Is the EMU a viable common currency area? A VAR analysis of regional business cycles

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Introduction and summary

In January 1999, 11 European countries bravely launched into a common currency area known as the European Monetary Union (EMU). By joining the common currency area, member countries have agreed to keep the value of their national currency fixed in terms of the currencies of the other EMU countries for an indefinite period. Consumers and businesses in these countries will, however, find that very little has changed. The most noticeable change will not occur until 2002 when national currencies are replaced by a common currency known as the *euro*. In the intervening period, prices will be denominated in terms of existing national currencies and euros. Consumers using cash will pay the national currency price, while consumers using credit cards (including U.S. visitors to the euro zone) will notice that their transactions are carried out in euros.

Although they might disagree about the exact size of the gains, most economists would agree that the EMU will yield significant microeconomic benefits through lower transactions and hedging costs. According to the European Commission, the gains from carrying out transactions in a single currency could be as high as 0.5 percent of European Union gross domestic product (GDP) per year. However, many economists are skeptical about the long-run viability of the EMU. Euro-zone members have given up the right to set their own interest rates and the option of moving their exchange rates against each other. The widespread view is that this loss of flexibility may involve significant costs (in the form of persistent high unemployment and low output growth) if their economies do not behave as one or cannot easily adjust in other ways. The ultimate concern is that for some countries, these macroeconomic costs will eventually outweigh the microeconomic benefits and lead them to abandon the EMU.

How well the EMU performs along the macro dimension will depend on how closely it fits the notion of an "optimal currency area" (OCA). Beginning with Mundell (1961), economists have long agreed that the following four criteria must be met for a region to be an optimal currency area: 1) countries should be exposed to similar sources of disturbances (common shocks); 2) the relative importance of these common shocks should be similar (symmetric shocks); 3) countries should have similar responses to common shocks (symmetric responses); and 4) if countries are affected by country-specific sources of disturbance (idiosyncratic shocks), they need to be able to adjust quickly. The basic idea is that countries satisfying these criteria would have similar business cycles, so a common monetary policy response would be optimal.

How far the euro zone is from an OCA is an open question for research, as is the more important question of whether the apparent deviation from an OCA is sufficient to question the long-run viability of the EMU. On the surface, the data seem to support the skeptics' view that the EMU is not an OCA. First, euro-zone countries have experienced frequent and often large idiosyncratic shocks over recent years. A well-known example is German reunification, which many argue led to the breakdown of the precursor to the EMU known as the European Monetary System (EMS) in 1992.[1] Second, persistently high unemployment rates throughout Europe suggest that EMU economies (especially their labor markets) are slow to adjust to all economic disturbances.

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The purpose of this article is to formally assess the long-run viability of the EMU. I do this by comparing the sources and responses to economic shocks to the EMU with those from a well-functioning currency union, the U.S. My working hypothesis is that if the EMU is as close to an OCA as the U.S. is, based on the criteria outlined above, it may well be a viable currency union in the long run. If, on the other hand, the EMU is less like an OCA than the U.S. is, one might question the long-run viability of this monetary union.

Despite all the effort that has gone into the EMU debate, there is little in the way of empirical research on the sources and responses to economic shocks to this region. I use a statistical technique known as a structural vector autoregression (VAR) to extract these components from the data. My analysis suggests that U.S. regions are highly symmetric. U.S. regions face common sources of disturbance, to which they respond in a similar way. In contrast, the EMU countries can be grouped into a symmetric *center* and a clearly asymmetric *periphery*. Center countries are Austria, Belgium-Luxembourg (treated as one country for data purposes), France, Germany, Italy, the Netherlands, Portugal, and Spain, while the periphery countries are Finland and Ireland. Center countries display many of the characteristics of U.S. regions when compared on OCA criteria. Periphery countries appear to have quite different sources of disturbance from the center. In addition, they seem to respond to common shocks in a different way from the center countries. I conclude on the basis of this statistical analysis that the EMU will be a viable currency union for the center countries, but question the viability of a union with countries in the periphery.

