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Monetary Policy Under EMU: Differences in the Transmission Mechanism?

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Joaquim Levy

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Monetary Policy Under EMU: Differences in the Transmission Mechanism? [1]

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Abstract

This study identifies differences in the monetary policy transmission mechanism across the countries in the euro area. It is argued that part of the differences in the response of economic activity to monetary policy during the pre-EMU period, found in other studies, reflected differences in monetary policy reaction functions, rather than different transmission mechanisms. In light of this, the paper constructs an empirical model on the basis of common reaction functions. The results confirm that even when a common monetary policy is implemented, its effects on economic activity are likely to differ across EMU countries. The paper also constructs an aggregate measure of the effect of monetary policy on prices and output. Finally, the paper examines the relative strength of the credit, exchange rate, and interest rate channels of monetary transmission in EMU countries.

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I. Introduction and Motivation for the Study

The introduction of a single currency in Europe and the establishment of the European Central Bank (ECB), which is responsible for the conduct of monetary policy across the single currency area, have rekindled the debate on optimal currency areas (see Alesina and Barro, 2000, for example). This debate is fueled by concerns that important differences in the monetary policy transmission mechanism across member states could exacerbate existing cyclical divergences, further complicating the task of the ECB in determining policy for the euro area. Recent developments—including increasing inflation differentials, divergent growth paths and signs of stagflation—have highlighted the challenges faced by the ECB and underscore the need for a good understanding of the monetary policy transmission mechanism in the euro area.

The results from earlier studies comparing the monetary transmission mechanism in (the soon to be) euro-area countries have varied considerably, although sharing a few common threads.[2] In an influential study, Gerlach and Smets (1995) concluded that while the effects of monetary policy shocks were not vastly different across countries, they were somewhat larger in Germany than in France or Italy. On the other hand, Dornbusch, Favero, and Giavazzi (1998) found that the effect of changes in short-term interest rates on output—holding the intra -"euro area" exchange rate constant—was about twice as large in Italy as in Germany and France, and about three times as large as in Spain. Ramaswamy and Sloek (1998) found that the full effect of an unanticipated contraction in monetary policy on output in Austria, Belgium, Finland, Germany, and the Netherlands took twice as long to occur and was twice as deep as in France, Italy, Portugal, and Spain. On balance, even though the results of this research tend to disagree on the precise nature of any one individual country's responsiveness to monetary policy shocks, a few, albeit qualified, conclusions can be drawn—most notably that output in Germany and France is more affected by monetary shocks than in either Spain or Italy.

Although these studies provide interesting analysis for the differences in the transmission mechanism for the pre-EMU period—during which most countries participated in the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS)—the conclusions have little bearing on policymaking under EMU. First, there is a need to appropriately model the mechanism under the new conditions prevailing under EMU—specifically, irrevocably fixed exchange rates between member countries and the elimination of differentials in short-term interest rates. Second, there is room to improve the methodology employed in earlier studies. In particular, the failure to use common reaction functions across countries has hampered an accurate assessment of the relative strength of the transmission mechanism. Thus, the strength of the monetary transmission mechanism observed in earlier studies in Germany and countries that closely followed Germany (e.g., Austria and the Netherlands) in the pre-EMU period may be explained better by the monetary policy setting in these countries than by a stronger

[2] See Gerlach and Smets (1995), Dornbusch, Favero, and Giavazzi (1998), Britton and Whitley (1997), Ehrmann (1998), Ramaswamy and Sloek (1998) and references therein, for example.

transmission mechanism per se. The second group of countries—including Italy, France, and Spain—were distinguished by a different monetary regime focused more on domestic considerations. These differences in monetary policy regimes have vanished under EMU with the establishment of a single monetary authority.

The econometric methodology employed in this paper avoids some of the pitfalls of earlier studies and enables us to simulate a model that captures the policy setting in EMU and to identify properly differences in the monetary policy transmission mechanism across these countries.[3] By imposing a common reaction function across all countries, the model helps isolate the underlying differences in the monetary transmission mechanism per se. As a proxy for the euro area, the reaction function is estimated using data from Germany. Consequently, it is assumed that information from other countries, including from the other large euro-area economies, do not enter the monetary policy reaction function of the ECB. In reality, euro-area developments, and certainly developments in the bigger four economies, would influence the ECB's monetary policy reaction function. Nevertheless, using German data alone allows us to identify the monetary policy responses that resemble the behavior of the ECB. Responses based on aggregated euro-area data are contaminated by the responses of central banks in the pre-EMU that are unlikely to be representative of ECB behavior under EMU. One drawback of this approach is that the trade links and cross-country linkages are not directly captured. It is possible that a proper modeling of these spillover effects could result in smaller differences across countries than found in this paper. To simulate EMU, the empirical analysis takes into account the fact that the exchange rate channel is in part muted under EMU, and that short-term interest differentials between member countries no longer exist. The methodology delineated in the paper is sufficiently general that it can be applied to a range of econometric specifications and models.

The primary mandate of the European Central Bank is to control inflation. Nevertheless, a question of great interest to policymakers in the 12 euro-area countries is to what extent a "one-size-fits-all" monetary policy is likely to have diverse effects on economic activity across member countries. Consequently, one of the aims of this paper is to compare the effects of monetary policy on real GDP across euro-area members, but also to measure its effects on euro-area consumer prices. The empirical results confirm that the impact on economic activity is likely to differ across EMU countries. The individual country results provide a sound basis for assessing the average euro-area response of prices to a common monetary policy shock.[4] The

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[3] As of January 1, 2001, the member states participating in the final stage of EMU were: Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. The analysis in the paper does not cover Luxembourg and Greece.

[4] Recent research points to potentially serious problems in dynamic econometric models using data based on aggregated averages (e.g., euro-area variables aggregated from country data) in the presence of heterogeneous country responses (see Pesaran and Smith, 1995, and Rebucci, 2000, for example). Taking these problems into account, the paper allows for modeling

(continued…)

results confirm that the impact of monetary policy on euro-area consumer prices will be rather subdued under EMU. Sluggish price responses to monetary policy are also a common finding for the United States. Although the overall openness of the euro area is unchanged under EMU, that of individual countries has changed significantly, implying that under a common monetary policy the indirect effects of monetary policy on inflation (via the exchange rate) will be muted.

Of course, due to the reduced form nature of the econometric exercise undertaken in this paper, it is possible that this analysis cannot fully account for the structural/regime change that might follow the introduction of the a common currency in the euro area. It is therefore possible that part of the differences in the transmission mechanism that are identified here under EMU still reflect historical differences that cannot be adequately captured in a reduced form model—even after imposing a structure that could be expected to describe fully EMU (i.e., a common monetary policy reaction function and fixed intra-euro exchange rates). Furthermore, some of these differences, to the extent that are explained by pre-EMU institutional characteristics, could also be expected to diminish. For example, borrowing constraints in one country (that emerge following a monetary tightening) can be less binding if firms or individuals can borrow more easily from other countries.

The second aim of the paper is to unravel the reasons behind these differences in the strength of the transmission mechanism across countries. Most of the research on the transmission of monetary policy has focused on measuring the effects of monetary policy on output, with less attention paid to the relative strength of the different channels through which monetary policy affects output. More recently, growing attention has been given to understanding these channels, in particular the ones linked to fluctuations in bank credit (DeBondt, 1998; Favero, Giavazzi, and Flabbi, 1999; Cecchetti, 1999), the exchange rate (Dornbusch, Favero and Giavazzi, 1998) and the interest rate channel (Ehrmann, 2000, and Mojon, 2000, for example). The results in this paper suggest that the interest rate channel, rather than the credit and exchange rate channels, explains the lion's share of the observed differences. However, the results also point to an important role for the credit and exchange rate channels in a few countries. While differences due to the credit channel are likely to diminish over time as financial markets integrate further, those that are driven by the exchange rate and the interest rate channels could persist.

The rest of this paper is structured as follows. Section II provides some theoretical perspectives on the monetary transmission mechanism and how its operation will differ under EMU. Section III delineates the methodology used in the study, as well as the empirical results. Section IV includes an examination of the contribution of the credit, exchange rate, and interest rate channels that underpin the strength of monetary transmission across countries. Section V concludes the paper.

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heterogeneous responses of countries by estimating separately the effects of common monetary policy. The results are then aggregated to obtain the likely response for prices to a monetary shock at the euro-area level.

II. Monetary Policy Under EMU

The ECB's primary target is price stability, and in order to achieve this, it looks at developments in all member countries, weighing their implications for movements in the EMU-wide price level. A simple model can provide a stylized reaction function along these lines. It can also help elucidate the effects on economic activity in member countries if the ECB's monetary policy followed such a reaction function.

For this purpose, assume that inflation in the euro area, which is reduced to two countries for simplification, is defined as $\pi_{euro}=\theta\pi_1+(1-\theta)\pi_2$, with $0 < \theta < 1$. Inflation in each country responds differently to the output gap as well as to other variables of interest, including productivity growth, summarized by the variable X:

$$\pi_1 = \alpha_{11}(y_1 - y_1^p) + a_{12}X_1 + \varepsilon_1$$
$$\pi_2 = \alpha_{21}(y_2 - y_2^p) + a_{22}X_2 + \varepsilon_2$$

where ε_1 and ε_2 are country-specific shocks.

Also, following Dornbusch, Favero and Giavazzi (1998), assume that the policy instrument R and output are related as follows in the two countries:

$$y_1 = -\gamma_1 R + z_1$$
$$y_2 = -\gamma_2 R + z_2$$

The parameters γ_1 and γ_2 summarize the potency of the monetary transmission mechanism in each country: a change in monetary policy, through changes in liquidity and the exchange rate, for example, brings about changes in real GDP and prices. Hence, knowledge of the magnitude of these impact multipliers is crucial for the design of an optimal monetary policy.

