta r_t^* + u_t \right]. \tag{36}$$

In equilibrium the government spending will thus be higher, the higher the core inflation is; and the real interest rate will be higher, the higher the core inflation, the foreign real interest rate and the domestic demand shocks are. Moreover, from the equilibrium government spending, it is clear that if the government has no aversion to increase government spending – thus if $\eta_g = 0$, there are no limits on how much the fiscal authorities will increase government spending in order to meet their goal for the output gap.

The equilibrium is pictured in figure 2. The left hand side of the figure shows the effects of a demand shock; and the right hand side the effect of an increase in core inflation (a supply side shock). A demand shock shifts both the fiscal reaction function (inwards) and the monetary reaction function (upwards): and in total the real interest rate increases and government spending remains unchanged. Turning to the supply side disturbance, this only shifts the monetary reaction function (upwards) and it results in an increase in both the real exchange rate and the government spending.

Figure 2 and equation (35) show that there exists – in the language of Svensson (1997) – a state-contingent governmental bias; and average government spending will vary without any effect on the average output gap. As shown by Leitemo (op.cit.) this was also so in the case of a single country with an independent central bank. Nothing changes in a monetary union in this respect; and introducing demand-spillovers in the model discussed by Leitemo will give the same government spending as here.
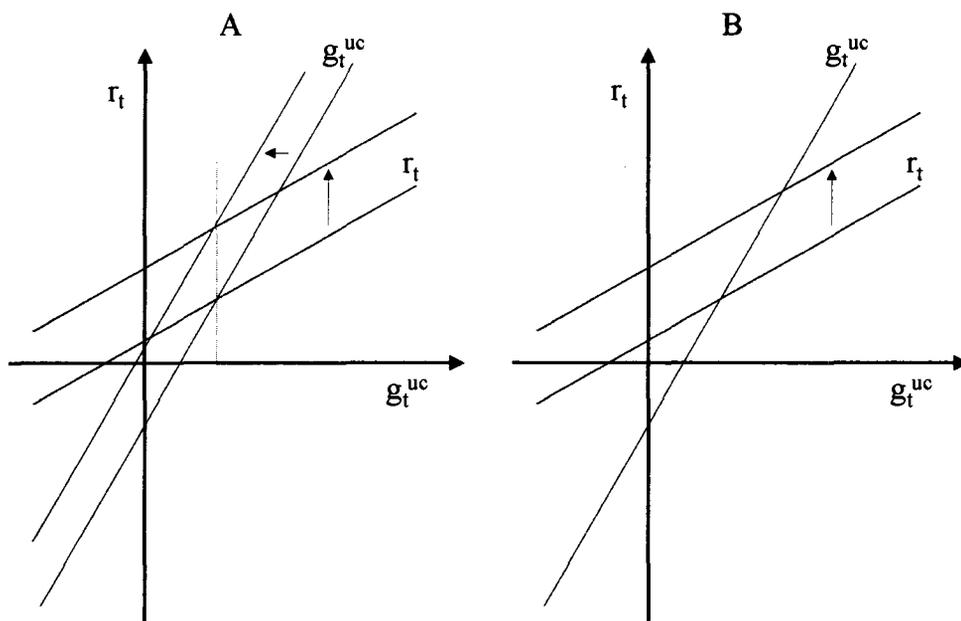
Figure 2: The Fiscal and Monetary Policy Game

In this case, government spending and the output gap are given by:

$$g_{jt}^{uc} = g_t^{uc} - \frac{2\mu \left(\mu - \frac{1}{2}\right) \kappa}{\frac{\eta_g}{\eta_y} + 2\mu \left(\mu - \frac{1}{2}\right) \kappa^2} \left[u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_t\right)\right] \tag{37}$$

$$y_{jt}^{uc} = y_t + 2 \left(\mu - \frac{1}{2}\right) \left(\frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 2\mu \left(\mu - \frac{1}{2}\right) \kappa^2}\right) \left[u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_t\right)\right]. \tag{38}$$

Therefore, the new thing about the monetary union set-up is that there will also be a stabilization bias.[17] This is seen by comparing equations (37) and (38) with

---

[17]In the appendix I show that among the strategic set-ups consider in this paper, the fiscal authorities ex ante prefer the coordinated Stackelberg game. In order to conduct the welfare analysis of the different game, I ask if the fiscal authorities ex ante would prefer the outcome in the coordinated Stackelberg to the other strategic set-ups. Accordingly, I imagine an institutional stage before the games are played; and in this stage the fiscal authorities choose which set-up they would prefer.
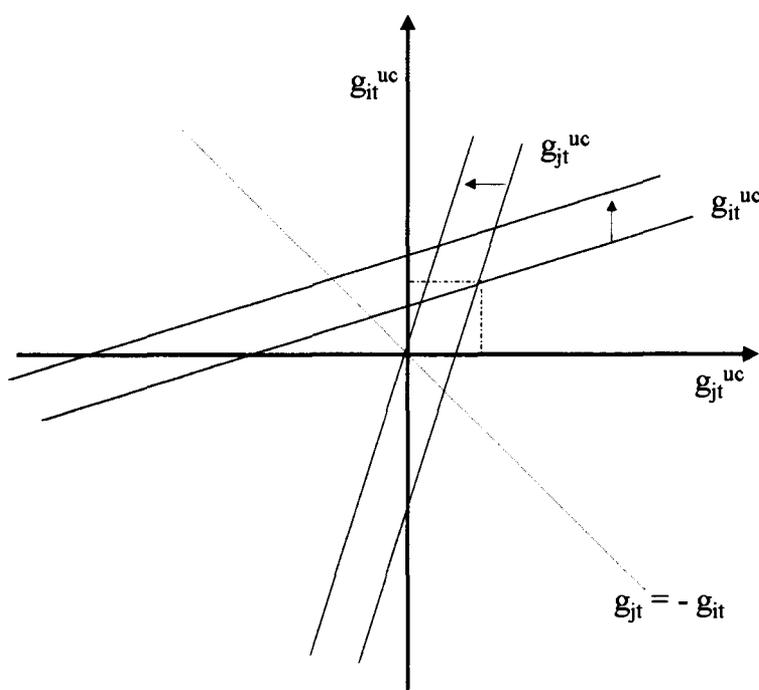
Figure 3: The uncoordinated Cournot equilibrium

