Zentrum für Europäische Integrationsforschung
Center for European Integration Studies
Rheinische Friedrich-Wilhelms-Universität Bonn

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Working Paper

B 04
2002

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March 2002

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Thanks to Mat Canzoneri, Jürgen von Hagen, Matthias Brückner and participants of a research seminar at the University of Bonn for helpful comments. Obviously, we are responsible for all remaining shortcomings.

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Abstract

This paper uses a semi-structural dynamic modelling approach to investigate asymmetric monetary transmission in Europe. A system of equations containing reaction functions for monetary policy, output and inflation equations is simultaneously estimated for France, Germany, and Italy. Extensive cross equation tests show that relatively large differences in simulated impulse responses are still consistent with the notion that the transmission mechanism is homogeneous across the three major EMU countries. However, monetary policy impulses show a relatively stronger effect on the output gap in Italy and Germany. Out-of-sample tests do not find a structural break in the transmission mechanisms prior to EMU.

JEL classification: E52, F41

Keywords: European Monetary Union, Monetary Policy, Semi-structural modelling

1. Introduction

The creation of the European Monetary Union (EMU) raises the question whether the common monetary policy has the same impact in all member countries. Differences in the transmission mechanisms in Europe imply that uniform policy impulses by the European Central Bank (ECB) lead to asymmetric business cycles across the EMU. These result in adjustment problems and may create tensions in the decision-making process of the ECB (see, e.g., Aksoy et al., 2002).

Prior to EMU, there has been a considerable convergence in the cyclical behaviour of the EMU member countries (ECB, 1999). Furthermore, after the establishment of EMU some further convergence in transmission mechanisms is expected to take place (Clausen, 2001). Nevertheless, some differences in transmission patterns are likely to persist (Cecchetti, 1999; Mojon, 2000). Furthermore, recent differences in growth rates across the EMU as well as the prospect of EU enlargement to Eastern Europe with countries having very different transmission profiles keep the interest in asymmetric monetary transmission in Europe.

Reflecting the importance for ECB policy-making, numerous studies deal with this issue. A considerable part of the early empirical evidence has been surveyed by Dornbusch et al. (1998) and Guiso et al. (1999). Dornbusch et al. define three basic requirements for empirical studies related to the *pre*-EMU period in order to provide valuable information on monetary transmission *after* the formation of EMU. First, the direct impact from a change in interest rates on output and prices has to be separable from the indirect impact via exchange rates. This exchange rate channel has to be decomposable into an intra-EMU and an extra-EMU channel, since the former disappeared with the establishment of EMU. Otherwise, asymmetries in policy transmission might be identified that basically result from intra-European exchange rate changes. Second, in order to model the common monetary policy in Europe the empirical set-up has to allow for a *simultaneous* change of monetary policy in *all* EMU countries. Third, the empirical approach has to provide information on the statistical significance of asymmetries in the transmission mechanism. As both surveys illustrate, numerous previous studies on asymmetric monetary transmission in Europe fail to meet these requirements. Even the recent study by Angeloni et al. (2002) does not contain statistical tests of differences in estimated coefficients or simulated impulse responses.

A fourth condition can be added. The creation of EMU and the corresponding change in the policy regime may result in a structural break in the transmission mechanisms in Europe. Some authors believe that financial market efficiency suggests a rapid adjustment of the behaviour of economic agents after entering the new monetary regime (see Arnold and de Vries, 2000). Consequently, analyses using pre-EMU data provide very limited information for the ECB. While we expect some convergence in transmission mechanisms across the EMU, these adjustments are likely to take place gradually (see Hayo, 1999 or Clausen, 2001). In this case, historical data and related empirical studies provide useful information about the transmission mechanism after the formation of EMU.

2. Methodology and data

This paper uses a semi-structural dynamic modelling approach for assessing the degree of asymmetric monetary transmission in Europe. This approach avoids problems related to constructing conclusive statistical cross-country tests that are a typical weakness of VAR studies (such as in Clements et al., 2001, Ehrmann, 2000, Peersman and Smets, 2001). In most studies

At the same time, statistical problems as evident in more structural approaches (see Dornbusch et al., 1998 or Peersman and Smets, 1999) can be addressed by providing a consistent but more flexible dynamic modelling framework that is a reasonably accurate reflection of the data generating process (see Hendry, 1995).