Previous empirical analysis of the EMU

The EMU has spawned a number of empirical papers aimed at understanding the nature of regional business cycles and the regional impact of fiscal and monetary polices. The approaches vary considerably. For example, Carlino and DeFina (1998b) examine the regional effects of monetary policy within the EMU. Their approach is indirect. In earlier work, Carlino and DeFina (1998a) estimated the effects of U.S. monetary policy on the 48 contiguous U.S. states (and eight Bureau of Economic Analysis [BEA] regions). They build on this analysis in the later paper by estimating the cross-sectional relationship between the long-run regional output response to monetary policy and industry structure. Their findings suggest that monetary policy has a larger impact on more industrial-oriented U.S. regions, such as the Great Lakes. They use these cross-sectional U.S. findings and the industry structure of EMU countries to speculate on the long-run regional impact of monetary policy within the EMU. Their results suggest that monetary policy will have a differential impact on EMU countries. This implies that the EMU is not an OCA, since it fails to meet the symmetric responses criterion. In a competing study, Dornbusch, Favero, and Giavazzi (1998) test this hypothesis directly using time-series methods and find that the effect of monetary policy is not statistically different across EMU countries. Their study suggests EMU countries have similar responses to monetary policy shocks, which is necessary for a region to be an OCA. An obvious limitation of this work is that it is silent on the incidence of other disturbances affecting the EMU countries and the broader question of whether the EMU will be viable in the long run.

Eichengreen has approached the question of whether the EMU is an OCA from a number of interesting directions. Eichengreen (1992) joins others in gauging the importance of country-specific shocks by computing the variability of bilateral EMU real exchange rates, for example, the real exchange rate between Germany and France. The basic idea is that these relative price fluctuations reflect shifts in demand and supply affecting one EMU country relative to another, so countries with more highly correlated disturbances will have less volatile bilateral real exchange rates. The typical approach of this type of study is to compare the volatility of bilateral EMU real exchange rates with the volatility of relative output prices of U.S. BEA regions. A common finding is that the bilateral real exchange rates of EMU countries are considerably more volatile than the relative output prices of U.S. regions. This suggests that the EMU is further than the U.S. is from being an OCA. An obvious weakness of this type of analysis is that it does not directly compare the EMU and the U.S. using the OCA criteria outlined earlier.

Observing this limitation, Eichengreen and Bayoumi (1993) approach the issue in a more direct way. They estimate individual models for U.S. BEA regions and EMU countries using a technique developed by Blanchard and Quah (1989), which allows them to extract unobserved components from the data that describe so-called demand and supply shocks. Demand and supply shocks are distinguished by the fact that demand shocks are assumed to have a temporary impact on the economy, while supply shocks are assumed to have a permanent effect on the economy. Eichengreen and Bayoumi (1993) then compare the correlation coefficients of German supply (and demand) shocks and those of other EMU countries with the correlation coefficients of U.S. Mideast supply (and demand) shocks and those of other U.S. regions. They show that U.S. regional supply (and demand) shocks tend to be more highly correlated than EMU regional supply (and demand) shocks. The final step of their analysis is to compare regional responses to demand and supply shocks. Their results suggest that the response functions of U.S. regions are more alike than those of EMU countries. On the basis of this analysis, they conclude that the EMU is further than the U.S. is from being an OCA, which leads them to argue that the EMU may find it more difficult than the U.S. to operate a monetary union.