equations (30) and (31). Using the latter pair of equations (with $\mu > \frac{1}{2}$) gives:

$$\frac{\partial y_{jt}^{uc}}{\partial u_{jt}} < \frac{\partial y_{jt}^{cs}}{\partial u_{jt}} \Rightarrow \frac{1}{\frac{\eta_g}{\eta_y} + 2\mu\left(\mu - \frac{1}{2}\right)\kappa^2} < \frac{1}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}$$

$$\Rightarrow 2\left(\mu - \frac{1}{2}\right) < \mu \Rightarrow \mu < 1.$$

Fiscal policy will thus – if $\mu < 1$ – react too much to idiosyncratic shocks so that government spending will vary too much and the output gap will vary too little compared to the coordinated Stackelberg equilibrium.[18] The reason is that the fiscal authorities do not take into account that both the central bank and the other fiscal authority also react to the shocks. I will return to how the bias is related to these two factors below.

The equilibrium is shown in figure 3, which shows the "reduced form" reaction

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[18] I use the coordinated Stackelberg game as the benchmark throughout this paper due to the fact among the strategic set-ups, this game gives the lowest expected costs. This is shown in the appendix.

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functions of the two fiscal authorities.[19] Compared to figure 1 average government spending no longer sums to zero. Furthermore, the reaction functions are steeper in the uncoordinated Cournot game since the fiscal authorities react more aggressively on factors affecting the output gap – including fiscal spending in the other country.

3.3 The uncoordinated Stackelberg equilibrium

In this case, the fiscal authorities do not coordinate but take each others action as given. They are able to commit to a fiscal rule taking the monetary policy rule into account, however, and therefore they act as Stackelberg leaders in the game with the central bank. The fiscal authorities therefore minimize their cost function (equation 21) subject to the constraint in equation (23). The first order condition is then given by:

$$0 = \eta_y \left(\mu - \frac{1}{2} \right) \kappa y_{jt} + \eta_g g_{jt} \tag{39}$$

$$g_{jt} = - \left(\mu - \frac{1}{2} \right) \frac{\eta_y}{\eta_g} \kappa y_{jt}. \tag{40}$$

Due to the fact that the fiscal authorities take the monetary policy reaction into consideration, they will react less to changes in the output gap compared to the uncoordinated Cournot equilibrium discussed above. Still, however, they will not take the other country's output gap into account.

The average government spending and the real interest rate are given by:

$$g_t^{us} = \left(\mu - \frac{1}{2} \right) \frac{\kappa \, \eta_y}{\gamma \, \eta_g} \widehat{\pi}_t \tag{41}$$

$$r_t^{us} = \frac{1}{\beta} \left[\left(1 + \left(\mu - \frac{1}{2} \right) \frac{\kappa \, \eta_y}{\gamma \, \eta_g} \right) \frac{1}{\gamma} \widehat{\pi}_t + \beta r_t^* + u_t \right]. \tag{42}$$

---

[19]In this case, the term "reduced" relates to the fact that I show the game in two dimensions, since I have eliminated the central bank. To find the reaction functions I have inserted into the first order condition for the output gap from equation (23) – where I have taken the monetary policy reaction function into account – and then solved for fiscal spending. This gives:

$$g_{jt} = \frac{\mu \left(\mu - \frac{1}{2} \right) \kappa^2}{\frac{\eta_g}{\eta_y} + \mu \left(\mu - \frac{1}{2} \right) \kappa^2} g_{it} - \frac{\mu \kappa}{\frac{\eta_g}{\eta_y} + \mu \left(\mu - \frac{1}{2} \right) \kappa^2} \left[y_t + 2 \left(\mu - \frac{1}{2} \right) [(u_{jt} - u_t - \beta (\pi_{jt} - \pi_t))] \right]$$

This shows that compared to the uncoordinated Cournot equilibrium the average fiscal spending reacts less to changes in the underlying rate of inflation in equilibrium. The reason is that the fiscal authorities take into account that fiscal policy is less effective due to the monetary policy response.

The government spending and the output gap in the uncoordinated Stackelberg set-up are given by:

$$g_{jt}^{us} = g_t^{us} - \frac{\left(\mu - \frac{1}{2}\right)^2 \kappa}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2 \kappa^2} \left([u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)]\right) \tag{43}$$

$$y_{jt}^{us} = y_t + 2\left(\mu - \frac{1}{2}\right) \frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2 \kappa^2} \left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right]. \tag{44}$$

Comparing equations (43) and (44) with equations (30) and (31) shows that fiscal policy in this case reacts too little to idiosyncratic shocks and thus the output gap varies too much. The key to understanding why this is so is the reduced-form demand function in equation (23), and look at what happens following a negative demand shock in country j. The output gap in country j decreases, while – due to the sum of the fiscal and monetary channel (see text above) – the output gap in country i increases. For that reason, the fiscal authorities in country j wishes to increase government spending. This will, however, also decrease the output gap in country i, which is too high; and thus, for the union as a whole there is a double gain of the increase in fiscal spending in country j. In the uncoordinated Stackelberg equilibrium, the fiscal authorities do not take this "second gain" into account, and will thus choose a too small reaction.

