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Measuring the Effects of Monetary Policy in the Euro Area: The Role of Anticipated Policy

by

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Abstract:

This paper investigates within a SVAR framework the effects of anticipated monetary policy in the euro area. Building on a procedure recently proposed by Cochrane which yields the response of output to an anticipated monetary policy impulse, we show that in the past twenty years anticipated monetary policy has had a considerable influence on output. Moreover, we compute the output effects of the systematic monetary policy response to aggregate demand and supply shocks and find that monetary policy pursues a counter-cyclical policy in response to demand shocks and, despite considerable lags, is pro-cyclical with regard to supply shocks. (98 words)

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1. Introduction

There exists a considerable amount of literature that analyses the effects of monetary policy on the business cycle using the method of structural vector autoregression (SVAR). A standard finding of these studies is that the effects of monetary policy shocks on aggregate output and the price level are rather small and therefore do not play a considerable role in business cycle generation or stabilization.[1] Whereas such analyses focus on the role of unanticipated policy shocks, analysis of the effects of systematic and hence anticipated monetary policy, in contrast, has been somewhat neglected. To fill this gap, Cochrane (1998) recently made an important contribution to this latter field by developing an algorithm that allows one to identify impulse response functions for unanticipated and anticipated policy actions, depending on an exogenous choice parameter that indicates the relative effectiveness of anticipated monetary policy.

In this paper, we apply the methodology proposed by Cochrane to an aggregate euro area dataset. Moreover, based on these results we construct a historical time series of output fluctuations attributable to anticipated and unanticipated monetary policy actions. In doing so, we modify the historical decomposition technique, a standard tool in applied SVAR analysis, to account for anticipated monetary policy actions. The objective of this modification is twofold:

First, the approach proposed in this paper allows us to extend the SVAR analysis of the real effects of monetary policy to go beyond shocks to also investigate the real effects of anticipated monetary policy. If monetary policy matters for business cycle fluctuations, it is likely to be the anticipated part that has sub-

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[1] Sims (1998), p. 933, summarizes the literature as follows: "... (2) Responses of real variables to monetary policy shifts are estimated as modest or nil, depending on the specification. ...". See also the survey in Christiano et al. (1999), particularly p. 70.

stantial real effects, since unexpected monetary policy shocks are usually not found to contribute much to output fluctuations. To shed light on this question, we compute the output effects of anticipated monetary policy for different assumptions about the effectiveness of anticipated relative to unanticipated policy.

Second, having a measure of the effects of the anticipated part of monetary policy makes it possible to gain a better understanding of the effects of non-monetary policy shocks. The SVAR model employed in this paper identifies two such non-monetary policy shocks, a real demand shock and an aggregate supply shock. The overall effects of an aggregate supply shock, for example, can be decomposed into the direct effect of the shock and the indirect effect attributable to the systematic monetary policy response to this shock. In a standard SVAR analysis the output impulse response function to such a shock encompasses both the direct and the indirect effects and does not allow to estimate these two effects separately. In particular, conventional SVAR analysis remains silent on the role of systematic monetary policy in propagating this shock. If one observes, for example, that an adverse supply shock like a strong increase in oil prices is followed by a recession it remains unclear whether the recession is due to the direct effects of higher oil prices on the economy or to the effects of a tighter monetary policy stance in response to the inflationary pressures arising from this shock. This paper investigates this issue by identifying the role of systematic policy in propagating the output effects of non-monetary policy shocks.[2] To illustrate this point, this paper presents an analysis of the role of systematic monetary policy for euro area business cycle fluctuations in the period from 1980 to 2000.

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[2] For a discussion of this issue see also Bernanke et al. (1997), who investigate the real effects of systematic monetary policy with the help of stochastic simulations.

For our analysis of the effects of monetary policy we use the SVAR model proposed by Monticelli and Tristani (1999) as a starting point. Given that we aim to show how the analysis of anticipated monetary policy actions can in principle be accomplished with any SVAR model, it is not necessary for our purposes to add another model to the already rich SVAR literature. Using a standard model ensures that the discussion of the underlying model can be kept brief in the following.

The paper is organized as follows. In section 2 the SVAR model for the euro area proposed by Monticelli and Tristani is introduced. The following section discusses the limitations of the interpretation of conventional impulse response functions and presents the Cochrane method, which allows it to compute impulse response functions for anticipated monetary policy actions. In section 4 this methodology is extended to construct an index of the output effects of anticipated monetary policy. Section 5 investigates the contribution of systematic monetary policy to euro area business cycle fluctuations. The final section summarizes our findings.

2. A SVAR Model for the Euro Area

In their paper "What Does the Single Monetary Policy Do? A SVAR Benchmark for the European Central Bank", Monticelli and Tristani propose a parsimonious SVAR model for the monetary transmission mechanism in the euro area. This model is used in the remainder of the paper to demonstrate how typical SVAR models can be modified to obtain an index of the output effects of anticipated monetary policy. The Monticelli and Tristani model appears to be well qualified for this purpose, because it employs common identifying restrictions and impulse response functions that correspond well to widely held views about the monetary transmission mechanism. Another advantage of this model is its robustness; the two authors have shown that the dynamic features of this model remain essentially unchanged when the sample period or other aspects of the modeling approach are varied. This section discusses the specification and identification of the model and presents the impulse response functions.

2.1 Specification and Identification of the SVAR Model

The SVAR model proposed by Monticelli and Tristani is a trivariate model containing the growth rate of real output as the real activity variable (Δy), the rate of change over the previous quarter of the consumer price index as the inflation series (p), and the 3-month interbank interest rate as a measure for the nominal short term interest rate (s). The latter variable is the monetary policy instrument in this setup. An important assumption for the following analysis is that the central bank can sufficiently control the short term interest rate. The model is specified in levels, that is, only the output series is differenced, but not the inflation rate and the nominal interest rate. The data set is comprised of quarterly aggregated data for the euro area, with data available for a time span beginning in 1980: 1 and ending in 2000: 4.[3]

We estimate the reduced form of the model using three lags as suggested by the Akaike information criterion and a Likelihood Ratio test. Regarding the deterministic component of the empirical model, we include a constant, a segmented trend variable and a step-dummy. The latter two variables represent a departure from Monticelli and Tristani model. For our purposes it has proven important to model the deterministic component of the nominal short-term inter-

[3] The data has been taken from the euro area Area-Wide Model (AWM) data set, published by Fagan et al. (2001). From 1996 onwards, the time series have been updated using data from the ECB Monthly Bulletins. These time series have been obtained from DATASTREAM. A plot of the time series is included in the appendix.

est rate carefully since it approximates in the analysis of the monetary policy stance the neutral interest rate. Usually, the neutral rate is assumed to be constant in time. In the euro area, however, the short-term interest rate is characterized by a downward trend over most of the sample period. If this trend reflected a change in the policy stance, monetary policy would have been on a course of ever easier monetary policy, which is unlikely. Thus, the trending behavior is likely to reflect a changing neutral rate, which is modeled here with the help of a segmented time trend and a step-dummy. The time trend, which is intended to model the reduction in trend inflation in the euro area, ends in 1997:2 and subsequently remains constant, yielding the segmented trend variable. The secular decline in inflation modeled by this variable is likely to have induced a similar reduction in the neutral interest rate. The step-dummy variable, which takes the value one from 1997: 3 onwards and is zero otherwise, is intended to model a downward shift in the equilibrium real short-term interest rate due to the risk premium becoming smaller during the transition to European Monetary Union (EMU). A more detailed explanation of the role of these two variables in our model is given in section 4. Also, an impulse dummy taking the value one in 1987:1 and zero otherwise is included to capture a large outlier in the output growth series, which has led to substantial problems with the normality assumption for the residuals of the system. Standard tests for the residual properties, which are given in Table 1A in the appendix, show that the specification with three lags and the three intervention variables yields well-behaved residuals. The stability of the reduced form system has been tested using the Hansen (1992) test, which indicates no sign of instability.

A final issue in the specification of our model concerns the existence of cointegration relationships. In contrast to Monticelli and Tristani, who assume that all three variables are stationary, we find on the basis of unit root tests that only the growth rate of output is stationary, whereas the inflation rate and the nominal interest rate are integrated of order one.[4] This is also in line with results found by other authors for the euro area, for example Coenen and Vega (1999) or, more recently, Brand and Cassola (2000). These results raise the possibility that the inflation rate and the nominal interest rate are cointegrated, as suggested by the Fisher effect postulating that the nominal interest rate corresponds to the sum of the ex-ante real interest rate and expected inflation.[5] Since in the long-run expected inflation and actual inflation should coincide, the Fisher effect suggests that the inflation rate and the nominal short-term interest rate move together one-for-one. To test for cointegration, we test the rank of our model employing the familiar Johansen procedure. The results of the rank test, which are reported in Table 3A in the appendix, indicate that our model actually contains three stationary relations.[6] One of those is likely to correspond to the stationary output growth series. If the Fisher effects holds in the euro area, the real short-term interest rate can be expected to form another stationary relation in our model. Moreover, if the inflation rate and the nominal interest rate move together one-for-one in the long-run, this implies that they share the same permanent component. Since the segmented trend variable has been included to model the underlying trend in inflation, both the inflation rate and the nominal short-term interest rate are likely to be stationary around this trend.

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[4] Table A2 in the appendix shows the results of augmented Dickey Fuller (ADF) tests, which test the null hypothesis of non-stationarity.

[5] Coenen and Vega (1999), for example, provide evidence for a cointegration relationship between the nominal short-term interest rate and inflation in the euro area consistent with the Fisher effect.

[6] The three intervention dummies have been restricted to enter only the cointegration space. If they enter the model unrestricted, the segmented trend variable would imply a quadratic trend in the variables, the step-dummy would imply a trend in the variables from 1997:3 onwards and the impulse dummy would imply a permanent change in the level of the output series. Restricting the intervention variables to the cointegration space rules out these effects.

To investigate whether the three cointegration vectors correspond indeed to these three stationary relations, we impose the corresponding restrictions on the cointegration space and find that they are not rejected at the 10% significance level. The results for the estimated stationary relations and their loadings are reported in Table 4A in the appendix. The first stationary relation ($\boldsymbol{b}_1$) contains only the differenced output series and the impulse dummy capturing the large outlier in this series in 1987:1. The second stationary relation, $\boldsymbol{b}_2$, models the real short-term interest rate, which is given by the difference between the nominal short-term interest rate and the annualized inflation rate.[7] Moreover, the step-dummy variable is allowed to enter this relation in order to model the downward shift in the equilibrium real interest rate following EMU. Consequently, the step-dummy is denoted in the following as the EMU dummy variable. The estimated coefficient for this variable suggests that the prospect of a stability oriented common monetary policy has lowered the equilibrium real interest rate in the euro area by 3 percentage points. But with a standard error of 1 percentage point this effect is estimated quite imprecisely. Taking the long-run average of the real short-term interest rate as an approximation of the equilibrium real interest rate in the euro area, this result implies that the equilibrium real interest rate has declined from a value of 5 percent in the time period from 1980 until 1997 to a new value of approximately 2 percent thereafter. Interestingly, a similar value for the equilibrium real interest rate is obtained if one approximates the equilibrium value with the trend component of the real short-term interest rate and employs a filter estimation method like the band pass filter. In general, plausible estimates of the equilibrium real interest rate range

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[7] Since the inflation rate is computed as the rate of change over the previous quarter, the coefficient for inflation is restricted here to –4 so that the inflation variable represents the annualized rate of inflation rate.

from 2 percent up to 3.5 percent.[8] Finally, the third stationary relationship, $\boldsymbol{b}_3$, models the nominal short-term interest rate as a function of both the segmented trend variable and the step-dummy variable. The former is intended to capture the effect of the secular decline in inflation on the nominal interest rate and the latter to capture the effect of EMU. As discussed in more detail in section 4, the resulting trend component is interpreted in the remainder of this paper as an approximation of the neutral interest rate. The estimated loadings for the third relation $(\boldsymbol{a}_3)$ support this interpretation: If the short-term interest rate deviates from its trend component this leads to an error-correction mechanism involving the output series, with a higher short-term interest rate leading to a decline in output. This is consistent with our view of the nominal short-term interest rate as the monetary policy instrument and the trend component as representing the neutral interest rate, since deviations of the interest rate from the trend component correspond in this case to a change in the monetary policy stance, with tighter (easier) monetary policy having a restrictive (stimulating) effect on output.

One avenue of further research would be to impose the restrictions yielding these three stationary relations on the cointegration space and to proceed with a SVAR analysis that takes these restrictions into account.[9] However, this path would lead away from the benchmark model chosen in this paper. For this reason the following analysis imposes no restrictions on the cointegration space.

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[8] Taylor (1993) computes the equilibrium real interest rate for the USA on the basis of the long-run average growth rate of the U.S. economy. A corresponding calculation for the euro area yields an equilibrium rate of approximately 2 percent. An alternative method is to use of the long-run average of the German real short-term interest rate. This is the method employed by the six leading German economic research institutes who choose a value of 3.5 percent for the equilibrium real interest rate in the euro area. See Arbeitsgemeinschaft (1999), p.38.

[9] In other words, one could proceed here with a common trend analysis. This is essentially what Coenen and Vega (1999) do.

In a seminal paper Sims et al. (1990) have shown that imposing no restrictions of this kind involves no loss of information with respect to the long-run properties of the system. Regarding the estimated VAR coefficients, conventional OLS estimation still leads to consistent estimates and in many instances these are asymptotically normal distributed such that standard tests can be applied. This implies that we can use the model proposed by Monticelli and Tristani even though, in contrast to their assumptions, the inflation rate and the nominal short-term interest rate are not stationary variables but integrated and cointegrated.[10]

The identification of the system takes the reduced form VAR as a starting point; the moving average representation of this system has the form

(1) $Y_t = C(L)u_t$,

where Y_t is a vector containing the variables growth rate of output, the inflation rate and short-term interest rate, L is a lag operator, $C(L)$ is a matrix polynomial and u is a vector containing the reduced form disturbances. The objective is to recover the structural model from the data, which is given by

(2) $Y_t = C^*(L)e_t$.

The vector e_t in (2) is a vector of structural innovations, which are assumed to be orthogonal to each other, and $C^*(L)$ gives the impulse response

[10] In general, the spurious regression problem involving only integrated (but not cointegrated) variables is not a major issue in the VAR literature, because each equation contains lags of the variable to be modeled on the right hand side as well. Hence, the VAR model includes a random walk behavior of a variable as a special case. For a further discussion of this issue see Kugler (1996), pp. 355. In the context of this paper this implies that even when the short-term interest rate and the inflation rate are integrated but there is no cointegration relationship, the absence of cointegration should not pose a particular serious problem for the VAR model. This highlights a strength of this approach, namely that not much needs to be known about the stationarity and the cointegration properties of variables to proceed with a VAR analysis. Consequently, it has become quite common to estimate VAR systems in levels without paying much attention to these issues. For an example see Bagliano and Favero (1998).

functions. These show how the variables in Y_t respond to an innovation in one of the elements in e_t, holding all other innovations at all dates constant. This gives insight into the dynamic relationships between the variables; consequently, the matrix $C^*(L)$ is of central interest in the SVAR analysis. The link between (1) and (2) is established by the assumption that the vector of reduced form disturbances is a linear combination of the structural innovations, so that $u_t = Ae_t$ holds, where A is a 3x3 matrix. This implies

(3) $$Y_t = C(L)Ae_t = C^*(L)e_t \ .$$

The matrix $C(L)$ can be estimated in a straightforward way; to obtain the matrix $C^*(L)$, which is of interest here, the nine elements of the matrix A need to be known. Three restrictions on A are implied by the orthogonality assumption: Denoting the variance-covariance matrix of u_t and e_t with Σ_u and Σ_e, respectively, it becomes apparent that $A^{-1}\Sigma_u A^{-1}{}' = \Sigma_e$ has to hold. The orthogonality assumption restricts the off-diagonal elements of Σ_e to zero, which gives three independent zero restrictions. Another three elements of A are obtained by the normalization of the system. The final three elements of A have to be determined with the help of identifying restrictions motivated by economic theory.

Monticelli and Tristani derive their theoretically motivated identifying restrictions from the conventional aggregate supply / aggregate demand (AS/AD) model. Given that this framework is reviewed in most macroeconomic textbooks, a formal presentation can be omitted here.[11] Within this framework the three structural innovations are assumed to represent shocks to aggregate supply, innovations to the LM curve and innovations to the IS curve (real aggregate demand shocks). The LM curve shocks represent money supply shocks. This is

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[11] The model proposed by Monticelli and Tristani is closely related to the seminal SVAR model in Gali (1992), who uses the conventional IS/LM framework in conjunction with a vertical long-run supply schedule to model business cycle fluctuations in the US.

motivated by the observation that central banks conduct monetary policy by targeting the interest rate, so that shocks to money demand are fully accommodated, thereby implying that unexpected shifts of the LM curve can be attributed to shocks to the policy stance. Two features of the AS/AD model are crucial to justify the three remaining identifying restrictions in the Monticelli and Tristani model. First, the aggregate supply curve is assumed to be vertical in the long-run, so that there are no long-run effects of demand disturbances on output. Due to the presence of price and nominal wage rigidities aggregate demand disturbances can have output effects, but only in the short-run. Hence, only supply shocks (technological innovations etc.) can have a lasting effect on economic activity. By setting the long-run effects of IS and monetary policy shocks on output to zero, this assumption yields two identifying restrictions. Second, a 'minimum delay restriction' for the short-run effects of monetary policy shocks on output is imposed, which gives the third identifying restriction needed here to obtain a just identified model. According to this restriction monetary policy actions have no contemporaneous effects on real activity. This is motivated by lags in the monetary transmission mechanism. More specifically, for the quarterly model considered here this assumption implies that it takes as least three months before monetary shocks has real effects. Nevertheless, monetary policy shocks are allowed to have contemporaneous effects on prices. This accounts for possibly fast effects of policy actions via the exchange rate channel on the price level.

2.2 Impulse Response Functions

This section discusses the effects of aggregate supply, monetary policy and aggregate real demand shocks on the economy.[12] The impulse response functions are computed for a one standard deviation shock to the system.