My empirical analysis builds on Eichengreen and Bayoumi (1993) along two dimensions. First, I update their work by analyzing more recent data. Eichengreen and Bayoumi's data spanned the years from 1963 to 1986, while I consider data covering the years from 1969 to 1997. These data are likely to be more informative about the behavior of countries under the EMU, since they include a greater number of years over which the EMU countries were part of the forerunner to the EMU, the EMS. Second, I adopt a different way of decomposing the data that allows me to directly measure the extent to which regional business cycles are driven by common and country-specific shocks. My conclusions differ from Eichengreen and Bayoumi's. In contrast to their findings, I show that with the exception of two relatively small countries, Finland and Ireland, the euro zone shares many of the regional business cycle characteristics of the U.S. In other words, the EMU comes as close to being an OCA as the U.S. does. I argue on the basis of these results that the long-run viability of the EMU is similar to that of the U.S. monetary union.

A weakness of all the foregoing empirical research is that historical data may be an unreliable guide to the way euro-zone countries will behave under the EMU. This observation is a simple application of the *Lucas critique*. The basic idea is that historical data may be uninformative since the structure of euro-zone economies (and possibly the world economy) will likely undergo significant change after the EMU adopts a common currency. Frankel and Rose (1998) find empirical support for this proposition by showing that one form of structural change that may occur under the single currency, greater trade flows between countries, leads to more highly correlated business cycles. A consequence of their work for all EMU studies is that countries that may appear from historical data to be poor candidates for inclusion in the euro zone may indeed turn out to be suitable candidates after joining the union. This clearly has implications for earlier work that argued against the long-run viability of the EMU. I argue that the EMU will be viable in the long run, so Frankel and Rose's results merely reinforce my conclusions.

How similar are EMU country business cycles?

A simple and direct way of assessing the similarity of regional business cycles is to calculate the correlation between aggregate and individual region business cycles. High correlations are indicative of common sources and responses to disturbances. In figure 1, I plot cyclical movements in U.S. aggregate and regional real income.[2] The underlying data are BEA annual state personal income from 1969 to 1997. These data are deflated by the national consumer price index.[3] I use personal income rather than gross state product because the former span a longer period.[4] The eight BEA regions are the Great Lakes, Plains, New England, Mideast, Southeast, Southwest, Rocky Mountains, and Far West.[5] The lowest correlation between a region and the U.S. aggregate is 0.76 for the Southwest, with the highest at 0.98 for the Southeast and Great Lakes. This suggests that common shocks explain a large share of the variation in U.S. regional income.

I repeat this exercise for the EMU. Figure 2 plots the cyclical fluctuations of aggregate and regional EMU income. The underlying data are International Monetary Fund (IMF) estimates of real annual GDP from 1969 to 1997. The correlations between regional and aggregate activity can easily be divided into two groups. The first group—Austria, Belgium-Luxembourg, France, Germany, Italy, the Netherlands, Portugal, and Spain—resemble the U.S. regions, with correlations ranging from 0.72 (Spain) to 0.90 (Germany and Italy). The second group of Finland and Ireland, with correlations of 0.45 and 0.58, respectively, appear to have business cycles that are quite different from the rest of the euro zone.

With the exception of Finland and Ireland, the coherence between EMU regional business cycles appears to be as high as that of U.S. BEA regions. On the basis of these results, a subset of the EMU can not be ruled out as a viable currency union. An obvious weakness of this approach is that it does not allow for a comparison of the sources of disturbances or responses to disturbances across regions. Next, I describe a statistical technique that overcomes this limitation. Using these results, I can more closely gauge the extent to which the EMU and the U.S. meet the OCA criteria described earlier.