Our empirical design draws upon recent developments in macro-econometric modelling: Central bank behaviour is modelled using reaction functions in the spirit of Taylor (1993) where interest rate setting responds to the output gap and to inflation. This approach receives considerable empirical support not only in the US (e.g. Rudebusch and Svensson, 1999) but also in the euro area (Peersman and Smets, 1999; Gerlach and Schnabel, 2000). The specification of the transmission mechanism of monetary policy draws upon Rudebusch and Svensson (1999). An output gap equation models the demand side and an inflation equation represents the supply side in the respective economies. The output gap is driven by interest rates, exchange rate developments, and foreign lagged output gaps. Inflation is governed by the current output gap and lagged inflation.

Our analysis focuses on France, Germany and Italy as the most important EMU member countries, which together account for almost three quarters of aggregate European output. The overall system consists therefore of nine equations. The model is estimated using the technique of full-information maximum likelihood (FIML). The system context allows for extensive tests of cross equation hypotheses. The semi-structural dynamic modelling approach employed in this paper to assess the effects of monetary policy differs from VAR models in several respects. First, as a result of the large number of variables we do not treat all variables as endogenous. Second, we do not include all variables in all equations to achieve identification. Third, we do not impose the same lag length for each variable in each equation due to limited degrees of freedom. Fourth, testing coefficient estimates is statistically possible and makes economic sense.

The quarterly data start in 1979 – introduction of the European Monetary System (EMS) – and end before the establishment of EMU in 1998. We use the money market rate, seasonally adjusted quarterly data for real GDP, and consumer prices from the IMF International Financial Statistics database (March 2001 CD-Rom). The disaggregated exchange rate variables are taken from Deutsche Bundesbank (1998). The exchange rate variable is *exactly* decomposed into the *effective* exchange rate vis-à-vis the members of EMU and the rest of the world (excluding other EU members).[1]

In order to derive the output gap, we apply a Hodrick-Prescott filter to the GDP series to extract a trend from the data. This trend is subtracted from the original GDP series, divided by the trend estimate and multiplied by 100 in order to convert values to percent. Inflation is the rate of change of the consumer price index with respect to the previous quarter. The exchange rate variables are expressed in natural logarithms and computed as moving averages over the last four quarters in order to dampen the impact of temporary fluctuations in the exchange rate. Unit root tests (not shown) find short-term interest rates, output gaps, inflation rates and the effective exchange rates to be stationary. In the estimation, the econometric model is therefore treated as stationary.

3. Estimating monetary policy effects

The interpretation of the estimation results and the tests for the statistical significance of asymmetries require the underlying system to pass standard diagnostic tests. Initial estimations of the full system showed problems with outliers causing non-normality of the residuals. The inclusion of several impulse dummies related to the reunification of Germany and to realignments in the EMS removed these problems. Insignificant lags in the interest rate and inflation equations were removed based on a consistent testing-down procedure at a 5% significance level. To control for possible data mining and to check whether a structural break occurred prior to the establishment of EMU, we performed out-of-sample evaluations of our model. Despite the limitations in the degrees of freedom, we reserved eight quarters for Chow-tests for structural stability. Since we use lagged variables, the model is estimated over the period 1980:1 to 1996:4.

Table 1: Diagnostics of the system

	AR(2)-test	Normality	Chow1-test	Chow2-test
Vector statistics	F(162,276)=1.23	$Chi^2(18)=22.08$	F(72,58)=1.51	F(72,58)=1.22

Notes: * and ** indicate statistical significance at a level of 5% and 1%, respectively. Chow1-test is the standard Chow-test. Chow2-test takes parameter uncertainty into account. AR(2)-test is an LM-test for autocorrelation containing two lags.

[1] EMU refers to the three largest countries, France, Germany, and Italy. Our treatment of the exchange rate channel is superior to previous studies. Traditionally, the exchange rate channel is modelled asymmetrically using only the DM-Dollar exchange rate for Germany and the bilateral exchange rates with the DM for the other European countries (see e.g. Dornbusch et al., 1998).

Table 1 displays standard diagnostic statistics for the baseline nine-equation system.[2] These tests do not show any problems of misspecification. There is no evidence of autocorrelation or non-normality of the residuals. The out-of-sample Chow tests do not indicate instability of the estimates. Hence, the model does not experience a major structural break prior to EMU.

In order to address possible violations of the homoscedasticity assumption, heteroscedasticity-consistent standard errors (White, 1980) have been computed. In general, these do not indicate any problems, and, in view of the known small-sample problems of the White-estimates, we generally continue to use normal standard errors in our interpretation of the results.

Whereas the complete system is estimated simultaneously, we present the actual results for output gaps, interest rates, and inflation rates in three groups in order to facilitate the cross-country comparison. Table 2 contains the estimates for the output gaps.