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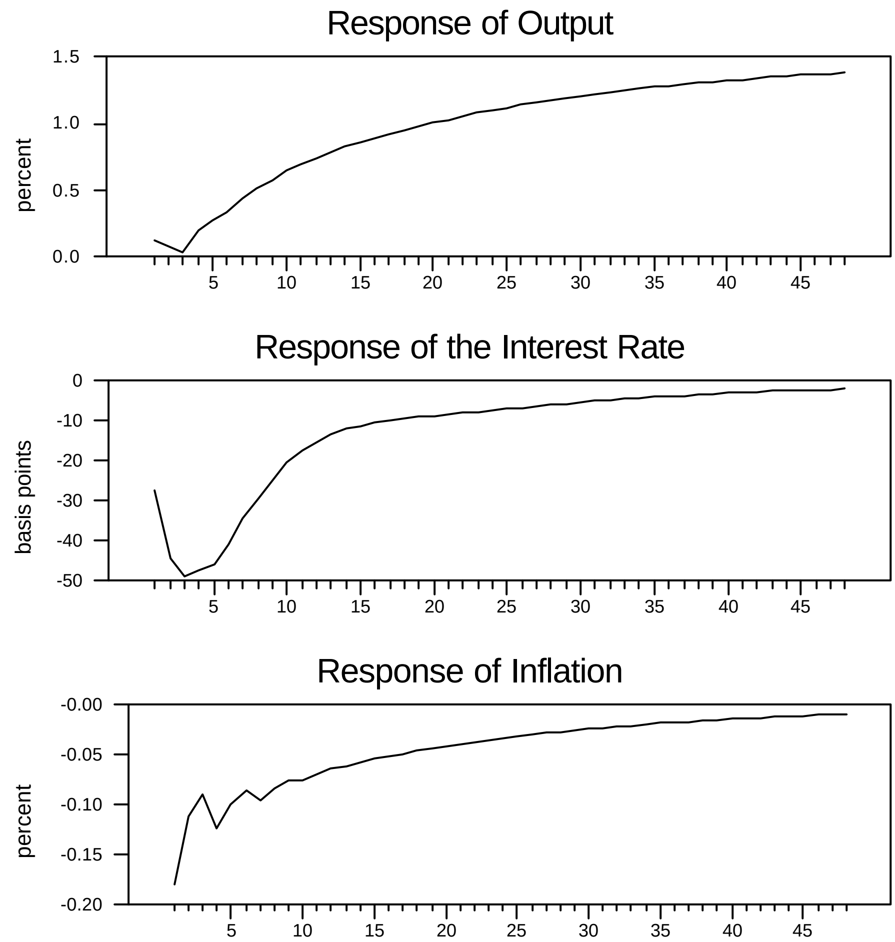
[12] We are grateful to Monticelli and Tristani for providing us with their RATS code.

Figure 1: The Effects of a Supply Shock



Beginning with the supply shock, Figure 1 shows the impulse response functions for output, the nominal short-term interest rate and the inflation rate.[13] In general, the impulse response functions for the supply shock correspond well to widely held views about the reaction of the economy to a positive supply side shock like a drop in oil prices or an increase in productivity. There is an initial increase in output of approximately 0.1 percent, while the inflation rate declines by about 0.20 percent below its base line.[14] In this respect it is interesting to no-

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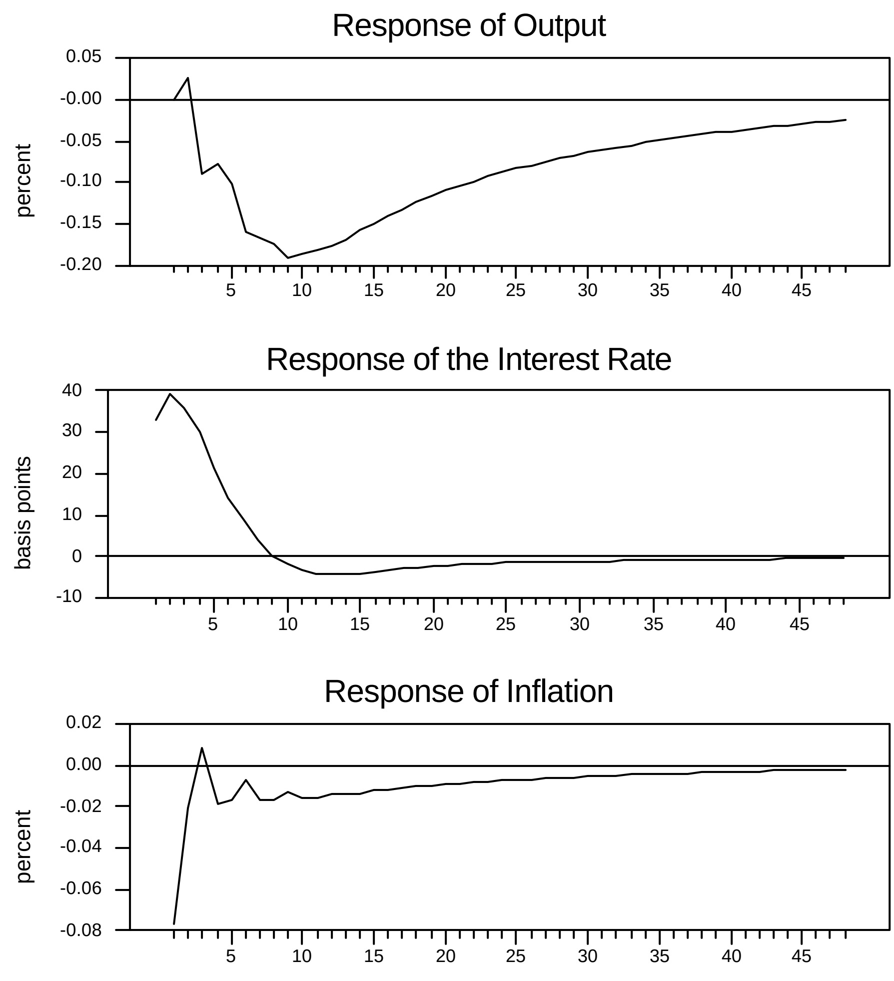
[13] It should be noticed that the inflation rate is the rate of change over the previous quarter, and not the annualized rate.

[14] In all graphs of the impulse response functions the base line is represented by the zero line and corresponds to the path the respective variable would have followed in the absence of the structural shock hitting the economy.

tice that it is a key feature of the AS/AD framework that a supply shock moves output and prices in opposite directions. Since this restriction has not been imposed formally on the model, the fact that the impulse response functions conform to this pattern is reassuring. The impulse response function for the nominal interest rate depicts the response of monetary policy to this positive supply shock. In general, the monetary policy response is consistent with a monetary policy strategy of inflation targeting. In particular, the fall in inflation allows the central bank to ease monetary policy. Initially, the short-term interest rate is lowered by 30 basis points, followed by another reduction in the interest rate by 20 basis points in the next two quarters. After about one year, the output response gathers pace and output increases in the following three years to a level about 1 percent higher than the base line, which represents about two thirds of the total increase in output following the supply shock. Thereafter, it takes another six years for output to reach its new equilibrium value, which is about 1.5 percent higher than the base line. It is likely that the easing of monetary policy in the first three quarters has contributed to the subsequent acceleration in the output response. Moreover, the easing of the monetary policy stance is largely reversed three years after the supply shock, which is followed by a slowing down in the pace of adjustment of output to its new equilibrium value, pointing again to an important role of monetary policy for the adjustment process. Concurrently, the decline in inflation is reversed relatively quickly. After three years the inflation rate is approximately only 0.05 percent higher than the base line. This suggests that the easing of monetary policy is successful in reversing the initial fall in inflation. The inflation response indicates that policy makers in Europe are prepared to accommodate a one time drop in the price level, but not a permanent decline in the inflation rate following a positive supply shock.

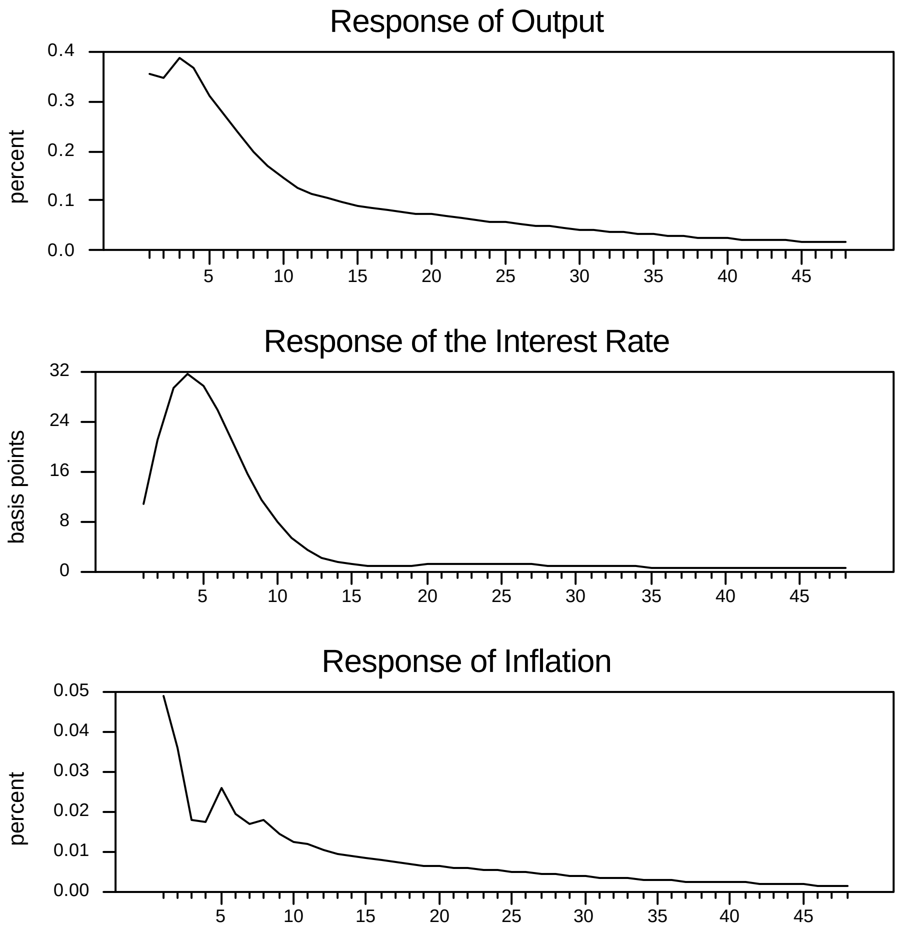
Regarding the effects of the monetary policy shock, the impulse response functions for this structural shock are reported in Figure 2. This shock leads to an initial increase in the nominal short rate of about 35 basis points. While the contemporaneous output response has been restricted to zero, there is a noticeable initial drop in the inflation rate. This could be due to the exchange rate channel, since a tightening of the monetary policy stance is likely to induce an appreciation, which lowers the costs of imports, and thus reduces the price level. Such a reduction in the price level implies a one-time drop in the inflation rate. The interest rate remains around 35 basis points above its base line for about one year. The higher interest rate leads to a gradual increase in output. Given that a monetary policy shock has no effect on potential output in the AS/AD framework, this decline in output corresponds to a negative output gap. The maximum effect of the policy shock on output is reached after two years, when output has declined by about 0.2 percent. The negative output gap is presumably the main

Figure 2: The Effects of a Monetary Policy Shock



factor behind the renewed decline in inflation that sets in about one year after the policy shock. The neutrality restriction implies that output eventually returns to its base line value, and, consequently, the output gap begins to close after approximately three years. This coincides with an ‘undershooting’ of the nominal short-term rate, with monetary policy stimulating real activity. The easing in the policy stance is likely to contribute to the closing of the output gap, but since the ‘undershooting’ is quantitatively small, this easing of the policy stance is presumably not a major factor. With the closing output gap the inflation rate also returns to its base line. In summary, the monetary policy shock has no long-run effect on output but leads to a permanently lower price level.

Figure 3: The Effects of a Real Demand Shock



The third structural shock in the system is the real demand shock, which raises output by about 0.4 percent (Figure 3). Since a real demand shock does not affect potential output either, this corresponds to a positive output gap. Inflation increases by 0.05 percent. The central bank raises the short rate contemporaneously by 10 basis points above its base line followed by another 20 basis points. The tightening of policy is probably an important factor for the relatively fast closing of the output gap, which takes approximately three years. With the closing of the output gap, the initial rise in inflation is reversed and the nominal short rate returns to its base line as well.

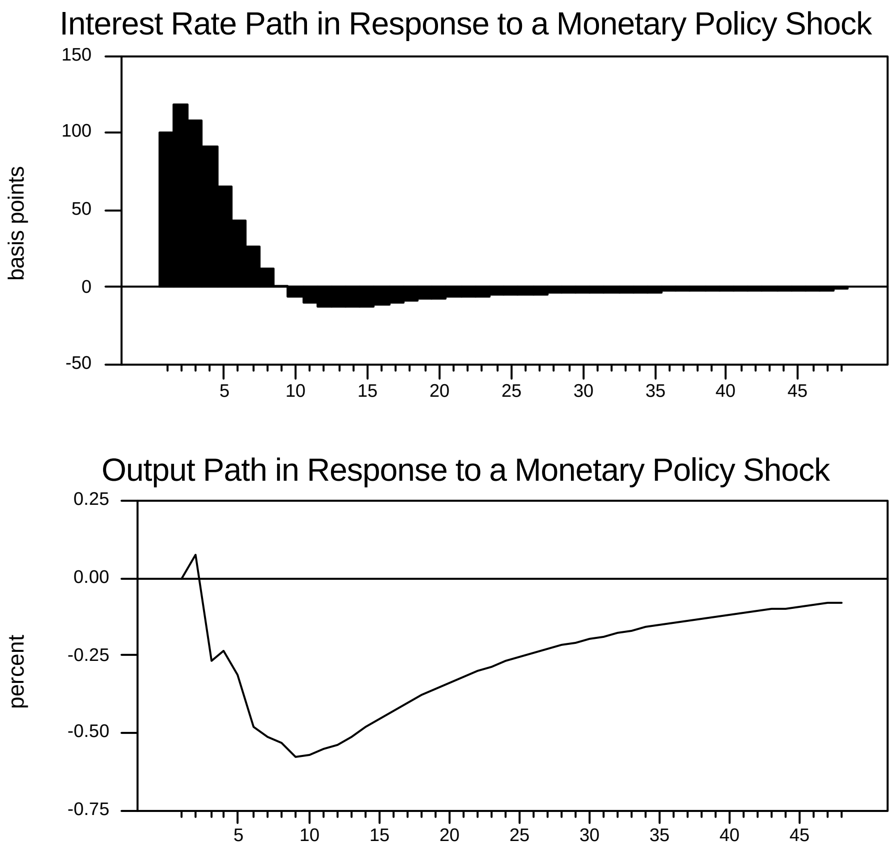
3. Beyond Shocks — Measuring the Output Effects of Anticipated Monetary Policy Actions

The preceding chapter has shown that unanticipated monetary policy shocks have a noticeable effect on output. Moreover, it has become apparent that monetary policy also plays a role in the propagation of aggregate supply and demand shocks. That is, systematic monetary policy is a potentially important factor in the propagation of business cycle fluctuations. Since systematic monetary policy is not conducted in a manner that surprises economic agents, it is possible to form expectations about the systematic component of monetary policy, thereby enabling economic agents to anticipate monetary policy. This implies that having an empirical measure that quantifies the real effects of anticipated monetary policy actions would be rather useful for the analysis of output fluctuations. However, conventional impulse response analysis remains largely silent on this issue. To fill this gap, Cochrane (1998) develops such a measure with the help of an additional identifying assumption regarding the relative effects of anticipated and unanticipated monetary policy actions. This chapter introduces his methodology and applies it to euro area data.

3.1 What Standard Impulse Response Functions Do Not Tell

To provide some intuition for the methodology proposed by Cochrane (1998), we first outline his view on the limitations of conventional impulse response analysis.[15] His line of argument can be illustrated with the help of Figure 4, which plots the interest rate and the output response to a monetary policy shock. The impulse response functions are taken from the empirical model introduced in the preceding chapter, but are rescaled so that the monetary policy shock corresponds to an initial tightening equivalent to a 100 basis points increase in the nominal short-term interest rate.

Figure 4: Response of Output and the Interest Rate to a Monetary Policy Shock



[15] It should be noticed that the point raised by Cochrane does not break new ground, but refers to the inherent temptation in the SVAR literature to read more into impulse response functions than is warranted.

Referring to a similar figure, Cochrane notes that the discussion of the output effects of a monetary policy shock often focuses on the output impulse response function alone, while the further policy actions depicted in the interest rate impulse response function are disregarded. With regard to the euro area model considered here, viewing the lower panel in Figure 4 in isolation suggests that the output effects of a monetary policy impulse are hump shaped, peaking after two years, and then take a considerable time to die out. They are also quite large, since a policy shock that raises the short rate initially by 100 basis points reduces output by approximately 0.6 percent. It is now tempting to conclude that these are exactly the output effects to be expected when the ECB raises the interest rate by one percentage point. Indeed, conventional wisdom states that the full output effects of such a policy action materialize after only about two or three years, which corresponds exactly to the output impulse response function depicted here. But such a conclusion would be premature, since the output response depicted in the second panel of Figure 4 is conditional on the interest rate path given in first panel. In this context it is noteworthy that a monetary policy shock does not lead to an interest rate hike of 100 basis points lasting for one quarter, but according to the interest rate impulse response function this tight policy stance lasts for four quarters. Cochrane stresses that this information should not be neglected in the interpretation of the output impulse response function. His point is that impulse response functions capture *history*, as he puts it, in the sense that they give the average path of output and the interest rate following a monetary policy shock.[16] So when European policy makers raise the short rate unexpectedly, this is on average followed by another three quarters of tight policy before the central bank begins to return policy to its base line. And on average this particular policy course has the output effects given in the second panel. Unfortunately, the average path of the interest rate and output fol-

[16] Cochrane (1998), p. 278.

lowing a monetary policy impulse provides at best an incomplete answer regarding the output effects of monetary policy actions. Cochrane summarizes this by asking "What does this *history* tell us about the *effects* of monetary policy? What does it tell us, for example, about the course of events we should expect if there is a monetary shock *not* followed by the customary further expansion of money [To illustrate his point Cochrane uses a VAR model where a monetary policy shock corresponds to an increase in the money supply.]?".[17] Contrary to widespread beliefs, conventional impulse response analysis is unsuitable for the task of simulating the effects of different policy scenarios.

For applied business cycle analysis this is a serious shortcoming. Most business cycle researchers have an idea about the policy course the central bank is going to pursue in the near future, and these interest rate projections usually play an important role for the output forecast. This in turn leads to the central question regarding the output effects of the projected interest rate path. The impulse response functions discussed above are not of much help here for two reasons. First, they give the output response to an unexpected monetary policy shock, whereas the interest rate projections by definition describe the anticipated part of the interest rate movements. Second, even if the researcher is only interested in the output effects of a monetary policy shock observed in the current period, the output impulse response function is still conditional on interest rates following their customary path after the shock. If monetary policy deviates from this path, the impulse response function are not helpful in predicting the output effects of the monetary policy shock.

To obtain a more complete answer regarding the effects of a given monetary policy action, Cochrane argues that an additional theoretical, identification is

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[17] Cochrane (1998), p. 278.

necessary. More specifically, his approach requires an identifying assumption which specifies the output effects of an anticipated monetary policy impulse relative to those of an unanticipated monetary policy shock of similar size. With this identifying assumption at hand it is possible to calculate from the estimated impulse response functions the output effects of a given anticipated policy impulse.

The intuition behind the algorithm he proposes for this purpose can be illustrated again with the help of Figure 4. To begin with, it is helpful to assume that only unanticipated monetary policy actions have real effects, as postulated, for instance, by New Classical models. In this case, the output response depicted in the second panel is entirely due to the monetary policy shock, whereas the further tightening of policy in the wake of the initial interest rate hike corresponds to the systematic part of monetary policy. Since this subsequent monetary tightening is anticipated by economic agents, it irrelevant for the path of real activity. This implies that in this special case a monetary policy shock has exactly the output effects shown by the respective impulse response function, no matter what monetary policy course the central bank pursues following the shock. In other words, the output response is truly ‘policy

Next, it is assumed that anticipated monetary policy actions also have real effects. For this assumption to hold one has to leave the framework of New Classical models and turn to New Keynesian models instead, for example. Reconsidering Figure 4 from this viewpoint, part of the output response depicted in the lower panel is now accounted for by the systematic and, hence, anticipated interest rate response to the policy shock. In particular, the sustained tightening of policy visible in the interest rate impulse response function is bound to have left its mark on the output path following the monetary policy shock. More specifically, it is likely that the maximum effect of a policy shock on real activity is reached only after two years because policy remains tight for one year and then becomes only gradually less restrictive. This suggests that the output effects of a monetary policy shock that is not followed by the customary sustained tightening of policy but instead by an immediate return to a neutral policy stance (an unanticipated 'blip', in the notation of Cochrane), could be small and immediate instead of large and hump shaped. This would represent a substantial departure from the conventional view about monetary policy effects.

