Monetary transmission evidence

SUMMARY

We examine the euro area monetary policy transmission process using post-1999 data, with two main questions in mind: has it changed after – and because of – economic and monetary union (EMU) and, if so, is it becoming homogeneous across countries? Given the data limitations, we concentrate on three components of the transmission mechanism: the banking, the interest rate and the asset market channels. We find evidence that the transmission through banks has become more potent and homogeneous across countries. On the financial market channels, our evidence is somewhat weaker but suggestive. The interest rate channel appears to have changed even before EMU, and now affects national economies in a broadly similar way. The asset market channel (proxied by the stock market effects of monetary policy) also seems to work rather homogeneously across national markets (no comparison with pre-EMU is available here). A positive answer to both questions raised above represents, in our view, the best working hypothesis under current knowledge.

— Ignazio Angeloni and Michael Ehrmann

Economic Policy October 2003 Printed in Great Britain

Monetary transmission in the euro area: early evidence

Ignazio Angeloni and Michael Ehrmann
European Central Bank

1. MOTIVATION AND EMPIRICAL STRATEGY

In this paper we attempt a first empirical assessment of the effect of economic and monetary union (EMU) on monetary transmission in the euro area. We compare post-EMU with pre-EMU data, using developments in other (non-EMU) countries as controls.[1] In doing so, it is important to bear in mind that EMU is a *process*, not a one-time event. The transition to a new currency and monetary policy was something economic agents had time to prepare for, and adjust to, over a number of years. This complicates significantly the task of identifying causal links. In any event, we address several related questions, only some of which are of causal nature: Has the euro area transmission mechanism changed lately? Has it changed *in coincidence* with EMU? Has it changed *because of* EMU? What is the direction of change?

The views expressed in this paper are not necessarily shared by the ECB or the Eurosystem. All the usual disclaimers apply. We thank seminar participants at the University of Bonn, the Bundesbank, the ECB, the participants in the 37th *Economic Policy* Panel, our discussants Paul de Grauwe and David Miles and the editors for helpful comments. We also thank Anil Kashyap for many inspiring discussions about the transmission mechanism over the last few years. The Directorate General Statistics of the ECB provided generous statistical support. Sandrine Corvoisier skilfully assisted in processing the data.
The Managing Editor in charge of this paper was Paul Seabright.

[1] From this viewpoint, we move a step forward relative to recent studies such as that conducted by the so-called 'Eurosystem Monetary Transmission Network', that used pre-EMU data to infer about the post-EMU transmission mechanism (Angeloni *et al.*, 2003a). A review of the recent literature is contained in an earlier version of this paper: see Angeloni and Ehrmann (2003).

Economic Policy October 2003 pp. 469–501 Printed in Great Britain

These questions link up with another issue of great policy relevance, the *differentiation* of monetary policy effects across countries. Several authors have argued that the pre-EMU monetary transmission process was uneven across countries, in a way that would complicate the conduct of the single monetary policy.[2] Others have noted that such differences are difficult to detect empirically.[3] Arguably, some of the cross-country differences in monetary transmission, those linked more directly to the existence of currency segmentation and to the different monetary regimes, should fade away quickly once a common currency is adopted. Therefore, looking at the two issues in conjunction seems particularly promising.

Unfortunately, studying the monetary policy transmission process in the euro area is difficult at this stage, due to the extreme scarcity of data. Ideally, one would like to compare a model of the euro area against models of the individual member countries' transmission processes, where changes of key parameters could be measured and tested. This is clearly not feasible with four years of data. Euro area-wide models estimated using 'synthetic' variables for the pre-EMU period do exist,[4] but they assume homogeneity across time and countries, blurring crucial distinctions that we want to address. Even national data are, in many cases, not complete and homogeneous enough in key areas such as inventories, housing or durable consumption.

Our research strategy is to focus on a selected number of links in the transmission process that are important, for which data are available, and where EMU-related changes are likely to occur rapidly. These criteria led us to concentrate on two building blocks: the banking sector and the financial markets. The next few paragraphs explain this choice in more detail.

In the survey of the transmission mechanism published in the *Journal of Economic Perspectives* (1995), four channels are distinguished through which monetary policy affects aggregate demand: the bank lending channel, the interest rate channel, the asset market channel and the exchange rate channel. The bank lending channel is a natural focus of our attention as it matches all three criteria above. Banks have a central role in financial intermediation in the euro area.[5] Monthly data (the lowest usable data frequency with four years of data) exist. Finally, post-EMU changes, if any, are likely to occur quickly, as banks are directly exposed to the action of the central bank and operate in the euro area interbank market, that has been fully integrated since 1999 (Hartmann *et al.*, 2001). The interest rate and asset market channels also fulfil the criteria: they are important for the transmission mechanism, high frequency data exist and the financial markets are likely to be immediately affected by the new risk-return configuration determined by EMU.

[2] E.g. Cecchetti (2001), Mihov (2001).

[3] Kieler and Saarenheimo (1998), Guiso *et al.* (1999) and Angeloni *et al.* (2003a).

[4] The most frequently quoted structural models are Fagan *et al.* (2001) and Smets and Wouters (2002); for a VAR study, see Peersman and Smets (2003).

[5] Micro evidence on banks tends to support that the bank lending channel, as proposed by Kashyap and Stein (1997), is a relevant element in the transmission process in a number of euro area countries (Ehrmann *et al.*, 2003, and references therein).

Different considerations apply to the exchange-rate channel. This channel compounds two separate links, one from monetary policy to the exchange rate and the other from the latter to the domestic economy. The first link is notoriously very volatile and unsystematic.[6] The second one is likely to decline in importance after EMU, since the euro area economy is much less open to international trade than the constituent countries. For these reasons the exchange rate channel is not analysed in this paper, though we regard it as an interesting avenue of future research.

The final link in the transmission mechanism is that between aggregate demand and output and prices. This breakdown depends on factors – such as wage-price setting mechanisms and other elements affecting the supply side response – that normally change slowly, depending on deep-rooted features of goods and labour markets. Structural reforms in these markets are a necessary complement of EMU, as recognized by the Lisbon process, but implementation takes time and their dividend in terms of macroeconomic performance materializes only gradually. Moreover, from our perspective, these phenomena would need to be analysed with quarterly or even annual data. For all these reasons, we do not think that such analysis is feasible at the present stage.

Summing up the rest of the paper, our evidence on the banking sector and the financial markets is presented in Sections 2 and 3, respectively. Our next and final step is to bring the separate pieces of evidence together, seeing what overall message may be drawn. We will do so in Section 4, using what has been called, in another context, the 'Sherlock Holmes' approach. Like Sherlock, we will try to solve our case by 'weaving together all the bits of evidence into a plausible story' (Leamer, 1978). We hope our story will be informative and suggest also where else to look in order to complete the picture.

2. EVIDENCE ON THE BANKING CHANNEL

2.1. Market-structure and signal-quality effects

Our focus in this section is on detecting any changes in the reaction of banks to monetary policy that may be related to the introduction of the euro, and on whether they indicate that the monetary transmission mechanism is becoming more homogeneous across countries.

One can think of two classes of reasons why behavioural changes may have occurred in banking. The first relates to the fact that, with the transition to the euro, the *nature of the monetary policy signals* has changed. A new central bank is in charge,

[6] Recent research on how the exchange rate channel affects output and prices in the euro area (see van Els *et al.*, 2003) assumes uncovered interest parity (UIP) holds. However, the empirical support for UIP is weak. Calvo and Reinhart (2000) suggest that the link between policy interest rates and the exchange rate has the theoretically expected sign about 50% of the time, i.e. like tossing a fair coin.

with a new strategy and a new euro-area orientation. The policy actions of the ECB convey different information relative to those of pre-existing national central banks, particularly in countries where the policy regime has changed most significantly. In particular, if the volatility of monetary policy has declined as a result (and it has, as we shall see), the response of banks to a policy signal of any given size is likely to have increased.[7]

The second potential reason for behavioural changes relates to possible modifications in the *structure of banking markets*. There can be several ways for this to take place, all stemming from the fact that the single currency removes one source of segmentation across national banking markets – the exchange rate risk. Suppose national banking markets are segmented and banking systems differ with respect to some intrinsic characteristic (say, efficiency, although the same line of reasoning could apply to other factors as well). Bank efficiency would affect lending conditions to national customers, including the response of such conditions to shocks. Once segmentation is removed, prices of banking products tend to converge due to competition; inefficient banking systems, no longer able to pass extra costs on to customers, would eventually restructure or see their market shares reduced. Price convergence does not require cross-border activity, but only contestability of markets. The converse, however, is not true: significant cross-border business would be *prima facie* evidence that markets are contested.

Bank competition across frontiers can alter the cross-border pattern of monetary transmission in several ways. Under segmented markets, each national banking system transforms domestic deposits into domestic loans, using a domestic technology, with the national central bank influencing the process via the interbank market and the cost of raising deposits. Banking efficiency is reflected in the spreads between the lending and interbank rates and between the interbank and deposit rates. Once markets integrate, competition in the loan and deposit markets tends to equalize these spreads.[8] Interbank market integration, which allows relatively inefficient banks to access the better deposit raising technology of the foreign banks, also tends to equalize deposit spreads. Alternatively, foreign deposit and loan markets can be accessed through foreign branches, with similar effects. Finally, another (more indirect) way in which lending conditions can be altered is through cross-border mergers and acquisitions (M&A). For example, M&A can induce banks to sever their customer relationship with small borrowers, a factor normally leading to loans being priced more sluggishly and inefficiently.[9]

The *market-structure* channel is probably slower to operate than the *signal-quality* channel. Whether the euro has already had an influence on the competition among national banking sectors is an open question. Some evidence on the effect of the introduction

[7] This follows from a simple errors-in-variables argument. If a signal is observed with noise with variance σ^2, the response by the banks to it is reduced (assuming linearity) by a factor of $\sigma^2/(\sigma^2 + s^2)$, where s^2 is the variance of the signal.

[8] We abstract here from the characteristics of the local borrowers. Alternatively, one could reason in terms of borrower-risk-adjusted terms.

[9] Sapienza (2002) analyses the link between M&A in banking and loan supply conditions and provides arguments and evidence along these lines.

of the euro on bank market penetration is contained in a more extended version of this paper (Angeloni and Ehrmann, 2003), which shows that:

- Cross-border lending and deposit taking among euro area countries has tended to increase after 1999, but no dramatic changes have taken place.
- On the contrary, cross-border interbank activity has been rising sharply, in absolute terms and relative to control cases (non-euro area countries). This confirms that the euro area interbank market is well integrated.
- Cross-border branching shows no sign of increase in the euro area after 1999; it is very extensive in small countries and very limited in large ones, and, on the whole, not too different in scale from what one observed across US states.
- There is some sign of increase in cross-border bank mergers, relative to past trends and to control cases. The level of this phenomenon, however, remains low relative to most of the comparators (notably, the USA).