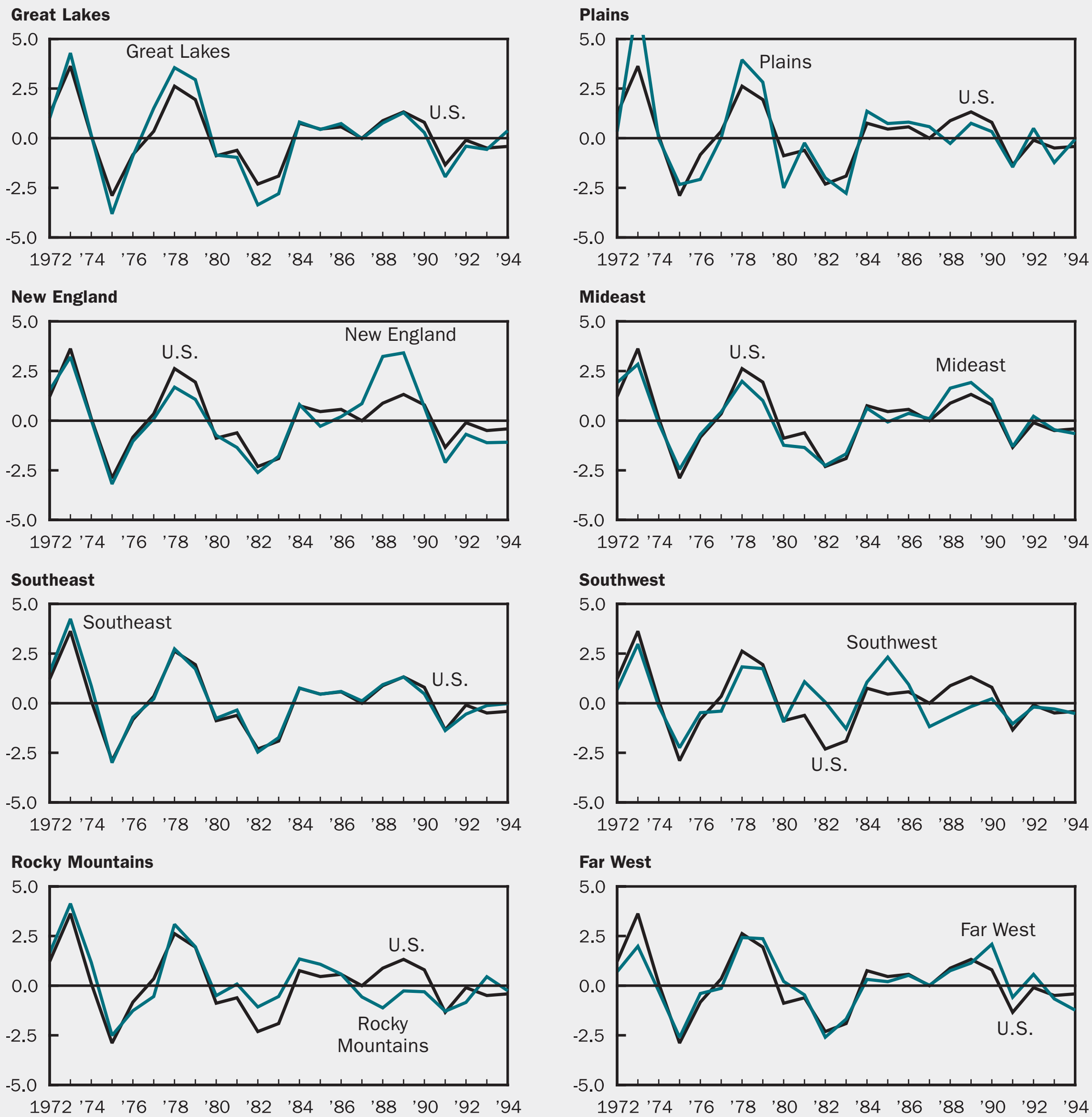
Are the sources of shocks and responses to them similar across EMU countries?