3.4 The coordinated Cournot-equilibrium

In this game, the governments coordinate their fiscal policy in order to minimize equation (25) subject to the aggregate demand functions in equation (8).The first order conditions are given by

$$0 = \eta_y \kappa \left(\mu y_{jt} + (1 - \mu) y_{it}\right) + \eta_g g_{it} \tag{45}$$

$$g_{jt} = -\frac{\eta_y}{\eta_g} \kappa \left(\mu y_{jt} + (1 - \mu) y_{it}\right). \tag{46}$$

The fiscal authorities react to changes in a weighted output gap, where the weights are given by how the effect of government spending divided between the two countries. The governments will thus take into account the effect of fiscal spending both on its own output gap and on the output gap of the other country. The reason is that holding the real exchange rate constant, an increase in government spending in country j with one unit will increase the output gaps in country j and i by $\mu\kappa$ and $(1 - \mu)\kappa$, respectively.

The average government spending and the real interest rate will be given by

$$g_t^{cc} = \frac{\eta_y}{\eta_g}\frac{\kappa}{\gamma}\widehat{\pi}_t \tag{47}$$

$$r_t^{cc} = \frac{1}{\beta}\left(\frac{1}{\gamma}\left(1 + \kappa\frac{\eta_y}{\eta_g}\right)\widehat{\pi}_t + \beta r_t^* + u_t\right). \tag{48}$$

This implies that average government spending – and thus the bias – is higher in this case than in the unconstrained Cournot case. This follows from the fact that given an increase in the real interest rate, each of the fiscal authorities will increase government spending both due to the impact on its own output gap and on the output gap in the other country. Therefore, faced with an increase in core inflation, the monetary authorities will have to increase the real interest rate more in order to meet the monetary policy goal.

In this case government spending and the output gap in country j can be written as:

$$g_{jt}^{cc} = g_t^{cc} - \frac{4\left(\mu - \frac{1}{2}\right)^2\kappa}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right] \tag{49}$$

$$y_{jt}^{cc} = -\frac{1}{\gamma}\widehat{\pi}_t + 2\left(\mu - \frac{1}{2}\right)\left(\frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}\right)\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right], \tag{50}$$

which implies that there will be no stabilization bias. This is due to the symmetry (and the linearity) of the model, which makes the decision of the average government spending independent of the distribution between the two countries. Since the fiscal authorities coordinate they will choose the right mix of fiscal spending between the two countries, but choose a too high average compared to the coordinated Stackelberg equilibrium. This is easily seen by rewriting the first order condition – equation

(46) – as:

$$g_{jt}^{cc} = -\frac{\eta_y}{\eta_g}\kappa\left(\mu y_{jt} - (1-\mu)(2y_t - y_{jt})\right)$$

$$= -\frac{\eta_y}{\eta_g}\kappa\left(2\left(\mu - \frac{1}{2}\right)y_{jt} + 2(1-\mu)y_t\right),$$

where in the first equality I have used the definition of the average output to substitute for the output gap in country i. The fiscal authorities choose the "correct" reaction to the country-specific output gap, but react too much to changes in the average.

3.5 Comparing the different set-ups

Table 1 shows which biases the different strategic set-ups generate. In all the set-ups, except in the coordinated Stackelberg game, there will be an average bias in fiscal spending; thus the fiscal authorities will react to an increase in the average core inflation by increasing fiscal spending. Furthermore, in both cases where the governments do not coordinate, there will be a stabilization bias as well: In the uncoordinated Stackelberg game the fiscal authorities will react too little to idiosyncratic shocks so that the output gap will vary too much, while in the uncoordinated Cournot game they will react too much and the output gap will vary too little.

Table 1: The biases in the different set-ups

Game	Average (state-contingent) bias	Stabilization bias
Coordinated Stackelberg	No	No
Coordinated Cournot	Yes	No
Uncoordinated Stackelberg	Yes	Yes (Negative)
Uncoordinated Cournot	Yes	Yes (Positive)

The table might give the impression that the coordinated Cournot game is preferable to both the uncoordinated games. However, this is not necessarily the case. Comparing the average fiscal bias and the equilibrium changes in government spending to a change in the demand shock gives:

$$0 = g_t^{cs} < g_t^{us} < g_t^{uc} < g_t^{cc}, \text{ and}$$

$$\frac{\partial y_{jt}^{uc}}{\partial u_{jt}} < \frac{\partial y_{jt}^{cc}}{\partial u_{jt}} = \frac{\partial y_{jt}^{cs}}{\partial u_{jt}} < \frac{\partial y_{jt}^{us}}{\partial u_{jt}}.$$

The coordinated Cournot equilibrium does not generate a stabilization bias, but it generates an average bias that is larger than in both the uncoordinated equilibria.

The ranking between the coordinated Cournot equilibrium and the two uncoordinated equilibia will depend both on the behavior of the different shocks – and on relationship between them – and on the importance of the demand spill-overs between the two countries. I will not go into detail about this here, but some features seem worth mentioning. First, the more differently the two countries behave, the more important it is to have a correct stabilization. Therefore, the coordinated Cournot equilibrium will be preferable. This is also true if the variance of the average core inflation is small so that the average bias is small. Second, if the demand spill-overs are high – i.e. μ is close to one half – the stabilization bias will be of less importance. The reason is that it will be difficult for the two countries to do affect the demand in each of the countries separately.

To sum up: The most important lesson drawn from comparing the different set-ups is that neither coordinating fiscal policy nor having the fiscal authorities acting as Stackelberg leaders will necessarily be welfare improving.[20] Consequently, an important factor for the attempts to coordinate fiscal policy to be successful, is that there is a clear understanding of how the central bank is operating. Moreover, there is a need of some instrument to make the fiscal authorities able to commit to a level of fiscal spending. These two factors would make it possible that the fiscal authorities act as Stackelberg leaders in the game with the central bank.

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[20]This is easily shown by looking at two simple examples. First, if there are no idiosyncratic disturbances – $\sigma_{\omega_1} = \sigma_{\omega_2} = \sigma_\omega$ and $\sigma_{u_1} = \sigma_{u_2} = \sigma_u$ – the stabilization bias disappears and the uncoordinated Cournot game will be preferable to the coordinated Cournot game. Second, if there are no demand-linkages – $\mu = 1$ – the uncoordinated Cournot game is preferable to the uncoordinated Stackelberg game.