With our limited data samples, identifying separately the *market-structure* and the *signal-quality* effects econometrically is not possible. The econometric evidence below, on the mechanics of bank interest rate determination and its response to policy shocks, aims at estimating the total effect without trying to disentangle the two possible causes.

2.2. Transmission of monetary policy to bank interest rates

We use monthly data on lending and deposit interest rates, across a variety of instruments and maturities, on a comparable basis for five euro area countries and for the euro area as a whole.[10] We look at how bank rates react to changes in the money market rates. These results provide answers to the questions posed in the introduction in two ways. First, changes in the pass-through parameters can tell us something about whether the transmission through bank rates has changed. Breakpoints in 1999 are an obvious focus of attention. We are also interested in the direction of change – such as whether there is more powerful or more rapid transmission. Second, our detailed sector-level and country data allows us to examine cross-country homogeneity, particularly since 1999.

We calculate three parameters:

- the impact effect (within a month);
- the maximum effect (whenever it occurs);
- the time needed to reach this maximum effect – across all rates and countries, and for the euro area average.

[10] Data is available on the ECB website (www.ecb.int). Furthermore, all the data used in this paper are available and documented on the *Economic Policy* website (www.economic-policy.org).

Table 1. Effect of money market rates on lending and deposit rates (country averages)

Country (no. of rates)	Impact coefficient		Maximum response		Time to max	
	1990–1998	1999–2002	1990–1998	1999–2002	1990–1998	1999–2002
Germany (8)	0.441	0.387	0.852	0.765	6.875	4.750
France (2)	0.017	0.621	0.325	1.158	6.000	5.000
Italy (7)	0.153	0.396	0.541	0.931	4.714	6.286
Spain (9)	0.404	0.470	0.717	1.184	5.111	5.444
Netherlands (4)	0.389	0.468	0.800	0.850	4.750	3.000
Euro area (10)	0.241	0.380	0.475	0.744	14.600	5.000
UK (10)	0.422	0.423	1.481	0.810	6.700	6.100
Sweden (2)	0.395	0.581	0.609	0.455	1.500	1.000
Japan (10)	0.524	0.239	0.882	0.323	5.100	2.000
US (5)	0.838	0.744	1.367	1.304	4.400	3.800
Std dev. among euro area countries	*0.186*	*0.093*	*0.215*	*0.186*	*0.932*	*1.210*
Coeff. of Var. among euro area countries	*0.663*	*0.200*	*0.332*	*0.191*	*0.170*	*0.247*

Notes: The coefficients are averages from models for various retail rates. OLS regression equation for the impact coefficient: $\Delta r_t^{bank} = \alpha + \beta \Delta r_t^{mmkt} + \varepsilon_t$. Maximum response and time to max are computed from VAR responses of retail rates to a unitary shock to money market rates (obtained from a Choleski decomposition). Regression equation: $x_t = \alpha + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \varepsilon_t$, where $x_t = [r_t^{bank}\ r_t^{mmkt}]'$. Sample size: 1990:1 (or later)–2002:7.

Source: Authors' calculations.

To do this we use two models. The impact effect is estimated using a simple regression of changes in the bank rate on changes in the money market rate and a constant, whereas we use a simple bivariate VAR in levels to calculate the peak effect and the timing.[11] The results, grouped by country, are summarized in Table 1.

The table shows results for the five largest euro area countries, for the area as a whole, and for a 'control group' including UK, Sweden, Japan and USA. Impact and peak effects and the time to maximum effect (in months) are given for two sub-periods: 1990–8 and 1999–2002. Data are averaged across types of rates for each country (the number of rates available for each country is indicated).

There is a clear upward movement of both the impact and the peak response, except in Germany, where both decline slightly. Moreover, the dispersion of these two parameters across the euro area countries declines between the first and the second period.[12] There are no analogous changes in the control group. In contrast to these changes in the *size* of the coefficients, we find no evidence that the *speed* of the pass-through has become faster, either in the euro area or in the control group. In Table 2 we show the same coefficients grouped not by country, however, but by loan or deposit type. Mortgage and business loans show the largest increase in the impact coefficient between pre-1999 and the successive period. The increase in the peak coefficient is more evenly distributed. Some tests of cross-country restrictions on the impact coefficient are shown in Table 3. At the standard significance levels, only mortgage loans, business loans (long-term) and time deposits (long-term) pass the cross-country homogeneity test. Interestingly, maturity seems to matter: equality is accepted in all the long-term loan and deposit categories, and rejected in the short-term ones. It is clear that, despite the sizeable changes that have taken place between our two time sub-periods, considerable ground still needs to be covered before a full or near homogeneity of the transmission through bank rates is achieved in the euro area.

To check whether the break between the first and the second sub-period is indeed located at or around the start of 1999, we estimated the regressions of the first columns of Tables 1 and 2 using rolling-window samples of 36 months. The results are reported in Figure 1 for a selection of euro area rates, with a vertical line marking the first window that includes observations post-EMU. The coefficients generally start rising

[11] These simple regressions could potentially be affected by omitted variable or endogeneity bias if third factors (like the business cycle) affected both rates separately or if money market rates responded to bank rates. We have controlled for this bias in two ways: by adding the change in industrial production in the equation; and by performing Hausman endogeneity tests on all equations. We found evidence of such bias at the 5% level in only 5 out of the 80 equations we estimate for the euro area and the euro area countries, and in only 7 out of the 54 equations for the control countries, which we take as evidence that our results are generally unbiased. Both tests gave identical results. The VAR shocks were all standardized by dividing by their standard error.

[12] The somewhat surprising results for France – a nearly zero coefficient in the first period, rising to a fairly high level in the second – may depend on data quality: the two French retail rate series are in fact collected at quarterly frequency and interpolated monthly, which can induce spurious lags in the univariate equation. If the French equation is estimated with one lag, the estimated coefficients are: 0.168 pre-EMU; 0.308 post-EMU. The decline in the standard deviation and in the coefficient of variation across countries are both confirmed using these alternative estimates for France.

Table 2. Effect of money market rates on lending and deposit rates (averages by instrument)

Type of business (No. of rates)	Impact coefficient		Maximum response		Time to max	
	1990–1998	1999–2002	1990–1998	1999–2002	1990–1998	1999–2002
Euro area						
Mortgage loans (5)	0.249	0.394	0.517	0.840	3.200	4.000
Loans to consumers (5)	0.299	0.298	0.684	0.832	7.400	6.200
Loans to corporations (11)	0.350	0.534	0.811	1.110	14.636	5.000
Deposits (19)	0.297	0.404	0.565	0.836	5.105	5.105
UK, Sweden, Japan, US						
Mortgage loans (5)	0.289	0.458	0.711	0.609	3.200	2.400
Loans to consumers (6)	0.336	0.203	0.872	0.424	9.000	6.167
Loans to corporations (5)	0.554	0.478	1.132	0.810	5.000	3.800
Deposits (11)	0.746	0.510	1.567	0.830	4.364	3.091

Source: Authors' calculations; see Table 4.

Table 3. Tests for homogeneity of the impact effect of changes in money market rates to bank rates across euro area countries, grouped by instrument

Type of business (No. of rates)	1990–1998		1999–2002	
	χ^2	Significance	χ^2	Significance
Mortgage loans (4)	5.702	0.223	1.069	0.899
Loans to consumers (4)	16.395	0.003	21.596	0.000
Long-term loans to corporations (4)	4.681	0.322	3.714	0.446
Short-term loans to corporations (5)	106.504	0.000	20.167	0.001
Savings deposits (6)	48.035	0.000	39.936	0.000
Long-term time deposits (4)	20.091	0.000	6.053	0.195
Short-term time dep., current account (4)	135.865	0.000	47.887	0.000

Notes: SUR models comprising national rates only (i.e., excluding euro area rates), where each equation is estimated as $\Delta r_t^{bank} = \alpha + \beta \Delta r_t^{mmkt} + \varepsilon_t$; for further explanations see Table 1.

Source: Authors' calculations.

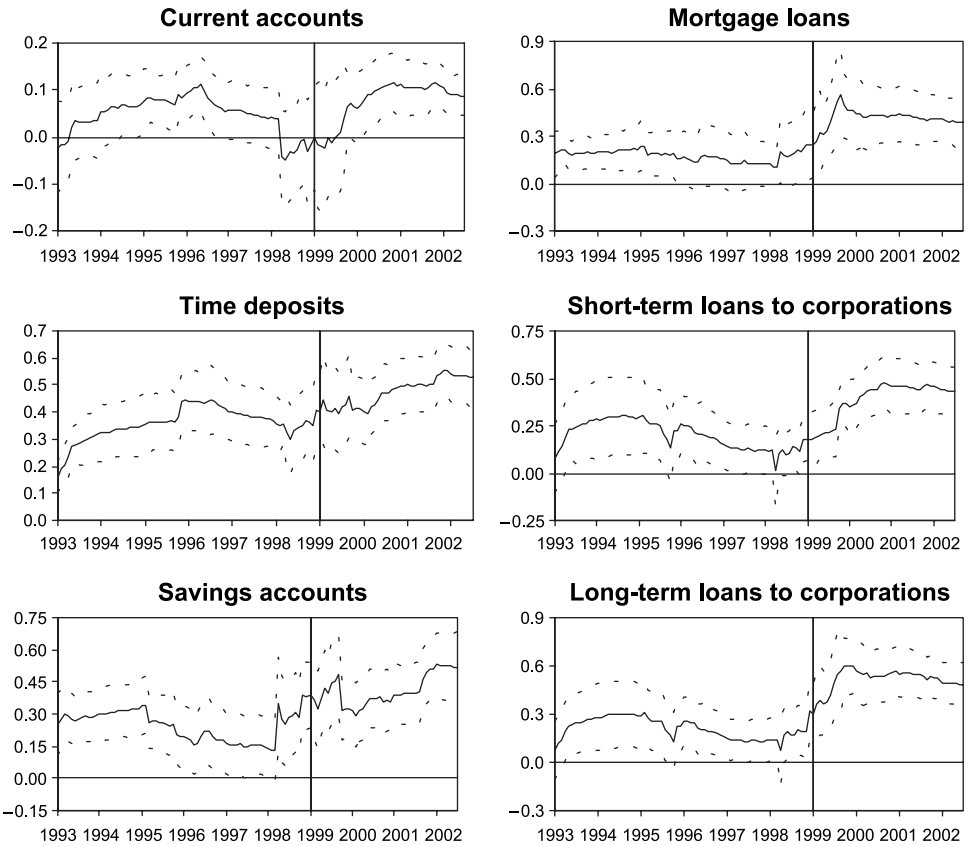

Figure 1. Rolling window estimates of the impact effect of changes in money market rates to bank rates: euro area

Notes: Solid line: rolling window coefficient estimates; dashed lines: 95% confidence bands; vertical line: first window with observation under EMU; x-axis represents the end point of the respective regression windows; further explanations: see Table 1.