Methodology

My starting point for isolating the sources of regional shocks and responses to them is recent work analyzing the regional effects of U.S. monetary policy. The typical approach is to use a structural vector autoregression (VAR). A VAR is a statistical method that allows one to estimate how an unpredictable change (or disturbance) in one variable affects other variables in the economy. For example, one of the questions raised by theoretical research is whether a change in monetary policy has a stronger effect on regions that devote a larger share of activity to industrial production. A VAR allows one to estimate the way that an unpredicted change in monetary policy

FIGURE 1

Cyclical movements of U.S. regional output
(percent)

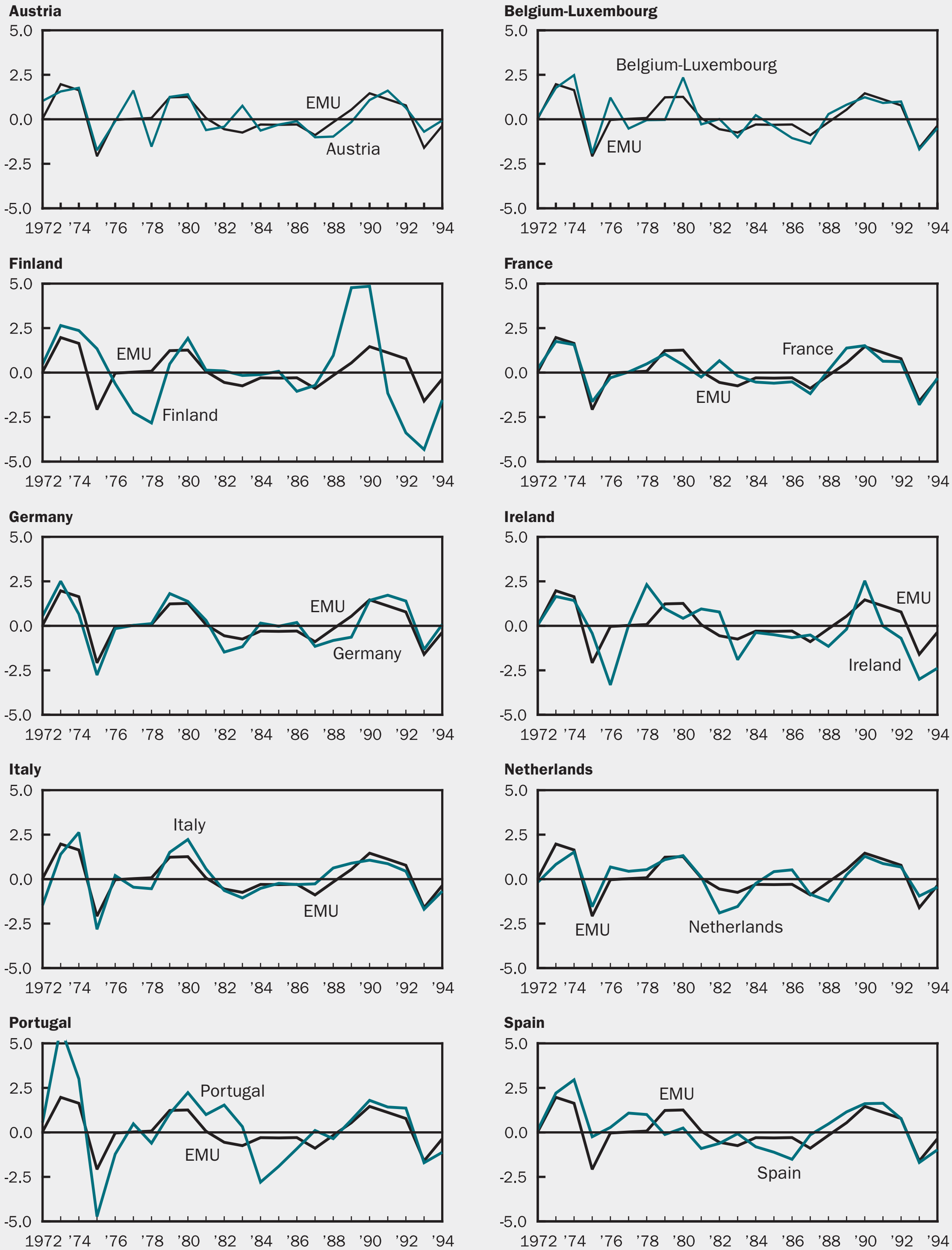


Note: Personal income data are filtered using the annual "business cycle" band-pass filter described in Baxter and King (1995).