4 Fiscal concern about real exchange rate variability

As mentioned above, Leitemo included the real exchange rate in the objective function of the government. This might be rationalized by the fact that a too fluctuating real exchange rate may harm the tradeable part of the economy. As far as the Cournot games are concerned, this will not change anything, since the fiscal authorities take the Central Bank action – and therefore the real exchange rate – as given when they choose fiscal spending. In the two Stackelberg games, on the other hand, fiscal concern about real exchange rate variations will change the outcome, and I will discuss both the games in turn.

The idea that the fiscal authorities also care about variations in the real exchange rate might be expressed as

$$L_{jt} = \frac{1}{2} \left\{ \eta_y \left(y_{jt} \right)^2 + \eta_g \left(g_{jt} \right)^2 + \eta_e \left(e_{jt} \right)^2 \right\},$$

where η_e is the weight put on variations in the real exchange rate. As above, the authorities are assumed to minimize the sum of the two cost functions in the coordinated Stackelberg game and their own cost function – taking the action of the other fiscal authority as given – in the uncoordinated Stackelberg game. In both cases, the minimization is carried out subject to the reduced form output gap – equation (23) – and the real exchange rate – equation (18).

4.1 The coordinated Stackelberg game with fiscal concern about exchange rate variability

In this case the first order condition changes to:

$$0 = \eta_y \left(\mu - \frac{1}{2} \right) \kappa \left(y_{jt} - y_{it} \right) + \eta_g g_{jt} - \eta_e \frac{\kappa}{\beta} e_t \tag{51}$$

$$g_{jt} = -\frac{\eta_y}{\eta_g} \left(\mu - \frac{1}{2} \right) \kappa \left(y_{jt} - y_{it} \right) - \frac{\eta_e}{\eta_g} \frac{\kappa}{\beta} \left(r_t - r_t^* \right), \tag{52}$$

where I have used equation (19) to substitute for the real exchange rate in the latter equality. As in the case above, the fiscal authorities take the output gaps in

both countries into account. The new thing is that they will choose the optimal mix between fiscal and monetary policy:[21] fiscal policy will react more the higher the relative weight on real exchange rate stability – the fraction $\frac{\eta_e}{\eta_g}$ – and the more effective fiscal policy is relative to the effectiveness of monetary policy – the fraction $\frac{\kappa}{\beta}$.

It is important to note that fiscal policy only will react to changes in the average real exchange rate, and not to changes in the country-specific real exchange rates as such. Therefore, if the country-specific real exchange rates change in opposite direction leaving the average real exchange rate constant, fiscal policy will not change. I will return to this below.

To find the average government spending, I take the union average of equation (52). Thereafter I insert for the real interest rate from equation (20). This gives average government spending and real interest rate equal to

$$g_t^{cs} = -\frac{\kappa}{\beta^2 \frac{\eta_g}{\eta_e} + \kappa^2} \left(\frac{1}{\gamma}\widehat{\pi}_t + u_t \right) \tag{53}$$

$$r_t^{cs} = \frac{1}{\beta} \left(\frac{\beta^2 \frac{\eta_g}{\eta_e}}{\beta^2 \frac{\eta_g}{\eta_e} + \kappa^2} \left(\frac{1}{\gamma}\widehat{\pi}_t + u_t \right) + \beta r_t^* \right). \tag{54}$$

The average government spending will thus no longer be zero as it was the case when the fiscal authorities gave no weight to avoiding real exchange rate variability. Faced with an increase in the average core inflation or an in increase in the average demand shock, the fiscal authorities will change government spending in order to avoid "large" changes in the real exchange rate.

To find equilibrium government spending in country j, I do the same as above and insert for the difference in the output gaps – calculated from equation (24). Then I use the average government spending and the real interest rate from equations (53)

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[21]To be precise, the government also choose an optimal mix between fiscal and monetary policy in the case above; the mix dictated by letting $\eta_e = 0$.

and (54). This gives government spending and the output gap as:

$$g_{jt}^{cs} = g_t^{cs} - \frac{4\left(\mu - \frac{1}{2}\right)^2 \kappa}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2 \kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right] \tag{55}$$

$$y_{jt}^{cs} = y_t + 2\left(\mu - \frac{1}{2}\right)\frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2 \kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right]. \tag{56}$$

Therefore, except from the fact that the average government spending is different, both government spending and the output gap behaves exactly as in the case above where the fiscal authorities did not care about real exchange rate variability. This might seem strange at first glance since the weight put on avoiding real exchange rate variability will not influence the output gap. The reason is as follows: first, average output gap is still pinned down by the monetary policy goal, so the fiscal authorities will not try to influence this. Second, the fiscal authorities can only influence the real exchange rate through monetary policy changes to average fiscal policy; and therefore, they are not able influence the country-specific real exchange rates separately. This is why the first order condition above – equation (51) – included only the average real exchange rate.

As far as the two Cournot games are concerned, the fiscal concern about real exchange rate variability will not affect how well the fiscal authorities react to idiosyncratic disturbances. There will be another bias, though, since the fiscal authorities will not choose the optimal mix of monetary and fiscal policy.

4.2 The uncoordinated Stackelberg game with fiscal concern about exchange rate variability

In this case the first order condition changes to:

$$0 = \eta_y\left(\mu - \frac{1}{2}\right)\kappa y_{jt} + \eta_g g_{jt} - \frac{1}{2}\frac{1}{\beta}\eta_e \kappa e_{jt} \tag{57}$$

$$g_{jt} = \frac{\eta_y}{\eta_g}\left(\mu - \frac{1}{2}\right)\kappa y_{jt} - \frac{1}{2}\frac{\eta_e}{\eta_g}\frac{\kappa}{\beta}\left(e_t + \left(\pi_{jt} - \pi_t\right)\right). \tag{58}$$

Compared to the coordinated game, the fiscal authorities in this case – as in the case with $\eta_e = 0$ – do not react to changes in the output gap in the other country.