The methodology proposed by Cochrane has the objective to compute the output response to such an unanticipated 'blip'. Using the identifying assumption about the effectiveness of anticipated relative to unanticipated policy the output effects of an anticipated 'blip' can be computed. Before introducing a formal presentation of Cochrane's methodology, the next section discusses first the theoretical relevance of the thesis that anticipated monetary policy has real effects.

3.2 Real Effects of Anticipated Monetary Policy — A Theoretical Perspective

3.2.1 New Classical Economics and the Policy Ineffectiveness Proposition

Since the insights of New Classical economics regarding the short-run neutrality of expected money have become standard fare in macroeconomic textbooks, it is well worth asking whether there is a case for real effects of systematic monetary policy in the first place. Otherwise, conventional impulse response analysis works just fine, as has been pointed out above. Since the assumption that anticipated policy can have real effects is crucial for the motivation of the Cochrane approach, this section reviews the debate about the short-run neutrality of money.

In an influential paper, Gordon (1982) summarizes the 'policy ineffectiveness' proposition developed by Robert E. Lucas, Thomas J. Sargent and Neil

fully in the long-run to anticipated changes in nominal aggregated demand.[20] This view predicts that initially the more rapid anticipated growth of money would be reflected partly in faster inflation and partly in a temporary rise of real output above its natural level. Eventually, the gradual adjustment process would be completed, so that in the long-run the inflation rate would rise by a full 5 percent and real output would return to its natural level. This alternative view depends crucially on factors like adjustment costs, long-term contracts or the decentralization of decision making, which prevent prices from jumping instantaneously in response to a nominal disturbance. Gordon concludes[21]: "Thus the real issue separating proponents from critics of the LSW proposition is the importance of inertia in price adjustment; for LSW to be true, there can be no inertia, whereas inertia is the essence of the alternative NRH-GAP approach."[22]

Regarding the three assumptions mentioned above, an implication of the preceding discussion is that the assumption of rational expectations alone does not lead to the policy ineffectiveness proposition, since it is the degree of instantaneous price flexibility that is the central issue in the debate between the approaches. Consequently, Gordon notes that it is misleading to label the LSW proposition the 'rational expectations approach', as is sometimes done.[23] In a world characterized by price inertia in response to an anticipated nominal dis-

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[20] He labels this approach with the acronym NRH-GAP, which stands for the combination of the long-run Natural Rate Hypothesis with the short-run Gradual Adjustment of Prices. See Gordon (1982), p. 1089.

[21] Gordon (1982), p. 1090.

[22] NRH-GAP is the label he has chosen for his alternative approach. See the preceding footnote.

[23] For a discussion of the role of rational expectations in modern macroeconomics see also McCallum (1999), p. 3. He also points out that the strong association of the hypothesis of rational expectations with the policy ineffectiveness proposition was a widespread misconception in the 1970s and early 1980s.

turbance, agents with rational expectations will take this inertia into account when forming their price expectations, so rational expectations and price inertia are in principle compatible with each other.[24] In other words, the assumption of rational expectations does not automatically imply that prices have to be flexible. Rather, as McCallum (1999) points out, the hypothesis of rational expectations presumes only that agents form expectations so as to avoid systematic expectations errors. To do so, the agents have to behave as if they knew the structure of the actual economy. This implies that their expectations will agree with the theoretical model they 'inhabit', because this model is intended to represent the true structure of the economy. Consequently, when the theoretical model does not specify prices to be instantaneously flexible, the agents in his model will not believe in instantaneously flexible prices either. Thus, it is the assumption of perfect market clearing or, more precisely, perfect price flexibility, not rational expectations, that is central for the policy ineffectiveness proposition.[25]

Regarding this point, Tobin (1980) remarks that "the market-clearing assumption is just that, an assumption. It is not justified by any new direct evidence that a Walrasian auctioneer process generates the prices observed from day to day or month to month or year to year, or by any new theory telling how separate Marshallian markets or administered prices yield Walrasian results." Tobin goes on to note that in accordance with 'the methodology of positive economics' this assumption should be empirically tested to help resolve the debate. There is indeed a wide body of literature devoted to this subject, including the aforementioned paper by Gordon, who finds on the basis of long time series data for the USA strong evidence for his view of a gradual adjustment process of

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[24] For a simple, formal illustration of this point see Buiter (1980), pp. 40.

[25] The third assumption regarding the one-period aggregate information lag is crucial for unexpected monetary policy shocks to have real effects, but this is not the issue here.

prices. Regarding more recent work on this subject, Ball and Mankiw (1994a) conclude from their survey of evidence from microeconomic studies of prices that the finding of substantial stickiness is universal. However, there is no consensus on this question in the literature yet, since, for example, McCallum (1999) disagrees on this point. Still, even though McCallum finds the microeconomic evidence regarding the stickiness of prices non-compelling, he notes[26]: "More influential, I believe, has been the perception that sharp major changes in monetary policy conditions (e.g., in the United States during 1981) have in fact had major real effects in the same direction, together with the belief that price stickiness provides the most satisfactory means of rationalizing the fact." This suggests that the notion that systematic monetary policy has real effects is at least not an outlandish one.

Going beyond the empirical debate, there was an impression among many theoretical economists that one should not give up the perfect market clearing assumption easily, even if it does not hold exactly in the real world. After all, economic models always represent a simplification of the real world. In particular, the alternative of sluggish price adjustment appears to collide with another fundamental principle of economics, namely that economic agents always strife to maximize their utility. This argument can be illustrated with the help of the thought experiment outlined above, where output is initially at its natural level, until the government accelerates the growth rate of the money supply. But now it is assumed that prices adjust only gradually. In a sticky prices world this nominal disturbance induces agents to produce more goods and services than they otherwise would have preferred to do. They can return to their original demand and supply schedules only after they have managed to adjust their prices to off-set the nominal impulse in full. Given that output is initially at its natural

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[26] McCallum (1999), p. 28.

level, which is a natural starting point for an economic modeling exercise, the increase in real activity is clearly welfare reducing. This leads to the question of why all agents not adjust their prices immediately to avoid this welfare loss? It appears to be somewhat contradictory that on the one hand economic theory postulates optimizing behavior, but on the other hand here is a situation where economic agents clearly fail to act in their own self interest by not adjusting their prices promptly. Or, in Lucas's famous quip, traditional models assume that people leave $ 500 bills on the sidewalk.[27] This behavior of not adjusting all prices promptly becomes even more puzzling if one considers that an easy solution is available in the form of full indexation of prices or wages.[28] Thus, the early models proposed by Fischer (1977) and Taylor (1979) provide only an incomplete response to the New Classical position. These authors show that if firms and workers fix nominal wages using long-term contracts, anticipated monetary policy can have real effects in spite of rational expectations. However, both sides would benefit from indexation, thereby eliminating the nominal rigidity inherent in the long-term contracts, which is responsible for nominal disturbances having real effects in these models. In other words, the assumption of inflexible long-term contracts appears to be at odds with the notion that optimizing agents do not enter contracts that are unfavorable to them, since the lack of nominal flexibility prevents an optimal response to aggregate demand fluctuations. This suggests that the perfect market-clearing assumption has some logical appeal even if it is empirically at best a rough approximation of the real world. However, this viewpoint risks ignoring that New-Keynesian economics have made substantial progress in the last twenty years to incorporate price inertia into a fully optimizing modeling framework.

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[27] Barro (1979) puts this more technically by noting that not all feasible trades that are to the perceived mutual advantage of the exchanging parties have been exhausted in this situation.

[28] See Gordon (1990), pp. 1139, on the indexation puzzle.

3.2.2 New Keynesian Economics — A Rationale for the Effectiveness of Systematic Monetary Policy

The label "New Keynesian economics" denotes the research efforts aimed at providing a theoretical framework where optimizing agents choose to create nominal rigidities.[29] This research program is modest in the sense that it does not seek to formulate a new theory of fluctuations, as Ball et al. (1988) write, but instead attempts to strengthen the foundations of the traditional Keynesian view that fluctuations in output arise largely from fluctuations in nominal aggregate demand.[30] They write[31]: "In particular, its goal is to answer the theoretical question of how nominal rigidities arise from optimizing behavior, since the absence of an answer in the 1970s was largely responsible for the decline of Keynesian economics." The central thesis is that nominal rigidities, and hence the real effects of nominal shocks, can be large even if the frictions preventing full price flexibility are small. Thus, seemingly minor aspects like the costs of price adjustment can account for large non-neutralities. The explanation of large effects of nominal rigidities rests on four foundations: imperfect competition, small

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[29] Sometimes this label is also used for the type of models associated for instance with authors like Barro and Grossman (1976) or Malinvaud (1977), where prices are assumed to be initially fixed. These models emphasize that economic agents face quantity restrictions on some markets following a disturbance, since lack of price flexibility implies that markets do not always clear. This section does not refer to this research direction, since these models assume price stickiness without providing the microfoundations for this feature.

[30] While New Keynesian economics primarily explain why due to lack of full price flexibility nominal shocks have real effects, this approach also helps to account for the output effects of real demand shocks like changes in government spending. In this context it is helpful to note that the effect of a money supply shock on output is usually modeled via its effect on real money balances, which enter the aggregate demand function. If one interprets the money term in the aggregate demand equation simply as a shift term, it becomes clear that a real demand disturbance, which shifts aggregate demand too, works through the same transmission channels as a change in money. For a more detailed discussion of this point see Ball et al. (1988), p. 17.

[31] Ball et al. (1988), p. 4.

'menu' costs of price adjustment, real rigidities and staggered price adjustment. The remainder of this section provides a short introduction into the particular role assigned to the individual building blocks.[32]

The assumption of imperfect competition is central for New Keynesian theories for a number of reasons. To begin with, under perfect competition firms are price takers, not price-setters. In other words, under perfect competition it does not even make sense to ask the question under which conditions a firm chooses to keep its price fixed in response to a nominal disturbance. The framework of imperfect competition is therefore a natural starting point for New Keynesian models.

Second, Mankiw (1985) and Akerlof and Yellen (1985) have shown that small costs of price adjustment and imperfect competition are not only separate building blocks of a New Keynesian model, but are also highly complementary. They point out that under imperfect competition the profit loss of a firm due to non-adjustment of prices following a nominal shock is of second order only. This implies that the cost of price rigidity to the firm is small. In contrast, the macroeconomic effects of price rigidity are probably of first order. This argument can be illustrated with the help of an aggregate demand function where output is a function of real balances; in this case, a change in money will lead to a proportional change in output, implying a first order output effect. Therefore, the macroeconomic effects are likely to be much larger than the costs of non-adjustment a firm faces. This results helps to resolve the aforementioned puzzle of why optimizing agents fail to adjust their prices in response to a nominal shock, even though price stickiness leads to unwanted fluctuations of activity

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[32] For a more detailed discussion of the building blocks of New Keynesian models see Ball et al. (1988). This section draws very much on their work and in addition on the survey by Ball and Mankiw (1994a).

and thus reduces their welfare: An individual firm does not adjust its price because with imperfect competition it finds that the gains of price flexibility are smaller than the costs associated with price adjustment.

An intuitive interpretation of this result is provided by Blanchard and Kiyotaki (1987), who show that the social costs of price rigidity are likely to exceed the private costs incurred by firms, because imperfect competition creates aggregate demand externalities. For instance, if the money stock falls and prices do not adjust, the lower real money stock reduces total spending in the economy and the demand curve each firm faces shifts inward, leading to a fall of the firm's profits. If a single firm adjusts its price, this has no effect on the position of its demand curve. Changing prices for the individual firm means only that it moves to a new point on the curve, which yields a second order profit gain by optimally dividing the losses from recession between reduced sales and a lower price. In contrast, if all firms adjusted their prices to the contractionary money supply shock, the lower aggregate price level would return real money balances to their original level and the demand curve would shift back out again. The gains in profit would be large, since the recession would end. The externality arises, because an individual firm does not take this effect into account. Each firm believes that, as a small part of the economy, it cannot end the recession. As a consequence, it may not bother because of small price adjustment costs to make price adjustments that, taken together, would make everyone better off.

Third, the assumption of imperfect competition implies that the effects of nominal rigidity on welfare are also first order. Under imperfect competition, the price determined by profit-maximization is socially sub optimal. More specifically, the price is too high, while output is too low. This implies that welfare would be higher if prices fell below the profit-maximizing price. In case of a contraction of the money supply, non-adjustment of prices means that the actual price is kept above the price compatible with profit-maximization, which leads to a first order welfare loss. A positive demand shock, on the other hand, can lead to a first order welfare gain if prices are kept fixed, since in this case the profit-maximizing price is higher than the price chosen by the firm. In other words, booms raise welfare. This is in line with the public perception that booms represent the 'good times', but stands in stark contrast to the implications of perfect competition models, where all fluctuations are welfare reducing. In this context, it is interesting to notice that half the welfare loss of a business cycle occurs in the latter models during upswings and booms when workers are required to work more than they supposedly want to.[33]

Fourth, from the assumption of imperfect competition follows that output is demand determined. From the perspective of Keynesian thinking about the nature of the business cycle this is an appealing feature, which is not obtained by the assumption of price stickiness alone. To the contrary, when prices are rigid it is more natural to assume that quantity equals the smaller of demand and supply. In case of a recession the demand side would determine output, in line with the Keynesian perspective. But in a boom prices are below their market clearing level and thus there would be no supply response to the demand pull. This implies that in a boom output is determined by supply conditions, not by demand.

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[33] Even though aggregate demand externalities can have first order welfare effects, it would be premature to conclude that aggregate demand fluctuations are inefficient, and thus that stabilization policy is desirable. The reason for this is that while recessions lower welfare it also true that booms raise welfare and thus the average effect of demand fluctuations is unclear. However, this result could change if the aggregate supply curve is nonlinear, so that decreases in demand have large output effects, whereas increases in demand trigger large price responses and hence have only small output effects. Such an asymmetry would strengthen the view that demand stabilization is desirable, since stabilization would raise here the average level of output as well as reduce the variance of output and inflation. This scenario corresponds well with traditional Keynesian thinking about business cycle fluctuations, where it is often assumed that prices are more sticky downwards than upwards, which leads to the non-linearity of supply discussed here. For a more detailed discussion of sources of a nonlinear aggregate supply curve see Ball and Mankiw (1994a), pp. 145. However, Ball and Mankiw (1994b), p. 248, provide a counterexample where this kind of asymmetry does not provide a rationale for demand stabilization.

With imperfect competition, however, firms would meet the expanded demand even when prices do not rise, since they have set their initial price above marginal costs. Thus, a change in demand conditions always causes output to move into the same direction.

In the second building block of New Keynesian models, the so-called 'menu' costs of price adjustment, the question arises as to what these costs are. Literally speaking, the term 'menu costs' refers to the costs of printing new menus, catalogs or to the costs of changing price tags, etc. However, as Ball and Mankiw (1994a) notice, this term should be interpreted more as a metaphor, like the term 'shoe leather costs' is a metaphor for the costs of inflation. In this broader sense it captures also the costs associated with gathering the relevant information and the time and attention required of managers to make and implement decisions. To minimize these costs, firms may decide to review their prices only at fixed intervals, leading to infrequent price adjustment as long as the private costs of non-adjustment are small. More generally, Ball and Mankiw point out that this metaphor is similar to the parable of the Walrasian auctioneer, who ensures that prices always move instantaneously to equilibrate supply and demand. Just like models of perfect competition do not offer a literal account of the mechanism behind instantaneous perfect price flexibility, it is not necessary to identify exactly sources of menu costs in actual economies in order to study models with sticky prices.[34]

The two building blocks discussed so far, imperfect competition and 'menu costs', establish that nominal rigidities can be far larger than the frictions that cause them. However, as shown by Ball and Romer (1990), they are not suf-

[34] As regards this argument, Ball and Mankiw (1994a), p. 143, write: "It is no more appropriate to insist on an exact identification of menu costs than it is to demand the social security number of the Walrasian auctioneer."

ficient to explain non-neutralities of the size observed in actual economies[35]: „For plausible parameter values, small nominal frictions produce only small rigidities. Thus Mankiw's and Akerlof and Yellen's argument, by itself, is not successful in providing foundations for the Keynesian assumption of nominal rigidity." Ball and Romer proceed to show that a high degree of real rigidity in combination with small nominal frictions can lead to large non-neutralities with real rigidity defined as a small response of real wages and real prices to changes in real demand. It is important to notice in this context that real rigidities alone are no impediment to full price flexibility. Therefore they do not imply non-neutrality by themselves, since adjustment to a nominal shock does not require a change in real prices. Instead, real rigidities increase the nominal rigidity arising from a given small cost of price adjustment. In this sense they serve as an amplifier in the transmission process from small costs of price adjustment to substantial nominal rigidity. An example for a source of real rigidities relevant in this context are firms paying efficiency wages. To provide some intuition why the assumption of efficiency wages can have the effect of greatly increasing the non-neutrality inherent in a New Keynesian model, it is useful first to consider an economy with imperfect competition and menu costs but no real rigidity. A nominal shock in this case leads to an increase of aggregate demand, which in turn triggers a rise in demand for labor. It is a stylized fact of most economies that labor supply is quite inelastic, which implies that the shift in labor demand leads to a large rise of real wages. With such a sizeable increase of labor costs a firm has every incentive to raise prices to pass this cost increase on to customers. Consequently, nominal rigidity would not be an equilibrium. However, efficiency wages with nominal rigidity may turn out to be sustainable at small private costs for the firm. The assumption of efficiency wages implies that firms set wages initially above market clearing level. Therefore, during times of rising

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[35] Ball and Romer (1990), p. 184.

aggregate demand the firm is able to find additional labor that is willing to work at the existing real wage level. To put it differently, with this assumption real wages are not tied directly to the inelastic labor supply and therefore real wages are likely to be less procyclical. It is this feature that helps to explain nominal rigidities. With acyclical real wages, shifts in aggregate demand have little effect on marginal costs, and so the desire of firms to change prices is small.[36]

The introduction of real rigidities also implies that a hybrid world, in which some prices are sticky and others are flexible, is likely to be more accurately described by a sticky-price model than by a model with perfect price flexibility. The definition of real rigidity asserts that firms do not wish to change their real price in response to a real shock; in other words, they desire to keep their price relatively close to those set by the other firms in the economy. Consequently, a flexible price firm does not adjust its nominal prices substantially if other firms in the economy do not do so, since proceeding unilaterally with price adjustment causes the real price of the firm to change markedly, which it seeks to avoid according to the real rigidity assumption. Therefore, flexible price firms 'inherit' sluggish price adjustment from the fixed price firms, as Ball and Mankiw describe it.