Table 2: FIML-system: Output gap equations

France	Coeff.	S.E.	Germany	Coeff.	S.E.	Italy	Coeff.	S.E.
$Fint_{t-1}$	0.044	0.048	$GInt_{t-1}$	$-0.384^{(*)}$	0.206	$IInt_{t-1}$	0.012	0.055
$Fint_{t-2}$	-0.141^{*}	0.064	$GInt_{t-2}$	0.480	0.299	$IInt_{t-2}$	-0.065	0.066
$Fint_{t-3}$	0.101	0.064	$GInt_{t-3}$	-0.173	0.258	$IInt_{t-3}$	0.022	0.066
$Fint_{t-4}$	-0.056	0.048	$GInt_{t-4}$	-0.136	0.168	$IInt_{t-4}$	-0.141^{**}	0.052
$FGap_{t-1}$	0.630^{**}	0.116	$FGap_{t-1}$	$-0.433^{(*)}$	0.232	$FGap_{t-1}$	-0.003	0.117
$FGap_{t-2}$	0.125	0.114	$FGap_{t-2}$	$0.421^{(*)}$	0.215	$FGap_{t-2}$	0.120	0.116
$GGap_{t-1}$	0.001	0.060	$GGap_{t-1}$	0.542^{**}	0.116	$GGap_{t-1}$	0.081	0.059
$GGap_{t-2}$	-0.138^{*}	0.060	$GGap_{t-2}$	-0.013	0.111	$GGap_{t-2}$	-0.148^{*}	0.061
$IGap_{t-1}$	0.308^{*}	0.121	$IGap_{t-1}$	0.257	0.230	$IGap_{t-1}$	0.464^{**}	0.126
$IGap_{t-2}$	-0.110	0.114	$IGap_{t-2}$	-0.548^{*}	0.219	$IGap_{t-2}$	0.012	0.114
$FEMU_{t-2}$	-34.40^{**}	7.964	$GEMU_{t-2}$	1.685	0.412	$IEMU_{t-2}$	-23.17^{**}	7.583
$FEMU_{t-3}$	37.16^{**}	8.029	$GEMU_{t-3}$	-16.59	13.04	$IEMU_{t-3}$	21.74^{**}	7.490
$FROW_{t-2}$	-8.216	11.82	$GROW_{t-2}$	21.95	13.27	$IROW_{t-2}$	19.73^{*}	7.875
$FROW_{t-3}$	3.665	11.41	$GROW_{t-3}$	-21.34	32.49	$IROW_{t-3}$	-15.38^{*}	7.905
			D90:1-93:1	12.68^{**}	31.96			
Ó	0.430			0.797			0.474	

[2] The estimation and the statistical tests were performed with PC FIML 9.0. See Doornik and Hendry (1997) for a detailed description of the tests.

Notes: (*), *, ** indicate statistical significance at a level of 10%, 5% and 1%, respectively.

The labels F, G, and I represent France, Germany, and Italy, respectively. The short-term interest rate is denoted by *Int*, the output gap by *Gap*, the inflation rate by *Infl*, and the effective exchange rates by *EMU* and *ROW*. For Germany, we included a dummy from 1990:1 to 1993:1 to account for the post-reunification period.

A priori, we expect negative signs for the impact of interest rates and exchange rates, while the sign for the lagged own and foreign output gaps are not determined. Output gaps are affected by two opposing influences. On the one hand, we expect a positive transmission of shocks via trade linkages. On the other hand, an interest rate response to a shock in one country affects another country with an opposite sign. Whether cyclical spill-overs across the EMU members turn out to be positive or negative thus depends on the relative strength of trade versus interest rate effects. Apart from that, symmetric (asymmetric) demand shocks may lead to positive (negative) signs of the foreign output gaps.

The interest rate variables are found to be significantly negative but at different lags. The own lagged output gaps are always significant and positive, with the strongest effect in France and considerably smaller but similar effects in Germany and Italy. The cross-country lagged output gaps are often insignificant, sometimes significant even with a wrong sign, which means that it is hard to detect empirically reliable output spill-over effects within the EMU. Thus, abstracting from the influence of symmetric or asymmetric demand shocks, trade effects and interest rate effects appear to be of broadly similar size. The exchange rate variables also display sign reversals at different lags.

Overall, we find statistically significant results for both lagged and foreign output gaps, interest rates and exchange rates in each national gap equation. From a technical point of view, the existence of significant lags at different lengths with opposite signs suggests unexplained dynamics being picked up by the lags. Deletion of one lag generally leads to a loss of significance of the other lag as well.