Source: Author's calculations from U.S. Department of Commerce, Bureau of Economic Analysis, 1969–97, "State personal income," database.

FIGURE 2

Cyclical movements of EMU regional output
(percent)



Note: Gross domestic product filtered as described in figure 1.
Source: Author's calculations from International Monetary Fund, gross domestic product data.

affects the output of regions with relatively large and small industrial sectors.

There is a wide range of variables one can use in analyzing regional business cycles. I follow the approach of Carlino and DeFina (1998a) by limiting the analysis of U.S. regional business cycles to eight VARs, which essentially study interaction between the U.S. and a given region, in this case the eight BEA regions. I adopt a slightly different structural model by drawing on the approach of Christiano, Eichenbaum, and Evans (1994) in their work on identifying and measuring the aggregate effects of U.S. monetary policy shocks. Each U.S. regional VAR is designed to study how unpredicted changes in world oil prices, aggregate U.S. and regional income, and U.S. monetary policy (U.S. federal funds rate) affect the region's income.

VAR studies of international business cycles take a somewhat similar approach to the U.S. regional business cycle literature. International research has focused almost exclusively on the relationship between U.S. and G-7 (Group of Seven) business cycles under different exchange rate regimes.[6] This type of analysis is generally restricted to bilateral VARs involving the U.S. and a G-7 country. I adapt this approach to the EMU. I employ 10 VARs. Just as in the U.S. regional case, each EMU VAR is designed to study how unpredicted changes in world oil prices, aggregate EMU and country of interest income, and EMU region monetary policy (German short-term interest rate) affect the EMU country's income.

I estimate the U.S. and EMU VARs using annual data over a common period spanning 1969 to 1997. I limit the U.S. and EMU VARs so that they estimate relationships between the four variables (world oil prices, aggregate income, regional income, and a regional short-term interest rate) with data from the last two years. In other words, I estimate the link between movements in aggregate and regional income that occurred within the last two years.

Before I can shed light on the nature of regional disturbances and responses to them, I need to impose some structure on the system of equations described by the VARs. There are numerous forms of identifying restrictions in the literature. In their work on the EMU, Eichengreen and Bayoumi (1993) impose long-run restrictions on the data motivated by a theoretical model. I use a recursive structure popularized by Sims (1972). This approach imposes restrictions on the covariance structure of the disturbances of the model. In particular, structural disturbances are identified by imposing a recursive information ordering. Throughout the analysis, I impose the following information ordering: world oil prices; aggregate regional income; indicator of regional monetary policy; and regional or country income. This approach assumes, as in Christiano, Eichenbaum, and Evans (1994) that the monetary authority chooses the value of the monetary policy instrument after observing contemporaneous movements in oil prices and aggregate output.[7] In this setting I can conveniently refer to the structural disturbances as an oil price or global shock, aggregate output shock, monetary policy shock, and region- or country-specific output shock.

With these models in hand, I am able to assess the similarity of EMU and U.S. regional business cycles along two dimensions. First, by studying the sources of regional economic disturbances in the U.S. and EMU, I can determine the extent to which fluctuations are caused by common and idiosyncratic shocks. In the U.S. case, common shocks include unpredicted changes to world oil prices, aggregate U.S. income, and U.S. monetary policy (U.S. federal funds rate). Similarly, in the case of the EMU, aggregate shocks include unpredicted changes to world oil prices, aggregate EMU income, and EMU monetary policy (German short-term interest rate). Idiosyncratic shocks are captured by U.S. region-specific and EMU country-specific output shocks. The relative importance of the various sources of disturbance will be revealed by the share of the one-step-ahead forecast error of U.S. region or EMU country income that is due to unpredicted changes in the disturbance. In a perfectly symmetric case, regions would have none of their forecast error explained by region-specific shocks and the same shares for the various common shocks.