Now, suppose that the ECB is minimizing a loss function given by:

$$L = \pi_{eu}{}^2 = [\theta\pi_1 + (1-\theta)\pi_2]^2$$

The reaction function of the monetary authority will be a function of a number of variables (e.g., shocks to prices), including the parameters of its own objective function. In particular, the rule that minimizes the Central Bank's loss function is given by:

$$R = \frac{[\theta\alpha_{11}z_1 + (1-\theta)\alpha_{21}z_2] + [\theta\alpha_{12}X_1 + (1-\theta)\alpha_{22}X_2] + [\theta\varepsilon_1 + (1-\theta)\varepsilon_2]}{\theta\alpha_{11}\gamma_1 + (1-\theta)\alpha_{21}\gamma_2}$$

and implies that the change in the interest rate in response to an inflation shock, output shock, or the exogenous variable X will be given by:

$$\frac{\partial R}{\partial \varepsilon_1} = \frac{\theta}{\theta\alpha_{11}\gamma_1 + (1-\theta)\alpha_{21}\gamma_2}$$

$$\frac{\partial R}{\partial z_1} = \frac{\theta\alpha_{11}}{\theta\alpha_{11}\gamma_1 + (1-\theta)\alpha_{21}\gamma_2}$$

$$\frac{\partial R}{\partial X_1} = \frac{\theta\alpha_{12}}{\theta\alpha_{11}\gamma_1 + (1-\theta)\alpha_{21}\gamma_2}$$

In this basic model, which depicts EMU, the objective loss function of the ECB does not attach any weight to output developments (i.e., the ECB is portrayed as pursuing "strict inflation targeting," that is, its actions are consistent with strict inflation targeting). Such an objective function cannot be used to characterize the pre-EMU environment in which countries' objective functions varied according to the weights that each one attached to inflation and output stabilization. For this purpose, consider two countries with different loss functions, each with different weights on output stabilization:

$$L_1 = \pi_1^2 + b_1 {y_1}^2$$
$$L_2 = \pi_2^2 + b_2 {y_2}^2$$

The reaction functions are given by:

$$R_{pre-EMU,1} = \frac{\alpha_{11}z_1 + \alpha_{12}X_1 + \varepsilon_1}{\alpha_{11}\gamma_1 + b_1\gamma_1}$$
$$R_{pre-EMU,2} = \frac{\alpha_{21}z_2 + \alpha_{22}X_2 + \varepsilon_2}{\alpha_{21}\gamma_2 + b_2\gamma_2}$$

and if the two countries differ in terms of the weight that each attaches to output stabilization relative to inflation, say $b_1 > b_2$, responses to inflation shocks could vary significantly (e.g., they will be smaller in the country that cares more about output, other things being equal):

$$\frac{\partial R_{pre-EMU,1}}{\partial \varepsilon_1} < \frac{\partial R_{pre-EMU,2}}{\partial \varepsilon_2}$$

Therefore, Country 1 reacts less aggressively—or reverses a change in stance more quickly— to a shock in inflation, given that it attaches more weight on output stabilization. Hence, even if the transmission mechanisms are similar across the two countries, that is, $\gamma_1=\gamma_2$, the observed response of monetary policy based on historical data will be different. EMU will bring about a convergence of "tastes," and thus a more uniform response to shocks. Thus, when comparing the monetary transmission mechanism in Europe, it is important to isolate interest rate movements that were simply due to the different weights that the monetary authorities attached to inflation and output.

Furthermore, monetary policy under EMU depends on a weighted average of country- specific shocks. In the pre-EMU period, the monetary authorities were in a position to fully offset a country-specific shock if they chose to do so. Under EMU, the response will be proportional to the size of the country that experiences the shock. In fact, the ECB will offset a European shock defined as: $\varepsilon_{euro} = \theta\varepsilon_1 + (1-\theta)\varepsilon_2$:

$$\frac{\partial R_{EMU}}{\partial \varepsilon_{euro}} = \frac{1}{\theta\alpha_{11}\gamma_1 + (1-\theta)\alpha_{21}\gamma_2}$$

Under these circumstances, if $\theta \neq ½$ the common interest rate may respond to a shock ε_1 in a much weaker way than the small country would have chosen, possibly allowing an unsustainable growth rate to persist for too long, with adverse effects on inflation. At the same time, if $\gamma_1 >> \gamma_2$, the small country may be heavily affected by a shock to the large country—than would have been the case under independent monetary policies—again either allowing growth to continue beyond a safe threshold if the policy stance is too lax in the large country, and possibly with large effects on output when tightening eventually takes place.

The model thus formalizes a number of insights for the analysis of monetary policy in the new environment created by EMU:

i. Responses to shocks depend on the preferences of the authorities with respect to inflation and output. To compare differences in the potency of the monetary transmission mechanisms using pre-EMU data, it would be necessary to control for differences in the objective functions of policymakers that existed in the pre-EMU period.
ii. Significant differences in the transmission mechanism can be very costly to small countries whose macro conditions may have little bearing on the setting of the common policy stance.
iii. Moreover, monetary policy under EMU is focused on euro-area developments, i.e., it is essential that one be able to capture common policy shocks to understand how individual countries—and the aggregate—will behave in the new setting.

III. DIFFERENCES IN THE TRANSMISSION MECHANISM OR MONETARY POLICY REACTION FUNCTION?

A. Identification of Monetary Policy Shocks

The theoretical discussion from the previous section allows us to derive the monetary authorities' responses to (random and exogenous) shocks (e.g., to prices) and to measure the effect of these actions on GDP and prices. The purpose of this section is to try to compare empirically the effects of monetary policy on GDP (and the CPI) across countries in the euro area. This involves the identification of changes in monetary policy and, in a second stage, the estimation of its impact on other variables. However, as pointed out in Christiano, Eichenbaum, and Evans (1998), it is important to avoid focusing exclusively on the actions of policy-makers (i.e., observed changes in interest rates) to identify changes in monetary policy, since these may reflect endogenous responses (i.e., reactions) of policy-makers to nonmonetary developments in the economy, and not changes in monetary policy per se. Instead, the task is to identify purely exogenous shocks and examine how these affect interest rates, and thus GDP and prices.

Consider a monetary policy reaction function that translates information in Ω_t into changes in the instrument R_t. The function $f(\Omega_t)$ is linear and Ω_t and ξ_t, the policy shocks, are assumed to be orthogonal:

$$R_t = f(\Omega_t) + \xi_t$$

One interpretation of $f(\Omega_t)$ and Ω_t , as elaborated by Christiano, Eichenbaum, and Evans (1998) is that they represent the central bank's feedback rule and information set, which includes, for example, past and contemporaneous information on prices and economic activity. The vector ξ_t , on the other hand, can be interpreted as representing exogenous shocks. In order to measure the effects of monetary policy shocks or surprises that are purely unanticipated—or uncontaminated by co-movements in interest rates, GDP, or the CPI that originate elsewhere—it is necessary to define the vector of policy shocks ξ_t. The standard approach, which is also followed here, is to make enough identifying assumptions— including assumptions about the nature of interaction of the policy shock with the variables in the feedback rule—so as to estimate the central bank's reaction function or feedback rule.

The econometric methodology in this case assumes that the structural model of the economy is given by:

$$A_0 z_t = \sum_{i=1}^{n} A_i z_{t-i} + \varepsilon_t$$

where z_t is an (n x 1) vector of endogenous variables and ε_t is the vector of structural disturbances.

Estimation of a (reduced form) VAR model,

$$C(L)z_t = u_t$$

with C(L) a matrix-polynomial in the lag operator, implies that the structural errors are related to the VAR errors by:

$$\varepsilon_t \equiv A_o u_t$$

Consequently, to derive impulse responses to autonomous (structural) shocks, the A_o matrix needs to be identified.

A standard model to analyze the effects of monetary policy shocks on GDP is one that includes real GDP, the price level (CPI), sometimes commodity prices, the short-term domestic interest rate, the effective exchange rate, and money or private sector credit. A Choleski decomposition based on the ordering of variables described above implies then that shocks to GDP in country i affect all variables in the same period but that none of the variables in the model affect GDP contemporaneously; the second variable (e.g., the CPI) is affected contemporaneously by the first variable only, and so on. This particular ordering, therefore—with GDP first, CPI second, and the interest rate ordered third—allows us to interpret the interest rate equation in the VAR system as a monetary policy reaction function, as it implies that interest rates react to contemporaneous movements in GDP and CPI. Therefore, monetary shocks are defined as changes in interest rates not explained by these variables (and the other lagged variables in the system).[5]

The model is estimated in (log) levels for a number of reasons. First, cointegration tests reveal the existence of at least one cointegrating vector among the variables. In light of this cointegration, the system's dynamics can be estimated consistently (Sims, Stock, and Watson, 1990; and Hamilton, 1994). Second, estimating a model in first differences alone when cointegration exists discards the information contained in the levels and leads to model misspecification (Ericsson, 1997), and imposing inappropriate cointegrating relationships may bias impulse responses from the reduced form VAR (Ramaswamy and Sloek, 1998). Furthermore, as noted by Ramaswamy and Sloek (1998), there is an economic rationale for estimating the model based on the effect of interest rates on output in levels, rather than first differences. First difference models imply that changes in interest rates have a permanent effect

[5] See, for example, Christiano, Eichenbaum, and Evans (1996); Barran, Coudert and Mojon (1996); and Ramaswamy and Sloek (1998).

on output, while a model in levels allows the past historical relationship to reveal the long-run impact of interest rate shocks.[6]

B. The "Off-the-Shelf" Model and the Role of Individual Countries' Reaction Functions

We first estimate a simple, standard model for each country with $z_t^i = (y_t^i, p_t^i, R_t^i, e_t^i, cre_t^i)$, where the subscript i refers to country i, y is the (natural) log of GDP, p is the log of the consumer price index, R the short-term interest rate, e is the log of the effective exchange rate, and *cre* is the log of private sector credit. The model is estimated for each country over the period 1983:1-1998:4, as a number of earlier studies indicate structural breaks in the early 1980s (Ehrmann, 1998; Juselius, 1998).[7]

The derived impulse responses, shown by the solid lines in Figure 1, indicate that the real effects of a monetary shock—i.e., the effects on real activity—vary considerably across countries. (The impulse response functions show the effects over 20 quarters of a unit shock in the interest rate in period 1.) In Austria, Germany, and the Netherlands, monetary shocks appear to have a strong effect on output.[8] In Finland and Spain, on the other hand, the effects are extremely weak, while they are moderate in Belgium, France, Italy, and Portugal.