Table 3 presents the estimates of the interest rate reaction functions. We assume that the current output gap and the current inflation rate determine the level of the interest rate. We also allow for interest rate smoothing (up to lag four) and one outlier per equation. As an “anchor” interest rate, i.e., the rate prevailing when all other variables are equal to their target values, we include a constant term in the German equation. For the other countries, we do not include a constant term but instead the German interest rate. The underlying assumption is that due to the existence of the EMS, German interest rates affect other member’s interest rates. Robustness checks for France show that the impact of the contemporaneous German interest rate is significantly positive while an additional constant term is not significant. The interest rate linkage with Germany is weaker in the case of Italy. This is unsurprising, given the fact that the Lira devalued several times over our sample period and the corresponding exchange rate band exceeded the one between the Franc and the DM.

Table 3: FIML-system: Interest rate reaction functions

France	Coeff.	S.E.	Germany	Coeff.	S.E.	Italy	Coeff.	S.E.
$FInt_{t-1}$	0.747^{**}	0.072	$GInt_{t-1}$	1.423^{**}	0.091	$IInt_{t-1}$	0.631^{**}	0.068
$FInt_{t-4}$	$0.097^{(*)}$	0.049	$GInt_{t-2}$	-0.537^{**}	0.089	$IInt_{t-4}$	0.238^{**}	0.059
$FGap_t$	0.270^{*}	0.104	$GGap_t$	0.056	0.060	$IGap_t$	0.851^{**}	0.164
$FInfl_t$	0.355^{*}	0.145	$GInfl_t$	0.330^{*}	0.148	$IInfl_t$	0.697^{**}	0.123
$GInt_t$	0.126^{*}	0.054	Constant	0.458^{*}	0.175	$GInt_{t-4}$	0.045	0.043
D81:2	4.085^{**}	0.745	D91:1	1.160^{*}	0.504	D92:3	3.090^{**}	0.651
Ó	0.779			0.431			0.829	

Notes: (*), *, ** indicate statistical significance at a level of 10%, 5% and 1%, respectively.

Regarding the other core variables in the reaction function, we obtain for France significant effects for the output gap and the inflation rate. The Italian reaction function looks similar but shows a larger influence of output and inflation. In Germany, the output gap does not have a significant influence on interest rates, while the coefficient on inflation is relatively large. In addition, a significant dummy in the German equation relates to the reunification. The dummy variables for France and Italy capture the October 1981 realignment of the Franc and the EMS crisis in 1992, respectively. These events turned out to be insignificant in the German reaction function. This can be interpreted as further evidence of German dominance in the EMS (see, e.g., Wyplosz, 1989, von Hagen and Fratianni, 1990).

Table 4 presents the estimates for the inflation equations. In all countries, the output gap has a significant impact on inflation. In France, it is slightly above the 10%-significance level but considerably lower when heteroscedasticity corrected standard errors are used (p-value: 0.079). The inflation dynamics are remarkably homogeneous with significant and similar coefficients occurring at the same lag length (except the third lag in the Italian equation). Several impulse dummies in the French inflation equation capture outliers. All dummies can be related to devaluations toward the

DM within the EMS.[3] In the case of Germany, we need one dummy to capture reunification. Overall, the inflation processes are similar across countries.[4]

Table 4: FIML-system: Inflation rate equations

France	Coeff.	S.E.	Germany	Coeff.	S.E.	Italy	Coeff.	S.E.
$FInfl_{t-1}$	0.486**	0.064	$Ginfl_{t-1}$	0.385**	0.073	$IInfl_{t-1}$	0.327**	0.077
						$IInfl_{t-3}$	0.179*	0.071
$FInfl_{t-4}$	0.427**	0.058	$Ginfl_{t-4}$	0.454**	0.070	$IInfl_{t-4}$	0.400**	0.083
$FGap_t$	0.056	0.037	$Ggap_t$	0.215**	0.060	$IGap_t$	0.179*	0.071
D81:3	1.335**	0.267	D91:1	-2.426**	0.425			
D82:3	-2.228**	0.270						
D87:1	0.816**	0.260						
Ó	0.296			0.573			0.487	

Notes: (*), *, ** indicate statistical significance at a level of 10%, 5% and 1%, respectively.

Employing our baseline model, we can illustrate the nature of spill-over effects in the EMS by simulating an asymmetric economic shock. We use the German reunification as an example. We assume that this event raised the German output gap by about 1.5 percentage points due to government transfer programs and higher consumption in East Germany. At the same time, the inflation rate increased by about 2 percentage points. Implementing these two shocks simultaneously in our model generates the impulse responses displayed in figure 1.