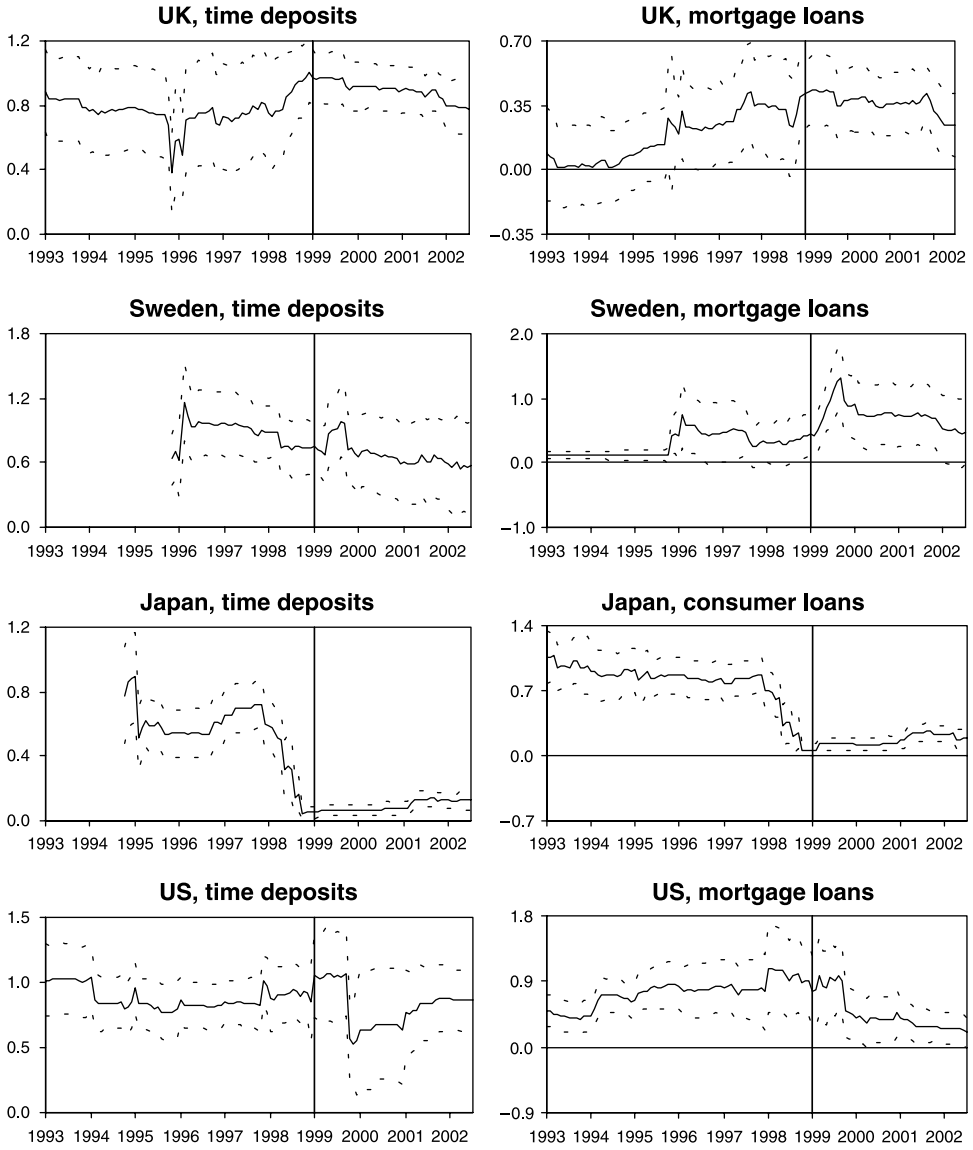

Figure 2. Rolling window estimates of the impact effect of changes in money market rates to bank rates: other countries

Notes: Solid line: rolling window coefficient estimates; dashed lines: 95% confidence bands; vertical line: first window with observation under EMU; x-axis represents the end point of the respective regression windows; further explanations: see Table 1.

once observations after 1999 enter the regression window and keep rising while new observations from the new regime are added. Figure 2 shows that no such pattern can be found for the countries outside the euro area.

As we have suggested earlier, identifying the factors behind these changes, specifically in terms of the *market-structure* versus *signal-quality* interpretation, is difficult with the

data available today. The second interpretation seems to square well with our evidence: the impact of money market rates on bank rates rises in most cases after 1999, except in Germany; it is probably not a coincidence that the volatility of money market rates falls after 1999 in all countries, except in Germany.[13] However, the first interpretation could have a role, too, in explaining why the estimated responses of banks to policy signals are increasingly homogeneous across countries.

A related piece of evidence pointing to structural changes in credit markets concerns the maturity of bank loans. One established empirical regularity is that the maturity (or duration) of financial contracts tends to be inversely related, across countries, to the level and the variability of inflation (Borio, 1995). High inflation countries tend to be characterized by shorter financial contracts. The loan market of the euro area is no exception to this rule; countries with a recent history of high inflation, such as Italy and Spain, were until recently characterized by shorter average loan maturity than, say, Germany. This has a potential implication for the transmission process, since a shorter (or equivalently, floating rate) loan or mortgage contract tends to generate cash-flow responses to changes in policy-driven interest rates that are different from those of long contracts (at fixed rate). The interesting message coming from Table 4 is that such differences are in the process of being reduced (gradually, but steadily) in the euro area. For all categories of loans taken into consideration (covering loans to both non-financial corporations and households) the cross-country variance of maturity (measured crudely by the share of loans with original maturity over 5 years) is on a declining trend. The maturity in Spain and Italy is on the rise, conceivably as a result of the fact that expectations of price stability have been strengthened; in France it is roughly constant. Interestingly, Germany again stands out from the crowd: historically it had the highest share of loans beyond 5 years, but maturity is now slowly declining.

3. EVIDENCE ON THE FINANCIAL MARKET CHANNELS

In focusing on the non-bank financial sector, we are again looking for evidence that can help us characterize the post-EMU transmission process and to show whether any change has taken place, particularly with regard to the degree of cross-country homogeneity. Relative to the bank lending channel, which at least conceptually is relatively straightforward to define (though quite difficult to identify empirically), the range of financial market channels is broader, more articulate and complex to pin down. Transmission through the financial markets can take place in a number of

[13] Between the pre-EMU (1990–8) and the post-EMU (1999–2002) periods, the variance of three-month interest rate changes dropped from 0.24, 0.41, 0.14 respectively in France, Italy and Spain to 0.04. In Germany, it increased from 0.03 to 0.04. The *signal-quality* interpretation also seems consistent with recent estimates of De Bondt *et al.* (2003), showing that the relevance of bond yields in affecting bank lending rates declined recently relative to money market rates in a number of euro area countries. The signal conveyed by long-term rates may not be so relevant anymore, since money market rates have become more informative.

Table 4. Share of loans with original maturity over 5 years, euro area

	1997	1998	1999	2000	2001	2002Q2
Non-financial corporations						
Euro area	49.76	50.63	49.25	47.96	48.05	48.52
of which: France	53.67	56.01	57.01	54.89	56.22	55.33
Germany	64.29	65.12	61.45	60.80	60.78	61.60
Italy	24.37	25.23	26.85	26.95	27.77	29.39
Spain	36.80	38.08	39.26	38.71	41.42	42.99
Netherlands	60.21	60.05	61.40	58.24	58.50	56.95
Std. Dev. of euro area countries	*16.81*	*16.70*	*15.48*	*14.54*	*14.05*	*13.06*
Coeff. of Var. of euro area countries	*0.35*	*0.34*	*0.31*	*0.30*	*0.29*	*0.27*
Households – consumer credit						
Euro area	48.61	48.37	44.47	44.76	45.37	45.59
of which: France	22.21	22.23	23.96	25.00	27.25	27.61
Germany	66.84	66.87	58.78	58.17	59.38	59.99
Italy	17.90	17.88	18.02	20.99	24.28	25.08
Spain	36.23	40.47	42.12	43.46	45.10	44.69
Netherlands	21.12	22.28	19.29	18.90	20.20	18.92
Std. Dev. of euro area countries	*20.25*	*20.36*	*17.61*	*16.95*	*16.51*	*16.81*
Coeff. of Var. of euro area countries	*0.62*	*0.60*	*0.54*	*0.51*	*0.47*	*0.48*
Households – other lending						
Euro area	66.14	65.81	58.27	57.76	58.23	58.03
of which: France	76.75	76.65	76.20	74.85	72.50	72.97
Germany	81.61	82.54	70.70	70.45	70.59	70.15
Italy	25.70	25.56	28.83	30.45	34.40	35.31
Spain	56.98	55.76	56.51	59.63	57.65	55.12
Netherlands	44.98	44.95	45.58	41.10	43.27	41.88
Std. Dev. of euro area countries	*23.02*	*23.31*	*19.17*	*19.04*	*16.70*	*16.68*
Coeff. of Var. of euro area countries	*0.40*	*0.41*	*0.35*	*0.34*	*0.30*	*0.30*

Notes: Standard deviation and coefficient of variation are calculated for Germany, France, Italy, Spain and the Netherlands.

Source: ECB; authors' calculations.

different ways, involving difficult issues of conceptual as well as empirical identification. A short discussion on the logical framework can be of help.