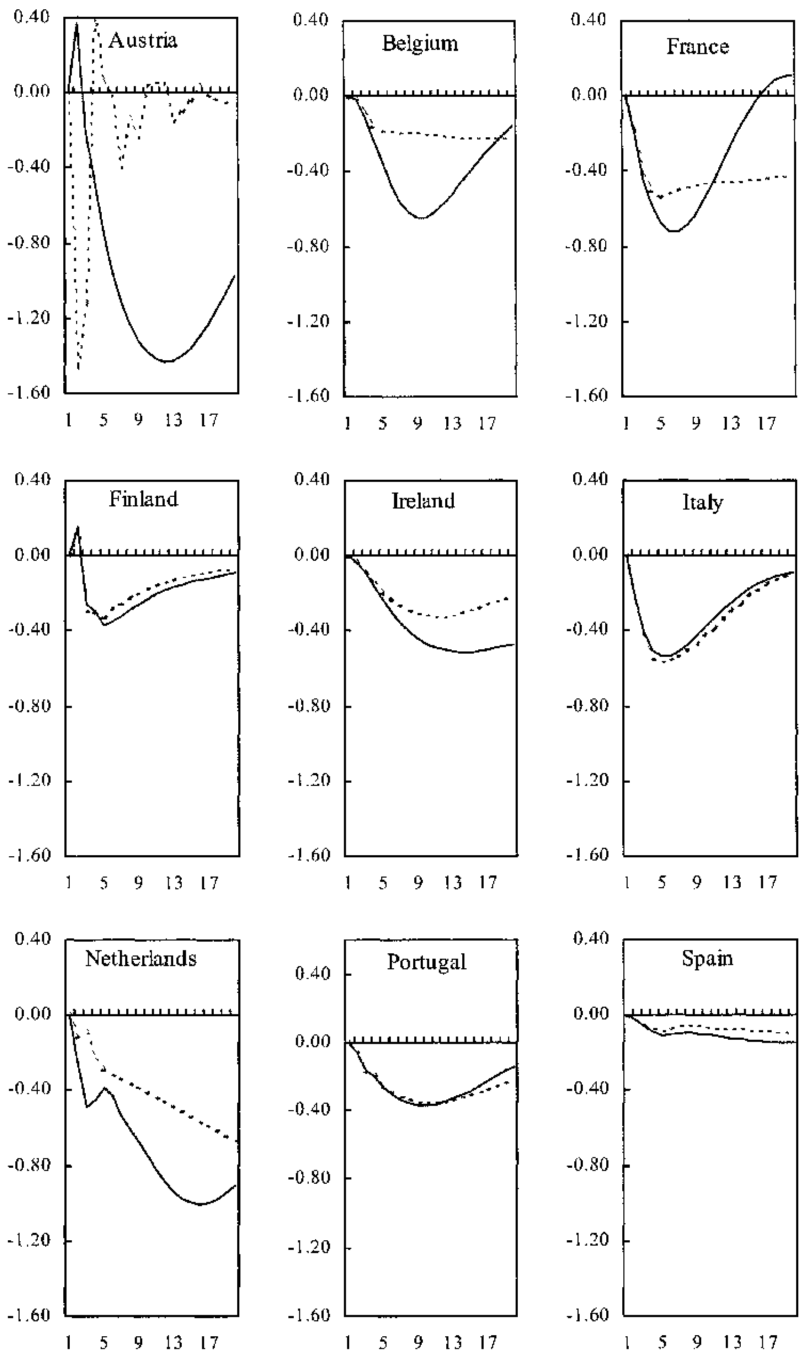
It is perhaps not a coincidence that the countries that appear to be affected more strongly by innovations in monetary policy are those that had been closely following German monetary policy in the ERM. Interestingly, the effect of monetary innovations on output in individual countries also appears to be related to the persistence of such innovations in the interest rates. Figure 2 compares the persistence of monetary shocks in each country—as measured by the impulse response of the domestic interest rate to a unit shock in that variable—and contrasts that with the average persistence for the euro area (shown by the dotted lines in Figure 2). This measures the extent to which a change in the stance of monetary policy is sustained for a period long enough to ensure that the target of monetary policy is realized. In countries where monetary policy was more closely aligned to German monetary policy—Austria, the Netherlands, and Belgium—the interest rate shock is persistent and the

[6] Log level variables were utilized in the studies of Sims (1992); Christiano, Eichenbaum, and Evans (1996); Leeper, Sims and Zha (1996); Levy and Halikias (1997); Halikias and Levy (1996, 1997); Ramaswamy and Sloek (1998); Gaiotti (1999); and Kim (1999).

[7] Two lags are included for each variable—with the exception of Germany and the Netherlands—as Schwartz or Akaike Information Criteria indicated that longer lag periods are not justified. In Germany and Finland, dummy variables were added to control for the effects of German unification and the breakup of the Former Soviet Union (see Appendix for details).

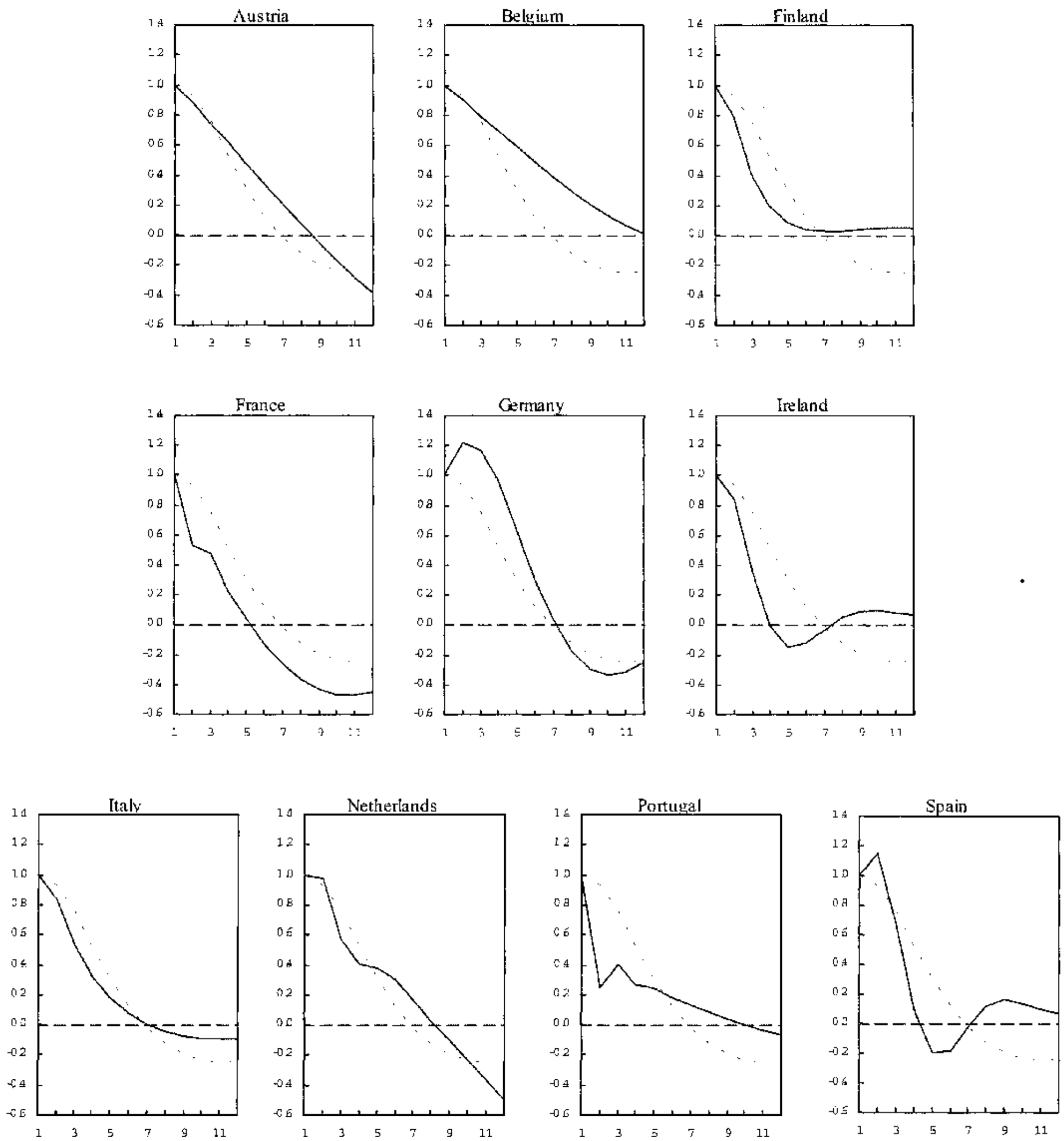
[8] The difficulties in appropriately capturing the effects of German unification (attempted here by the inclusion of the appropriate dummies) probably affect (weaken) the statistical significance of the results for Germany.

Figure 1. Pre-EMU Model: Impact on GDP of Unit Monetary Shock 1/
(percent deviation from baseline, by quarter)



Source: Staff estimates.
1/ Solid lines obtained using the "off-the-shelf" standard VAR specification; dotted lines show response of GDP when German interest rate is used to identify (country) idiosyncratic monetary shocks.

Figure 2. Pre-EMU: Persistence of Interest Rate Shocks 1/
(level of interest rate, by quarter, after shock in period one)



Source: Staff estimates.
1/ Dotted lines show the euro-area average.

path is similar to that in Germany. In the second group of countries, interest rate shocks appear to die out quickly.[9] In addition to the issue of persistence discussed above, the short-run impact of monetary policy on output is also related to the "credibility" of the central bank. It could be argued that if agents know that the monetary authority is credible, they will adjust prices quickly, thereby reducing disinflation costs. On these grounds, one would expect that the impact on GDP would be higher in countries where monetary policy is less credible. One problem with this argument, however, is that the credibility of the monetary authorities (or the lack thereof) is, in part, reflected in the identified monetary policy "shocks" themselves.[10] The impulse response functions captured in Figure 2 are based on the "observed" monetary shocks in different countries, and the lack of "credibility" may, in this case, reflect the quick reversal of the monetary stance, independent of the success achieved in controlling prices.[11,12]

This intuition may be further illustrated by looking at the idiosyncratic part of monetary policy in those countries that were more closely aligned with Germany. Country idiosyncratic monetary shocks are those interest rate movements that cannot be explained by contemporaneous changes in CPI or GDP (or by lagged information from the system) and changes in German monetary policy. To identify these idiosyncratic shocks, it is first necessary to add German interest rates as an exogenous variable to each ERM country's interest rate and exchange rate equations. The impact of idiosyncratic shocks on real output, shown by the dotted lines in Figure 1, is striking. The results indicate much smaller variance in the response of output to monetary policy, and lend credence to the view that the differences in the real effects of monetary policy in the pre-EMU era were due, in part, to how closely countries followed the more persistent path of monetary policy of the Bundesbank.

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[9] Results were largely similar when we used an alternative ordering scheme (GDP-prices-exchange rate-interest rate-credit).

[10] These shocks are essentially the unexpected changes in the instrument, and could have been generated by an unanticipated change in policy not unrelated, for example, to the lack of credibility (e.g., the lack of credibility forces a central bank to abandon an exchange rate peg and its anti-inflation program).

[11] For example, in a country with "noncredible" monetary policy, the optimal behavior for agents who knew that the tightening would not last long could be to avoid any adjustment, thus with no effect on GDP.