We observe an initial increase in the German interest rates by about 1.5 percentage points. The output gap falls after the initial positive impulse of 1.5 percentage points until it reaches a minimum after three years. German interest rates start falling again and output recovers such that the output gap reaches its starting value after about five years. German inflation decreases cyclically after the initial shock until it reaches its original value after approximately four years.

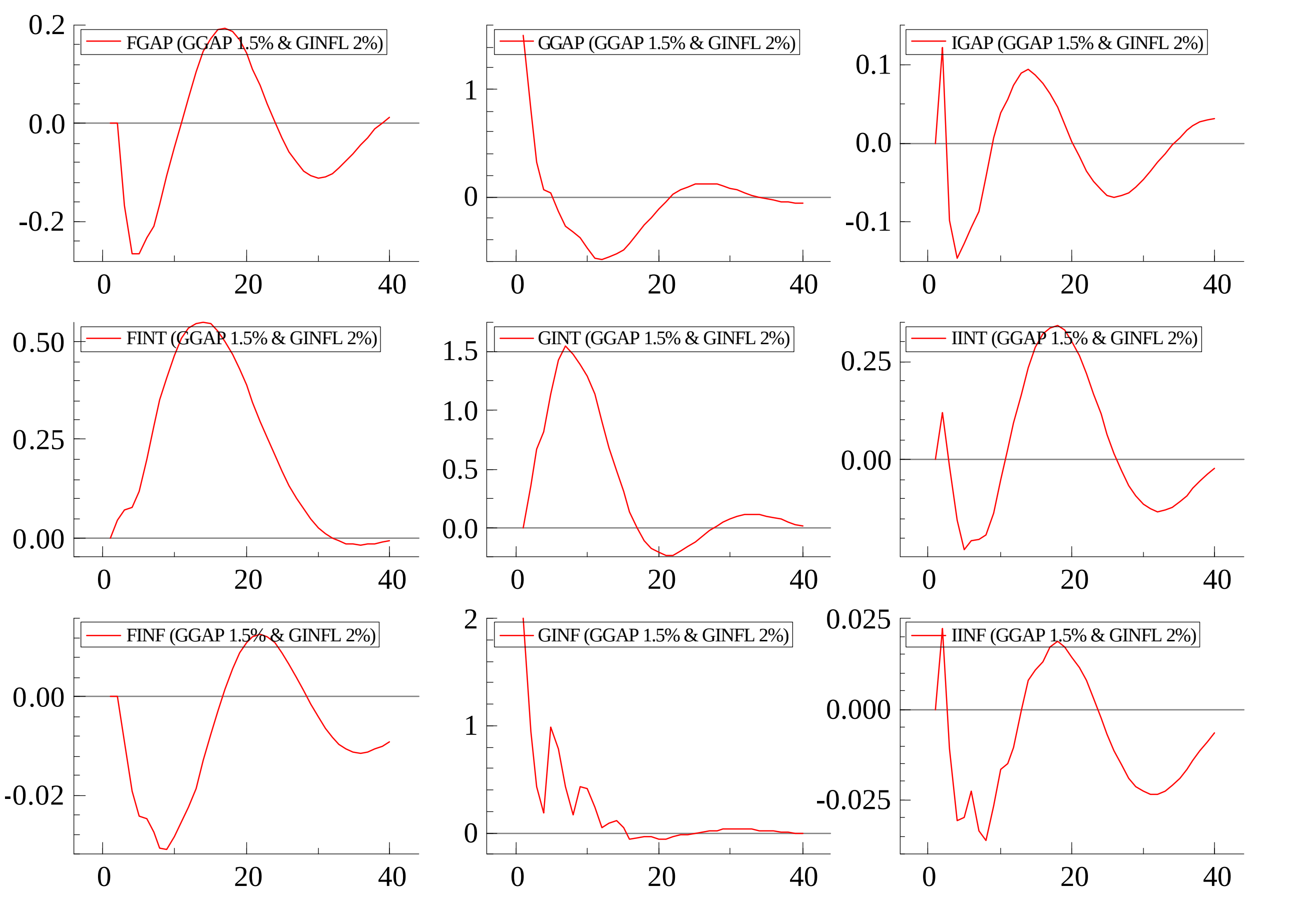
In the other countries, the subsequent developments are primarily governed by the national reaction functions. The difference between the tight connection of the Franc with the DM and the much weaker link of the Lira is pronounced. The French interest rate development follows Germany's lead relatively closely. In Italy, the direct impact of the German interest rate hike only occurs at the

[3] The French Franc was devalued against the DM on 5 October 1981 by 8.8%, 14 June 1982 by 10.6%, and 12 January 1987 by 3%.