Referring again to the survey in the *Journal of Economic Perspectives*, we focus here on what Mishkin (1995) there calls the 'interest rate' and the 'asset price' channels. In Mishkin's definition the interest rate channel (IRC) is the traditional Keynesian effect whereby monetary policy is transmitted, through liquidity and expectations effects, to the structure of nominal and real interest rates, and then indirectly to investment and consumption plans by non-financial firms and households. More specifically – see Angeloni *et al.* (2003a) – the IRC is the mechanism that operates in the absence of capital market imperfections, i.e. only through the intertemporal reallocation of expenditures that follows a change in expected real interest rates (which are the *prices* of such reallocation). In principle this definition excludes asset market or 'broad credit channel' effects stemming from changes in 'external finance premia', emphasized by Bernanke and Gertler (1995) and Bernanke *et al.* (1999). In practice it is very difficult

to distinguish between a 'pure' IRC and these other influences, as recently pointed out by Bernanke.[14]

Attacking empirically all these subtle distinctions would be impossible with our limited data. Our pragmatic way forward is to concentrate, first, on something that approximates the IRC in its purest form, looking at how nominal and real interest rates (short and long term) on riskless assets behave across sample periods. We do this in the next subsection. After this, in the following subsection we approach one key building block of the 'asset price' channel, by comparing the impact of monetary policy on national stock markets.

3.1. Interest rate channel

To test for the effect of monetary policy through the IRC one could directly estimate dynamic models, like the ones of Tables 1 and 2, on real and nominal market interest rates, and see how the coefficients change across sub-periods. The problem in doing so is that models must be very simple, since data are scarce. For the bank rates analysed in Section 2.2 this yielded sensible results, because the laws of motion of bank rates are relatively simple: bank rates are set administratively, in less than fully competitive markets, using relatively simple adjustment schemes. The empirical literature suggests that simple specifications are normally adequate to explain bank rates, usually as a function of signals provided by the central bank.[15] On the contrary, financial market rates are determined in highly efficient markets, and their dynamics and reaction to news is much more complex.[16] This may explain why our attempts to fit simple schemes linking market rates to monetary policy were unsuccessful, for all our short sub-samples. We have therefore resorted to a less data-demanding procedure, as follows.[17]

Our basic idea is that, if the IRC has become homogeneous in the euro area after 1999, then it must be true that riskless rates in real terms follow the same law of motion in all member countries. This is certainly true for nominal rates, which after EMU are forced to coincide by arbitrage given the absence of exchange-rate risk, but not necessarily for real rates if the transmission is not homogeneous. A comparison between pre- and post-EMU evidence can be based on simple measures of unconditional co-movements of real interest rates, at different maturity, across countries. As clarified

[14] See his discussion in Angeloni *et al.* (2003a).

[15] See, among many others, Neumark and Sharpe (1992) or Hannan and Berger (1991), which suggest that the main determinant of bank pricing is a simple markup on those market interest rates that are closely controlled by monetary policy.

[16] A monetary policy tightening tends to increase nominal interest rates due to the liquidity effect, and decrease nominal rates due to its effects on inflation expectations. Furthermore, their reaction is affected by expectations on future monetary policy actions. Due to this complexity, the empirical literature has generally found only a weak relationship. Kuttner (2001) discusses the methodological requirements that are needed to estimate the effects of monetary policy on market determined interest rates in a systematic way, suggesting that a careful distinction of anticipated and unanticipated policy actions is needed.

[17] Conversely, we have applied this simplified procedure back on the data underlying Tables 1 and 2, obtaining good results (available on request).

more formally below, under plausible conditions unconditional co-movement implies that the effects of monetary policy on interest rates are similar.

We use nominal short (3-month interbank) and long (10-year government bond) rates, and proxy inflationary expectations with the 12-month forward changes of national Harmonized Indices of Consumer Prices.[18] Lacking robust evidence on the stationarity of the data,[19] we look at both levels and changes of the data. As a measure of co-movement across countries we use the *variance of the interest differential*, rather than the more common *correlation coefficient*.[20] We examine three time periods. The first, 1990–4, spans from the removal of short-term capital controls to the ERM crisis of 1992–3 and its aftermath. The second, 1995–8, covers a time when interest differentials were strongly affected by the so-called 'convergence trades' in the financial markets, driven by expectations of EMU. This has conceivably produced a convergence in interest rate levels, but not necessarily in higher-frequency movements. The third, 1999–2002, coincides with the first 4 years of EMU, and is the period in which we are most directly interested.

Table 5 contains measures of interest rate co-movement, within the euro area countries and for three control groups: the euro area versus the rest of the EU; the euro area versus the USA and Japan; and four main US Census regions among themselves.[21] To obtain the results for groups of countries, bilateral variances are aggregated using GDP weights. The *within* euro area variance, expressed as a single number, can then be compared with that *between* the euro area and the control groups, and with that *within* the USA.

The variance of *real* interest differentials in the euro area (*in levels*), dramatically declines for both short and long rates. In the control countries there is also some decline, but less strong. There is no decline among the US regions. When one looks at variances of monthly *changes* of real interest differentials, a different pattern emerges. The main reduction in the variance is between the first period (1990–4) and the second (1995–8), not after 1999; there is a similar decline between the euro area and other EU, but not with the other control groups. Within the USA the variance of the differential does not decrease. The overall message is mixed: there is a sharp convergence, but it does not take place unambiguously after EMU (it depends a lot on whether levels or changes are considered), nor does it exclusively take place among euro area members. The other EU countries (UK, Sweden, Denmark) converge too. The developments are instead quite different if one looks at other areas (euro area versus USA and Japan, or within USA).

[18] Using backward inflation rates gives similar results.

[19] With our short data samples, standard tests of stationarity would probably lack power. Looking at levels and changes together should provide some robustness. Some evidence on stationarity will emerge from our results.

[20] The variance of the differential seems more accurate for our purpose. A correlation coefficient of one is necessary but not sufficient for the variance of the differential to be zero: if the variances are different, the differential varies even if the two rates are perfectly correlated. Hence the variance criterion is more restrictive. On the other hand, the variance of the differential can fall if the variances change, even if the correlation remains constant or even declines.

[21] US regional price data from the Bureau of Labor Statistics (www.bls.gov/cpi/) refer to four regions: West, Midwest, South, Northeast. We also tried with city data, available from the same source (results available), finding that the variance of between-city inflation differentials is much wider than that of between-region differentials. Hence, US regional data seem to provide a closer analogue to our euro area country data. We thank Steve Cecchetti, without involving him, for useful information about these data.

Table 5. Variance of real interest rate differentials: measures of cohesion

	Interest rate levels			Interest rate changes		
	1990–1994	1995–1998	1999–2002	1990–1994	1995–1998	1999–2002
Euro area						
Short rate	2.66	2.09	0.39	0.66	0.20	0.10
Long rate	1.92	1.67	0.39	0.23	0.13	0.10
Euro area and other EU						
Short rate	4.46	2.31	1.31	0.99	0.18	0.12
Long rate	1.87	0.98	0.43	0.34	0.12	0.10
Euro area, Japan and USA						
Short rate	3.88	1.99	1.19	0.40	0.24	0.12
Long rate	1.04	2.07	0.42	0.22	0.24	0.15
US regions						
Short/long	0.23	0.15	0.32	0.07	0.05	0.19

Notes: The cohesion index is calculated as $\sum w_i w_j \mathcal{Z}_{i,j} / \sum w_i w_j$, where $\mathcal{Z}_{i,j}$ are bilateral variances and w_i weights proportional to GDP; euro area countries without Luxembourg and Greece. Short rate: 3-month interbank rates. Long rate: 10-year government bond rates. Real rates are constructed by subtracting one-year ahead inflation rates. Sample size: 1990:1–2002:2.

Source: Authors' calculations.

Some comparisons with our control groups are interesting. Post-EMU the euro area variances are 0.39 and 0.10, for levels and changes respectively. The comparable values for the control groups are similar or (for short-term rates) higher. In the USA, the variance of the real interest rate differential in level is 0.32, and in first difference is 0.19. These figures are qualitatively the same as in the euro area.

In order to gain further insight into the co-movement of interest rates, it is useful to expand the analysis of variances to the frequency domain. This will allow us to understand whether interest rates co-move in the low frequencies (the long-term trends), in the medium frequencies (over the business cycle), or in the high frequencies. We do so by calculating the spectrum of bilateral interest rate differentials for all country pairs, and by aggregating these densities to a euro area measure with GDP weights as above.[22] The results are provided in Figure 3. As before, we report results for the interest rate differentials calculated from interest rates in levels (left panels) as well as monthly changes of these differentials (right panels).

As usual, the density is shown for a frequency range of zero to π, where zero corresponds to the lowest frequency (the long-run behaviour), and π to the highest. In the intermediate range, a value of 0.5 on the x-axis corresponds to cycles of a frequency of about 12 months, 1.0 about 6 months, and 2.0 about 3 months.

The values on the *y*-axis indicate how the variance is distributed over the various frequencies, where the area below the spectrum (over the whole frequency range from

[22] For a process y_t, the spectrum at frequency ω is defined as $s_y(\omega) = \frac{1}{2\pi} \sum_{j=-\infty}^{\infty} \gamma_j e^{-i\omega j}$, where $\gamma_j = E(y_t - E(y_t))(y_{t-j} - E(y_t))$, and $i = \sqrt{-1}$. This implies that the integral over the spectrum is equal to the variance of y_t: $\int_{-\pi}^{\pi} s_y(\omega) d\omega = \sigma_y^2$. Since the spectrum is symmetric, it holds that $2\int_0^{\pi} s_y(\omega) d\omega = \sigma_y^2$ (Hamilton, 1994, ch. 6).

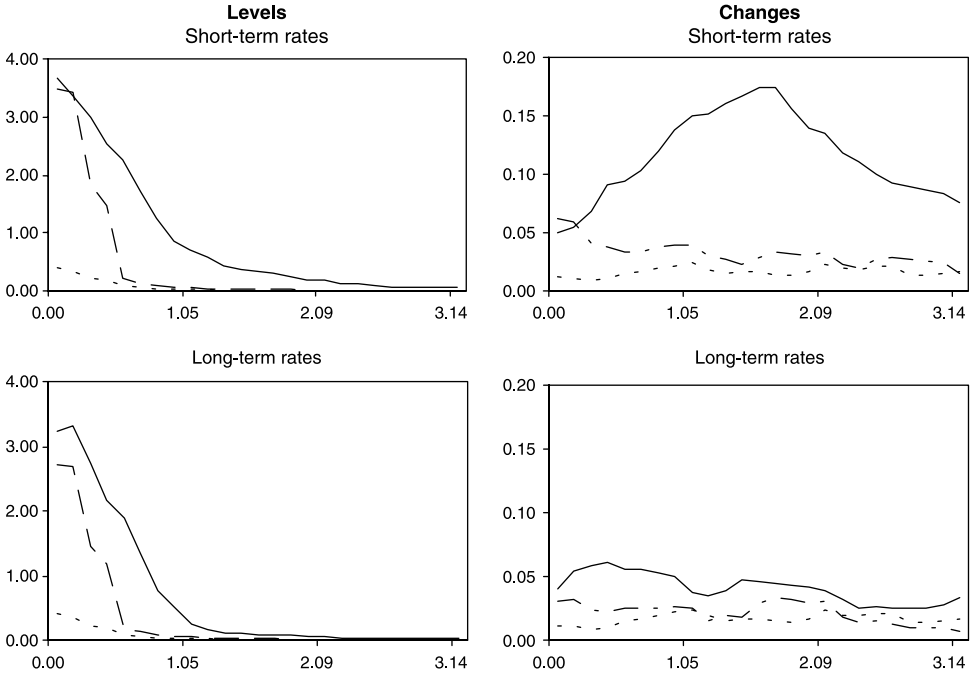

Figure 3. Spectral density of real interest rate differentials within the euro area

Notes: Solid line: 1990–4; long dashed: 1995–8; short dashed: 1999–2002.