[12] The differences in the persistence of monetary shocks in the pre-EMU era might be explained by different relative weights that monetary authorities attached to inflation and output, as discussed in the first section.

C. A Single Monetary Policy: The Model for EMU

Although the addition of the German interest rate (as an exogenous variable) allows for a more accurate identification of monetary shocks, it does not provide a direct way to analyze the overall impact on euro-area GDP and prices. This implies that this model is of limited use for measuring the effect of monetary policy across the countries in EMU. To estimate such a model, it is necessary to (i) estimate and simulate a "common" interest rate reaction function, and (ii) exclude from each country's model the exchange rate equation, since under EMU the extra-EMU exchange rate is determined at the euro-area level (and intra-EMU variations are completely eliminated). The impulse response obtained for each country, under these constraints, can be aggregated to provide a meaningful representation of the impulse response for the aggregate euro area.

To estimate a "common" interest rate reaction function, that is, one determining monetary policy for the euro area as a whole, this paper builds on Halikias and Levy (1996, 1997), taking the German interest rate as a proxy for the common rate and distinguishing between shocks to the German rate and to the interest rate differential of each country vis-à-vis the German rate. This approach allows one to model the common monetary policy as endogenous and generate impulse responses to innovations to the common policy. The model in this paper, therefore, improves upon Halikias and Levy (1996, 1997) in two main respects: (1) it introduces a two-block structure that ensures that the endogenous common monetary policy is exactly the same for every country studied; and (2) it fixes the intra-euro-area exchange rate to take into account the irrevocable locking of exchange rates that took place in January 1999. Additional details regarding the model can be found in the Appendix.

This two-block model provides a flexible framework for studying a number of issues related to the effects of a common monetary policy under EMU. This is particularly the case because the pre-EMU models, which allow for flexible exchange rate responses to monetary policy shocks, cannot be used to provide a measure for the aggregate euro-area impact. This is simply due to the fact that such an aggregation would entail a restriction in terms of intra-euro-area exchange rate movements—that is, an appreciation in one country would have to be matched by a depreciation in another currency. Ignoring this restriction could exaggerate the impact of monetary policy on prices for the euro area via the exchange rate channel. To measure the costs to individual countries of relinquishing their exchange rate, the EMU model is re-estimated allowing the intra-EMU exchange rate to be determined freely in the model. Although exchange rate variability had diminished considerably prior to the beginning of Stage-III of EMU, Table 1 shows that intra-EMU effective exchange rates continued to fluctuate considerably during the 1990s (e.g., in France, Italy, and Spain).

The effects of monetary policy for the euro area

How effective is monetary policy at controlling prices at the euro-area level? To answer this question, the models for each country are estimated and the responses aggregated to obtain a euro-area response to a common monetary shock.[13] Figure 3 shows the response of the euro-area CPI to a common monetary and to an exchange rate shock in the first two panels. It also shows the effects of a monetary policy shock on euro-area aggregate GDP in the last panel. The EMU model refers to the responses based on the two-block model that simulated EMU by assuming a common monetary policy reaction function and fixed intra euro-area exchange rates.

As a result of a unit increase in the euro-area interest rate under EMU, inflation rises somewhat and starts to decline very slowly only after 7-8 quarters. Sluggish price responses to monetary policy appear to be a common finding in similar models for the USA (e.g., Christiano, Eichenbaum, and Evans, 1996, and Bernanke and Gertler, 1995). In contrast, GDP declines significantly, with a unit increase in the interest rate resulting in a 1 percent decline in GDP after 7 quarters. This is rather strong when compared with estimates provided by the ECB (based on aggregate euro-area data), which suggest that a unit increase in the interest rate leads to a ¾ percentage point decline in GDP after 5 quarters (Figure 3).

How do countries share the costs of a "one-size-fits-all" monetary policy?

The results reveal heterogeneous responses of real output to a common policy shock (Table 2, and solid line in Figure 4). The effect of a 1 percentage point increase in interest rates on real GDP some 8 quarters after the initial shock varies from a negligible effect in Portugal to minus 2 percent in France, with an average response of about 1 percent below the baseline. In most countries, the peak response occurs between 6 and 8 quarters after the initial shock, although output responds with a considerable lag in Ireland, the Netherlands, and Portugal.[14]

Figure 4, which compares the response of GDP based on the EMU model (but with a specification that allows intra-euro-area exchange rates to change) also confirms the notion that for some countries (most notably France and Germany), the fixed intra-member exchange rates of EMU make it costlier to adjust to a common shock. The case of Germany is striking, as it reveals that the appreciation of the DM vis-à-vis the other euro-area countries (in response to a monetary tightening) has a positive effect on GDP through its dampening effect on prices. These differences would suggest that a single monetary policy may impose significant costs countries for which the exchange rate channel of the monetary transmission mechanism was important (e.g., Germany as seen in Figure 4; see also the discussion by Jahnke and Reimers, 1995, for example). In addition, costs could be significant for smaller countries that are not fully synchronized (in terms of their business cycles) with the core euro-area countries: the higher persistence of monetary policy implies long episodes of tightening (loosening) with few reversals in the stance of monetary policy.

[13] The weights were constructed using 1999 GDP numbers for these euro-area countries.

[14] Asymptotic standard errors are not reported, given the difficulty of computing these for over-identified systems.

Table 1. Intra Euro-Area Effective Exchange Rate Volatility
(percent, quarter-on-quarter)

	1979-89	1990-99	1995-99	1979-99
Austria	0.48	0.15	-0.03	0.32
Belgium	-0.25	0.15	-0.05	-0.06
Finland	0.22	-0.55	0.02	-0.15
France	-0.36	0.28	0.09	-0.06
Germany	0.69	0.21	-0.07	0.46
Ireland	-0.31	-0.03	0.10	-0.17
Italy	-0.72	-0.70	0.17	-0.71
Luxembourg	-0.21	0.05	-0.04	-0.08
The Netherlands	0.38	0.11	-0.07	0.25
Portugal	-2.10	-0.13	-0.03	-1.15
Spain	-0.51	-0.56	-0.15	-0.53

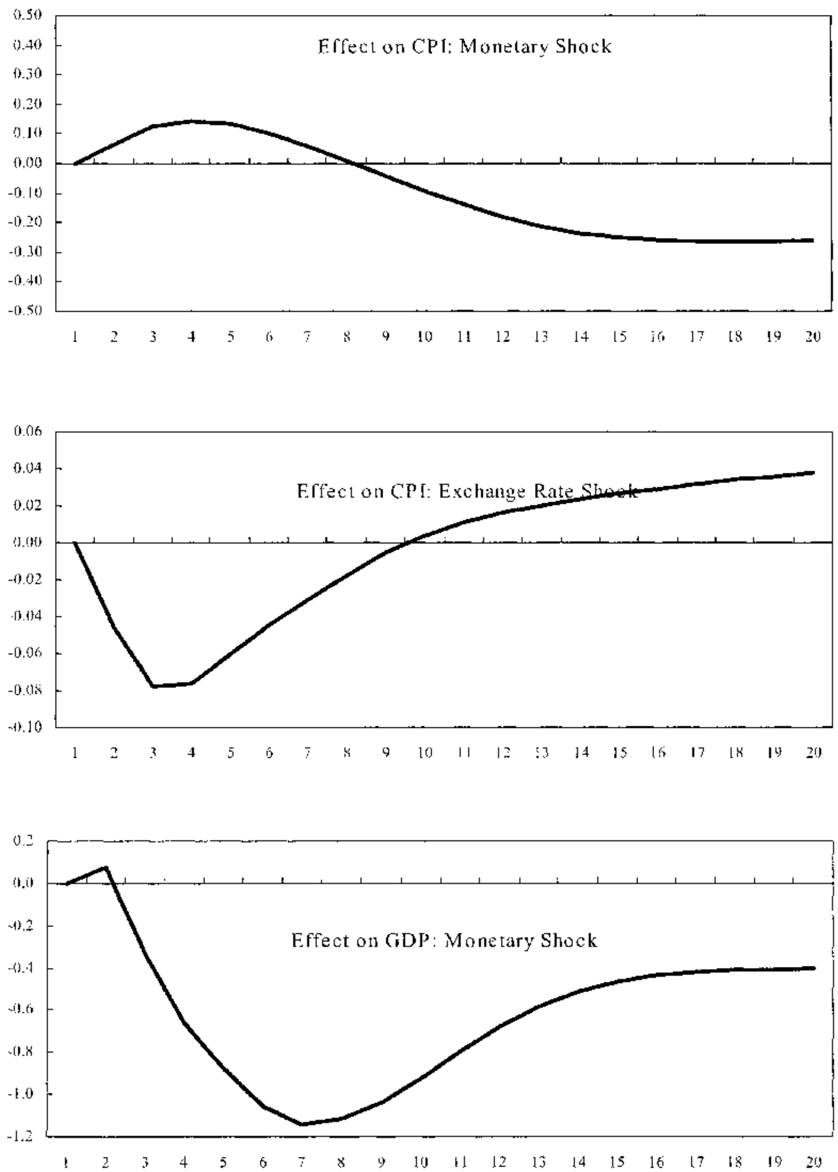
Table 2. Effect on Real GDP (Percent Deviation from Baseline) of a Unit Change in Interest Rate Under EMU

	6 qtrs.	8 qtrs.	12 qtrs.	Max effect over 20 periods (% deviation from baseline)	Time of Max effect (quarters)
Austria	-1.0	-0.9	-0.2	-1.0	7
Belgium	-1.2	-1.4	-0.6	-1.4	8
Finland	-1.5	-1.7	-0.9	-1.7	7
France	-1.9	-2.2	-1.6	-2.2	8
Germany	-0.8	-0.6	-0.3	-0.8	6
Ireland	-0.4	-0.9	-0.3	-1.2	11
Italy	-1.1	-1.1	-1.1	-1.1	6
The Netherlands	-0.2	-0.3	-0.7	-1.1	20
Portugal	0.3	0.1	-0.3	-0.3	15
Spain	-0.8	-1.2	-1.0	-1.3	20
Euro Area 1/	**-1.1**	**-1.1**	**-0.8**	**-1.3**	**8.9**

1/Weighted average based on 1999 GDP.