The model outlined so far still cannot account for the persistence of the real effects of nominal shocks. Once all prices have adjusted, the nominal rigidity is eliminated and output returns to its equilibrium value. However, business cycle fluctuations can last for several years, while prices are unlikely to be fixed for such a long time. To illustrate this point, it is assumed in the following example that all firms choose to adjust their prices only once a year, for instance on January 1. If the central bank chooses to contract nominal demand and to en-

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[36] See also Jeanne (1998) for a dynamic general equilibrium model where real rigidities in the labor market amplify nominal rigidities in the goods markets.

gineer a recession on January 2, the real output effects will last only until January 1 the following year, when all firms adjust their prices downwards in proportion to the fall in money supply.[37] In this scenario a recession can last at most for one year. It is the task of the fourth building block in New Keynesian models, staggered price adjustment, to explain the persistence of output effects in response to nominal shocks. Price staggering means that firms do not change their prices all simultaneously, but adjust their prices at different dates.[38] With synchronized price adjustment, all firms adjust fully to a nominal disturbance as soon as their next adjustment date arrives. With staggering of prices, however, some firms have to make the first step and thus have to change their prices while all other firms in the economy maintain fixed prices. This implies that their real price changes, which they deem to be undesirable under the assumption that real rigidities prevail. Therefore, these firms will change their price only slightly. As a consequence it will take many rounds before full adjustment to the nominal disturbance is completed. This helps to explain the persistence of the real effects of a nominal shock, since full adjustment can take much longer than the period for which each price is fixed.

To summarize, the four building blocks imperfect competition, 'menu al rigidity and price staggering are mutually reinforcing and provide a framework where optimizing agents may choose to create substantial nominal rigidity, even though this leads to unwanted economic fluctuations in the pres-

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[37] Hence the real money balances return to their original level, the aggregate demand curve shifts back outward again and the recession ends.

[38] In the literature two forms of price staggering are discussed. With 'time-contingent' price adjustment a firm adjusts prices at intervals of fixed length, while with 'state-contingent' adjustment it does so whenever the state of the economy warrants it in the sense that the deviation between the actual price and the optimal price given the state of the economy makes it worthwhile to pay the 'menu costs' and to adjust the price. Taylor (1979) shows -contingent' adjustment that staggering produces considerable inertia of the price level. For a discussion of 'state-contingent' adjustment see Ball and Mankiw (1994a), pp. 140.

ence of nominal demand shocks. So from a theoretical perspective the assumption that systematic and thus anticipated monetary policy has real effects does not seem to be unreasonable.

Finally, there is a widespread perception that systematic and, hence, anticipated monetary policy matters.[39] In particular, it is thought that monetary policy in pursuing its price stability goal has played a significant role in causing many of the recessions in past decades.[40] In this respect it appears that the work by Friedman and Schwartz (1963) on the monetary history of the United States has been particular influential. However, providing direct econometric evidence on the real effects of systematic monetary policy actions is a highly challenging undertaking, since this requires to deal with a formidable identification problem.[41] Systematic policy responds itself to developments in the real sphere; therefore, determining the output effects of such a policy action requires one to separate the output movements attributable to policy from those the central bank responded to in the first place.[42] The seminal contribution in this regard is Romer and Romer's (1989) paper „Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz". The two authors employ the so-called

[39] Otherwise, for instance, the substantial literature on the virtues of competing monetary policy rules like nominal GNP targeting, the famous Taylor (1993) rule or the rule proposed by McCallum (1987) would be misplaced, since the ability of these rules to reduce the variance of output usually plays an important role in their evaluation. If systematic monetary policy has no output effects, because it is anticipated by agents, there would be no reason to expect monetary policy rules to be effective in reducing the variance of output in the first place.

[40] See for example Fuhrer and Schuh (1998), p. 4.

[41] A number of New Classical economists have attempted to provide evidence that anticipated money growth has no real effects, see for example Barro (1977). A critical review of this work can be found in Buiter (1983) and Mishkin (1982). The latter author attempts to develop a more reliable methodology and finds that anticipated monetary policy does seem to matter.

[42] For a survey of the methodological challenges in this regard and available empirical evidence see for example Friedman (1995).

'narrative approach', which is based on careful reading of the minutes of the meetings of the Federal Reserve's Open Market Committee. Using these documents the authors attempt to identify times "when the Federal Reserve specifically intended to use the tools it had available to attempt to create a recession to cure inflation," and proceed to investigate whether the following policy actions, which where announced in the minutes and thus did not come as a surprise to the public, had significant output effects.[43] Romer and Romer justify this focus on these particular episodes by pointing out that policy decisions to reduce inflation come as close as practically possible to being independent of other factors that affect real activity. They write[44]: "In other words, we do not believe that the Federal Reserve states an intent to cause a recession to lower inflation only at times when a recession would occur in any event." They find evidence for substantial falls of output and a rise of unemployment following a shift of monetary policy to an anti-inflationary stance. Comparable evidence for other countries is, however, in short supply. Nevertheless, the hypothesis that anticipated monetary policy has real effects appears to be justified, if not proven, from an empirical perspective as well.

3.3 Computing the Output Effects of Anticipated Monetary Policy Using the Cochrane Methodology

Having provided in the previous two sections the background for the Cochrane methodology, this section introduces his approach and presents results for the euro area. The objective of his procedure is to derive impulse response functions which show the response of output to an anticipated and an unanticipated change in the policy instrument. Regarding the policy instrument itself, it is important to

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[43] Romer and Romer (1989), p. 134.

[44] Romer and Romer (1989), p. 134.

notice that his algorithm is applied to impulse response functions after they have been estimated and in general the algorithm works independently of the choice of the policy instrument, which could be either an interest rate or a money stock variable. For instance, Cochrane uses his methodology for both types of policy variables, as he considers a VAR with M2 as the policy variable and a system with the Federal funds rate as proxy for the policy instrument. In the following, we denote the policy instrument as i^p, which represents in the context of our empirical model the nominal short-term interest rate, but could represent also, depending on the respective model chosen by the researcher, a monetary aggregate or the real short-term interest rate.[45] Cochrane focuses on the output effects of a 'blip' in the policy instrument, defined as an unit increase in the policy instrument lasting for one period, with the policy instrument returning in the period after the shock immediately to its neutral value.[46] It will become apparent in the following that the impulse response function to an anticipated 'blip' is quite useful, because it can be interpreted in a similar way as the dynamic multipliers obtained from more traditional structural macroeconomic models. In particular, with the impulse response function to an anticipated 'blip' it becomes possible to compute the output effects of a given interest rate path. In applied business cycle research, this allows, for example, one to compute the output effects of the interest rate path the central bank is expected to follow in the forecast period, thereby helping to alleviate a serious shortcoming of SVAR models for business cycle analysis, as has been discussed above.

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[45] More precisely, i^p measures the monetary policy stance, which in our model corresponds to the deviation of the nominal interest rate from the neutral interest rate. This is discussed in more detail in section 4.

[46] With the nominal interest rate as the policy instrument, as in our model, this implies that the interest rate is increased for one period by 100 basis points. In case of a monetary aggregate as the policy instrument, the money stock is increased by 1 percent.

3.3.1 The Cochrane Methodology

To illustrate the Cochrane methodology it is useful first to introduce two theoretical benchmark models, each representing diametrically opposed views on the effectiveness of anticipated policy. One polar case is a model inspired by New Classical economics, where it is assumed that expected monetary policy has no output effects:

(4) $y_t = a^*(L)\left[i_t^p - E_{t-1} i_t^p\right] + b^*(L) d_t$,

where y_t is output, $\left[i_t^p - E_{t-1} i_t^p\right]$ denotes an unanticipated innovation in the policy instrument and d_t is a non-monetary shock, for instance a supply side shock.[47] The parameter of interest is the lag-polynomial $a^*(L)$, which gives the output response to the unanticipated 'blip' in the policy instrument.[48] Whereas New Classical economics postulate that only unanticipated monetary policy has real effects, the other polar case can be represented by the following equation,

(5) $y_t = a^*(L) i_t^p + b^*(L) d_t$,

where no distinction between anticipated and unanticipated money is made. Accordingly, the real effects of a given policy action do not depend on the question whether this policy move was anticipated or not. Cochrane points out that one may complain about the lack of micro-foundations of equation (5); however, he replies[49]: "Most importantly, this model is implicit in any discussion that does

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[47] It is assumed that d_t and the monetary shock $\left[i_t^p - E_{t-1} i_t^p\right]$ are orthogonal.

[48] It is an important point of New Classical economics that the parameter $a^*(L)$ changes if monetary policy shifts to a new regime. However, stability tests conducted in section 2 do not point to instability of the proposed euro area system, so empirically this issue does not pose much of a problem here.

[49] Cochrane (1998), p. 284.

not explicitly distinguish effects of anticipated vs. unanticipated monetary policy. Since almost no policy discussions make this distinction, even among academics, it seems worth interpreting the data with this view." Regarding applied business cycle for the euro area, the latter argument is illustrated by the fact that, for instance, the regular business cycle reports published together by the six leading German economic research institutes never make such a distinction in their analysis of monetary policy in the euro area.[50] Having introduced the two polar cases, Cochrane proposes the following model as an intermediate case, where anticipated monetary policy can have some effects, even though unanticipated monetary policy actions might have stronger effects[51]:

$$(6) \qquad y_t = a^*(L)\left[l\, i_t^p + (1-l)\left(i_t^p - E_{t-1} i_t^p\right)\right] + b^*(L) d_t$$

The parameter l is crucial here in the sense that it ties down to what extent anticipated monetary policy is effective relative to its unanticipated counterpart. With $l = 0$, anticipated policy has no output effects and equation (6) reduces to (4); with $l = 1$, on the other hand, equation (6) reduces to (5) and anticipated policy is as effective as unanticipated policy. In the intermediate case, assuming for example $l = 0.5$, anticipated policy is half as effective as unanticipated policy.[52] For this intermediate case it is useful to rearrange equation (6) to obtain

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50 These business cycle reports are better known under the name 'Gemeinschaftsdiagnose'.

51 A simple textbook model with these properties is for example presented in Romer (1996), pp. 262.

52 This becomes clear if one notices that the term $\left[i_t^p - E_{t-1} i_t^p\right]$ becomes zero in case of an anticipated change in monetary policy. Therefore, with $l = 0.5$ the output effect of anticipated policy is $a^*(L) \cdot 0.5 \cdot i_t^p$.

To compute the effect of an unanticipated change in the policy instrument, it is convenient to assume that $E_{t-1} i_t^p = 0$.

In this case, the output response to an unanticipated change in policy is given according to equation (6) by $a^*(L)\left[0.5 i_t^p + 0.5\left(i_t^p - 0\right)\right] = a^*(L) i_t^p$. In summary, with $l = 0.5$ anticipated monetary policy is only half as effective as unanticipated policy.

$y_t = a^*(L)\left[lE_{t-1}i_t^p + \left(i_t^p - E_{t-1}i_t^p\right)\right] + b^*(L)d_t$, where the term $E_{t-1}i_t^p$ corresponds to the anticipated component of monetary policy and $\left[i_t^p - E_{t-1}i_t^p\right]$ is the unanticipated component. It is apparent now that the lag polynomial $a^*(L)$ gives the output response to an unexpected 'blip' in the policy instrument, whereas $la^*(L)$ gives the response of output to an expected 'blip'. This implies that once one has retrieved $a^*(L)$ with the help of the Cochrane methodology, the response to an anticipated 'blip' can be computed in a straightforward way by multiplying the response to an unanticipated 'blip' with l. In this context it needs to be stressed that setting a value for l is equivalent to imposing an identifying restriction, which is required by the Cochrane procedure to distinguish between the effects of anticipated and unanticipated policy. In other words, his methodology requires two inputs: First, the estimated impulse response functions and second, an assumption about the numerical value for l. Regarding the latter, this is indeed a choice parameter which cannot be estimated from our data set, because systems with different l are observationally equivalent.

Before proceeding, a short comment on the choice of l may prove to be useful. The discussion in section 3.2 has indicated that given imperfect competition, menu costs, real rigidities and price staggering a case can be made that anticipated monetary policy has real effects. Regarding these four factors, it appears that the extent of real rigidities plays a particular important role, since real rigidities amplify the effects of menu costs and contribute to the persistence of shocks due to their role in price staggering. Thus, they determine to a considerable degree the effectiveness of anticipated policy regarding real variables. If the economy is characterized by a high degree of real rigidity, this would suggest to choose a high value for l. A second factor in this regard, which is stressed Ball et al. (1988), is the average rate of inflation. A high level of trend inflation causes firms to adjust their prices more frequently, thereby reducing nominal rigidity. Hence, high inflation economies could be modeled with a lower value for, holding everything else constant.

Next, the question arises how to derive an estimate of $a^*(L)$ from the estimated impulse response functions, given a value for l. In this context it is helpful to write out the SVAR model with the impulse response functions[53]:

$$(7) \qquad \begin{bmatrix} i_t^p \\ y_t \end{bmatrix} = \begin{bmatrix} c_{i^p i^p}(L) & c_{i^p y}(L) \\ c_{y i^p}(L) & c_{yy}(L) \end{bmatrix} \begin{bmatrix} e_{i^p,t} \\ e_{y,t} \end{bmatrix},$$

where e_{i^p} denotes the identified monetary policy shock, whereas e_y is some shock to output, which is of no further relevance here. As is common in the SVAR literature, the structural shocks are assumed to be orthogonal and after suitable normalization one obtains $E\left(\begin{bmatrix} e_{i^p,t} \\ e_{y,t} \end{bmatrix} \begin{bmatrix} e_{i^p,t} & e_{y,t} \end{bmatrix}\right) = I$. The two impulse response functions of interest are $c_{yi^p}(L)$, which gives the response of output to a monetary policy shock, and $c_{i^p i^p}(L)$, which gives the path of the policy instrument following a policy shock. The accompanying discussion to Figure 4, which plots the equivalent impulse response functions for the euro area system, has shown that to understand the effects of a monetary policy shock on output one has to take both impulse response functions into account. By setting the shock $e_{y,t}$ to zero, the path of output and the policy instrument is a function of the monetary policy shock only, leading to the following simplification:

$$(8) \qquad i^p{}_t = c_{i^p i^p}(L) e_{i^p,t}$$

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[53] All identifying assumptions are assumed to have been imposed on the model, so that the system (7) gives the estimated impulse response functions to the structural innovations present in the model. To simplify notation the deterministic components are suppressed in this presentation.

$$y_t = c_{yi^p}(L)\varepsilon_{i^p,t}.$$

Next, (8) is inserted into (6), the shock term $\varepsilon_{i^p,t}$ drops out and one obtains

(9) $\quad c_{yi^p}(L) = a^*(L)\left[\lambda c_{i^p i^p}(L) + (1-\lambda)c_{i^p i^p}(0)\right].$[54]

This is the central equation in the Cochrane approach.[55] It shows that the term $a^*(L)$, which this procedure seeks to obtain, is a function only of the parameter λ and of the impulse response functions $c_{yi^p}(L)$ and $c_{i^p i^p}(L)$. All three quantities are available; the first is tied down by the identifying restriction set on this parameter and the latter two have been estimated beforehand in the course of a conventional SVAR analysis. All that remains to be done is to retrieve $a^*(L)$ from (9). To do this, Cochrane expands and matches powers of L and obtains

(10) $\quad a_0^* = \dfrac{c_{yi^p,0}}{c_{i^p i^p,0}}; \; a_j^* = \dfrac{c_{yi^p,j} - \lambda \sum_{k=0}^{j-1} a_k^* c_{i^p i^p,j-k}}{c_{i^p i^p,0}}$ with $j \succ 0$.

This recursive algorithm is easily programmable in standard software like RATS.[56] It gives the response of output to an unanticipated 'blip'; thus, the response of output to an unexpected unit increase in the policy instrument lasting for one period. Once one has calculated $a^*(L)$ from (10), it is straightforward to obtain the output response to an anticipated 'blip', since this is simply $\lambda a^*(L)$. Intuitively, this algorithm works as follows: First, the initial response of output

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[54] The parameter $c_{i^p i^p}(0)$ gives the initial impact of a monetary policy shock on i^p. This is exactly the innovation in the policy instrument that is of central interest in New Classical models and has been denoted in the earlier equations as $\left[i_t^p - E_{t-1} i^p\right]$. Also, the further path of policy instrument following this innovation, which is given by $c_{i^p i^p}(L)$, is anticipated by agents and therefore does play no role when it comes to unanticipated monetary policy.

[55] The parameter $b^*(L)$ is irrelevant for identifying $a^*(L)$ and is therefore dropped from (9).

[56] We are grateful to John H. Cochrane for making available to us his GAUSS code. The RATS version is available from the present authors upon request.

to a unit innovation in the policy instrument is computed, a_0^*. The initial impulse to the policy instrument is followed by an endogenous policy response, which is given by $c_{i^p i^p}(L)$. If $l \succ 0$, this will have an effect on output. The second part of the algorithm removes the output effects attributable to this endogenous policy response and thereby obtains the output reaction which is solely due to the initial monetary policy impulse.

With $l = 0$, this algorithm yields $a^*(L) = c_{yi_p}(L)/c_{i^p i^p}(0)$, so that $a^*(L)$ coincides with the output impulse response function $c_{yi^p}(L)$ obtained from a conventional SVAR analysis, only that the latter is rescaled to give the response of output to a unit innovation in the policy instrument. This reconfirms the point made in section 3, that in the special case where anticipated monetary policy has no real effects, the conventional output impulse response function unambiguously gives the output response to a monetary policy shock, regardless of the further path of the policy instrument following the shock. If, on the other hand, there is no distinction between anticipated and unanticipated monetary policy, so that $l = 1$, the output response to a unit impulse to the monetary policy instrument is given by $a^*(L) = c_{yi^p}(L)/c_{i^p i^p}(L)$. With $l = 1$, it has been shown above that equation (6) reduces to (5), which is often employed within the context of traditional structural models (as opposed to the structural vector autoregression models considered here) to estimate $a^*(L)$ using conventional regression methods. In this case the elements of the lag polynomial $a^*(L)$ are called dynamic multipliers. In contrast to a conventional impulse response function obtained from a SVAR model, dynamic multipliers give the output effects of monetary policy actions without separating the changes in the policy instrument into the anticipated and unanticipated components.[57] The estimated dynamic multipliers can be used to identify the impact of a given path of the policy instrument on output, regardless of whether this course of monetary policy is anticipated or not. As has been discussed above, such a task cannot be performed with a SVAR model using conventional impulse response analysis, because this would yield only the output response to a monetary policy shock $(c_{yi^p}(L))$ but not the dynamic multipliers given by $a^*(L)$. To obtain $a^*(L)$ from a SVAR model, one needs to control for the endogenous response of the policy instrument to the policy shock, which is exactly what the Cochrane procedure does. In other words, with this procedure it becomes possible to employ SVAR models for tasks which have been previously the domain of traditional structural models.

3.3.2 Empirical Results Using the Cochrane Algorithm

Regarding the empirical results for the euro area, Figure 5 plots the unanticipated interest rate 'blip' in the upper panel and the corresponding output response for different values of l in the lower panel. Setting $l = 0$, one obtains the same impulse response function as displayed in Figure 4: A monetary policy shock that raises the nominal interest rate by 100 basis points reduces output by 0.6 percent after two years, when the output effect is at its peak. Afterwards, the output effect gradually dies out. Allowing for some real effects of anticipated policy changes this picture markedly. With $l = 0.2$, for example, anticipated policy is assumed to be only marginally effective, but this is sufficient to make the impulse response function for the unanticipated blip considerably less hump-shaped: The peak effect of a monetary policy impulse does not materialize after

[57] See Bagliano and Favero (1998), pp. 1071, for a discussion of the differences between traditional structural models and SVAR models.

two years, but is now reached after about one year. The effect is also smaller, reducing output at its peak by 0.35 %. For $l = 0.5$ and $l = 1$ the peak effect materializes even faster (2 quarters) and then declines more rapidly so that the total of the real effects measured over time becomes smaller by a sizeable amount.