Furthermore, they react less to changes in the average real exchange rate since they do not take into account the effect on the other country; and last, they react to changes in domestic prices, which will affect the real exchange rate.

Taking the union-average of equation (58), using equation (17) for the output gap and equation (20) for the real exchange rate, the average government spending and real interest rate might be found to be:

$$g_t^{us} = \frac{1}{1 + \frac{1}{2}\frac{1}{\beta^2}\frac{\eta_e}{\eta_g}\kappa^2}\left(\mu - \frac{1}{2}\right)\frac{\eta_y}{\eta_g}\frac{\kappa}{\gamma}\widehat{\pi}_t - \frac{\kappa}{2\beta^2\frac{\eta_g}{\eta_e} + \kappa^2}\left(\frac{1}{\gamma}\widehat{\pi}_t + u_t\right) \qquad (59)$$

$$r_t^{us} = \frac{1}{2\beta^2\frac{\eta_g}{\eta_e} + \kappa^2}\left[2\beta\frac{\eta_g}{\eta_e}\left(\frac{1}{\gamma}\widehat{\pi}_t + u_t\right) + 2\kappa^2\beta\frac{\eta_y}{\eta_e}\left(\mu - \frac{1}{2}\right)\frac{1}{\gamma}\widehat{\pi}_t\right] + r_t^*. \qquad (60)$$

Consequently, average government spending now consist of two parts. The first part is due to the average bias as in the case above, which is now reduced. This is so because the fiscal authorities will react less to a change in the output gap. The second part is due to the trade-off between real exchange rate and government spending variability. Compared to the coordinated equilibrium described above, the trade-off is distorted since the governments do not take into account the effect on the other country.

Inserting for the output gap from equation (24) into the first order condition and using the average government spending from equation (41) gives:

$$g_{jt}^{us} = g_t^{us} - \frac{2\left(\mu - \frac{1}{2}\right)^2\kappa}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right] \qquad (61)$$

$$- \frac{\frac{1}{2}\frac{1}{\beta}\frac{\eta_e}{\eta_y}\kappa}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left(\pi_{jt} - \pi_t\right).$$

Therefore, the equilibrium output gap will be given by:

$$y_{jt}^{us} = y_t + 2\left(\mu - \frac{1}{2}\right)\left(\frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2\kappa^2}\right)\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right] \qquad (62)$$

$$+ 2\left(\mu - \frac{1}{2}\right)\frac{\frac{1}{2}\frac{1}{\beta}\frac{\eta_e}{\eta_y}\kappa^2}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left(\pi_{jt} - \pi_t\right).$$

The effect for the stabilization bias of introducing fiscal care about real exchange rate variability is that nothing happens as far as the reaction on demand shocks are

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concerned, while the fiscal authorities will react even less to idiosyncratic supply side shocks.

5   Concluding remarks

The paper discusses coordination problems in a monetary union. The main findings are that lack of coordination between monetary and fiscal policy leads to a state-contingent bias and that lack of coordination between the fiscal authorities will lead to a stabilization bias. The latter refers to the fact that the fiscal authorities do not react correctly to idiosyncratic shocks, and the nature of the stabilization bias will depend on whether the fiscal authorities act as Stackelberg leaders in the game with the central bank.

The most famous monetary union is the European Monetary Union consisting of most of the countries in the European Union. The European Central Bank is an independent institution with price stability as its major goal; and thus the set-up used in this model should in principle be able to shed some light upon the conduct of fiscal policy by the different European fiscal authorities.

Except from the positive issues – that fiscal policy on average might react too much to factors driving core inflation and that the fiscal response to idiosyncratic shocks might be distorted – the model also points at some normative issues, namely about coordination of fiscal policy. The first issue regards the rather obvious fact that the central bank will only react to average developments in the union. Therefore, the goal of the fiscal authorities should be to react to idiosyncratic disturbances. The second issue regards the attempts to coordinate fiscal policy within the union; and the model discussed here points towards two important factors for such attempts to be successful. First, there must be a clear understanding of how the central bank is operating; and, second, there is a need of some instrument to make the fiscal authorities able to commit to a level of fiscal spending. This would make it possible for the fiscal authorities to act as Stackelberg leaders in the game with the central bank. If this is not the case, coordinating fiscal policy within the monetary union might lead to an increase in average fiscal spending, which is offset by the central

bank; and to biased reactions of the fiscal authorities to idiosyncratic disturbances.

6 Appendix

6.1 Fiscal spending and the output gap in the different strategic set-ups

6.1.1 Coordinated Stackelberg

To find equilibrium government spending in country j, note that using equation (24) the difference in output gaps between the two countries can be written as:

$$y_{jt} - y_{it} = 4 \left(\mu - \frac{1}{2} \right) [\kappa (g_{jt} - g_t) + u_{jt} - u_t - \beta (\pi_{jt} - \pi_t)]. \tag{63}$$

Inserting this into the first order condition (equation 26) and using $g_{jt} = -g_{it}$, government spending in country j can be written as:

$$0 = 4 \left(\mu - \frac{1}{2} \right)^2 \eta_y \kappa [\kappa g_{jt} + u_{jt} - u_t - \beta (\pi_{jt} - \pi_t)] + \eta_g g_{jt}$$

$$g_{jt}^{cs} = -\frac{4 \left(\mu - \frac{1}{2} \right)^2 \kappa}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} [u_{jt} - u_t - \beta (\pi_{jt} - \pi_t)] \tag{64}$$

$$= g_t^{cs} - \frac{4 \left(\mu - \frac{1}{2} \right)^2 \kappa}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} [u_{jt} - u_t - \beta (\pi_{jt} - \pi_t)]. \tag{65}$$

By inserting the latter equality into equation (24) and using the fact that $g_t = 0$, I can find the output gap in country j:

$$y_{jt}^{cs} = y_t + 2 \left(\mu - \frac{1}{2} \right) \left(1 - \frac{4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} \right) [u_{jt} - u_t - \beta (\pi_{jt} - \pi_t)] \tag{66}$$

$$= y_t + 2 \left(\mu - \frac{1}{2} \right) \frac{\frac{\eta_g}{\eta_y}}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} [u_{jt} - u_t - \beta (\pi_{jt} - \pi_t)], \tag{67}$$

which is the equation given in the text.