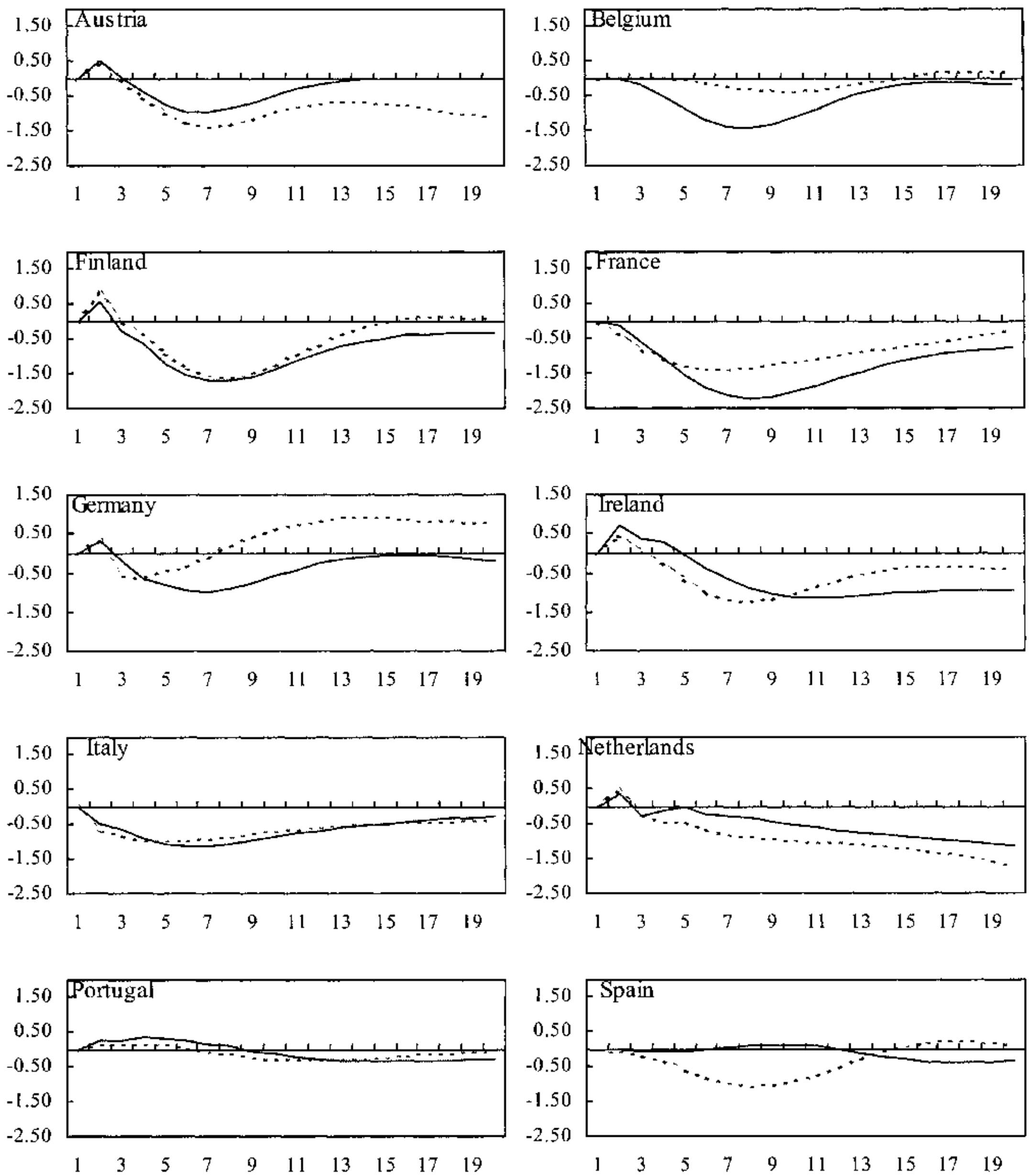
Figure 3. Euro Area: Effect on CPI and GDP of Monetary and Exchange Rate Shocks under EMU

(percent deviation from baseline, by quarter)



Source: Staff estimates.

Figure 4. EMU Model: Effect on GDP with Fixed/Flexible Intra-EMU Exchange Rate 1/
(percent deviation from baseline, by quarter)



Source: Staff estimates.
1/ Dashed lines: flexible intra-EMU exchange rate, solid lines: EMU (2-block) model.

These results suggest that the differences in the response of GDP in individual countries to a common monetary shock should be taken into account when judging the effects of monetary policy on euro-area-wide GDP for yet another reason. They indicate that the transmission mechanism, evidenced by the different responses of GDP to a common shock, is likely to be different across euro-area countries. Hence, a simple aggregation may not be the best solution to measuring the effect on monetary policy at the euro-area level.[15]

IV. WHAT EXPLAINS DIFFERENCES IN THE TRANSMISSION MECHANISMS UNDER EMU?

The previous section showed that the large pre-EMU/EMU differences in the potency of monetary policy can be explained partly by differences in the monetary policy reaction functions during the pre-EMU period. Controlling for these heterogeneous reaction functions allowed us to disentangle differences across countries that are purely the result of differences in the transmission mechanisms. In this section, we attempt to disaggregate the differences in the transmission mechanism due to the credit, exchange rate, and interest rate channels, and attempt to link the strength of these channels with the heterogeneous economic and financial characteristics of differing EMU economies. In recent years, a number of channels through which monetary policy may be transmitted have been identified and their operation described (e.g., Mishkin, 1996). This section provides a short description of the so-called credit, exchange rate, and interest rate channels; discusses the factors that might influence the potency of these channels across euro countries; and compares these characteristics of countries predicting the strength of these channels with the empirical results.

Using the EMU model, we disentangle the strength of each channel by estimating the difference in the response of output to a monetary policy shock when each channels is closed.[16] This method, which follows Morsink and Bayoumi (1999), involves re-estimating the post-EMU model with the variable in question treated as exogenous. With respect to the credit channel, for example, we eliminate the equation for credit, while maintaining lagged values of credit in each of the equations in the domestic block. The contribution of the exchange rate channel is estimated in a similar fashion.

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[15] Ciccarelli and Rebucci (2000) also examine the possibility of asymmetries in the transmission mechanism of monetary policy in Europe using a heterogeneous panel approach.

[16] The interest rate channel is treated as a residual; thus, the output response that cannot be attributed to the credit and exchange rate channels is assumed to be derived from the interest rate channel.

The credit channel

Monetary policy can affect output through its effects on credit.[17] According to advocates of the "credit view," monetary policy has a strong effect on the supply of credit by affecting banks' ability to provide loans to firms (the "supply effect"). Tighter monetary policy is seen as resulting in lower bank reserves, thus reducing the ability of banks to lend. The strength of this effect depends on the health of the banking system and the degree to which it can react to policy changes. Bank size determines differences in financing ability, with larger and more profitable banks having access to alternative financing mechanisms. However, the importance of the credit channel also depends on the extent to which a decline in credit has an effect on GDP growth—the "dependency effect." In this respect, the availability of other means of financing is crucial. Clearly the depth of the financial system and the ability of households and firms to raise capital have a bearing on the effectiveness of monetary policy. For example, smaller firms, which rely more on bank credit than larger ones and have more limited access to external funds, could be expected to be more affected by an increase in interest rates (Gertler and Gilchrist, 1993, 1994; Bernanke, Gertler, and Gilchrist, 1996).[18] Consequently, regional/country differences in the proportion of large and small firms and the sources of credit available to each could lead to different regional responses to monetary policy.

Figure 5 provides the empirical results from our test for the existence of the credit channel, where the output response to a monetary policy shock is measured both with and without an endogenous credit response.[19] The results suggest that such a channel is present in all the countries but Finland, Ireland, and Italy. The credit channel appears to be particularly strong in the Netherlands, where it explains the entire response of output to an interest rate shock, but also in Belgium, France, and Spain. While undoubtedly a significant aspect of the monetary transmission mechanism, what is most striking in many countries is the fact that the credit channel accounts for but a modest share of the total output response to monetary policy changes, particularly in the short run. Its contribution is more noteworthy over the longer term, where its principal contribution appears to be that of extending the effect of a monetary shock on output, rather than deepening the output response. This appears to be due to the rather slow

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[17] See Cecchetti (1999) for an excellent analysis of the credit channel.

[18] Monetary shocks can also be transmitted through the so-called balance-sheet channel. The operation of this channel is based on the asymmetric information that characterizes loan markets and the role of collateral. When interest rates rise, the value of collateral declines, which may prompt banks to reduce their exposure to firms. The problem can be particularly important for small firms, which rely more on collateral, given the higher relative cost (to banks) of screening and monitoring per unit of credit.

[19] As with results for the exchange rate channel (Figure 6), the estimates for Germany were estimated over the period 1979:2-1998:4, and were based on a model where the German block was estimated alone.

reaction of credit in response to changes in interest rates, rather than to the lagged reaction of output to changes in credit.

As indicated in our earlier discussion on supply and dependency effects, the overall strength of the credit channel depends on both the responsiveness of credit to changes in interest rates and the impact of changes in credit on output.[20] The results relating to the latter point to strong responses in France, the Netherlands, and, to a lesser extent, Austria and Belgium (bottom panel of Table 3). This is consistent with the results in Figure 5, which show that a strong credit channel exists in France, the Netherlands, Spain and Belgium.[21] The last two countries' strong response, although not explained entirely by the strong elasticity of GDP with respect to credit, is accounted for by the healthy response of credit to monetary policy shocks (top panel of Table 3).[22] An attempt to explain these differences based on the financial market characteristics of these countries met little success (see Appendix for more discussion). In particular, none of the characteristics analyzed here—the (lack of) depth of the financial system, (excessive) reliance of bank finance, and high level of corporate debt (Appendix Table 6)—can tell a convincing story that explains the strength of the dependency effect in the Netherlands, France, Belgium, and Spain. As far as explaining the apparent strength of the supply effect, only the relatively low bank profitability in Belgium and France can provide some explanation about the stronger reaction (i.e., decline) of credit in response to a monetary tightening. Notice, however, that although credit shocks appear to be unimportant in explaining output fluctuations in some countries (e.g., Portugal), this could reflect the fact that the rapid credit growth of recent years has financed a boom in consumer durables and housing—accompanied by a rising current account deficit—rather than a notable surge in growth above its historical average.

For the euro area as a whole, Table 3 shows that monetary policy does have a significant effect in restricting credit in the euro area; a unit increase in the interest rate leads to a 1.3 percent decline in credit. An exogenous decline in credit, on the other hand, has a relatively small effect on GDP.