Figure 5: Response of Output to an Unanticipated Interest Rate 'Blip'

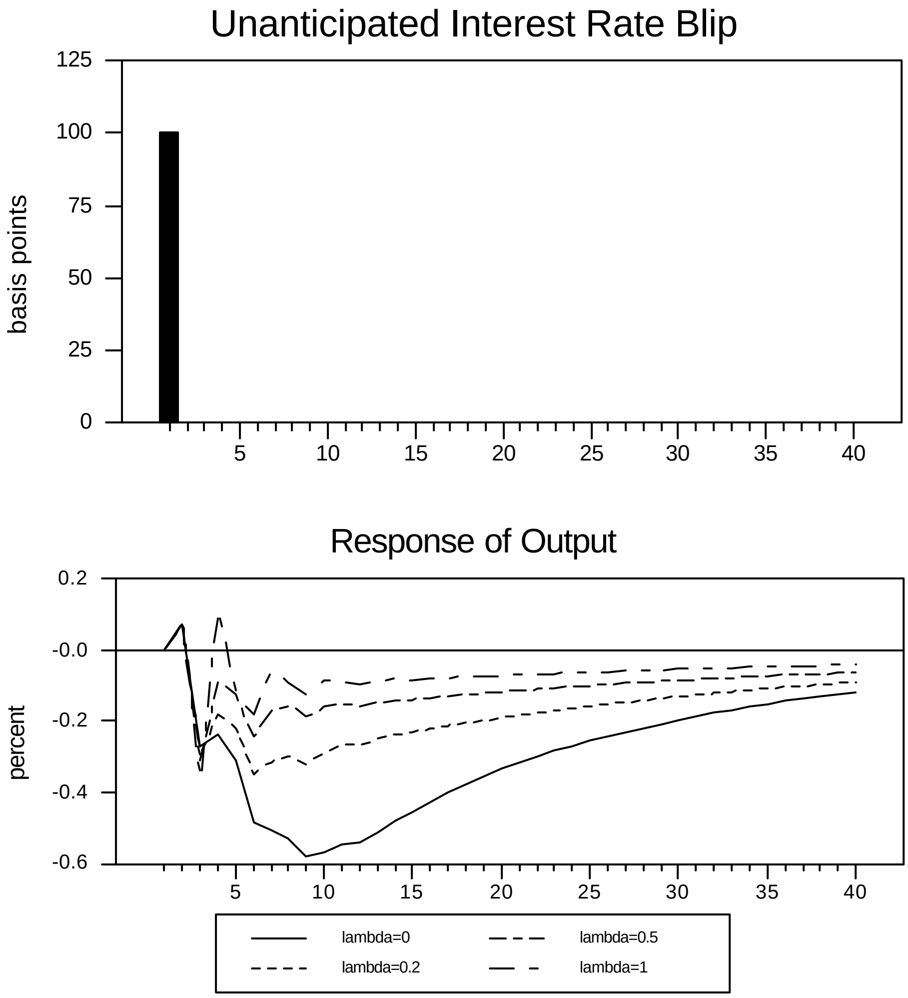
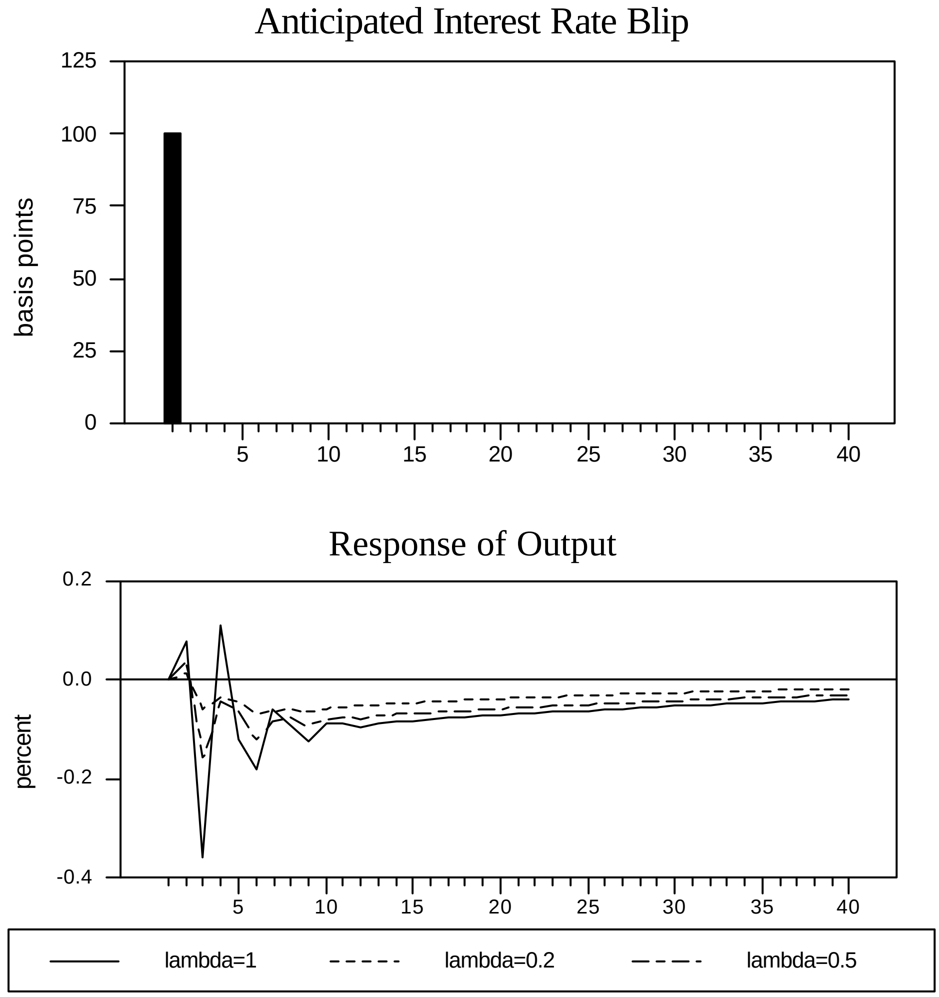


Figure 6: Response of Output to an Anticipated Interest Rate 'Blip'



The real effects of an anticipated 'blip' are shown in Figure 6. The shape of the impulse response functions are similar to those presented in Figure 5 since the only difference between the effects of an anticipated and unanticipated 'blip' is the scale factor l. Accordingly, for $l = 1$ the output impulse response functions for anticipated and unanticipated 'blips' are identical. This response is of particular interest since much of applied business cycle analysis work does not make a distinction between expected and unexpected policy actions and thus implicitly assumes that $l = 1$ holds. Unfortunately, the estimated output response is quite jagged, which suggests that it is estimated relatively imprecisely. Nevertheless, focusing on the underlying shape of the impulse response function, three noteworthy features of the output response can be observed. First, an anticipated 'blip' reduces output after two quarters by about 0.35 %. Second, the output effect fades quickly, declining to 0.1 % after about three years. Third, subsequent output returns only very slowly to the base line. This suggests that, contrary to conventional wisdom, the output effects of systematic policy set in soon after the monetary policy stance has changed, but these effects dissipate quickly if the new policy stance is not sustained even though it takes quite some time before the real effect has died out completely. This general pattern corresponds closely to the findings reported by Cochrane. For $l = 1$, he reports for his Federal funds rate VAR that the output effects peaks after three quarters, with output falling approximately 0.4 % below its base line; the results for his M2 VAR also show that the effects of policy become considerably less persistent if one allows for real effects of anticipated money. He writes[58]: "The anticipated money views result in estimates of a short, almost contemporaneous effect, of the sort generated by most current monetary theories."

It has been stressed above that the output response to an anticipated 'blip' can be interpreted like a dynamic multiplier. This makes it interesting to compare this SVAR measure with dynamic multiplies computed from more traditional non-VAR models. Figures 7 and 8 present two such comparisons. Beginning with figure 7, Gerlach and Smets (1999) have presented a small macroeconomic model for the euro area. Their equation for the output gap, z_t, is a function of its own lags and the German real short-term interest rate $(i_t - \bar{p})$, which they use as a proxy for interest rate policy in the euro area.[59] They find the following relationship between these variables:[60]

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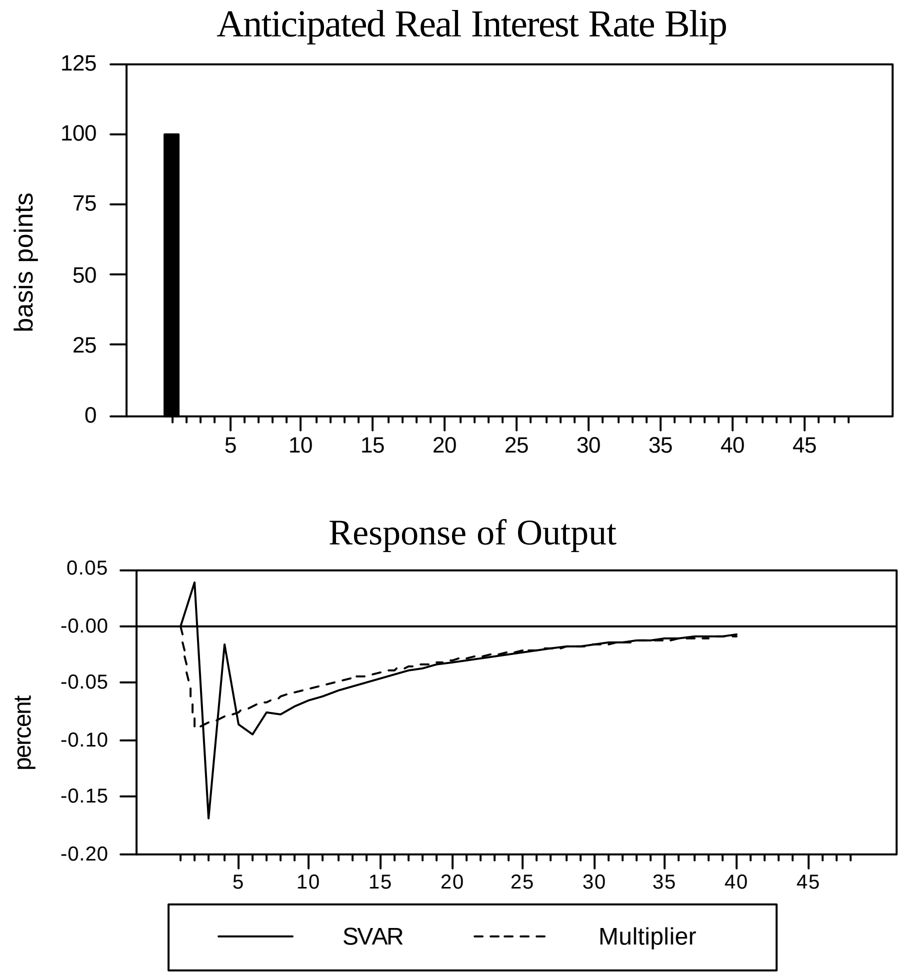
[58] Cochrane (1998), p. 295.

[59] The German real short-term interest rate is approximated as the difference between the nominal day to day rate and average German inflation over the last four quarters.

[60] Gerlach and Smets (1999), pp. 805.

Figure 7: Comparison of the SVAR measure to Dynamic Multipliers



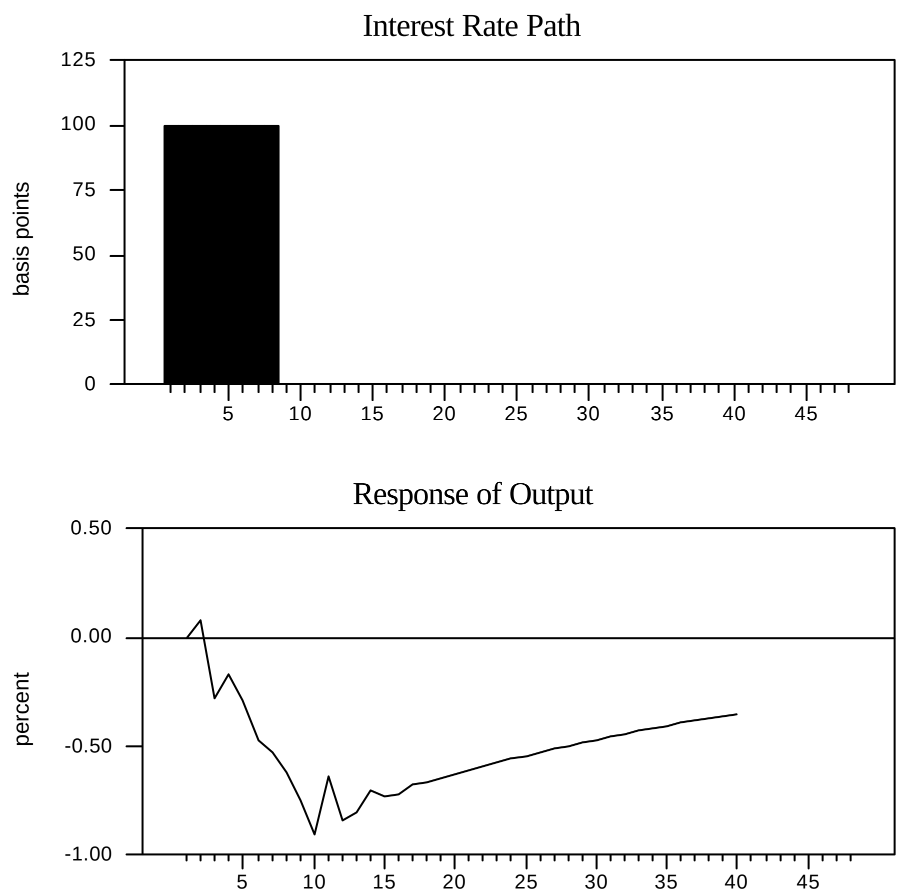
(11) $z_t = 0.94 z_{t-1} - 0.09\left(i_t - \bar{p}\right) + e_t^Z,$

where e_t^z presents a non-monetary aggregate demand disturbance. The dotted line in Figure 7 shows the output response to a real interest rate blip implied by this model together with the output response derived from the SVAR model considered here.[61] The SVAR measure has been computed for $l = 1$, so that

[61] The output response to an increase of the real short-term interest rate by 100 basis points is considerably smaller than the response to a similar increase of the nominal interest rate. The reason for this is that a one percentage point increase in the nominal rate reduces inflation considerably, so that the real short-term rate increases by more than the nominal rate. Hence, the nominal short rate needs to rise by less than one percentage point to raise the real rate by 100 basis points.

equation (6) reduces to (5), which is broadly comparable with (11). Qualitatively, the response of output is remarkably similar in both models. In particular it is noteworthy that the interest rate hike in the Gerlach/Smets model reaches its maximum effect on output after only one quarter, which confirms the central finding of the analysis above, which has also found that if one allows for real effects of anticipated policy the real effects of a monetary policy impulse reach their peak fast. Regarding the magnitude of the maximum effect, the models differ somewhat, but this is not particular surprising, since both models represent fundamentally different identification strategies and, in addition, have been estimated for different data sets. In summary, taking the results from Gerlach and Smets's estimation as a benchmark, the results derived from the Cochrane procedure applied to our SVAR model do not appear to be unreasonable.

Figure 8: Response of Output to a 100 Basis Points Increase in the Interest Rate Maintained Over Two Years



To provide another benchmark, Figure 8 draws on work by Fagan et al. (2001), who present an area-wide model for the euro area. To illustrate the dynamic properties of their model, they conduct a policy simulation where they increase the nominal short-term interest rate unexpectedly by 100 basis points and sustain this interest rate hike for two years, before returning the short rate to its base line. They report the following output response[62]: "As to activity, the outcome of higher interest rates is a lagged and gradual negative impact on GDP growth, ... As a result, the level of GDP is below its steady state value by around 1 percentage point after 3 years." In Figure 8 the output effects of this policy experiment are computed for the SVAR measure discussed here. Again $l = 1$ has been chosen, so that the output effects of an unanticipated 'blip' coincide with the effects of anticipated policy. Maintaining an interest rate increase of one percentage point over eight quarters can be thought of as a series of eight 'blips' following each other. The upper panel of Figure 8 gives the interest rate path, while the lower panel shows the corresponding output effect, which is obtained simply by adding up the real effects of the eight 'blips' making up the policy experiment. It is apparent that the output effect gradually builds up, reaches its peak after nine quarters and then declines slowly. After three years one observes a reduction in output of approximately 0.8 percent. This output effect is of a similar magnitude as that found by Fagan et al., which again suggests that the results of our model are not implausible.

4. The Effects of Anticipated Monetary Policy on Output

In this section, we proceed to construct an index for the output effects of anticipated monetary policy in the euro area. The objective is to analyze to what extent unanticipated and anticipated monetary policy actions have contributed to

[62] Fagan et al. (2001), p. 28.

aggregate output fluctuations over time. To this end, we use the impulse response functions for unanticipated and anticipated monetary policy actions estimated in the preceding section in conjunction with the historical decomposition technique often employed in the SVAR literature. This enables us to compute a time series reflecting the output effects of anticipated monetary policy. In the following section, we will use this technique to investigate the output effects of the systematic response of monetary policy to aggregate demand and supply shocks. We begin this section by first discussing the conventional historical decomposition technique and then introduce our modification to this technique.

4.1 The Historical Decomposition of Output

The idea of the historical decomposition technique, which is applied here to the output series, is based on the moving average representation of the structural model.[63] In particular,

(12) $$X_t = C_D(L)D_t + C(L)\boldsymbol{e}_t$$

is assumed to represent the moving average representation of the underlying structural model described in section 2. The vector X represents the three endogenous variables. The vector D contains the deterministic part of the model, which here consists of the constant and the three intervention variables. The term $C_D(L)$ represents a polynomial matrix giving the effects of D on the variables in X. The vector $\boldsymbol{e}$ contains the three structural shocks, namely the aggregate supply shock, the aggregate demand shock and the monetary policy shock. Finally, the matrix $C(L)$ contains the estimated impulse response functions,

[63] See e.g. Fackler and McMillin (1998) for a detailed description of the historical decomposition technique.

showing how the endogenous variables respond to the structural shocks. Equation (12) states that the dynamics of output, prices and the interest rate can be expressed as the sum of the deterministic and the stochastic component of the model. The latter is attributed to the three structural shocks driving the model. The historical decomposition focuses on the effects of these shocks. To simplify the exposition, the deterministic part of the model is omitted in the following presentation of the historical decomposition technique. For a particular period $t+j$, equation (12) can be written as

$$(13) \quad X_{t+j} = \sum_{s=0}^{j-1} C_s e_{t+j-s} + \sum_{s=j}^{\infty} C_s e_{t+j-s} \,,$$

with C denoting the impulse response to a structural innovation.