6.1.2 Uncoordinated Cournot

To find the government spending in the two countries and the real interest rate, I have to take into account how the real exchange rate is affected by the average government spending. Taking the union-average of the first order condition – equation (32), inserting for the average output gap - equation (13), and solving for average government spending gives

$$
\begin{aligned}
0 &= \eta_y \mu \kappa \left(\beta e_t + \kappa g_t + u_t \right) + \eta_g g_t \\
g_t &= \frac{\mu \kappa}{\frac{\eta_g}{\eta_y} + \mu \kappa^2} \left(\beta r_t - \beta r_t^* - u_t \right),
\end{aligned}
\tag{68}
$$

where I have used equation (19) to substitute for the real exchange rate in the second equality. Hence, the latter is the average fiscal authority reaction function given in the text.

Using equations (17) and (20), the average government spending and the real interest rate can be written as:

$$
\begin{aligned}
0 &= -\eta_y \mu \kappa \frac{1}{\gamma} \widehat{\pi}_t + \eta_g g_t \\
g_t^{uc} &= \mu \frac{\kappa}{\gamma} \frac{\eta_y}{\eta_g} \widehat{\pi}_t \\
r_t^{uc} &= \frac{1}{\beta} \left[\left(1 + \mu \kappa^2 \frac{\eta_y}{\eta_g} \widehat{\pi}_t \right) \frac{1}{\gamma} \widehat{\pi}_t + \beta r_t^* + u_t \right].
\end{aligned}
\tag{69}
\tag{70}
$$

Inserting for the output gap from equation (24) into the first order condition – equation (32) – gives

$$
\eta_y \mu \kappa \left(-\frac{1}{\gamma} \widehat{\pi}_t + 2 \left(\mu - \frac{1}{2} \right) \left[\kappa \left(g_{jt} - g_t \right) + u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_t \right) \right] \right) + \eta_g g_{jt} = 0,
$$

and therefore, using the average government spending from equation (35), equilib-

rium government spending can be written as:

$$\left[\eta_g + 2\mu\left(\mu - \frac{1}{2}\right)\eta_y\kappa^2\right]g_{jt} = \left(\eta_g + 2\mu\left(\mu - \frac{1}{2}\right)\eta_y\kappa^2\right)\mu\frac{\kappa}{\gamma}\frac{\eta_y}{\eta_g}\widehat{\pi}_t$$

$$-2\mu\left(\mu - \frac{1}{2}\right)\kappa\eta_y\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right]$$

$$g_{jt}^{uc} = \mu\frac{\kappa}{\gamma}\frac{\eta_y}{\eta_g}\widehat{\pi}_t - \frac{2\mu\left(\mu - \frac{1}{2}\right)\kappa}{\frac{\eta_g}{\eta_y} + 2\mu\left(\mu - \frac{1}{2}\right)\kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right] \tag{71}$$

$$= g_t^{uc} - \frac{2\mu\left(\mu - \frac{1}{2}\right)\kappa}{\frac{\eta_g}{\eta_y} + 2\mu\left(\mu - \frac{1}{2}\right)\kappa^2}\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right], \tag{72}$$

and the equilibrium output gap is found using the latter equality above and equation (24).

6.1.3 Uncoordinated Stackelberg

Taking the union-average of equation (39) and inserting for the average output gap from equation (17), the average government spending and real interest rate are given by:

$$0 = -\eta_y\left(\mu - \frac{1}{2}\right)\kappa\frac{1}{\gamma}\widehat{\pi}_t + \eta_g g_{jt}$$

$$g_t^{us} = \left(\mu - \frac{1}{2}\right)\frac{\kappa}{\gamma}\frac{\eta_y}{\eta_g}\widehat{\pi}_t \tag{73}$$

$$r_t^{us} = \frac{1}{\beta}\left[\left(1 + \left(\mu - \frac{1}{2}\right)\frac{\kappa}{\gamma}\frac{\eta_y}{\eta_g}\right)\frac{1}{\gamma}\widehat{\pi}_t + \beta r_t^* + u_t\right]. \tag{74}$$

Next, inserting for the output gap from equation (24) into the first order condition (equation 39) and using the average government spending from equation (41) gives:

$$\left(\mu - \frac{1}{2}\right)\eta_y\kappa\left(-\frac{1}{\gamma}\widehat{\pi}_t + 2\left(\mu - \frac{1}{2}\right)\left[\kappa\left(g_{jt} - g_t\right) + u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right]\right)$$

$$+\eta_g g_{jt} = 0$$

$$g_{jt}^{us} = \left(\mu - \frac{1}{2}\right)\frac{\kappa}{\gamma}\frac{\eta_y}{\eta_g}\widehat{\pi}_t - \frac{2\left(\mu - \frac{1}{2}\right)^2\kappa}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left(\left[u_{jt} - u_t - \beta\left(\pi_{jt} - \pi_t\right)\right]\right) \tag{75}$$

$$= g_t^{us} - \frac{\left(\mu - \frac{1}{2}\right)^2\kappa}{\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left(\left[u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right]\right). \tag{76}$$