[4] We checked the robustness of our results by adding oil prices expressed in national currency to the inflation equations. We found the corresponding elasticities to be statistically significant, but quantitatively unimportant. Our above conclusions remain intact. In the following, we continue to refer to the more parsimonious specification due to limits in the degrees of freedom.

fourth lag and with a quantitatively much smaller impact.[5] The macroeconomic development in Italy is therefore basically a response to the cyclical spill-over from Germany and France. Since these two countries exert a negative influence, at least after the primary positive impulse from Germany is over, the Italian output gap deteriorates. Then, both France and Italy's output gaps fluctuate around zero until they converge back to the starting values. In Germany, the response is somewhat faster. These fluctuations are also transmitted to inflation in France and Italy. Here, a deflationary period is followed by an inflationary period, analogous with the output gap cycle. In Germany, we find again that the adjustment back to equilibrium is much more rapid.

Figure 1: Simulating the effects of German reunification



To summarise, German reunification caused real costs for France and Italy in terms of cyclical variations of output and inflation. Both countries experience a contractionary and deflationary impact. While this result is not very surprising for France due to interest rate interaction, we find that the outcome is not very different for Italy, which does not follow German interest rates closely.

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[5] Recalculating the impulse responses after eliminating this link leaves the picture almost unchanged.

Note that our results differ from estimates by the Deutsche Bundesbank, where – based on a different methodology – the positive trade effect overcompensated the interest rate effect (see Deutsche Bundesbank, 1992).

The observed differences in the adjustment patterns in Europe result as a combination of asymmetric shocks, different interest rate responses by the central banks, and asymmetries in the transmission profiles in the three countries. Furthermore, they may not be statistically significant. We need to test for asymmetric monetary transmission in Europe.

4. Testing for asymmetric transmission

We use Wald-statistics to test for the existence of asymmetric transmission in the econometric system. Our dynamic model allows us to test for asymmetries at different time horizons. We restrict our attention to the effects after one quarter, one year and in the long-run. We acknowledge that our model is not specifically designed for the analysis of impact or long-run effects. For the former, data at a higher frequency are needed, while for the latter one ought to incorporate long-run relationships. Table 5 presents the respective coefficients and test results regarding the significance of interest rate variables in the output gaps. This is done country by country as well as jointly.

Table 5: Testing for interest rate effects on output gaps

	France	Germany	Italy	Joint
Impact effect	0.04	-0.38$^{(*)}$	0.01	
				$Chi^2(3) = 4.6$
One-year effect	-0.05*	-0.21*	-0.17**	
	$Chi^2(1) = 4.4$	$Chi^2(1) = 5.5$	$Chi^2(1) = 27.2$	$Chi^2(3) = 35.5^{**}$
Long-run effect	-0.21	-0.45$^{(*)}$	-0.33**	
	$Chi^2(1) = 2.58$	$Chi^2(1) = 3.69$	$Chi^2(1) = 17.2$	$Chi^2(3) = 23.3^{**}$

The impact effect is insignificant in France and Italy, while Germany shows a significant and strong negative effect. Testing all three coefficients jointly against zero leads to a non-significant outcome. The picture changes already at the one-year horizon. Now we obtain significant test results at the individual and the joint level. The tests concerning the long-run effect requires non-linear restrictions. Although the statistical significance declines in all countries, for example, the p-value in France is 0.108, the interest rate shock is found to have negative long-run effects. Monetary policy is not neutral in the long-run. This may result from the fact that our model does not really capture a "true" long-run. Taken together, these results suggest that the ECB can rely on an effective interest rate channel in all three countries and in the euro area as a whole. The exchange rate channel of monetary policy transmission does not seem to play a critical role (see also Angeloni et al., 2002). This holds in particular in the medium term, which is the most relevant one for practical policy purposes.

Table 6 investigates the degree of asymmetry in the interest rate channel across the three EMU member countries. Looking at the impact effect, the *difference* in the policy impact between France and Italy is not significant ($Chi^2(1) = 0.20$). The German impact effect, which is known from table 5 to be negative, differs significantly from Italy and almost significantly from France (p-value: 0.11). In conclusion, the impact effect of ECB policy in Germany is significantly stronger than in the other two countries.