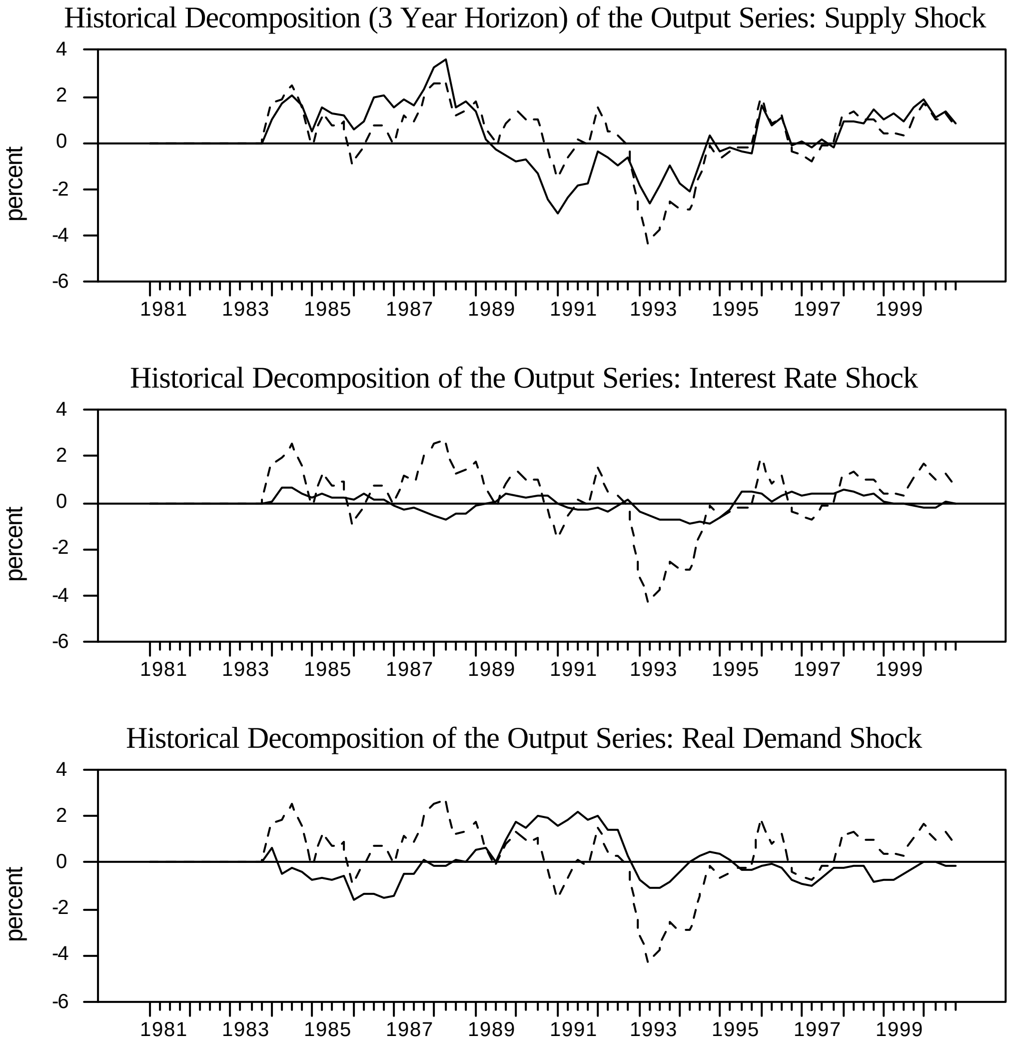
It is apparent from (13) that the variable X_{t+j} is composed of two types of terms. The term on the far right contains the information that is available at time *t*. Based on this information the expected X_{t+j} can be computed. This is the so-called 'base projection' of X_{t+j}, which contains also the effects of the deterministic part of the model. However, the base projection is unlikely to coincide with X_{t+j}, because in the time period from $t+1$ to $t+j$ 'new' structural innovations hit the system. By their very nature these shocks are unexpected; hence, the first term on the right-hand side can be interpreted as the forecast error of X_{t+j}. The historical decomposition is based on this part of the system, thereby allowing one to attribute the unexpected variation of X_{t+j} to individual structural innovations buffeting the economy, which is useful for exploring the sources of fluctuations.

Using the historical decomposition technique given by (13), there are essentially two ways to compute a time series of the forecast errors of X_{t+j}. One option is to set t to the beginning of the sample period and then to increase the forecast horizon *j* until the end of the sample period is reached. In our empirical model the beginning of the effective sample period is 1981:1. If we chose this approach to compute the historical decomposition, we would increase the forecast horizon period by period until it arrives at the end of the sample period, 2000:4. However, this approach has the disadvantage that the decomposition may not be very reliable for the early part of the sample period, because only a limited number of shocks have been identified and hence the decomposition proceeds on a rather small basis.[64] Still, this is not a major drawback as this period is presumably not of very much interest, while more recent developments are.

The alternative to this approach is to keep the forecast horizon fixed while the time index *t* moves from the beginning of the sample period to the end. The historical decomposition presented below is computed using this approach, with the forecast horizon set to $j = 12$. The forecast horizon of three years (12 quarters) is chosen because this horizon corresponds to a typical business cycle frequency. To illustrate the procedure, *t* is first set to 1981:1, the beginning of the effective sample period, and the decomposition for $X_{1981:1+12} = X_{1984:1}$ is computed on the basis of the structural innovations hitting the economy in the time period from 1981:2 until 1984:1. Next, *t* is set to 1981:2 and the decomposition of $X_{1981:2+12} = X_{1984:2}$ is obtained on the basis of the structural innovations occurring in the time from 1981:3 until 1984:2. This procedure is repeated until X_{t+12} reaches the end of the sample period. To summarize, the historical decomposition plots the variables in X_t as a function of the structural shocks occurring in

[64] To illustrate, it is useful to consider the decomposition of output in 1981:1, which is the first period for which estimates of the structural shocks are available. The change in output in this quarter is attributed in full to these three shocks, even though it is very likely that earlier shocks have had an influence as well. But their effect is not identified here, because they lie outside the effective sample period.

Figure 9: Historical Decomposition of the Output Series



the time period from t to $t-11$, thereby showing how at each point in time the economy has been influenced at the business cycle frequency by the three types of structural shocks in our model.

Figure 9 displays the conventional historical decomposition of the output series implied by our SVAR model. The solid line shows the contributions of the three individual shocks to the output fluctuations, while the dashed line represents the combined effect of all three shocks. It is apparent that the aggregate supply and the real demand shocks account for most of the output movements at the business cycle frequency, whereas monetary policy shocks account for only a small part of overall output variation.

The output effects of the real demand and the monetary policy shocks together provide a measure of the output gap in the euro zone. To evaluate whether the results given by the historical decomposition are plausible in the sense that they can be corroborated by a more conventional measure of demand conditions, Figure 10 compares the output gap implied by the SVAR model with the output gap estimated using the popular band pass filter.[65] Both measures are qualitatively similar. From a quantitative standpoint, there are three episodes where the results differ noticeably. The SVAR measure indicates a substantial shortfall in demand in 1986 and 1987, while the band pass filter indicates a more moderate decline in the output gap. According to the historical decomposition a marked improvement in supply conditions has a positive effect on output around this time. A possible explanation for the divergence between the two measures is that the band pass filter is likely to identify the improvement in supply conditions as having a positive effect on cyclical conditions, which partly offsets the negative effect of weak demand conditions.[66] Consequently, the SVAR output gap is more negative, because it takes only the demand conditions into account. The considerable divergence in supply and demand conditions in the early nineties also explains the different strength the two measures assign to the boom in 1990 and 1991. Particularly puzzling is the boom indicated by the band pass filter measure in the year 2000, because the SVAR decomposition of output indicates neither a strong improvement in demand nor supply conditions in this year. Nevertheless, the similarity of the two output gaps suggests that our SVAR model gives a fairly reasonable account of output fluctuations in the euro area.

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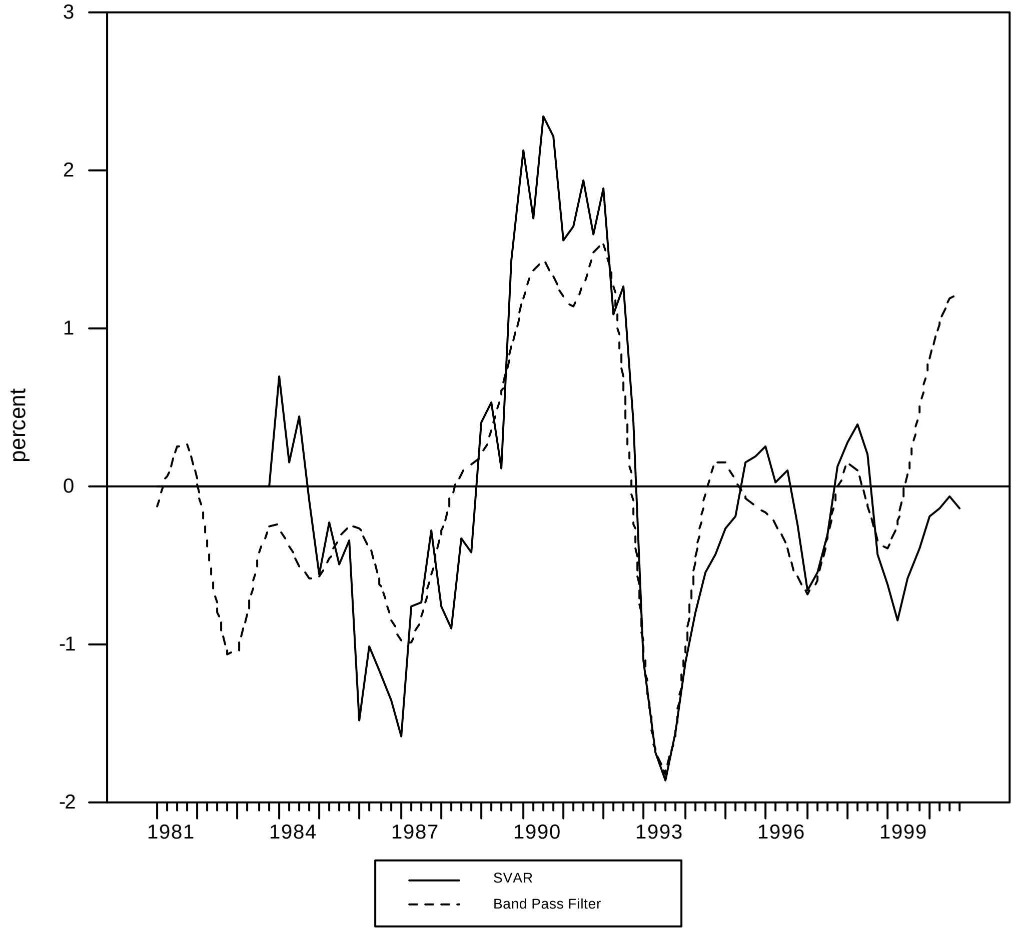
[65] The band pass filter has been proposed by Baxter and King (1995) to isolate business cycle fluctuations in macroeconomic time series. For quarterly data, the two authors recommend the "Burns and Mitchell" specification. This specification admits frequency components between 6 and 32 quarters, thereby removing low-frequency trend variation and smoothing high-frequency irregular variation, while retaining the major features of business cycles. See Baxter and King (1995), p. 22.

[66] See also Astley and Yates (1999), pp. 9, for a discussion of the implications of using a SVAR model and a filter method for the estimation of the output gap.

Figure 10: Comparison of Output Gaps Based on the SVAR Model and the Band Pass Filter



The historical decomposition of output reported in Figure 9 shows that monetary policy shocks are not a major source of output fluctuations at the three year forecast horizon. Further evidence to this effect is provided by the forecast error variance decomposition of the output variable. As the name suggests, this measure decomposes the variance of the forecast error. In contrast to the historical decomposition, which gives a decomposition of the forecast error in time, the second moment of the forecast error is of interest here. The variance decomposition is an alternative measure quantifying the importance of the three structural innovations for output fluctuations. It is computed on the basis of the impulse response functions alone; the time series of the structural innovations are not needed as an input. The intuition of the variance decomposition can be understood by revisiting the impulse response functions for the output variable. The first panel in the Figures 1 to 3 depicts the output movements induced by each of the three structural shocks. For a given forecast horizon and a given shock the corresponding impulse response can be used to compute the variance of output attributable to this shock. Once one has computed the total variance of output due to all three shocks for a given horizon, the variance decomposition for this horizon is obtained by calculating the contribution of the individual shocks to the total variance. Table 1 reports the variance decomposition of output for different forecast horizons. The results from the historical decomposition are confirmed here: The monetary policy shock accounts for less than ten percent of the forecast error variance at all horizons. Demand shocks dominate the short horizons, while supply shock becomes the single most important type of shock after about two years. This result is not specific to this empirical model of the euro zone; one obtains similar results when one computes the variance decomposition for the money demand system proposed by Coenen and Vega (1999).[67] More generally, Sims (1998 p. 933) states that this is a standard finding in SVAR literature. He summarizes the literature as follows: " ... (2) Responses of real variables to monetary policy shifts are estimated as modest or nil, depending on the specification. ... ."[68]

Table 1: Variance decomposition of output (in percent)

Horizon	Supply Shock	Monetary Policy Shock	Real Demand Shock
0	12.1	0.00	88.9
4	18.0	3.2	78.9
8	52.1	7.2	40.7
12	73.0	6.4	20.6
40	96.4	1.2	2.4

Notes: The horizon is in quarters. Due to rounding errors the rows do not always add up to 100.0.

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[67] Coenen and Vega (1999) do not show results for the variance decomposition, but they publish their data set and the specification of their model, so that this statistic can easily be computed for their model.

[68] For a critical appraisal of this claim see Faust (1999).

The present paper is line with the general finding that monetary policy shocks are not a major source of output fluctuations. In this context it is important to recall that monetary policy shocks only represent the unanticipated part of monetary policy. Hence, this finding does not imply that monetary policy is unimportant, but only that discretionary monetary policy does not contribute much to output fluctuations. Put another way, the output fluctuations due to the monetary policy shock reported in Figure 9 can be interpreted as an index of the output effects of monetary policy, but this index only captures the effects of monetary policy *shocks*.

4.2 Measuring the Output Effects of Anticipated Monetary Policy

The index we propose in the remainder of this paper goes beyond the effects of shocks, and instead aims to measure the effects of anticipated policy. The starting point for the construction of this index is not, as in the historical decomposition, the moving average presentation of the system, which expresses output as a function of the structural shocks, but a reformulation of equation (6) expressing output as a function of anticipated and unanticipated monetary policy:

$$(14) \quad y_t = l\, a^*(L) E_{t-1} i_t^p + a^*(L)\left(i_t^p - E_{t-1} i_t^p\right) + b^*(L) d_t \ .$$

The term $b^*(L)d_t$ is omitted in the following, because it is not related to monetary policy actions. The first term on the right hand side represents the part of output fluctuations attributable to anticipated monetary policy and the second term represents the output effects of unanticipated monetary policy. Focusing on the effects of anticipated policy, output in a particular period $t + j$ is given by

$$(15) \quad y_{t+j} = \sum_{s=0}^{j-1} l\, a_s^* E_{t+j-s-1} i_{t+j-s}^p + \sum_{s=j}^{\infty} l\, a_s^* E_{t+j-s-1} i_{t+j-s}^p + \ldots .$$

Compared to the moving average representation given by (13), in equation (15) the matrix C for the impulse responses to structural innovations is replaced by the vector la^*, which gives the output response to an expected unit impulse to the monetary policy instrument, and the vector e for the structural innovations is replaced through the time series for anticipated monetary policy, $E_{t-1}i_t^p$. Below, in accordance with the historical decomposition technique, we plot the time series given by the first term on the right hand side of equation (15), which shows for each point in time t the effects on output of anticipated monetary policy actions occurring in the time period from t to $t+1-j$. When we compute this index of the output effects, we choose again a forecast horizon of 12 quarters to investigate the role of anticipated monetary policy in output fluctuations at the business cycle frequency.

The empirical analysis in the preceding section has yielded most of the input required for the computation of this output index. Most importantly, in section 3 we estimated the output response to an anticipated 'blip' in the policy instrument, $la*(L)$. However, for the computation of our output index we still need to construct the series for the anticipated monetary policy stance, $E_{t-1}i_t^p$. The monetary policy stance has two components. On the one hand, we require a measure of the anticipated path of the nominal short-term interest rate, the policy instrument in our model. Below, we approximate the anticipated interest rate path with the variation of the interest rate explained by the interest rate equation of our VAR model. On the other hand, a measure of the neutral interest is needed, which defines the level of the policy instrument where monetary policy has no output effects. The anticipated monetary policy stance is given by the difference between the anticipated interest rate path and the neutral interest rate.

4.2.1 Measuring the Anticipated Monetary Policy Stance

The challenge in constructing a series of the anticipated monetary policy stance is finding an appropriate measure of the neutral interest rate. In the case of the euro area, this is complicated by the fact that the neutral interest has not been constant in the time period under investigation, as has been discussed earlier. For our purpose, it will prove useful to think of the neutral interest rate as the policy stance that is obtained when the central bank does not wish to influence the economy. In our SVAR model, the central bank sets the nominal short-term interest rate in response to aggregate supply and demand shocks. Moreover, the interest rate is determined by monetary policy shocks, representing the discretionary component of monetary policy. In the absence of those three type of shocks, the central bank has no reason to act and thus adopts a 'neutral' policy stance. In this case, it is apparent from equation (12) that the path of the nominal short-term interest rate is determined entirely by the deterministic component of this time series, so modeling this component is equivalent to modeling the neutral interest rate in the euro area.

According to the Fisher relation, the nominal interest rate corresponds to the sum of the ex-ante real interest rate and expected inflation.[69] The central bank pursues a neutral course only when it is satisfied with the state of the economy. This occurs when the economy is in equilibrium, and the expected inflation rate is equal to the central bank's inflation objective. This suggests a definition of the nominal neutral interest rate as the sum of the equilibrium real interest rate and the inflation objective.[70] This definition ensures that the ex-ante real interest rate is equal to its equilibrium value when monetary policy is on a neutral course.

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[69] For the euro area Coenen and Vega (1999) and, more recently, Gottschalk and Schumacher (2001) show that the nominal short-term interest rate and the annualized inflation rate cointegrate (1,-1), which is consistent with the Fisher relation in the long-run. Our cointegration analysis confirms this result.

[70] The equilibrium real interest rate is equal to the value the real interest rate has when the economy is in equilibrium. King (2000) calls this variable the natural rate of interest. Regarding the nominal neutral interest rate, he argues on the basis of the New IS-LM model that "a neutral interest rate policy must make the nominal interest rate vary with the natural rate of interest and the inflation target." See King (2000), p. 57.