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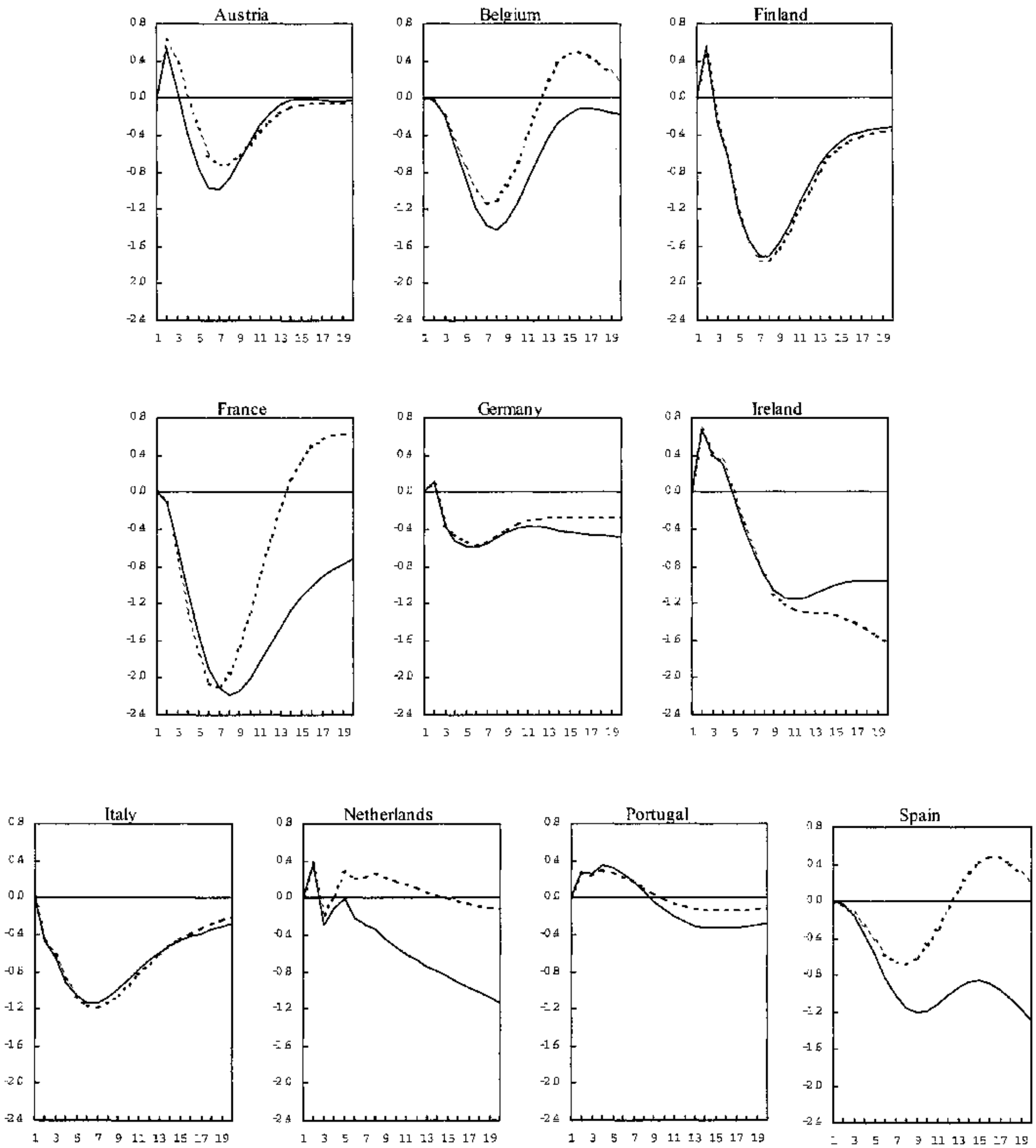
[20] The change in credit attributed to demand effects is captured by lagged and contemporaneous changes in GDP. Thus, orthogonal shocks to credit can be considered as shocks to credit supply, rather than credit demand.

[21] Differences in financial sectors across countries (Appendix Tables 4-7) were not well correlated with our empirical assessments of the strength of the credit channel.

[22] Changes in credit, resulting from a monetary shock, can also be propagated by demand effects (both with respect to income and the interest rate) rather than supply effects (i.e., lower supply of credit by financial institutions), which our model fails to identify.

Figure 5. Response of GDP to a Unit Shock to Interest Rate under EMU with Credit Channel Closed 1/

(percent deviation from baseline, by quarter)



Source: Staff estimates.

1/ Dotted lines show impulse response with credit channel closed.

Table 3. Monetary, Credit, and Exchange Rate Shocks Under EMU 1/

	Monetary Policy Shock		
Effect On:	Euro-Zone Effective Exchange Rate	Country-Specific Effective Exchange Rate 2/	Credit
Austria	0.6	0.46	-0.2
Belgium	0.6	0.46	- 2.2
Finland	0.6	0.78	-4.8
France	0.6	0.58	-2.1
Germany	0.6	0.67	-0.7
Ireland	0.6	0.81	-1.0
Italy	0.6	0.62	-1.1
The Netherlands	0.6	0.57	-2.2
Portugal	0.6	0.37	-1.3
Spain 3/	0.6	0.50	-3.5
Euro Area*	**0.6**	**0.60**	**-1.6**
	Effect on Output		
	Euro-Zone Effective Exchange Rate 4/	Country-Specific Effective Exchange Rate 4/	Credit Shock
Austria	0.2	--	0.3
Belgium	0.0	--	0.3
Finland	-0.3	--	0.0
France	-0.3	--	0.9
Germany	0.0	--	0.2
Ireland	-0.4	--	-0.1
Italy	0.0	--	0.1
The Netherlands	-0.3	--	0.4
Portugal	0.0	--	0.2
Spain	0.0	--	0.2
Euro Area*	**-0.1**		**0.4**

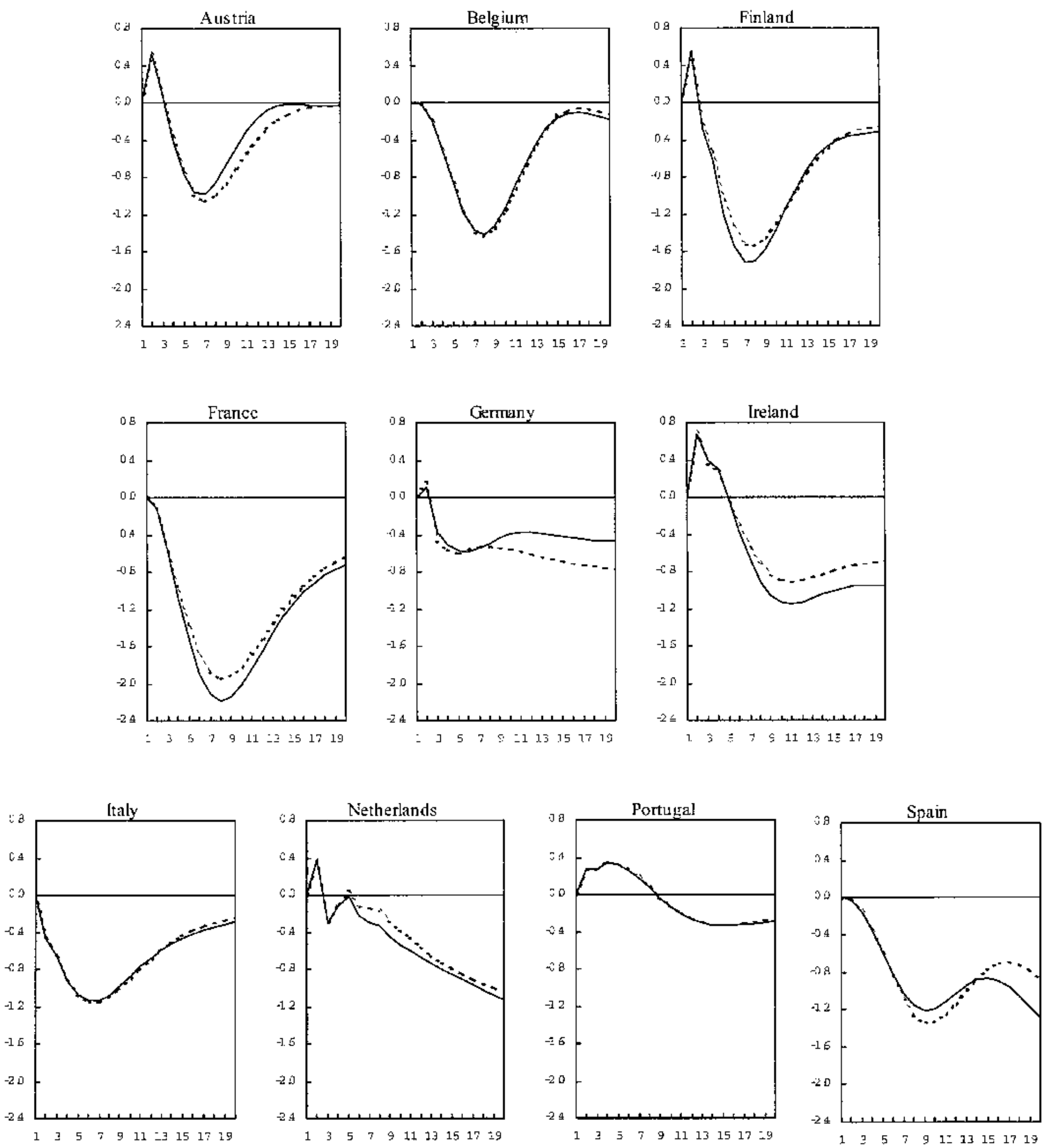
Source: Staff estimates.

*Weighted averages.

1/ Minimum or maximum effect of unit shock after 6-12 quarters. The effect is measured in terms of percent deviation from baseline.
2/ Calculated by multiplying the effect on the euro-zone effective exchange rate with the relative (to the euro-zone average) share of extra-euro-area trade for 1999.
3/ The estimate for Spain was different for the euro-zone effective exchange rate (not shown here), as the Spanish model is estimated over a different time period than the other countries.
4/ According to the model's specification, shocks to the euro-zone-effective exchange rate translate into changes in GDP through their effect on the country-specific exchange rate. This, in turn, is affected by the share of trade outside the euro zone (see text).

Figure 6. Response of GDP to a Unit Shock to Interest Rate under EMU with Exchange Rate Channel Closed 1/

(percent deviation from baseline, by quarter)



Source: Staff estimates.

1/ Dotted lines show impulse response with exchange rate channel closed.

The exchange rate channel

Also of interest is an examination of the exchange rate channel. Exchange rate fluctuations can have an important impact on output in an open economy. Thus, the exchange rate, to the extent that it is affected by monetary policy actions, can be an important transmission channel. A rise in domestic interest rates is likely to trigger an appreciation of the domestic currency, which in turn may result in a fall in net exports and output. The strength of the exchange rate channel in a given country thus depends on the responsiveness of the exchange rate to monetary shocks, as well as the openness of the country (a measure that shows how much a country exports relative to its GDP) and the sensitivity of exports to exchange rate variations (i.e., how much import demand is stimulated in partner countries by price movements).