Table 6: Testing for asymmetric interest rate effects on output gaps

	Fra versus Ger	Fra versus Ita	Ger versus Ita
Impact	$Chi^2(1) = 2.50$	$Chi^2(1) = 0.20$	$Chi^2(1) = 3.0^{(*)}$
One year	$Chi^2(1) = 2.98^{(*)}$	$Chi^2(1) = 8.97^{**}$	$Chi^2(1) = 0.17$
Long-run	$Chi^2(1) = 0.79$	$Chi^2(1) = 0.56$	$Chi^2(1) = 0.24$
Long-run with bilateral spill-overs	$Chi^2(1) = 1.47$	$Chi^2(1) = 0.56$	$Chi^2(1) = 0.01$

After one year, the cumulative influence of interest rate coefficients in the French output gap deviates significantly from the one in Germany. In conjunction with the results in table 5, the effect in France is found to be significantly smaller. The difference is, in the statistical sense, even more significant in the comparison between France and Italy despite the fact that the difference between the actual estimates is smaller than in the comparison of France and Germany. There is no significant difference between Germany and Italy. Overall, monetary policy effects at the one-year horizon are similar in Germany and Italy, while the effects in France are smaller in absolute terms. The differences in the long-run effects are not significant.

These tests do not consider output spill-over effects within Europe. In each country, foreign output gap variables entered the respective national gap equation (see table 2). Hence, changes in the output gap in one country following a monetary policy shock are transmitted to the other countries via the respective gap terms in the foreign output equations. We take these spill-over effects into account in our analysis of the long-run effect. Again, we find no significant differences among EMU member countries.[6]

Moving to the determinants of interest rate policy, we initially look at the short-run importance of the output gap and inflation in the reaction functions and test for differences in their importance. Again, this is done within and across countries. Table 7 presents the results for the within country tests. The first line gives the ratio between the two coefficients. The second line lists the results of our tests against unity, which means equal weights of both policy goals in the reaction function. The test statistics are insignificant in France and Italy. However, in Germany the difference is significant (p-value: 0.115) indicating that in Germany fighting inflation is more important in interest rate setting than the output gap. This result differs from outcomes of single-equation studies on reactions functions, e.g. Clarida et al. (1998).

Table 7: Testing restrictions on short-run reaction functions within countries

	France	Germany	Italy
Gap/inflation weight ratio	0.76	0.17	1.22
Testing ratio against unity	$Chi^2(1)=0.31$	$Chi^2(1)=15.0^{**}$	$Chi^2(1)=0.49$

Tests for asymmetries across countries may refer to the absolute or to the relative weighting of policy goals. The absolute weights are interesting because they determine the *size* of the interest rate responses to movements in the output gap and inflation. The relative weights of policy goals are important because they provide information how central banks are likely to react in the presence of supply shocks.

Table 8 contains the outcome of the short-run tests across countries. Regarding the absolute weight of the output gap, the tests show significant differences for all country pairs. As known from table 3, the Italian weight on the output gap is the largest, followed by France and Germany. For inflation, we find France and Germany to have similar absolute values, both being larger than in Italy. Tests of asymmetric relative weights of the output gap and inflation are insignificant for France and Germany as well as for France and Italy. However, the Null that the relative weights in Germany and Italy are equal can be rejected at the 1% level. To summarise, according to the short-

[6] For this reason, impulse responses based on VAR models investigating only national policy impulses without international output repercussions may be very misleading. The inclusion of output spill-overs in our model tends to dampen differences in output developments. Thus, investigating asymmetric monetary transmission in a system context is likely to lead to smaller differences in output developments than single-country studies.

run coefficients, Germany places the most emphasis on inflation, followed by France and with Italy at the end of the spectrum.

Table 8: Testing restrictions on short-run reaction functions across countries

Output Gap			Inflation Rate		
Fra vs. Ger	Fra vs. Ita	Ger vs. Ita	Fra vs. Ger	Fra vs. Ita	Ger vs. Ita
$Chi^2(1)=3.2^{(*)}$	$Chi^2(1)=11.0^{**}$	$Chi^2(1)=20.8^{**}$	$Chi^2(1)=0.02$	$Chi^2(1)=4.4^{*}$	$Chi^2(1)=3.6^{(*)}$
Difference in Gap/inflation ratios (short-run equal to long-run)					
Fra vs. Ger	Fra vs. Ita	Ger vs. Ita			
$Chi^2(1)=1.52$	$Chi^2(1)=0.95$	$Chi^2(1)=7.58^{**}$			

The focus on the short-run may be misleading because short-run coefficients mix optimal policy responses with respect to output gap and inflation with a parameter reflecting interest rate smoothing.[7] Therefore, it is interesting to look at the long-run responses for the three countries. Table 9 provides static long-run solutions with respect to output gap, inflation and the nominal "anchor". The nominal "anchor" gives the nominal interest rate when the actual output gap and inflation rate equal their target values. For France and Italy, these were derived by assuming that the target values in Germany are met.