6.1.4 Coordinated Cournot

Using the first order condition (45), the aggregate demand equation (23), and average government spending from equation (47), government spending in country j can be written as:

$$4 \left(\mu - \frac{1}{2}\right)^2 \eta_y \kappa \left[\kappa \left(g_{jt} - g_t\right) + u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_t\right)\right]$$

$$-\eta_y \kappa \frac{1}{\gamma} \widehat{\pi}_t + \eta_g g_{jt} = 0$$

$$g_{jt}^{cc} = \frac{\eta_y}{\eta_g} \frac{\kappa}{\gamma} \widehat{\pi}_t - \frac{4 \left(\mu - \frac{1}{2}\right)^2 \kappa}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2}\right)^2 \kappa^2} \left[u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_t\right)\right] \tag{77}$$

$$= g_t^{cc} - \frac{4 \left(\mu - \frac{1}{2}\right)^2 \kappa}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2}\right)^2 \kappa^2} \left[u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_t\right)\right]. \tag{78}$$

6.2 Pay-off comparisons

To calculate the costs for the fiscal authorities in the two uncoordinated equilibria, I use the first order conditions – equations (33) and (40) – to write the loss in period t as:

$$L_{jt}^{uc} = \eta_y \left(1 + \mu^2 \kappa^2 \frac{\eta_y}{\eta_g}\right) \left(y_{jt}^{uc}\right)^2 \tag{79}$$

$$L_{jt}^{us} = \eta_y \left(1 + \left(\mu - \frac{1}{2}\right)^2 \frac{\eta_y}{\eta_g} \kappa^2\right) \left(y_{jt}\right)^2, \tag{80}$$

for the uncoordinated Cournot and Stackelberg equilibria, respectively. Next, I insert for the output gap from equations (38) and (44). This gives:

$$L_{jt}^{uc} = \eta_y \left(1 + \mu^2 \kappa^2 \frac{\eta_y}{\eta_g}\right) \left(y_t\right)^2 \tag{81}$$

$$+2 \left(\mu - \frac{1}{2}\right) \frac{\eta_y \left(\frac{\eta_g}{\eta_y} + \mu^2 \kappa^2\right)}{\frac{\eta_g}{\eta_y} + 2\mu \left(\mu - \frac{1}{2}\right) \kappa^2} \left[u_{jt} - u_t - \beta \left(\pi_{jt} - \pi_{it}\right)\right] y_t$$

$$+ \left(\mu - \frac{1}{2}\right)^2 \frac{\eta_g \left(\frac{\eta_g}{\eta_y} + \mu^2 \kappa^2\right)}{\left(\frac{\eta_g}{\eta_y} + 2\mu \left(\mu - \frac{1}{2}\right) \kappa^2\right)^2} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it}\right)\right]^2 \Bigg\},$$

and

$$L_{jt}^{us} = \eta_y \left(1 + \left(\mu - \frac{1}{2} \right)^2 \frac{\eta_y}{\eta_g} \kappa^2 \right) (y_t)^2 \tag{82}$$

$$+ 2 \left(\mu - \frac{1}{2} \right) \frac{\eta_y \left(\frac{\eta_g}{\eta_y} + \left(\mu - \frac{1}{2} \right)^2 \kappa^2 \right)}{\frac{\eta_g}{\eta_y} + 2 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it} \right) \right] y_t$$

$$+ \left(\mu - \frac{1}{2} \right)^2 \frac{\eta_g \left(\frac{\eta_g}{\eta_y} + \left(\mu - \frac{1}{2} \right)^2 \kappa^2 \right)}{\left(\frac{\eta_g}{\eta_y} + 2 \left(\mu - \frac{1}{2} \right)^2 \kappa^2 \right)^2} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it} \right) \right]^2 \Bigg\}.$$

As far as the costs associated with the two coordinated equilibria, they can be written as:[22]

$$L_{jt}^{cs} = \eta_y \left(y_{jt}^{cs} \right)^2 + \eta_g \left(\frac{\eta_y}{\eta_g} \right)^2 \left(\mu - \frac{1}{2} \right)^2 \kappa^2 \left(y_{jt}^{cs} - y_{it}^{cs} \right)^2, \tag{83}$$

for the coordinated Stackelberg game, and

$$L_{jt}^{cc} = \eta_y \left(y_{jt}^{cc} \right)^2 + \eta_g \left(\frac{\eta_y}{\eta_g} \right)^2 \kappa^2 \left(\mu y_{jt} + (1 - \mu) y_{it} \right)^2, \tag{84}$$

for the coordinated Cournot game. Using the output gaps from equations (31) and (50), the losses can be expressed as:

$$L_{jt}^{cs} = \eta_y (y_t)^2 + \frac{2 \left(\mu - \frac{1}{2} \right) \eta_g}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it} \right) \right] y_t \tag{85}$$

$$+ \left(\mu - \frac{1}{2} \right)^2 \frac{\eta_g}{\left(\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2 \right)} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it} \right) \right]^2,$$

and

$$L_{jt}^{cc} = \eta_y \left(1 + \frac{\eta_y}{\eta_g} \kappa^2 \right) (y_t)^2 \tag{86}$$

$$+ 2 \left(\mu - \frac{1}{2} \right) \frac{\eta_y \left(\frac{\eta_g}{\eta_y} + 2 \left(\mu - \frac{1}{2} \right) \kappa^2 \right)}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it} \right) \right] y_t$$

$$+ \left(\mu - \frac{1}{2} \right)^2 \frac{\eta_g}{\frac{\eta_g}{\eta_y} + 4 \left(\mu - \frac{1}{2} \right)^2 \kappa^2} \left[u_{jt} - u_{it} - \beta \left(\pi_{jt} - \pi_{it} \right) \right]^2.$$

---

[22]As for the two uncoordinated equilibria, I use the respective first order conditions, hence equations (27) and (46).

In order to find the difference in ex post expected costs between the coordinated Stackelberg game and the other strategic set-ups, I would normally have to proceed as follows: First, calculate the differences using the equations above; and, second, take the expected value. However, due to the symmetry of the model, it suffices to calculate the average loss for the two countries. The reason is that with equal probability, the two fiscal authorities will face the loss for either country j and i.