Accordingly, our task is twofold: On the one hand we have to model the changing inflation objective in the time period under investigation, on the other hand we have to model the path of the equilibrium real interest rate. Since inflation is deemed to be ultimately a monetary phenomena, it is fair to suggest that the reduction in trend inflation occurring over most of the sample period reflects a commitment of monetary policy to a gradually downward shifting inflation objective. In 1997, with an average rate of 1.5%, inflation finally reached a level low enough to conform to the goal of price stability, so further reductions in the inflation objective are not required. To model this disinflation process, our segmented trend variable is comprised of a time trend for the time period from 1980:1 until 1997: 2 and a constant component for the remaining sample period.[71] With respect to the equilibrium real interest rate, this variable is usually assumed to be constant in time.[72] However, there is a widespread perception that with the advent of EMU the equilibrium real interest rate in the euro area has shifted downwards.[73] It is argued that with the ECB poised to take responsibility for monetary policy, a number of countries in the euro area have experienced a transition from a high- to a low-inflation environment, which has been accompanied by a reduction in the risk premium, leading to a lower equilibrium real

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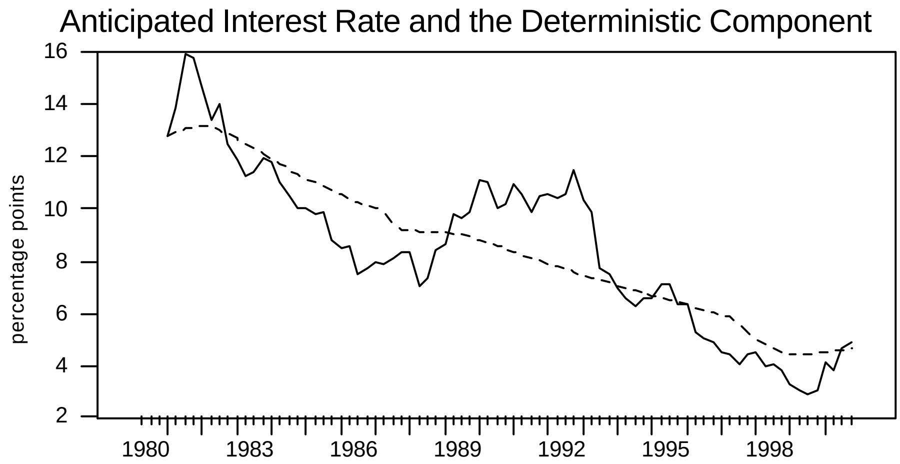
[71] Our results are, in general, not particular sensitive to the exact specification of this segmented trend variable.

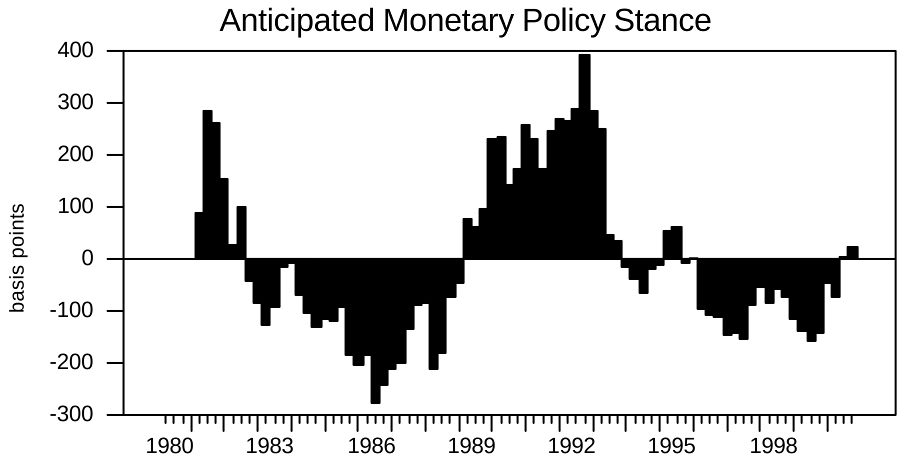
[72] Empirical evidence supporting this assumption includes the finding of a stationary real interest rate in the euro area in the time period from 1980 until 1997 in Coenen and Vega (1999). This finding implies that the real interest rate tends to return to a constant mean. Gottschalk and Schumacher (2001) show that the real interest rate in the euro area remains stationary after the beginning of the third stage of EMU, provided a one-time downward shift in the equilibrium real interest rate is accounted for. The cointegration analysis in this paper leads to the same conclusion.

[73] For this reason, most researchers in applied business cycle research employ data from Germany, a low-inflation country, to compute the equilibrium real interest rate, which is usually approximated with the average value of the real interest rate over long sample periods.

interest rate.[74] To account for this reduction in the equilibrium real interest rate due to EMU, we include a step-dummy in our model, which takes the value one from 1997:3 onwards and is zero otherwise.[75]

Figure 11: Anticipated Monetary Policy and the Monetary Policy Stance





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[74] For empirical evidence on the reduction in the risk premium see Gerlach and Schnabel (1999).

[75] The decision for the third stage of EMU to go ahead was made in the second quarter of 1998, but the transition to a low-inflation environment was completed in many countries already in 1997, so we choose an earlier date for our EMU-dummy variable to take effect. The results of our analysis are not sensitive with respect to the exact specification of the EMU-dummy variable.

To show the implications of these two intervention variables for the deterministic component of the nominal short-term interest rate, the resulting deterministic trend is plotted together with the interest rate in the upper panel of Figure 11. The lower panel shows the deviation of the anticipated interest rate from our estimate of the neutral interest rate. This measure is used in the remainder of this paper as an approximation of the anticipated monetary policy stance.

The deterministic component of the nominal short-term interest rate exhibits a smooth decline over most of the sample period.[76] From 1997 onwards, it converges to a new long-run value of around 4.5%. It is interesting to notice in this context that applied business cycle research often puts the value of the equilibrium real interest rate in the euro area close to 2.5%, while the inflation objective of the ECB is thought to be approximately 1.5%.[77] Taken together, this yields an estimate of the nominal neutral interest rate in the euro area of approximately 4.0%, which is close to the 4.5% predicted by our model. This suggests that the deterministic component of the nominal short-term interest rate represents a somewhat crude, but nevertheless plausible estimate of the neutral rate in the euro area. The lower panel shows the resulting measure of the anticipated monetary policy stance. Regarding the most recent past, this measure of the monetary policy stance shows that the short-term interest rate is approximately 25 basis points higher than the neutral interest rate, which suggests that monetary policy in the euro area is broadly neutral. The six leading German

[76] An exception is the 'bump' in 1987, which is attributable to the effects of the impulse dummy taking the value one in 1987:1 and zero otherwise, which has been included to capture an outlier in the output growth series.

[77] Alesina et al. (2001), for example, choose a value of 2.5% for the equilibrium real interest rate in their benchmark interest rate rule for the ECB. See Alesina et al. (2001), pp. 27. For a discussion of the inflation objective of the ECB, see Svensson (1999), p. 95.

economic research institutes come to the same conclusion, which gives additional support to our approach.[78]

4.2.2 The Output Effects of Anticipated Monetary Policy

Having obtained a measure of the stance of anticipated monetary policy, we now proceed to compute the output effects of these monetary policy actions. Figure 12 shows the results of our output index for different values of the parameter lambda and using a forecast horizon of 12 quarters. In the first panel, we start by assuming that there is no difference between the output effects of anticipated and unanticipated monetary policy actions, i.e., we are setting $l = 1$. The solid line presents for each point in time t the output effects of anticipated monetary policy actions occurring in the time from t to $t-11$. Since conventional SVAR analysis focuses on the role of unanticipated monetary policy actions on output, to compare the relative importance of anticipated and unanticipated monetary policy we also plot the output effects of the monetary policy shocks identified in section 3. The latter are computed in an analogous way to the output effects of anticipated monetary policy actions, and are given by the dotted line in Figure 12.[79] It is apparent from Figure 12 that anticipated monetary policy accounts for a considerable part of output fluctuations. For example, the expansionary monetary policy stance in the second half of the eighties increased output in the

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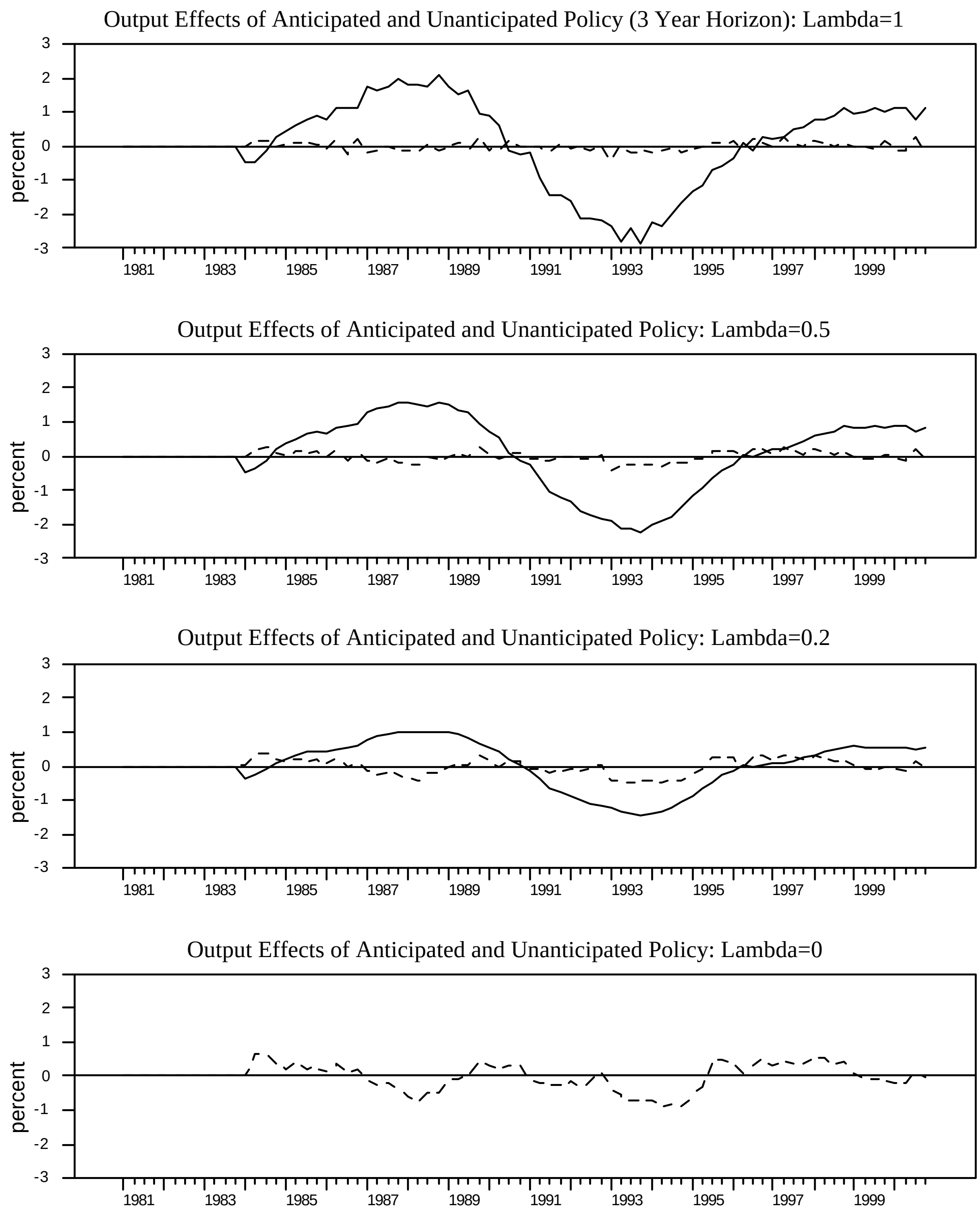
78 See Arbeitsgemeinschaft (2001), p. 18.

79 In particular, according to equation (14) the output effects of unanticipated policy, y^{up}_{t+j}, are given by $y^{up}_{t+j} = \sum_{s=0}^{j-1} a_s^* \left(i^p_{t+j-s} - E_{t+j-s-1} i^p_{t+j-s}\right) + \sum_{s-j}^{\infty} a_s^* \left(i^p_{t+j-s} - E_{t+j-s-1} i^p_{t+j-s}\right)$. Here, we approximate unanticipated monetary policy, $(i^p_t - E_{t-1} i^p_t)$, with the time series of monetary policy shocks estimated in section 3. The dotted line in Figure 12 corresponds to the first term on the right hand side of the expression for y^{up} for a forecast horizon of 12 quarters.

late eighties by about 2 percent above its base line[80], whereas the restrictive policy stance in the early nineties reduced output in 1993 by 3 percent below its base line.

Figure 12: The Output Effects of Anticipated and Unanticipated Monetary Policy



[80] The base line corresponds to the base projection of output, which gives the path of output that would have been obtained in the absence of anticipated monetary policy actions occurring in the time from *t* to *t-11*.

In the year 2000, output is approximately 1 percent above its base line due to an expansionary stance of anticipated monetary policy in the past three years. The output effects of unanticipated monetary policy actions are negligible in comparison. If one assumes that anticipated monetary policy is less effective than unanticipated monetary policy and accordingly chooses a value for the parameter l smaller than one, for example $l = 0.5$ or $l = 0.2$, the role of anticipated monetary policy for output fluctuations becomes smaller but remains considerable larger than the role of unanticipated monetary policy, even for $l = 0.2$. For $l = 0$, anticipated monetary policy actions have no output effects. The output effects of unanticipated monetary policy plotted in the last panel of Figure 12 correspond exactly to the output effects of monetary policy shocks plotted in Figure 9, which proved to be quite small in comparison to the effects of non-monetary policy shocks.

5. The Output Effects of the Systematic Monetary Policy Response to Non-Monetary Shocks

The finding in the previous section raises the question: What is behind anticipated monetary policy? Since most monetary policy actions presumably represent a systematic reaction to the state of the economy, the latter is likely to be an important determinant of the anticipated monetary policy stance. Within our model, the state of the economy is largely determined by demand and supply shocks.[81] The finding that anticipated monetary policy has considerable output effects raises the prospect that it may play an important role in the propagation of these two non-monetary shocks, since the systematic response of monetary policy to these shocks is likely to account for a large part of anticipated monetary policy actions.

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[81] The historical decomposition of output depicted in Figure 9 shows that these two type of shocks account for most of the output fluctuations at the business cycle frequency.

In this section, we employ the technique developed in the preceding section to investigate the contribution of systematic monetary policy to the real effects of aggregate demand and supply shocks. To accomplish this, we first determine the part of the monetary policy stance attributable to the systematic response of monetary policy to non-monetary shocks, which we denote as the systematic component of monetary policy. In a second step, we compute the output effects of this component of monetary policy.

5.1 The Systematic Monetary Policy Response to Demand and Supply Shocks

We begin by decomposing the monetary policy stance into three components. This decomposition uses the fact that in our model monetary policy responds to three kinds of disturbances:

First, the central bank responds in a systematic fashion to aggregate demand shocks. The systematic nature of this response implies that economic agents anticipate this policy response once they realize that a demand shock has occurred. Besides this anticipated component, the systematic policy response is also comprised of the contemporaneous response of monetary policy to the aggregate demand shock, which cannot be anticipated because the demand shock itself is unanticipated. However, empirically we find that the systematic policy response is dominated by its anticipated component. Regarding the nature of the systematic policy response to this shock, the impulse response analysis shows that an aggregate demand shock which raises output is accompanied in our model by higher inflation. Monetary policy responds by tightening the policy stance, thereby limiting the inflationary pressures arising from this shock. This is consistent with a counter-cyclical policy.

Second, the central bank responds in our model in a systematic fashion to aggregate supply shocks. The systematic response again consists of a large anticipated and a small unanticipated component. A positive aggregate supply shock which raises output tends to lower inflation. This allows the central bank to ease policy, thereby further stimulating output and bringing inflation back to target. This implies that monetary policy pursues a pro-cyclical course in response to a supply shock. Taken together, monetary policy actions triggered by aggregate demand and supply shocks represent the systematic component of monetary policy.

Third, discretionary policy, represented by the monetary policy shocks in our model, also plays a role in the behavior of the central bank. In this section, we define the monetary policy shock together with the endogenous interest rate response triggered by this shock as the monetary policy shock component of monetary policy.

Using the historical decomposition technique for the interest rate, Figure 13 shows the contribution of these three components to the movements of the interest rate.[82] As in Figure 11, the deviations of the interest rate from the neutral interest rate are depicted. The difference to Figure 11 is that Figure 13 consists

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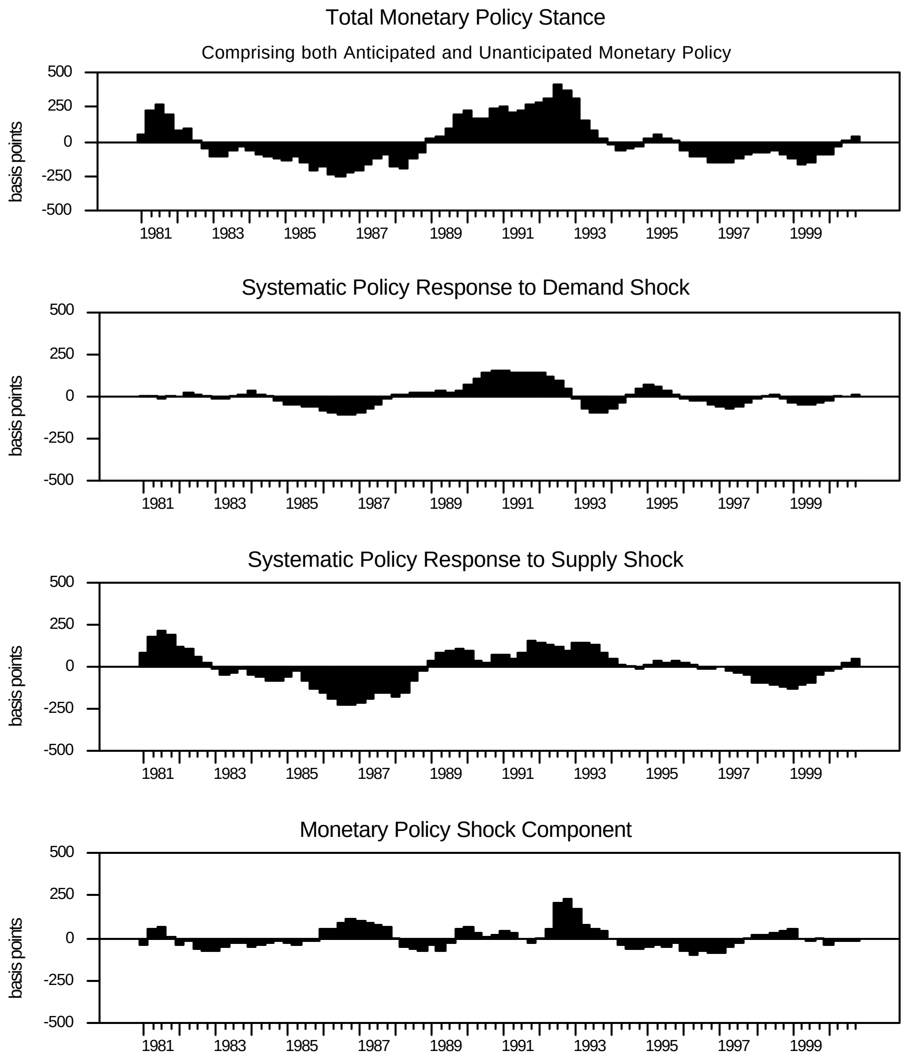
[82] In contrast to the historical decomposition for the output series, here we do not employ a forecast horizon of three years for the historical decomposition, but plot the interest rate in time t as a function of *all* realizations of a given structural shock that occurred since the beginning of the sample period. That is, we do not set the parameter j to 12 and then compute X_{t+12} by letting the time index t move from the beginning of the sample period to the end. Instead, we chose the other option for the computation of the historical decomposition and set in equation (13) the time index t to the beginning of the sample period and then increase j until X_{t+j} reaches the end of the sample period. For a given point in time t, the resulting historical decomposition plotted in Figure 13 shows the nominal interest rate as a function of all structural shocks which have occurred in the time period from the beginning of the sample period until time t. The reason for this departure from the earlier procedure is that, here, we are interested in the total effects of non-monetary shocks on the interest rate and not only on their effects at a business cycle frequency.

of not only the anticipated part of monetary policy but also its unanticipated part. However, the latter part is quantitatively very small, so the first panel of Figure 13 showing the 'total' monetary policy stance is almost identical to the anticipated monetary policy stance shown in Figure 11. The second and the third panel show the part of monetary policy accounted for by the systematic monetary policy response to aggregate demand and supply shocks. This part is considerable larger than the monetary policy shock component shown in the last panel. This suggests that the output effects of anticipated monetary policy shown

Figure 13: Decomposition of the Nominal Interest Rate



in Figure 12 reflect to a large extent the systematic response of monetary policy to aggregate demand and supply conditions.[83]

5.2 The Output Effects of the Systematic Component of Monetary Policy

Before investigating the output effects of systematic monetary policy, it is useful to recall how the conventional SVAR analysis accounts for the output effects of aggregate demand and supply shocks. As has been noted in the introduction of this paper, the output impulse response function to an aggregate supply shock, for example, contains both the direct and indirect effect of this shock. The indirect effect is attributable to the systematic response of monetary policy to this disturbance. The direct effect, on the other hand, denotes the output effects of the aggregate demand shock that would have been obtained if monetary policy had not reacted to this shock. In a conventional SVAR analysis, however, it is not possible to identify both effects individually. In the following analysis we use our measure of the output effects of anticipated and unanticipated policy actions to disentangle these two effects. In particular, we estimate the output effects of the systematic policy response to aggregate demand and supply shocks. These correspond to their indirect effects on the economy. Next, we compute the direct output effects. Having estimated both the direct and indirect effects, it is possible to evaluate the contribution of systematic monetary policy to the real effects of demand and supply shocks in our model.