Figure 6, which shows the response of GDP to a monetary shock muting the exchange rate channel, suggests that the importance of this linkage is relatively small under EMU—not a totally unexpected result, given the reduction in openness under monetary union. Countries where a noticeable—albeit still very weak—channel continues to exist are Finland, Ireland, and Netherlands, as expected based on their openness.[23] Overall, a ranking of the responses does accord quite well with our priors based on measures of openness and export price sensitivity. Specifically, the correlation coefficient between an exchange rate sensitivity index (i.e., a composite index of price sensitivity and openness for non-euro-area trade; see the Appendix for details on the derivation of this index) and the maximum output response over the period of 6-12 quarters are .46 and .64, if Belgium is excluded from the calculation. The culprit in the weak responses in many countries lies with the anemic reaction of output to changes in the effective exchange rate (Table 3).[24]

These results underscore the fact that a common shock to the euro will translate into different changes in effective exchange rates across countries, given the substantial variations in extra-EMU trade. For example, based on trade data for 1999, a 10 percent depreciation of the EMU-wide effective exchange rate would lead to an effective devaluation of over 13 percent in Finland and Ireland, and 7 percent in Portugal. These differential effects on the effective exchange rates of a 1 percent monetary shock are shown in Table 3. The aggregated euro-area effect shows that a 10 percent appreciation of the euro effective exchange rate will lead to a 1

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[23] These results are in line with recent estimates by Coutinho (2000), who finds the impact of a change in the effective exchange rate in the euro would lead to the strongest effects on the trade balance in the Netherlands, Ireland, France, and Finland, with a much weaker effect in Portugal and Italy.

[24] Barran, Coudert and Mojon (1996), using a pre-EMU model and data from 1976-94, also failed to find an exchange rate channel. They argue that restrictive fiscal policy—often implemented in the wake of a depreciation—countered the expansionary effects of devaluation on output.

percent decline in euro-area GDP. This is within the range of estimates provided by large models.

Where we cannot account fully for differences across countries with the credit or exchange rate channel, we infer that the interest channel explains the rest. The traditional or so-called interest rate channel works through changes in investment. A monetary tightening raises the cost of capital and leads to a decline in investment. The result is lower aggregate demand and output. In addition, an increase in the interest rate could affect aggregate demand through changes in consumption. For a borrower, a higher interest rate would result in lower consumption today. A lender may, on the other hand, postpone some part of consumption for the future, although it is sometimes argued that if the income effect is strong, consumption could, in this case, rise. The effect on investment and consumer spending should be relatively swift, as an increase in the short-term interest rate leads to higher long interest rates and, given sticky prices, to higher real interest rates.

Our empirical results suggest that the lion's share of the differences in the strength of monetary policy across countries relates to the interest rate channel. Between 8 and 12 quarters—the period of peak output response in most countries—the interest channel in most countries accounts for about 80 percent of the effects of monetary policy. Thus, while the credit channel appears important in a few countries, the overarching importance of differences in the strength of the interest rate channel—which is unlikely to melt away as financial integration proceeds apace—should not be forgotten.

V. Summary and Conclusions

The theoretical and empirical results presented in this paper suggest that EMU will alter the monetary transmission mechanism in a number of ways. The heterogeneous response to monetary policy shocks during the pre-EMU period reflected, in part, differences in reaction functions across countries and the relative importance countries attached to achieving low inflation. Under EMU, inflation is likely to assume a more prominent role in the ECB's objective function than it had for many countries during the ERM period; for some countries—in particular, France, Italy, Ireland, and Finland—the average policy shock will be of greater duration, with a concomitantly stronger effect on output.

Nevertheless, even when a common monetary policy is implemented, its effects on economic activity are likely to differ somewhat across EMU countries. Monetary policy exerts the most powerful effect on output in France and Finland, while the output responses of Portugal and the Netherlands are among the weakest. The timing and depth of the response to interest rate shocks varies markedly by country, suggesting that, in the absence of other offsetting policies (e.g., fiscal), a common monetary policy could still further exacerbate divergences in cyclical positions. Our theoretical model indicates that these difficulties are likely to be especially acute for smaller countries with relatively little weight in euro-area aggregate economic activity and for countries where output responds sharply to monetary policy (e.g., Belgium, Finland). This suggests that the role of fiscal policy may take on greater prominence in these countries than in the larger EMU countries where the transmission mechanism's strength is close to the average (e.g., Italy). The results also suggest that the impact of monetary policy on euro-area consumer prices will be modest under EMU.

The assessment of the reasons behind differences in the strength of the transmission mechanism revealed that the interest rate channel was by far the dominant factor, easily overshadowing the effects of the exchange and credit channels in most countries. Many of the theoretical and empirical guideposts for assessing where these channels would be the strongest do not appear to be borne out in our empirical results, although a more detailed cross-country study may help shed more light on this issue. As such, it is difficult to ascertain how the rapidly changing financial landscape in Europe will alter the transmission mechanism. Nevertheless, our empirical work suggests that these efforts should focus on the factors driving differences in the interest rate channel, given that the impact of the credit and exchange rate channels pales in comparison.

These conclusions have implications for candidate countries. In particular, the costs of adopting the euro for countries with similar monetary frameworks currently outside the area are likely to be considerably smaller than previously thought. The paper shows how important the monetary policy framework is in determining the effects of monetary policy on the overall economy.

The Basic EMU Model

To estimate a "common" interest rate reaction function, that is, one determining monetary policy for the euro area as a whole, this paper estimates a 2-block model with a common monetary policy set independently of developments in each country. The first block, specified by the first four equations and denoted with a superscript E, tries to capture the monetary policy reaction function of the ECB, which is proxied by German data.[25] Furthermore, note that in the pre-EMU model the interest rate can be expressed as the sum of the German interest rate and the differential vis-à-vis Germany, $R_t^i = R_t^{Ger} + (R_t^i - R_t^{Ger})$, while in a similar way the nominal effective exchange rate can be expressed as the sum of the intra-EMU and extra-EMU effective exchange rates, $e_t^i = w^{i,EMU} e_t^{i,EMU} + w^{i,XEMU} e_t^{i,XEMU}$. The "EMU model" for country i is then specified as follows:

$$\begin{pmatrix} y_t^E \\ p_t^E \\ R_t^E \\ e_t^E \\ y_t^i \\ p_t^i \\ cre_t^i \end{pmatrix} = \begin{pmatrix} b_{11}(L) & b_{12}(L) & b_{13}(L) & b_{14}(L) & 0 & 0 & 0 & 0 & 0 \\ b_{21}(L) & b_{22}(L) & b_{23}(L) & b_{24}(L) & 0 & 0 & 0 & 0 & 0 \\ b_{31}(L) & b_{32}(L) & b_{33}(L) & b_{34}(L) & 0 & 0 & 0 & 0 & 0 \\ b_{41}(L) & b_{42}(L) & b_{43}(L) & b_{44}(L) & 0 & 0 & 0 & 0 & b_{49}(L) \\ 0 & 0 & b_{53}(L) & b_{54}(L) & b_{55}(L) & b_{56}(L) & b_{57}(L) & b_{58}(L) & b_{59}(L) \\ 0 & 0 & b_{63}(L) & b_{64}(L) & b_{65}(L) & b_{66}(L) & b_{67}(L) & b_{68}(L) & b_{69}(L) \\ 0 & 0 & b_{73}(L) & b_{74}(L) & b_{75}(L) & b_{76}(L) & b_{77}(L) & b_{78}(L) & b_{79}(L) \end{pmatrix} \begin{pmatrix} y_{t-1}^E \\ p_{t-1}^E \\ R_{t-1}^E \\ e_{t-1}^E \\ y_{t-1}^i \\ p_{t-1}^i \\ cre_{t-1}^i \\ R_{t-1}^i - R_{t-1}^{EMU} \\ e_{t-1}^{i,EMU} \end{pmatrix} + u_t$$

and by including the interest rate differential $(R_t^i - R_t^{EMU})$ and the intra-EMU exchange rate ($e_t^{i,EMU}$) as exogenous variables, we can simulate the effects of monetary policy under EMU. The model essentially consists of a "common" interest rate reaction function[26] with a muted intra-EMU exchange rate.[27] The estimation captures the historical impact of a change in the interest rate on country *i's* GDP, as measured by the combined effect from the interest rate differential and the euro interest rate—proxied by the German interest rate—in country *i's* GDP equation and, more importantly, it allows us to simulate a common interest rate shock on GDP while keeping the interest rate differential fixed (exogenous). In a similar way, the addition of the intra- and extra-EMU effective exchange rates, in country *i's* GDP equation, allows us to

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[25] The German block excludes a variable for credit as the model yielded poor results for the 1983-98 period when this variable was included.

[26] The implied reaction function for Germany is well-behaved, with an exogenous shock to both GDP and the price level resulting in higher interest rates.

[27] This is achieved by modeling only the "euro" exchange rate (e^E) while dropping from the system the equation for country i's exchange rate.

capture the response of GDP to changes in the exchange rate and to simulate the effects of a change in the extra-EMU exchange rate under EMU. Consequently, in this framework impulse responses simulating the effect of a shock to the "euro" interest rate and changes in the extra-EMU effective exchange rate affect directly the GDP of euro-area countries.[28] A pseudo-recursive identification scheme is applied, which essentially keeps the "pre-EMU" triangular identification scheme for each country block. The identification scheme is given by:

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 & 0 & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \alpha_{65} & 1 & 0 \\ 0 & 0 & 0 & 0 & \alpha_{75} & \alpha_{76} & 1 \end{pmatrix} \begin{pmatrix} u_t^{y^{eu}} \\ u_t^{p^{eu}} \\ u_t^{i^{eu}} \\ u_t^{e^{eu}} \\ u_t^{y^{i}} \\ u_t^{p^{i}} \\ u_t^{ere^{i}} \end{pmatrix}$$

The contemporaneous value of the intra-EMU exchange rate is also included in the fourth equation, so as to ensure that changes in the effective exchange rate are limited to those common to all EMU countries, that is, the extra-EMU exchange rate. In the case of the Spanish model, a non-recursive identification scheme was necessary in the German block to achieve convergence. One weakness of this formulation is that it does not allow euro-area wide shocks to have an impact on interest rate policies (only German in this case), which could be somewhat problematic from the viewpoint of the largest economies.