$-\pi$ to π) equals the variance. This area shrinks considerably over the three sample periods analysed, which reflects the findings of decreasing variances presented in Table 5. More interestingly, however, we can now analyse the frequencies at which the variance reduction (and thus the interest rate co-movement) occurs.

The charts on the levels show that the variance is concentrated in the lowest frequency ranges (above 6–12 months), in all three periods. This signals that there is a trend in the real rate differentials, arguably due to the convergence process. There is a sharp reduction in the variance at these frequencies as one moves towards subsequent periods, particularly after 1999, signalling that the low frequency components of the variance are being removed as convergence is completed. The calculations with data in terms of changes (right panels) remove the trend component and permit a better inspection of the frequencies relevant for the monetary transmission process.

Focusing first on short-term rates, a hump shape shows up in 1990–4 in the spectrum between 3 and 6 months. This evidence is suggestive. Recalling the timing of foreign exchange crises in the ERM years, particularly the ones of 1992–3, it is plausible that such concentration of variance is due to divergent conduct of monetary policy to counteract exchange-rate tensions. The disappearance of the hump in 1995–8 and 1999–2002 is consistent with this suggestion. In the later periods the spectral density of short real rate differentials flattens, suggesting that the stochastic processes driving

short real rates in different euro area countries has approached random noise. The typical flat spectral shape of a white noise is reached only after 1999, however. Moving to long-term rates, the picture is slightly different. The hump characterizing the spectrum in the first period is around 12–24 months. In the subsequent periods the spectrum again flattens, particularly after 1999 (comparison with the previous chart should be made keeping in mind the different scale). The large decline in variance particularly at the low frequencies is interesting insofar as this is likely to be the relevant frequency for firm investment decisions. All this confirms that the convergence in the stochastic processes driving real rates (short and long) took place well before 1999, but that after 1999 there was further progress. After 1999, real rate differentials in the euro area (levels and changes) look a lot like white noise, except that some minor residual trend component is visible in the levels of both short and long-term rates.

To rationalize this evidence[23] we use a simple framework of how the IRC operates in a two-country area without and with monetary union. We start from two simple equations making financial market interest rates and expected inflation conditional on a series of past monetary policy signals ($m_{A,t-j}$), in a generic country A:

$$r_{A,t} = k_{A,1} + \sum w_{A,j} m_{A,t-j} + \varepsilon_{A,t} \tag{1}$$

$$\pi^{e}_{A,t} = k_{A,2} + \sum h_{A,j} m_{A,t-j} + \eta_{A,t} \tag{2}$$

where $r_{A,t}$ is a nominal rate, $\pi^{e}_{A,t}$ is expected inflation and $\varepsilon_{A,t}$ and $\eta_{A,t}$ are random shocks, including other factors affecting nominal rates and expected inflation. $k_{A,1}$ and $k_{A,2}$ are constant terms, the first of which incorporates the risk premia existing in interest rates. The parameters $w_{A,j}$ and $h_{A,j}$ represent the transmission process: specifically, $w_{A,j}$ expresses lagged liquidity and expectations effects acting upon the nominal rate, while $h_{A,j}$ denotes the lagged effects of monetary policy on expected inflation. The real rate is the difference between the two:

$$\rho_A = r_A - \pi^{e}_{A} = k_A + \sum (w_{A,j} - h_{A,j}) m_{A,t-j} + (\varepsilon_A - \eta_A) \tag{3}$$

where $k_A = k_{A,1} - k_{A,2}$. Consider two countries, A and B. The real interest differential between them is:

$$\rho_A - \rho_B = k + \sum (w_{A,j} - h_{A,j}) m_{A,t-j} - \sum (w_{B,j} - h_{B,j}) m_{B,t-j} + \varepsilon \tag{4}$$

where $k = k_A - k_B$ and $\varepsilon = (\varepsilon_A - \eta_A) - (\varepsilon_B - \eta_B)$.

After A and B form a monetary union, nominal rates are equalized, as are the parameters of the transmission process that affect them. So $r_A = r_B$ and $w_{A,j} = w_{B,j}$ by arbitrage. There is only one monetary shock, m_t. The real interest differential becomes:

[23] Readers puzzled by this post-data rationalization should reflect on the following quote from Sherlock: 'It is a capital mistake to theorise before one has data. Insensibly one begins to twist the facts to suit theories, instead of theories to suit facts.' Doyle (1951, *A Scandal in Bohemia*).

$$\rho_A - \rho_B = \pi^e_B - \pi^e_A = k + \sum(h_{B,j} - h_{A,j})m_{t-j} + \varepsilon \quad (5)$$

To verify the similarity of the transmission parameters between *A* and *B*, before and after they join the monetary union, ideally one would like to estimate fully specified versions of (1), (2) before and after EMU, and test for equality of the coefficients. As we have argued, there are problems in doing this, mainly linked to the fact that post-EMU data are too short to calculate reliable transmission parameters to financial market rates using time series data.

Our simplified framework follows directly from (4) and (5). The empirical analysis has shown three facts. First, the variances of the interest rate differentials decline over time. Second, if data in levels are considered, most of the decline takes place after 1999, while if data in terms of changes are used, a good deal of the variance reduction takes place in the earlier period 1995–8. Third, the spectra signal convergence to a white noise shape from 1990–4 to 1999–2002, with the period 1995–8 being somewhere in between: after 1999, some residual trend component is still visible in the data in levels. In Equation (4), prior to monetary union, $\rho_A - \rho_B$ is a low-variance white noise only if three conditions are met: (a) $m_{A,t-j} \cong m_{B,t-j}$ (the countries have similar monetary policies); (b) $w_{A,j} = w_{B,j}$ and $h_{A,j} = h_{B,j}$ (the transmission parameters are the same); (c) ε is a low-variance white noise. This is indeed a very stringent set of conditions, which can explain why we find large variances in the first period (pre-1994), and no white noise structure in either data in levels or changes. In Equation (5), $\rho_A - \rho_B$ is a low-variance white noise if (d) $h_{A,j} \cong h_{B,j}$ and (e) $\varepsilon \cong \eta_B - \eta_A$ is a low-variance white noise, assuming that k is indeed a constant. The residual low-frequency component observed in the level data suggests the possibility that the term k in Equation (5) may in fact embody some residual near-linear trend, which reduces to a constant when data are calculated in terms of changes. This seems indeed to be true in our data. Hence our evidence is consistent with condition (d) – the transmission parameters being the same, with some level-convergence still taking place after 1999. We do not exclude that other interpretations may be possible, however.

3.2. Stock market channel

The stock market is a key link of the transmission mechanism according to both monetarist and Keynesian views (see again Mishkin, 1995). Tobin's *q* theory assigns to stock prices a central role in transmitting policy shocks to firms' investment. At the same time, stock prices also affect the consumer, through wealth effects (see Meltzer, 1995). Structural macroeconometric models of the United States (such as that used by the Federal Reserve Board; see Reifschneider *et al.*, 1999) ascribe to the stock market a major role in the transmission of monetary policy. In Europe, where stock ownership is limited but growing fast, exploring this channel is important. Furthermore, the response of stock prices reveals the markets' view of the effects of monetary policy.

A second reason for looking at the role of the stock market in our case is empirical. We have at our disposal rich high-frequency data on national and euro area-wide stock market prices, including a breakdown by country and economic sectors. We also have a new high-frequency proxy that identifies unexpected monetary policy shocks. This variable – constructed by Ehrmann and Fratzscher (2002) – compares ECB monetary policy decisions with market expectations drawn from a Reuters poll of market participants before each ECB Governing Council meeting.[24] Combining the two, we can identify exogenous monetary policy shocks and obtain precise estimates of the causal effect of monetary policy on the national stock markets. Unfortunately, these high quality data are not available before EMU, so no comparison across time can be made.

We start by analysing the national stock market indices. The focus of our interest is whether the effects on national markets are sufficiently homogeneous. Our maintained prior is that the immediate stock market impact of the news contains information on the longer run effect, relevant from a monetary transmission perspective. To isolate the effect of monetary policy surprises from those of other news, our data set includes snapshots of stock market indices between 12:30 p.m. and 15:30 CET each day. The ECB monetary policy decisions are announced on meeting days of the ECB Governing Council at 13:45. At 14:30, the ECB President's press conference starts. This meeting is a televised session in which the motivations of the policy decision are discussed. By the end of the time window, at 15:30, it can thus be presumed that further information on the meeting's outcome has been incorporated in the market. The figure in the Appendix illustrates these windows and the stock market movements on a particularly interesting day, namely Thursday, 7 November 2002.[25]

The choice of a three-hour window represents an intermediate horizon compared to the existing literature. Andersen *et al.* (2003) analyse exchange-rate reactions to news using five-minute intervals. However, since asset prices have a tendency to overshoot in the short run, the effects measured at such high frequencies might be overstated. An analysis of daily returns, on the other hand, might underestimate monetary policy effects especially in small samples, since a lot of additional information affects asset markets during the course of a full trading day. Only in very long samples will the additional news cancel out. We would therefore hope that an intermediate horizon

[24] We use the mean of the survey as our expectations measure, and define monetary policy surprises as the difference between the announced interest rate decision and this expectations measure. As shown in Ehrmann and Fratzscher (2002), these expectations are unbiased and efficient.

[25] On that day, many market participants expected an interest rate cut by both the Bank of England and the ECB. Note that the Monetary Policy Committee of the Bank of England meets on Wednesday and Thursday at the beginning of each month, and the announcement of its deliberations, at 12:00 GMT, roughly coincides with the closing of the ECB Governing Council meeting (after allowing for time difference). The US Fed had reduced the federal funds target rate the day before by 50 basis points, and markets felt this might have been part of a concerted action with the Bank of England and the ECB. The decision by the Bank of England not to move rates (announced at 13:00 CET) contradicted this speculation, hence market participants apparently reconsidered their expectations of an interest rate cut by the ECB at the time of the Bank of England announcement. In the end both central banks left their policy rates unchanged. The chart shows that the 'negative surprise' in the UK impacts at 13:00 CET both the FTSE and the continental European markets. A similar downward effect follows the ECB announcement. Further adjustments take place subsequently, before and during the ECB press conference.