Table 9: Long-run reaction functions

	Output gap	Inflation rate	Nominal "anchor"
France	1.73	2.28	3.26
Germany	0.49	2.89	4.02
Italy	2.46	2.02	0.48

Regarding the long-run coefficients, our test results across countries are similar to our short-run results and are therefore omitted. Germany places the highest emphasis on deviations from the inflation targets and the lowest emphasis on deviations from the output gap, with France in the

[7] See, e.g., Judd and Rudebusch (1998). Note that the estimated policy weights can not be interpreted as a measure of policy preferences concerning output and inflation. The optimal policy response depends not only on policy preferences but also on the structure of the economy and the nature of shocks (see Clarida et al., 1999). Cecchetti and Ehrmann (1999) discuss in a simpler setting in reference to the Taylor rule how to trace policy preferences from macroeconomic outcomes.

middle and Italy at the other side of the spectrum.[8] We conclude that the Bundesbank is the most "conservative" of the analysed central banks, followed by the Banque de France and the Banca d'Italia.

Finally, we test for asymmetries in the impact of the output gap on inflation (Table 10). The impact can be measured in the short-run and in the long-run. Testing all three short-run coefficients jointly, we find them to be significantly different from zero. Comparing France and Germany reveals that in Germany the output gap has a significantly larger influence on inflation. This difference is not significant, though, in the comparison between these two countries and Italy. When we impose all three equality restrictions simultaneously, the Null can only be rejected at the 10% level.

Table 10: Testing *short-run* restrictions on the output gap in the national inflation equations

Joint zero restrictions	Fra vs. Ger	Frau vs. Ita	Ger vs. Ita
$Chi^2(3) = 41.4^{**}$	$Chi^2(1) = 5.4^{*}$	$Chi^2(1) = 2.8^{(*)}$	$Chi^2(1) = 0.1$

Table 11 gives long-run coefficients as well as significance tests. The long-run coefficients are generally larger than the short-run coefficients. The output gap has still the strongest influence on German inflation. However, France and Italy switched positions, with Italy showing the weakest long-run influence of the output gap on inflation. The long-run impact in France is not significant (p-value = 0.17) while Germany and Italy display significant long-run effects.

Table 11: Testing *long-run* restrictions on the output gap in the national inflation equations

Joint zero restrictions	France	Germany	Italy
Long-run coefficient	0.64	1.33	0.20
$Chi^2(3) = 7.0^{(*)}$	$Chi^2(1) = 1.9$	$Chi^2(1) = 3.5^{(*)}$	$Chi^2(1) = 3.8^{(*)}$
Asymmetric long-run effects:	Fra vs. Ger	Fra vs. Ita	Ger vs. Ita
	$Chi^2(1) = 0.74$	$Chi^2(1) = 1.81$	$Chi^2(1) = 0.28$

The latter tests involve the question whether there are long-run differences between the countries regarding the influence of the output gap on inflation. Here we do not encounter any significant

[8] Note that the long-run coefficient on the inflation rate is larger than unity in all three equations. This ensures that interest rate changes as a result of inflation rate deviations from target actually affect real interest rates in the right direction and that the system is dynamically stable.

results and we have to conclude that in the long-run, inflation mechanisms in these countries are symmetric.

5. Conclusions

Two conclusions emerge from our study: first, relatively large differences in simulated impulse responses are still consistent with the view that the transmission mechanism is homogeneous across the EMU countries. Tests for the statistical significance of asymmetries reveal that differences in the estimated coefficients are often not statistically significant, especially over the long-run. At the same time, we find that the output response after a monetary shock in France is significantly smaller compared to Germany and Italy in the medium-run. Since the medium-run is most relevant for monetary policy transmission, we cannot reject the notion that a common impulse from the ECB will have different effects in EMU member countries. Further convergence may occur as a result of EMU membership (see Frankel and Rose, 1998) but if, when and how that comes about remains to be seen.

Second, our out-of-sample tests suggest that the transmission mechanisms in Europe did not experience a major structural break *prior* to the establishment of EMU. The finding is relevant for economic policy, as it suggests the absence of a strong convergence effect. This leaves two interpretations: either there was a sharp-structural break only *after* the establishment the EMU came about (see Arnold and de Vries, 2000 for such a conjecture), or there will be a more gradual adjustment to the new economic regime over time making it more difficult for stability tests to clearly detect a structural break at a point in time (see Hayo, 1999 for some arguments). In the latter case, historical data and related empirical studies continue to provide useful information for the ECB about the transmission mechanism after the establishment of EMU. An analysis of this question is on our agenda for further research.

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ISSN 1436 - 6053

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