To assess the robustness of the results, a non-recursive identification scheme was used that allowed interest rates and exchange rates to vary simultaneously. To keep the German block just-identified (in terms of the German variables in the model), the exchange rate was assumed to be contemporaneously uncorrelated with output shocks. The results were largely similar, with the difference in the output response compared with the baseline model no greater than 0.2 percentage points of GDP.

Data issues

Quarterly figures on real GDP are drawn from the *OECD Analytical Database*. In the case of Portugal, data are from the Bank of Portugal, and Italian data are derived from the Bank of Italy. In the case of Austria, real industrial production data from the *OECD Analytical Database* were used as the real output variable, rather than real GDP; and two dummy variables (one for 1994-98 and one for 1998) were used in the output equation to account for the declining ratio of value added in industrial production. In the case of Germany, two dummy variables were added to help control for the effects of German Unification: one dummy for the second quarter of 1990; and one dummy for the three quarters of 1990. In addition, a dummy for the price level equation

[28] The differential is, in effect, treated as an exogenous variable, as there is no equation for this variable in the VAR system. The lagged values of the differential are included in each equation.

alone for the first quarter of 1993 is used, to address the effect of the lifting of rent controls in East Germany. For Finland, a dummy variable was added to the output equation to control for the effect of the breakup of the Former Soviet Union for the period after 1990:4. Data on consumer prices, interest rates, bilateral and effective exchange rates, and credit to the private sector are drawn from *International Financial Statistics*. Data on private credit required some splicing to adjust for breaks in the series for Belgium, Ireland, the Netherlands, and Germany. Data were spliced by using the rate of growth of M1 to link together the series. For the Netherlands, central bank data on credit to the private sector (year-on-year growth rates) for 1998 were used to extend the IFS data on private sector credit. Data for real GDP, consumer prices, and credit were seasonally adjusted. All data, except for interest rates, were converted to log levels. Data cover the period 1983:98, with the exception of Germany (1979:2-1998) for the assessment of the credit and exchange rate channels, France (1983-98:2), and Spain (1986-98).

The credit channels indicators

Three broad characteristics of the financial system may explain the relative strength of the credit channel in different EU countries: the size and concentration of the banking sector; the health of the banking system; and the importance of alternative sources of finance (e.g., Cecchetti, 1999). These characteristics help explain the strength of the "supply" and "dependency" effects across the euro-area countries.

Toward this end, we first gauge the potency of the "supply effect" by looking at the strength of the banking system and the ability of banks to respond to changes in monetary policy. It is generally argued that bigger and more profitable banks are less affected by interest rate changes than smaller ones (Kashyap and Stein, 1997, 2000). A prevailing characteristic of the four largest economies (Appendix Table 4) in the euro area is a large number of credit institutions, both in absolute and per capita terms—this being the highest in Austria and Germany and lowest in the Netherlands.[29] In addition, in those countries with the largest number of banking institutions, concentration ratios and profitability are also, generally speaking, lower. Among these countries France is an exception, since its ranks as average in the number of credit institutions and concentration ratios but lowest in terms of banks' return on assets. An index measuring the strength of the supply of credit effect—based on a weighted average of the number of credit institutions per capita, the concentration ratio, and the return on assets—suggests that an increase in the interest rates should influence more strongly the ability of banks

[29] Attempting to draw conclusions about the strength of the credit channel by comparing the number of institutions across countries can be misleading without a more detailed analysis of the banking system. Ehrmann and Worms (2001), for example, argue that small banks in Germany have indirect access to the inter-bank market through the head institutions of their sectors. Thus, although the large number of credit institutions in Germany would suggest a strong supply effect of monetary policy (i.e., by restricting the ability of these smaller banks to lend), that is not actually the case. This would be consistent with the result reported in Table 3 of a weak supply effect for Germany.

to lend in France and Germany, with the weakest response expected in the Netherlands and Spain. Thus, with the exception of France, the empirical results appear to have little relationship to what one would expect based on the financial sectors characteristics of Appendix Table 4; in Germany, for instance, the response appears fairly tepid, while in Netherlands—where a weak response was projected—the empirical estimates indicate that loans expand briskly to interest rate shocks.

The second question is whether, and by how much, output is affected by restricting the available supply of credit through the "dependency effect." This depends on the ability of households and firms to find alternative sources of finance in the event of a decline in credit supply, on the size of firms, and the depth of the financial system. The results here are also difficult to explain based on indicators of the availability of alternative finance (Appendix Table 5). Of the two countries that display the highest responsiveness of GDP to credit shocks, France has a relatively high number of publicly traded firms and a smaller share of loans as a percent of GDP. In the Netherlands, on the other hand, the share of loans as a proportion of GDP is very high, and that country is characterized by a relatively active stock market. Corporate debt is relatively high in Belgium, France, and the Netherlands, but the differences between this group of countries and the rest are not large.

Appendix Table 4. Credit Institutions in EMU Countries

	No. of Credit Institutions	No. of institutions per capita	Share of Deposits in Assets	Concentration Ratio	Return on Assets
Austria	995	123.0	35.3	48.3	0.4
Belgium	134	13.4	43.7	57.0	0.35
Finland	371	72.1	44.2	77.8	0.6
France	1299	22.7	39.1	40.3	0.3
Germany	3578	43.7	35.3	16.7	0.5
Ireland	70	20.3	43.4	40.7	1.2
Italy	935	16.0	34.3	24.6	0.6
Netherlands	90	5.8	45.7	79.4	0.6
Portugal	235	23.0	55.1	76.0	1.1
Spain	416	10.6	56.4	43.6	1.05

Sources: Cecchetti (1999) and European Central Bank (2000).

Appendix Table 5. Capital Markets in EMU Countries

	Publicly Traded Firm: total	Publicly Traded Firm: per capita	Market Cap.	Corporate Debt (%GDP)	Loans (%GDP)
Austria	106	13.15	15	46	111.0
Belgium	139	13.68	45	60	89.1
Finland	71	13.87	50	34	58.5
France	686	11.75	38	49	78.4
Germany	681	8.32	29	58	130.8
Ireland	76	21.59	18	13	124.5
Italy	217	3.78	21	37	57.1
Netherlands	217	13.97	96	48	124
Portugal	158	16.11	23	19	78
Spain	357	9.09	42	11	79.6

Sources: Cecchetti (1999) and European Central Bank (2000).

Appendix Table 6. Indicators of Households' Equity and Indebtedness

	Household Indebtedness 1/	Mortgages as Percent of GDP	Share of Household Debt at Adjustable Interest Rates	Home Owner-Occupation Ratio
Austria		15		54
Belgium	0.41	27	18	55
Finland		17		62
France	0.51	31	13	45
Germany	0.78	51	36	36
Ireland		27		79
Italy	0.32	7	60	50
Netherlands	0.65	56		35
Portugal	0.74	39		67
Spain	0.58	25		78

Sources: BIS; ECB; OECD; Dornbusch et al (1998); and Fund staff estimates.

1/1994 total household liabilities as a fraction of disposable income (BIS); for Portugal, IMF staff estimates for end-1999 based on data from the Bank of Portugal.

Appendix Table 7. Financial and Sectoral Characteristics

	Share of Corporate Lending in Total		Of Which Short Term Maturity		Expected Impact 1/	Memo Items:		Sectoral Index
	Value	Rank	Value	Rank		Share of Small Firms 2/	Firms' Leverage 3/	Ratio 4/
Austria	69.4	1	36.6	4	Stronger			7.9
Belgium	46.4	8	35.5	6	Medium	55.2	58	7.2
Finland	39.6	9	19.4	10	Weaker	52.8		10.0
France	49	5	36.3	5	Medium	56.3	49	7.2
Germany	51.6	3	44.9	3	Medium	56.9	61	10.2
Ireland	51.1	4	28.1	9	Medium			8.0
Italy	65.6	2	50.3	2	Stronger	78.5	62	5.8
Netherlands	46.5	7	32.5	7	Medium	60.7	64	6.3
Portugal	46.9	6	62.3	1	Medium	79.4		8.3
Spain	35.7	10	39.5	10	Weaker	74.1	56	7.3

1/Classification based on average rank with respect to share of corporate lending to total lending and share of this lending which is short-term. Classification is "stronger" or "weaker" if average rank is in the top 20th or bottom 20th percentile, respectively.
2/ Percent of firms that have fewer than 250 employees.
3/ Firms' leverage is total debt divided by total debt plus net capital in 1996. Sources: Cecchetti (1999), OECD and UN Statistical Yearbook, as cited in Carlino and DeFina (1998).
4/ Ratio of the share of manufacturing, construction, and transportation in GDP to the share of other sectors, excluding government and including financial, insurance and real estate services.

Derivation of the exchange rate sensitivity index

Appendix Table 8 provides information regarding the degree of sensitivity of exports to price movements and openness of the main euro -area countries. The export sensitivity measure is constructed by multiplying each EMU country's export share towards country i with country's i import price elasticity. The elasticities are obtained from Senhadji (1998) and Hooper, Johnson and Marquez (1998). The exercise covers about 85 percent of each country's exports. Openness is measured as the sum of imports and exports as a percent of GDP (divided by two). Both the overall degree of export sensitivity and the degree of export sensitivity vis-à-vis countries outside the EU11 area are shown; the latter measure aims at capturing the impact of exchange rates on trade after EMU. Finally the combined effect, which reflects the average elasticity multiplied by the openness measure, is also tabulated in Appendix Table 8. This is normalized against the average value of this combined effect in the sample.

Appendix Table 8. Openness and the Exchange Rate Channel

					Combined price sensitivity and openness			
	Price sensitivity		Openness		Overall		Extra euro area -trade	
	Overall	Outside euro area	Total trade	Extra euro-area trade	Normalized Value	Rank	Normalized Value	Rank
Austria	-17.4	-9.7	27.5	10.9	0.63	9	0.65	8
Belgium	-19.5	-9.1	67.6	26.4	1.73	1	1.50	2
Finland	-19.5	-20.0	24.6	16.8	0.63	8	1.19	3
France	-26.6	-14.4	18.7	10.6	0.65	7	0.65	7
Germany	-28.8	-19.5	21.4	12.9	0.81	5	1.01	4
Ireland	-20.7	-16.0	54.5	38.5	1.47	3	2.12	1
Italy	-23.5	-15.5	17.5	9.4	0.52	10	0.64	9
Neth.	-29.7	-9.8	43.0	23.5	1.60	2	0.98	5
Portugal	-29.3	-10.7	27.3	10.4	1.27	4	0.86	6
Spain	-27.6	-8.5	16.9	7.6	0.70	6	0.40	10

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