Table 6. Stock market responses to ECB monetary policy surprises

	β	*t*-stat
Austria (ATX)	−0.517	−1.248
Belgium (BEL20)	−1.318*	−2.252
Finland (HEX)	−2.585	−1.842
France (CAC40)	−1.775*	−2.263
Germany (DAX)	−2.660**	−3.112
Ireland (ISEQ)	0.551	1.056
Italy (MIB)	−1.812**	−2.648
Netherlands (AEX)	−1.845*	−2.488
Portugal (PSI20)	−2.320**	−4.231
Spain (SMSI)	−0.665	−1.288
Eurostoxx	*−1.938***	*−2.786*

Equality of beta coefficients of national indices with prior from sectoral weights

	χ^2	Significance
All countries	21.206	0.012
Excluding Ireland and Portugal	8.667	0.277
Five large countries	7.886	0.096

Notes: *, ** indicates significance at the 5 and 1% level, respectively. SUR equations, following Pearce and Roley (1983): $\ln(x_t^{15:30}) - \ln(x_t^{12:30}) = \alpha + \beta surp_t + \varepsilon_t$; Sample size: 1 January 1999–14 November 2002.

Source: Authors' calculations.

can approximately capture the relevant effects, by giving markets time to process the new information and settle, without leaving too much time for arrival of further news.

Table 6 shows estimates of the effect of our ECB monetary surprise measure on 10 national stock market indices. We used a Seemingly Unrelated Regression (SUR) model to allow for residual covariance across the indices. The models, though simple, produce estimates that are statistically precise and close to the theoretical priors.[26] The estimated impact of a monetary tightening on stock indices is negative in all 10 countries except Ireland, where it is positive and insignificant. The majority of the slope coefficients are significant. The effect on the area-wide Euro Stoxx, a Dow Jones capitalization-weighted index including a large variety of euro area stocks, shown for comparison, is within the range of the national effects, as one would expect. Focusing on bilateral differences across national coefficients (a measure of how geographically homogeneous the response is) one sees that there are three countries whose estimated coefficients are somewhat far from the average: Germany (higher negative coefficient), Portugal (higher) and Ireland (wrong sign).

One possible explanation for these differences is the sector composition of national stock markets. If economic sectors react to monetary policy differently, and if the sector composition of national markets differ, the responses of national markets could diverge even without asymmetries in the transmission process. We have included in

[26] All in all, the empirical literature has not been very successful in measuring the stock market impact of monetary policy. The comprehensive survey by Sellin (2001) which reports contributions up to 1998, concludes that increases in policy rates generally lead to lower stock prices. However, several recent papers, such as Bomfim and Reinhart (2000) and Roley and Sellon (1998), on the USA, conclude otherwise. Bomfim (2000) again finds evidence for the USA that accords with the theoretical priors.

Table 6 tests of cross-country restrictions that take the sector composition into account. Specifically, we reported tests of the hypothesis that differences in the national coefficients are proportional to the 'theoretical' ones, calculated using the sector-level impact effects[27] and data on the sector composition of national indices.[28] The test across all 10 countries for which data exist is accepted at the 1% level, but not at the 5% level. It is comfortably accepted if Portugal and Ireland are excluded. The test of equality across the five largest countries is also accepted.

4. FROM OBSERVATION TO DEDUCTION, AND FURTHER INVESTIGATION

Our observations stop here. There is little more, if anything, our data can tell us. Time for our modern-day Sherlock to return to his flat, fill his pipe, and measure the living room with endless strolls, immersed in impenetrable silence. What inference can be made? Is the case settled?

He would probably start from the most obvious. Banks, a major suspect, have changed something in their behaviour. There seems to be a connection with 'the crime', *post-hoc* and conceivably also a *propter-hoc*. Their key bank decision variables, the prices on the products they offer, have started (quite suddenly indeed, Watson) to behave in a different way at the time one would expect in case of guilt.

Different interpretations are possible. Banks may have reacted to increased pressure from the euro-induced new competitive environment. Has banking become more competitive across countries? There is some evidence of an increase in bank penetration: cross-country interbank lending has increased significantly after 1999, and the interbank market has integrated quickly. But other segments, more important from the viewpoint of the transmission mechanism (like direct lending to cross-border customers) lag behind. Increased bank penetration across borders can, at best, be part of the explanation.

On the other hand, other factors could also explain this change in bank behaviour. Money and financial market interest rates – the main drivers of bank rates – have also begun to move differently; and, as Sherlock would say, one true inference invariably suggests others.[29] Market interest rates have become more stable (except in Germany) and cohesive across borders. This could explain why the pass-through of money market rates to bank rates has increased (except in Germany). True, the *post-hoc* element here is weaker: market interest rates, in real and nominal terms, had already started to move differently in the pre-EMU period 1995–8. But the change strengthened, and became permanent, only after 1999. Cross-country real interest rate comovements within the euro area today mimic closely those observed among US regions. This suggests that also the interest rate channel, another important building block of the transmission process, has changed towards more homogeneity within the area, as one would expect.

[27] Angeloni and Ehrmann (2003) calculate the impact effects of monetary policy shocks on sector stock market indices.

[28] These data are shown on the *Economic Policy* website (www.economic-policy.org).

[29] Doyle (1951, *Silver Blaze*).

If all this holds true, then one would expect to also see changes in the transmission of monetary policy to asset prices after 1999. Present and expected future rates are the discount factors that translate future income flows into current asset prices. We have seen some evidence of cross-country responses of stock markets to monetary shocks. Other things being equal, stronger interest rate co-movements across countries should tend to generate more homogeneous stock price responses across countries, for given expected streams of future dividends. Unfortunately, our data did not allow a comparison across time to be made. But we observed that, after 1999, the impact of monetary policy on stock prices is not too dissimilar across countries. Whether this is due to the reaction of *both* expected future dividends *and* expected future interest rates, or only to the latter, remains an open question.

Is our case closed? We doubt Sherlock would conclude this quite yet. But we do think that he would consider a positive answer to the questions raised at the outset (has the transmission mechanism changed after EMU; is it becoming more homogeneous) as *the most plausible working hypothesis given the current state of knowledge*. He would then probably depart for further investigation. We instead stop here for now, leaving the rest for future research. The transmission of monetary policy in the euro area after EMU is a new research subject. Many promising developments come to mind, especially when more data become available. We just mention some here.

Financial integration in the euro area, in the banking as well as the non-bank financial sectors, particularly in its relation to EMU, needs analysing and monitoring closely. This should provide continuously new evidence also on the monetary transmission mechanism and its changes. Another frontier ahead seems to be the analysis of the impact of EMU on the euro area labour and product markets. Studying the origin and the nature of inflation persistence in the euro area is a crucial first step. Since extended post-EMU data series will be unavailable for some time, in the interim cross-sectional data should be exploited as much as possible. The role of the exchange rate in the euro area transmission process should also be analysed; this is something we have completely set aside in this paper. One should look afresh at this, using recent theories on pass-through and pricing to market as a starting point (see Bacchetta and Van Wincoop, 2002). Furthermore, the behaviour of euro area consumers and specifically their reaction to monetary policy and to financial factors merit further research. Relevant differences in the effect of monetary policy on consumer behaviour between the euro area and the United States have been noted, and call for explanation (see Angeloni *et al.*, 2003b).

Further ahead, the major challenge seems to be the construction of comprehensive models of the euro area, with proper microfoundation and a realistic characterization of the transmission process. There have been good steps in this direction – see Smets and Wouters (2002); Christiano *et al.* (2003) – but the goal is still very far off. Like Scotland Yard in our detective's tales, model builders are condemned by the nature of their approach always to be last in accounting for new events. Surely their story, when it comes, will be more complete and systematic than the one we have told here.

Discussion

Paul de Grauwe
University of Leuven, Belgium

This paper contains a lot of interesting information about the changes in the transmission process of monetary policies in EMU. As the authors recognize, the short period since the start of EMU puts severe limits on a satisfactory analysis of this issue. The authors have therefore decided to take a piecemeal approach, collecting bits and pieces of evidence and trying to develop a coherent story on the basis of these bits of evidence. There is of course a danger in this approach, in that the detective can be led onto a wrong track and develop a wrong story.

What do the authors establish as facts?

(1) The transmission of monetary policy to bank interest rates (deposit and lending rates) has become stronger: the impact of changes in central bank interest rates on the interest rates applied by commercial banks seems to have increased significantly since 1999. In addition, the authors claim that this transmission from the central bank interest rate to the commercial banks' interest rates has become more homogeneous. I will come back to this latter point because I will want to dispute this.
(2) The effects of monetary policy surprises on share prices are significant and appear at first sight to be relatively homogeneous. However, as the authors stress, the absence of pre-1999 data does not allow us to draw conclusions about the changes in the transmission process since 1999.

My comments are the following.

The transmission of monetary policy to bank interest rates

The authors provide interesting evidence about the transmission of monetary policy shocks (shocks in money market rates) to bank interest rates. However, their claim that this transmission has become more homogeneous is far from established. In Table 1 they show the standard deviations of the response coefficients across countries. These have declined after 1999.[30] It is unclear whether this decline is significant.

[30] The authors also show coefficients of variation. These, however, are not appropriate here. The coefficient of variation should only be used when one wants to compare the variation around the mean of two series that have a different dimension. For example when one compares the variation of (the levels) of the dollar/sterling rate with that of the dollar/yen rate, the coefficient of variation should be used and not the standard deviations. However, when one measures the dispersion of the transmission coefficients of monetary policy across countries (which should be between 0 and 1) there is no need to use the coefficient of variation because these transmission coefficients have the same dimension. In addition, and more importantly, the use of the coefficient of variation can lead to very misleading conclusions. The reason is that since the coefficient of variation is defined as the standard deviation divided by the mean it is very sensitive to small changes of the mean when the mean is close to zero. This is generally the case with interest rates, inflation rates, but also with transmission coefficients that come close to 0 as is the case in this paper. Relatively small changes of the mean then affect the coefficient of variation in a highly non-linear way.

For example, it appears that the decline in the dispersion of the impact coefficient is due to the extremely low value of the French impact coefficient prior to 1999. In Table 3, the authors provide significance tests of the degree of equality of the coefficients prior and after 1999. It appears from that table that there is little evidence that the transmission mechanism has become significantly more homogeneous.