Based on our index of the output effects of anticipated and unanticipated monetary policy actions, we can compute the output effects of systematic monetary policy in a straightforward way. Denoting the output effects of the

[83] This result is in line with another observation of Sims (1998 p. 933) about the findings of the SVAR literature: "(1) Most variation in monetary policy instruments is accounted for by responses of policy to the state of the economy, not by random disturbances to policy behavior."

systematic monetary policy response to an aggregate demand shock as $y_t^{sys,d}$, and writing the anticipated (unanticipated) component of the systematic monetary policy response to this shock as $E_{t-1}i_t^{sys,d}$ ($e_t^{sys,d}$), we modify equation (15) to obtain $y_t^{sys,d}$:

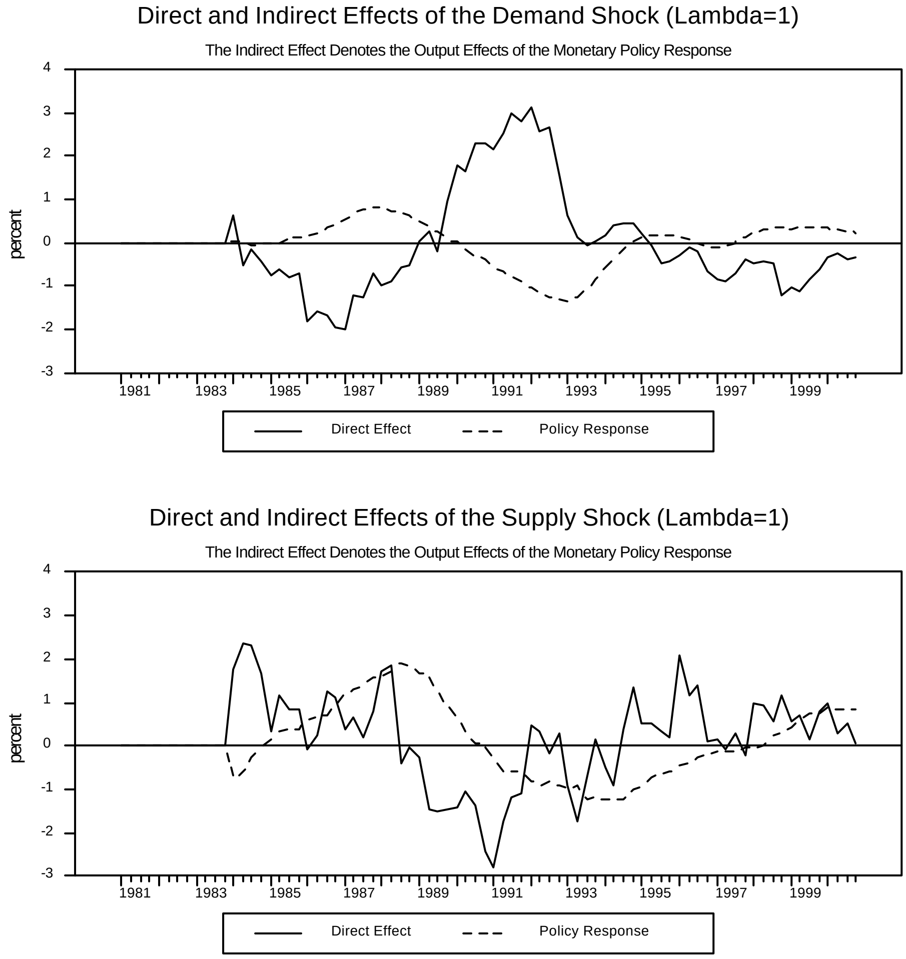
$$(16)\quad y_{t+j}^{sys,d} = \sum_{s=0}^{j-1} la_s^* E_{t+j-s-1} i_{t+j-s}^{sys,d} + \sum_{s=0}^{j-1} a_s^* e_{t+j-s}^{sys,d} + \sum_{s=j}^{\infty} la_s^* E_{t+j-s-1} i_{t+j-s}^{sys,d} + \sum_{s=j}^{\infty} a_s^* e_{t+j-s}^{sys,d}$$

Below, we plot the time series corresponding to the first and second term on the right hand side of equation (16) for a forecast horizon of 12 quarters, which show for each point in time t the effects on output of the anticipated and unanticipated systematic monetary policy actions taking place in the time from t to $t-11$ in response to aggregate demand shocks. The output effects of the systematic policy response to aggregate supply shocks are computed in an analogous way. As noted above, these effects correspond to the indirect effects of the two non-monetary shocks. Since the conventional historical decomposition of the output series yields the total effects of aggregate demand and supply shocks on output, we retrieve the direct effect of a given shock by subtracting the estimated indirect effect from the total effect. The results for the direct and indirect effects of the aggregate demand and supply shocks are plotted in Figure 14.

In the upper panel, the solid line represents the direct effect of the aggregate demand shocks and the dotted line shows the output effects of the systematic policy response to these shocks. The lower panel shows the results for the aggregate supply shock. To preserve space, only the results for $l=1$ are reported.[84] Regarding the aggregate demand shock, it is apparent that monetary policy operates in a counter-cyclical fashion, thereby helping to stabilize the economy. The systematic monetary policy response to aggregate demand shocks

[84] Full results are available from the authors upon request.

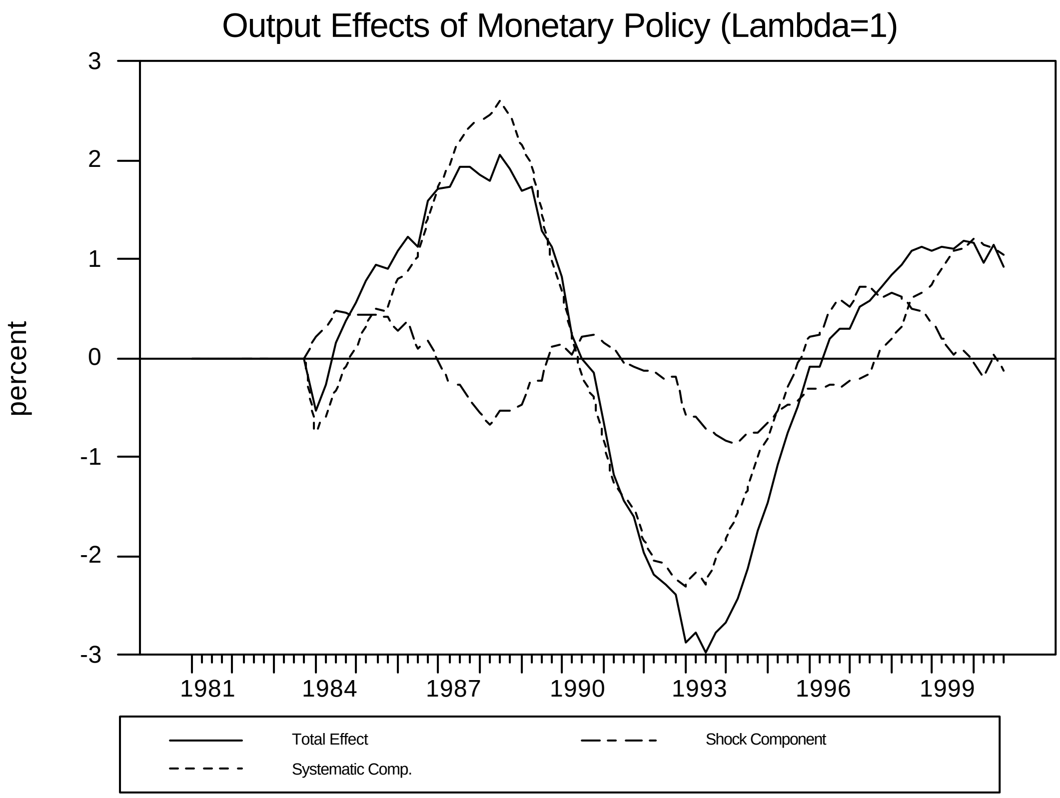
Figure 14: Output Effects of the Systematic Policy Response to Non-Monetary Shocks



is generally successful in filling in the troughs and shaving off the peaks of aggregate demand fluctuations, particularly so in the slump in the late eighties and during the boom in the early nineties. Nevertheless, compared to the direct effects of the aggregate demand shocks the output effects of the systematic policy response are moderate. Moreover, the effectiveness of the policy response is apparently reduced by lags in the decision making process and in the transmission mechanism. It seems systematic monetary policy contributed in particular to the recession in 1993, because the tight monetary policy stance maintained in the preceding boom was not reversed quickly enough when demand conditions faltered in the beginning of 1993. Since the middle of the nineties, the contribution of the systematic monetary policy response to aggregate demand shocks to output fluctuations is negligible. With regard to the systematic response of monetary policy to supply conditions, the lower panel of Figure 8 shows that monetary policy responds in a roughly pro-cyclical manner to supply conditions, but with a considerable time lag. The supply conditions are rather volatile and it is clear that monetary policy does not attempt to respond to all fluctuations. This reflects presumably the fact that supply conditions are difficult to identify and to interpret, which is likely to account also for the significant lag in the policy reaction.

Having estimated the output effects of systematic monetary policy, we end this section by comparing its role for output fluctuations to that of the monetary policy shock component. The output effects of the latter are computed in an analogous fashion to those of systematic monetary policy. The results are re-

Figure 15: Decomposition of the Output Effects of Monetary Policy



reported in Figure 15. Again, to preserve space, only the results for $l = 1$ are shown. The solid line shows the total effects of monetary policy on output. The dotted line shows the effects of systematic monetary policy, comprising the monetary policy response to both aggregate demand and supply shocks. The dashed line gives the output effects of the monetary policy shock component. In contrast to Figure 12, this includes in addition to the unanticipated monetary policy shocks also the effects of the anticipated endogenous policy response to these shocks. Even though the output effects of monetary policy shocks become larger when this component is accounted for, these shocks remain relatively small compared to the systematic component of monetary policy.

6. Conclusion

This paper builds on the work by Cochrane (1998), who introduced a procedure to compute the response of output to anticipated monetary policy actions from a standard SVAR model, by presenting the results of this procedure for the euro area. To this end, we re-estimate the SVAR model of the euro area transmission mechanism proposed by Monticelli and Tristani (1999) and apply the Cochrane procedure to the estimated impulse response functions. Compared to the conventional impulse response function showing the output response to a monetary policy shock, the output response to an anticipated interest rate impulse turns out to be rather small and immediate.

Furthermore, we construct an index of the output effects of anticipated monetary policy using the conventional historical decomposition technique in conjunction with the results from the Cochrane procedure. With this measure we can go beyond shocks, otherwise at the centre of SVAR analysis, and extend the analysis to the role of anticipated monetary policy for output fluctuations. The results confirm earlier findings that unanticipated monetary policy shocks are relatively unimportant for output variations, but we find that the anticipated part of monetary policy has considerable output effects, in contrast to monetary policy shocks where the output effects are considerably less.

To investigate this issue further, we compute the systematic response of monetary policy to aggregate demand and supply disturbances and estimate the corresponding output effects of these monetary policy actions. It becomes apparent that monetary policy pursues a counter-cyclical policy in response to aggregate demand shocks and a pro-cyclical policy in response to aggregate supply shocks, but in the latter case there are considerable lags.

Overall, this paper seeks to demonstrate that the scope of conventional SVAR analysis can be extended considerably using the techniques proposed in this paper. In principle, this extension can be applied to any SVAR model, since the only inputs required are the conventional impulse response functions and the estimated time series of the structural shocks. The usefulness of the extended SVAR analysis for applied business cycle research should have become evident from our analysis of the sources of output fluctuations in the euro area. Another potential application includes an evaluation of the effectiveness of different monetary policy rules regarding the stabilization of output. Generally, the techniques proposed here allow us to use SVAR models for tasks which have been previously the domain of traditional structural macroeconomic models.

Appendix

Figure 1A: The Time Series

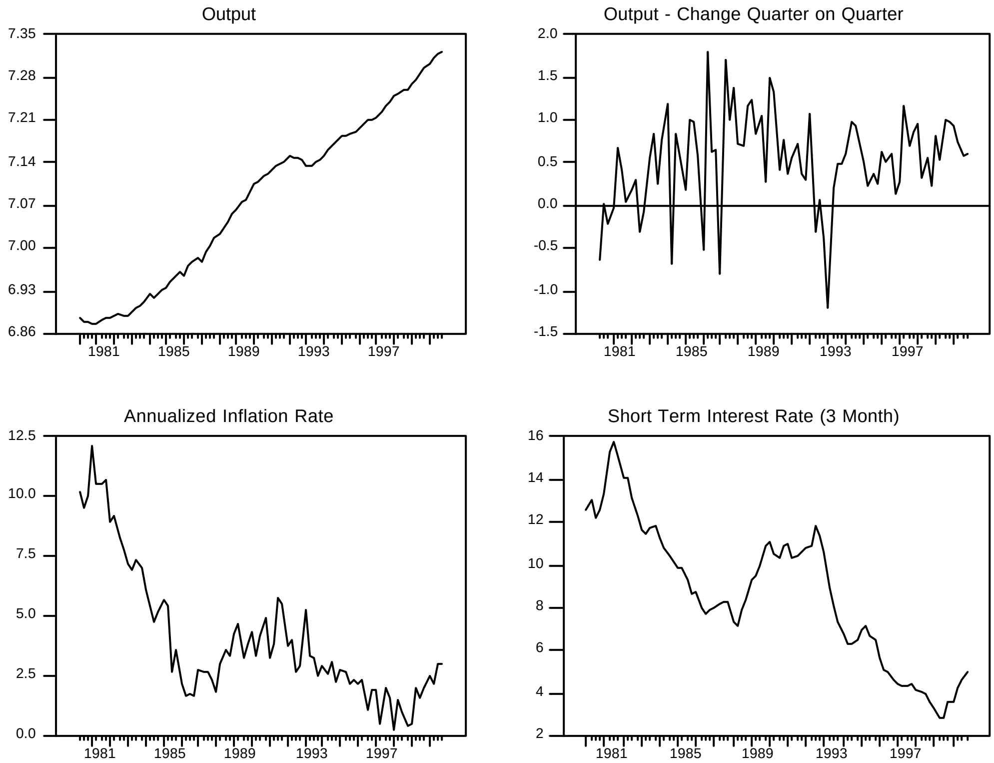


Table 1A: Misspecification Tests

Test	Multivariate Statistics	Univariate Statistics		
		Δy	s	*p*
AR (1–5)	1.29	1.17	2.06*	0.26
Jarque-Bera	3.33	1.65	1.21	0.53
ARCH (4)		0.84	1.01	1.05
White	0.82	0.70	1.92**	0.40
Hansen		2.56	2.24	1.54

Notes: The asterisks indicate a rejection of the null hypothesis at the 10% (*), the 5% (**), or the 1% (***) level. The AR (1-5) statistic gives the result of a LM-test for autocorrelated residuals up to order 5. For single equations this test statistic has a F(5,62) distribution, in the multivariate case it is F(45,149). Jarque-Bera is a normality test with a chi-square (6) distribution in the multivariate and a chi-square (2) in the univariate case. ARCH 4 is a LM test for autocorrelated squared residuals of order 4 with a F(4,59) distribution. The White statistic is the test statistic of a test for heteroscedasticity. The respective distributions are F(21,45) and F(126,239).Hansen is a stability test based on Hansen (1992); the critical values at the 5% and the 1% level are 3.15 and 3.69.

Table A2: Time Series Properties of the Data

Time Series	ADF	Order of integration
y	–2.34 (0,c,t)	I(1)
Δ y	–7.89*** (0,c)	I(0)
p	–1.41 (2,c,t)	I(1)
Δp	–11.93*** (0,c)	I(0)
s	–2.37 (1c,t)	I(1)
Δ s	–5.67*** (0,c)	I(0)

Notes: Δ is the first difference operator. The asterisks indicate a rejection of the null hypothesis at the 10% (*), the 5% (**), or the 1% (***) level. The critical values for the ADF test statistics are taken from Hamilton (1994). The brackets indicate the inclusion of a trend (t) and/or a constant (c) and the lag length. The latter is chosen so that a LM test for serial correlation does not reject the null hypothesis of no serial correlation of order 12.

Table A3: Testing the Cointegration Rank

Eigenvalues	H_0: rank $\leq$ r	Trace statistic	Critical Values (90%)
0.45	r=0	70.63***	36.73
0.18	r$\leq$1	22.64*	20.08
0.08	r$\leq$2	6.50*	6.19

Notes: The asterisks indicate a rejection of the null hypothesis at the 10% (*), the 5% (**) or the 1% (***) level. Critical values have been simulated with DisCo. The model has been estimated with three lags, an unrestricted constant and the the three dummy variables restricted to the cointegration space.

Table A4: The Three Stationary Relations

	The three stationary relations						The loadings					
	b_1	s.e.	b_2	s.e.	b_3	s.e.	a_1	s.e.	a_2	s.e.	a_3	s.e.
Δ y	1	—	—	—	—	—	–0.97	0.13	0.06	0.05	–0.16	0.04
p	—	—	—	—	—	—	0.01	0.07	0.04	0.02	–0.03	0.02
s	—	—	1	—	1	—	0.21	0.16	–0.09	0.05	–0.03	0.05
trend_8097	—	—	—	—	0.001	0.0002						
EMU-dummy	—	—	0.03	0.01	0.02	0.01						
dummy871	0.02	0.004	—	—	—	—						

Notes: s.e. denotes the standard errors of the stationary relations, b, and their loadings, a. The variable trend_8097 denotes the segmented trend variable, EMU-dummy is the step-dummy and dummy871 the impulse dummy.

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