For the coordinated Stackelberg equilibrium the average cost is given by:

$$
\begin{aligned}
\widehat{L}_t^{cs} &= \frac{1}{2}\sum L_{jt}^{cs} = \eta_y\,(y_t)^2 + \frac{1}{2}\frac{2\left(\mu - \frac{1}{2}\right)\eta_g}{2\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left[u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right]y_t \\
&\quad + \frac{1}{2}\frac{2\left(\mu - \frac{1}{2}\right)\eta_g}{2\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2}\left[u_{it} - u_{jt} - \beta\left(\pi_{it} - \pi_{jt}\right)\right]y_t \\
&\quad + \left(\mu - \frac{1}{2}\right)^2\frac{\eta_g}{\left(\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2\right)}\left[u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right]^2 \\
&= \eta_y\,(y_t)^2 + \left(\mu - \frac{1}{2}\right)^2\frac{\eta_g}{\left(\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2\right)}\left[u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right]^2,
\end{aligned}
$$

and therefore the second therm in equation (85) disappear. Consequently, the differences with the coordinated Stackelberg game and the other strategic set-ups can be calculated as:

$$
\begin{aligned}
\widehat{L}_t^{cs} - \widehat{L}_t^{uc} &= -\eta_y\mu^2\kappa^2\frac{\eta_y}{\eta_g}\,(y_t)^2 \\
&\quad + \left[\frac{1}{\left(\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2\kappa^2\right)} - \frac{\left(\frac{\eta_g}{\eta_y} + \mu^2\kappa^2\right)}{\left(\frac{\eta_g}{\eta_y} + 2\mu\left(\mu - \frac{1}{2}\right)\kappa^2\right)^2}\right] \\
&\quad \times \left(\mu - \frac{1}{2}\right)^2\eta_g\left[u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right]^2.
\end{aligned}
$$

A sufficient condition in order to make the term in square brackets negative, is that $\mu < 1$. Hence, the coordinated Stackelberg is preferable to the uncoordinated Cournot equilibrium.

Moreover,

$$\widehat{L}_t^{cs} - \widehat{L}_t^{us} = -\eta_y \left(\mu - \frac{1}{2}\right)^2 \frac{\eta_y}{\eta_g} \kappa^2 (y_t)^2$$

$$+ \left[\frac{1}{\left(\frac{\eta_g}{\eta_y} + 4\left(\mu - \frac{1}{2}\right)^2 \kappa^2\right)} - \frac{\frac{\eta_g}{\eta_y} + \left(\mu - \frac{1}{2}\right)^2 \kappa^2}{\left(\frac{\eta_g}{\eta_y} + 2\left(\mu - \frac{1}{2}\right)^2 \kappa^2\right)^2} \right]$$

$$\times \left(\mu - \frac{1}{2}\right)^2 \eta_g \left[u_{jt} - u_{it} - \beta\left(\pi_{jt} - \pi_{it}\right)\right]^2,$$

and therefore, because the term in the square brackets is negative as long as $\mu > \frac{1}{2}$, the coordinated Stackelberg game is preferable to the uncoordinated Stackelberg game.

Last,

$$\widehat{L}_t^{cs} - \widehat{L}_t^{cc} = -\eta_y \frac{\eta_y}{\eta_g} \kappa^2 (y_t)^2,$$

which is negative. Accordingly, the coordinated Stackelberg game is also preferable to the coordinated Cournot game.

References

Agell, Jonas, Lars Calmfors, and Gunnar Jonsson, "Fiscal Policy When Monetary Policy Is Tied to the Mast," *European Economic Review*, 1996, *40*, 1413–1440.

Alesina, Alberto and Guido Tabellini, "Rules and Discretion with Noncoordinated Monetary and Fiscal Policies," *Economic Inquiry*, October 1987, *25*, 619–630.

Andersen, Torben M. and Friedrich Schneider, "Coordination of Fiscal and Monetary Policy under Different Institutional Arrangements," *European Journal of Political Economy*, 1986, *2*, 169–191.

_ **and Jan Rose Sørensen**, "Unemployment and Fiscal Policy in an Economic and Monetary Union," *European Journal of Political Economy*, 1995, *11*, 27–43.

Ball, Laurence, "Policy Rules for Open Economy," October 1998. NBER Working Paper 6760.

Beetsma, Roel M. W. J. and A. Lans Bovenberg, "Monetary Union Without Fiscal Coordination May Discipline Policymakers," *Journal International Economics*, 1998, *45*, 239–258.

_ **and** _ , "Does Monetary Unification Lead to Excessive Debt Accumulation?," *Journal of Public Economics*, 1999, *74*, 299–325.

_ **and** _ , "Strategic Debt Accumulation in a Heterogeneous Monetary Union," October 2000. Mimeo, University of Amsterdam/Tilburg University.

Dixit, Avinash and Luisa Lambertini, "Symbiosis of Monetary and Fiscal Policies in a Monetary Union," March 2000. Mimeo, Princeton University/UCLA.

Leitemo, Kai, "Samspillet Mellom Penge- Og Finanspolitikken under et Underliggende Inflasjonsmål for En Liten Åpen Økonomi," December 1999. manuscript.

Nordhaus, William D., "Policy Games: Coordination and Independence in Monetary and Fiscal Policies," *Brookings Papers on Economic Activity*, 1994, *2*, 139–216.

Svensson, Lars E. O., "Optimal Inflation Targets, "Conservative" Central Banks, and Linear Inflation Contracts," *American Economic Review*, 1997, *87* (1), 98–114.

Tornell, Aaron and Andrés Velasco, "Fiscal Discipline and the Choice of Exchange Rate Regime," *European Economic Review*, 1995, *39*, 759–770.

van Aarle, Bas and Harry Garretsen, "Fiscal Stabilization in the EMU," *Review of International Economics*, 2000, *8* (4), 741–758.

von Hagen, Jürgen, "Monetary Policy and Institutions in the EMU," *Swedish Economic Policy Review*, 1997, *4*, 51–116.