Thus, I am tempted to be more cautious than the authors in my conclusion. Although I believe, as the authors do, that EMU contains a dynamic towards more homogeneity, until now there is insufficient evidence for sceptics like me to be convinced that the transmission of monetary policy shocks to bank lending rates has become more homogenous since 1999.

This conclusion may at first sight be inconsistent with other pieces of evidence provided by the authors, which is that there is a convergence of inter-bank rates and government bond rates since the start of EMU.

My explanation is the following. EMU had a strong integrating effect on inter-bank markets. In fact the start of EMU in 1999 fully integrated these markets into just one market where one interest rate prevailed. Similarly, the start of EMU had a strong integrating effect on the government bond market, leading to a strong (but not full) convergence of the government bond rates.

At the same time, however, EMU has had (up to now) little integrating effect on the retail segments of the banking markets. As a result, little convergence is observed in the lending rates that banks charge their customers in different euro zone countries. For the same reason these banks do not react in the same way to changes in monetary policies.

The effects of monetary policy surprises on share prices

The evidence provided here is quite interesting but difficult to interpret as the authors recognize. The main reason is that the absence of pre-1999 data precludes analysing the question of whether a convergence in the response of share prices to monetary policies has occurred.

I would like to make two observations:

(1) My reading of Table 6 suggests that the effect of monetary policy surprises on stock prices is relatively small. I arrive at this conclusion in the following way. From Table 6 we can compute that the mean stock market response to monetary policy surprises is −1.5. I assume that the mean monetary policy surprise is 0.25 (most of the changes in the interest rate decided by the ECB are of that order of magnitude). This means that on average monetary policy surprises led to a change in stock prices of about 0.4%. This is a surprisingly low response.

Incidentally, it would be interesting to report the R^2. This would give us some insight into the question of how much of the variability of the stock prices during the windows analysed by the authors were due to monetary policy surprises.

(2) There might be a lot of asymmetry in the transmission of monetary policy to stock prices across countries. I have also computed the standard deviation of the transmission coefficients across countries is equal to 1.02. This is considerably larger than those of the transmission coefficients from monetary policy to bank lending rates reported in Table 1. Of course, we still do not know whether these stock market responses to monetary policy surprises have converged after 1999. But it is interesting to observe that compared to the bank rate responses to monetary policy shocks, the share price responses appear to be more divergent across the euro zone.

In conclusion, I share the presumption of the authors that EMU will lead to more convergence in the transmission of monetary policies into the financial markets of the euro zone. In fact, this convergence has already happened in the money market and in the government bond markets. However, there is as yet insufficient evidence to claim that a conversion of the transmission of monetary policy has happened in the banking sectors of the euro zone countries. This lack of convergence has much to do with the fact that at the retail level the national banking systems remain fairly segmented in the euro zone.

Given the preponderance of banking finance in the euro zone this lack of convergence in the bank lending transmission limits the potential for a reduction of the asymmetries in the transmission of monetary policy to consumption, investment and output.

David Miles

Imperial College London, and CEPR

This paper uses recent evidence to assess whether there have been any changes in the monetary transmission mechanism within the Euro area. There is an enormous literature on the money transmission mechanism within developed economies. Much of that literature, and nearly all of it from the last 10 years, has involved estimating vector autoregression (VAR) models and looking at responses to what are called monetary policy shocks. This strikes me as a very unsatisfactory literature. The results always seem hard to interpret: the ranking of countries by sensitivity to interest rates is almost random and does not fit in with priors. Identification assumptions necessary to get any results seem to make a huge difference to models. And these VAR models are essentially a black box – they tell us little about the precise mechanisms at work within the overall transmission mechanism.

The paper by Angeloni and Ehrmann is admirable because it tries to look inside that black box. It focuses on some very specific parts of the transmission mechanism. In particular:

(1) The link between rates under the control of the relevant central banks (essentially short-term money market rates) and rates that affect businesses and households, namely bank borrowing and lending rates.
(2) The impact of unanticipated changes in interest rates on asset prices – specifically the impact upon stock prices.

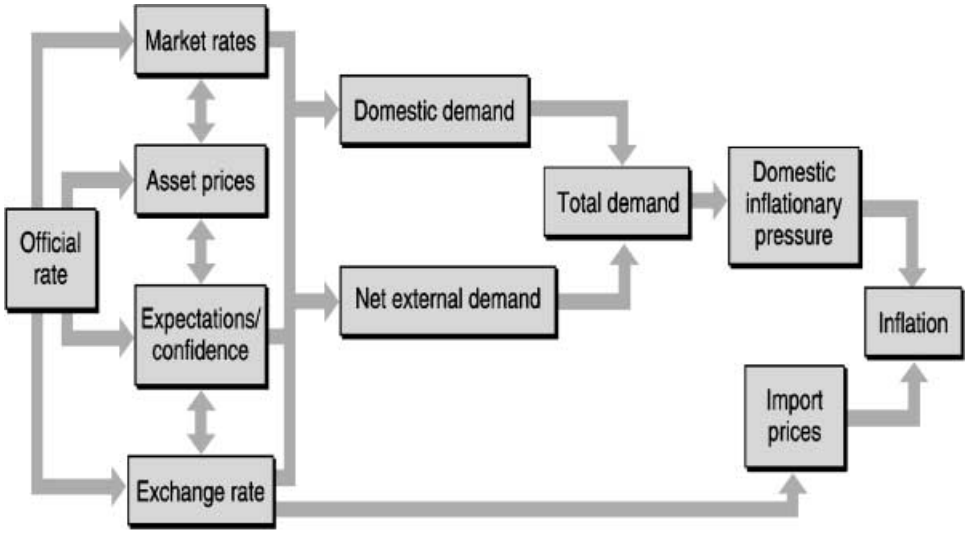

Figure 4. Stylized diagram of the transmission mechanism

The task the authors set themselves is to investigate whether these effects have changed since monetary union and how homogeneous such effects now are across the euro area.

It is important to emphasize at the outset what the paper does not do. By focusing on some very specific parts of the transmission mechanism it misses out most of the crucial links in the overall process connecting changes in monetary policy to the ultimate impacts upon the macroeconomic aggregates that matter – output, employment, unemployment and inflation. There is no evidence in this paper on how interest rate changes affect spending in different countries. There is no evidence on how changes in central bank rates affect the value of the currency – something which may generate significant cross-country differences in transmission mechanisms; nor is there any evidence on links through housing markets, which is another area where cross-country differences are likely to be significant. There are good reasons why the authors do not address these issues. But what we are left with is an analysis that really focuses on only a small number of the links shown in Figure 4 below, which describes the overall transmission mechanism. In effect, the authors are only looking at the links between the official rate and market rates and between the official rate and one particular set of asset prices – they are focusing on two of the arrows that are in the left-most part of the stylized diagram below of the monetary policy transmission mechanism.

What the authors find is that there seems to be a larger and somewhat more homogeneous impact response on commercial interest rates of changes in central bank rates since 1999. This isn't really a very surprising result. Now commercial bank rates across the euro area are responding to the same signal from the *single* central bank. It would be surprising if expectations of the degree of permanence of a European

central bank rate change should be systematically different in different parts of the monetary union. Before 1999 central banks across what is now the euro area were setting rates by reference to local conditions, so it is not surprising that the impact of those central bank decisions on commercial bank rates was rather different across countries. And, because rates were more volatile than they have been since 1999, it is not surprising that on average responses of commercial bank rates were somewhat lower. The key question here is, does this tell us much about the degree to which transmission mechanisms are now similar? It is not very clear to me that it does.

Nominal rate divergence at the short end of the maturity spectrum in the euro area has, of course, all but disappeared. This is a fairly obvious implication of the formation of a monetary union. It is more interesting that the authors find that there has been a significant increase in the degree of convergence of real rates of interest. And it is less obvious that this should have happened. It implies that actual, and probably also expected, inflation rates have also converged. But once again it is not obvious that this tells us that the transmission mechanism is now fairly homogeneous. It is, however, at least suggestive. (If transmission mechanisms were wildly different we would expect actual inflation rates not to be very close with a single interest rate). But, of course, we have only had a few years of experience since the monetary union was formed and so if overall transmission mechanisms remained rather different it is too early to expect this inevitably to have shown up in substantial divergence in inflation rates.

There are other interesting snippets of evidence in the paper. There is some evidence, for example, of a convergence in the original maturity of loan contracts. This is illuminating but once again does not really tell us anything firm about convergence in transmission mechanisms. The original maturity of the length of loans is far less relevant than the duration of those loans. I believe the evidence in the paper to be about the original maturity of loans, rather than about duration. In Spain and the UK the majority of mortgage lending remains at floating rates. The maturity of those loans is long, the duration is not. In Germany mortgage loans tend to be of shorter maturity than in the UK, but since they are primarily fixed rate loans the duration is much longer. Differences in duration matter much more for the transmission mechanism than do differences in the term over which the loan should be repaid.

Toward the end of their paper the authors look at the response of stock prices to unexpected changes in interest rates. The impact effects across countries do not really look that similar; although if we exclude some of the main outliers (which include Germany and Ireland) the differences across the remaining countries are not statistically very significant. But what we are trying to gauge here is whether there has been some convergence in transmission mechanisms since monetary union. It is a great shame here that there is no evidence on the sensitivity of asset prices to unexpected rate changes pre-1999.

The authors also note, early in the paper, that there has been some increase in mergers and acquisitions and slightly more cross-border flows in banking within the euro area. But once again the link from this evidence to the issue of whether there

has been overall convergence in transmission mechanisms is rather weak. To give a rather trivial example, the fact that Hong Kong Shanghai Bank Corporation bought Midland Bank in the UK some years ago really has very little to do with whether the UK monetary transmission mechanism has become more or less similar to that of Hong Kong. And the fact that US banks lend for mortgages in the UK most certainly does not make the products they sell similar to those offered in the US mortgage market. They are quite different.

The interesting questions about the monetary transmission mechanism in the euro area are all about the extent to which a change in European Central Bank rates affects demand and prices differently across member countries. Whether those differences are diminishing as a result of the monetary union and financial markets integration is really the central question. In this paper we have some suggestive facts about this but we do not have killer facts.

Panel discussion

Carlo Favero pointed out that the convergence of term premiums might simply be a consequence of the elimination of exchange rate risk. One remedy could be to look at the pass-through for long-term rates. However, his own research had shown that term premiums collapse for the long-term rates as well. He urged the authors to control for the intra-day fluctuation in the US stock market when investigating the impact of monetary policy shocks on stock prices. He also pointed out that the paper of Bartolini and Prati suggested the need to distinguish between rate hikes and cuts. David Begg suggested estimating VARs before and after 1999 instead of using survey data, because he had doubts about the quality of the survey data as an estimate of the size of the monetary policy surprise. Michael Ehrmann replied that though the Reuters data had weaknesses, the literature had found them to outperform market-based measures for the euro area and the USA. Moreover, the focus of the paper was not on the size of the surprise but its homogeneity.

Ghikas Hardouvelis urged the authors to extend the empirical study to bank-level data in order to use as much cross-sectional variation as possible, given that small magnitude of the time variation. This would allow them to control for such factors as bank size, asset and liability allocation. Concerning the analysis of monetary surprises on stock markets, he argued that Ireland might be an outlier because in the Irish case restrictive monetary policy can be good news since it contains inflation and reduces the risk premium. Thus, it would be interesting to rank countries with respect to their inflation rate and check whether there is something to this story.

Mike Artis pointed out that it is not so clear why convergence in transmission mechanisms is desirable if the propagation of shocks differs across countries. Moreover, one important component that might have induced convergence of transmission

across countries had ceased to exist since 1999: the dominant idiosyncratic monetary policy of the Bundesbank which tried to give a signal to wage setters by a particular conservative inflation target.

Winfried Koeniger followed Mike Artis's remarks by adding that it would be interesting to investigate whether the heterogeneity in the transmission mechanism addresses the structural heterogeneity of countries or if it exacerbates national or regional asymmetries.

APPENDIX

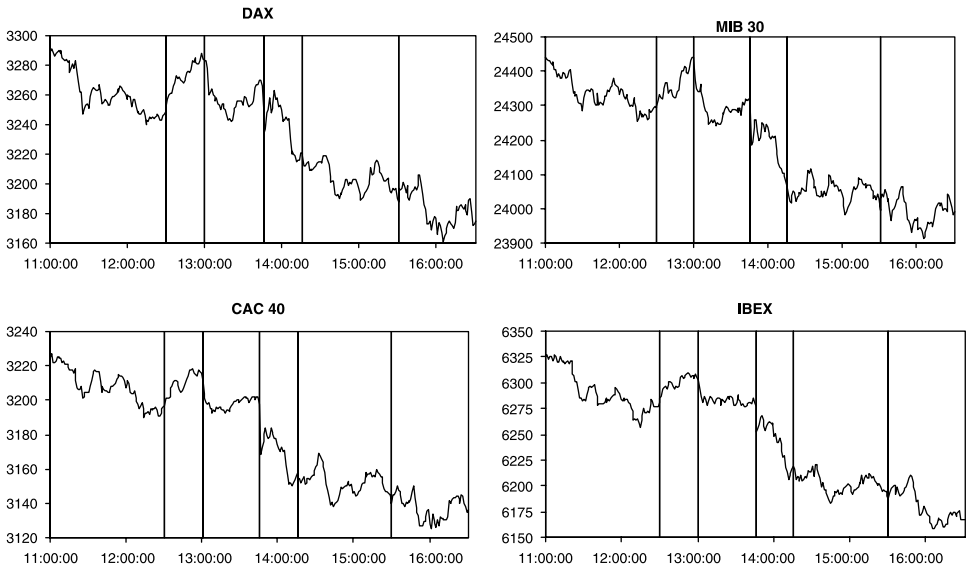

Figure A1. Stock market indices on 7 November 2002, 11:00–16:30

Notes: First vertical line: start of time window at 12:30; second vertical line: Bank of England announcement at 13:00; third vertical line: ECB announcement at 13:45; fourth vertical line: start of ECB press conference at 14:15; fifth vertical line: end of time window.

REFERENCES

Andersen, T.G., T. Bollerslev, F.X. Diebold and C. Vega (2003). 'Micro effects of macro announcements: real-time price discovery in foreign exchange', *American Economic Review*, 93(1), 38–62.

Angeloni, I., and M. Ehrmann (2003). 'Monetary policy transmission in the euro area: any changes after EMU?', ECB Working Paper Series, No. 240.

Angeloni, I., A. Kashyap and B. Mojon (eds.) (2003a). *Monetary Policy Transmission in the Euro Area*, Cambridge University Press, Cambridge, forthcoming.

Angeloni, I., A. Kashyap, B. Mojon and D. Terlizzese (2003b). 'The output composition puzzle: a difference in the monetary transmission mechanism in the Euro area and the US', *Journal of Money Credit and Banking*, forthcoming.

Bacchetta, P. and E. Van Wincoop (2002). 'A theory of the currency denomination of international trade', ECB Working Paper No. 177.

Bernanke, B. and M. Gertler (1995). 'Inside the black box: the credit channel of monetary policy transmission', *Journal of Economic Perspectives*, 9, 27–48.
Bernanke, B., M. Gertler and S. Gilchrist (1999). 'The financial accelerator in a quantitative business cycle framework', *Handbook of Macroeconomics*, Vol. 1c.
Bomfim, A.N. (2000). 'Pre-announcement effects, news, and volatility: monetary policy and the stock market', Board of Governors Finance and Economics Discussion Paper No. 2000–50.
Bomfim, A.N. and V. Reinhart (2000). 'Making news: financial market effects of Federal Reserve disclosure practices', Board of Governors Finance and Economics Discussion Paper No. 2000–14.
Borio, C.E.V. (1995). 'The structure of credit to the non-government sector and the transmission mechanism of monetary policy: a cross-country comparison'. BIS Working Paper No. 24.
Cecchetti, S. (2001). 'Legal structure, financial structure and the monetary policy transmission mechanism', in Deutsche Bundesbank (ed.), *The Monetary Transmission Process*. Palgrave, Basingstoke.
Calvo, G. and C. Reinhart (2000). 'Fear of floating', NBER Working Paper No. 7993.
Christiano, L., R. Motto and M. Rostagno, (2002). 'Banking and financial frictions in a dynamic, general equilibrium model', mimeo.
De Bondt, G., B. Mojon and N. Valla (2003). 'Term structure and the sluggishness of retail bank rates in euro area countries', mimeo, ECB.
Doyle, A.C. (1951). *Sherlock Holmes, Selected Stories*, Oxford University Press, Oxford.
Ehrmann, M. and M. Fratzscher (2002). 'Interdependence between the euro area and the US: what role for EMU?', ECB Working Paper No. 200.
Ehrmann, M., L. Gambacorta, J. Martinez-Pages, P. Sevestre and A. Worms (2003). 'Financial systems and the role of banks in monetary policy transmission in the euro area', forthcoming in I. Angeloni, A. Kashyap and B. Mojon (eds.), *Monetary Policy Transmission in the Euro Area*, Cambridge University Press, Cambridge.
Fagan, G., J. Henry and R. Mestre (2001). 'An area-wide model for the euro area', ECB Working Paper No. 42.
Guiso, L., A. Kashyap, F. Panetta and D. Terlizzese (1999). 'Will a common European monetary policy have asymmetric effects?', *Federal Reserve Bank of Chicago Economic Perspectives* 23(4), 56–75.
Hamilton, J.D. (1994). *Time Series Analysis*, Princeton University Press, Princeton.
Hannan, T.H. and A.N. Berger (1991). 'The rigidity of prices: evidence from the banking industry', *American Economic Review* 81, 938–45.
Hartmann, P., M. Manna and A. Manzanares (2001). 'The microstructure of the euro money market', *Journal of International Money and Finance* 20(6), 895–948.
Kashyap, A.K. and J.C. Stein (1997). 'The role of banks in monetary policy: a survey with implications for the European Monetary Union', *Federal Reserve Bank of Chicago Economic Perspectives*, September–October, 2–18.
Kieler, M. and T. Saarenheimo (1998). 'Differences in monetary policy transmission? A case not closed', *European Commission Economic Papers* No. 132.
Kuttner, K.N. (2001). 'Monetary policy surprises and interest rates: evidence from the Fed funds futures market', *Journal of Monetary Economics* 47, 523–44.
Leamer, E. (1978). *Specification Searches: Ad Hoc Inference with Nonexperimental Data*, J. Wiley & Sons.
Meltzer, A.H. (1995). 'Monetary, credit and (other) transmission processes: a monetarist perspective', *Journal of Economic Perspectives* 9, 49–72.
Mihov, I. (2001). 'Monetary policy implementation and the transmission in the European Monetary Union', *Economic Policy*, 33, 369–402.
Mishkin, F. (ed.) (1995). 'Symposium on the monetary transmission mechanism', *Journal of Economic Perspectives* 9(4), Fall, 3–10.
Neumark, D. and S.A. Sharpe (1992). 'Market structure and the nature of price rigidity: evidence from the market for consumer deposits', *Quarterly Journal of Economics* 107, 657–80.
Pearce, D.K. and V.V. Roley (1983). 'The reaction of stock prices to unanticipated changes in money: a note', *Journal of Finance* 38(4), 1323–33.
Peersman, G. and F. Smets (2003). 'The monetary transmission mechanism in the euro area: more evidence from VAR analysis', forthcoming in I. Angeloni, A. Kashyap and B. Mojon (eds.), *Monetary Policy Transmission in the Euro Area*, Cambridge University Press, Cambridge.

Reifschneider, D., R. Tetlow and J. Williams (1999). 'Aggregate disturbances, monetary policy, and the macroeconomy: The FRB/US perspective', *Federal Reserve Bulletin* (January), 1–19.
Roley, V.V. and G.H. Sellon (1998). 'Market reaction to monetary policy non-announcements', Federal Reserve Bank of Kansas City Working Paper No. 98–06.
Sapienza, P. (2002). 'The effects of banking mergers on loan contracts', *Journal of Finance*, 57, 329–67.
Sellin, P. (2001). 'Monetary policy and the stock market: theory and empirical evidence', *Journal of Economic Surveys* 15(4), 491–541.
Smets, F. and R. Wouters (2002). 'An estimated stochastic dynamic general equilibrium model of the euro area', ECB Working Paper No. 171.
Smets, F. and R. Wouters (2003). 'Shocks and frictions in US and Euro area business cycles: a Bayesian DSGE approach', EABCN Workshop in Madrid (ECB, mimeo), March 2003.
Van Els, P., A. Locarno, J. Morgan and J.P. Villetelle (2003). 'Monetary policy transmission in the euro area: what do aggregate and national structural models tell us?', forthcoming in I. Angeloni, A. Kashyap and B. Mojon (eds.), *Monetary Policy Transmission in the Euro Area*, Cambridge University Press, Cambridge.