Second, by studying the responses to economic disturbances, I can assess whether regions have similar responses to common shocks and determine the time it takes regions to respond to idiosyncratic shocks. The way that region and country income responds to various disturbances will be embodied in the estimated parameters of the VAR and revealed through the shape and size of the model's impulse response function. For a description of the methodology in greater detail, see the appendix.

Do U.S. regions have similar economic disturbances?

Tables 1 and 2 report decompositions of the forecast errors of income for U.S. regions and EMU countries, respectively. These decompositions indicate the share of the error attributable to a particular disturbance for a given forecast horizon. The one-step-ahead errors are informative about the similarity of disturbances across regions within a currency area, while step lengths of greater than one contain joint information about the similarity of disturbances and responses to disturbances.

Table 1 reveals that a large share of the disturbance to U.S. regions is due to common shocks (that is, unanticipated shocks to world oil prices, aggregate U.S. income, and U.S. monetary policy). For example, common disturbances explain a large share of the variation in the Southeast, Great Lakes, Mideast, and Far West's one-step-ahead forecast error (84 percent to 95 percent). The Rocky Mountains and Plains appear to have the largest region-specific influences, with 60 percent and 64 percent, respectively, of the variation in their one-step-ahead forecast errors explained by common disturbances. New England and the Southwest fall somewhere in between, with common disturbances explaining a little more than 70 percent of the variation in their one-step-ahead forecast errors. The relative importance of different common shocks is also similar across U.S. regions. Shocks to aggregate U.S. income are a more important source than shocks to world oil prices and

TABLE 1

Forecast error variance decompositions for real personal income of U.S. regions

Great Lakes

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Great Lakes income
1	35	58	0	6
2	39	53	5	3
5	21	21	57	1
10	26	20	51	3

Plains

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Plains income
1	16	47	0	36
2	25	54	2	18
5	18	33	33	15
10	23	29	29	19

New England

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	New England income
1	35	36	0	29
2	38	14	5	44
5	33	4	26	37
10	33	8	29	29

Mideast

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Mideast income
1	12	74	1	14
2	16	42	11	31
5	24	15	33	27
10	26	17	31	25

Southeast

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Southeast income
1	41	54	0	5
2	58	36	2	4
5	39	14	37	10
10	38	14	39	9

Southwest

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Southwest income
1	2	72	0	26
2	1	68	2	30
5	3	50	16	31
10	2	48	26	24

Rocky Mountains

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Rocky Mtns. income
1	20	40	0	40
2	24	30	2	44
5	10	17	32	40
10	9	19	46	26

Far West

Years ahead	Percentage of forecast error due to: Oil prices	U.S. income	Fed funds rate	Far West income
1	26	57	1	16
2	40	42	0	18
5	42	32	7	18
10	43	31	13	13

Notes: Each panel describes the decomposition of the forecast error for the region of interest's income. The first column in each block refers to the number of years (s = 1, 2, ..., 10) ahead for the forecast. Columns indicate the percentage of the s-step-ahead forecast error arising from a particular structural disturbance.

Source: Calculations from author's statistical model, using the following annual data series: IMF—world crude oil prices; BEA—personal income by state; and Federal Reserve Board of Governors—federal funds rate.

U.S. monetary policy. Overall, these results suggest that U.S. regions have similar sources of economic disturbances.

Table 1 also provides some indication of the similarity of responses to disturbances. Looking at horizons of greater than one year, the relative importance of

TABLE 2

Forecast error variance decompositions for real gross domestic product of EMU countries

Austria

Years ahead	Oil prices	EMU GDP	EMU interest rate	Austrian GDP
	Percentage of forecast error due to			
1	17	43	1	39
2	12	50	15	24
5	13	23	50	13
10	22	13	56	9

Belgium-Luxembourg

Years ahead	Oil prices	EMU GDP	EMU interest rate	Bel-Lux GDP
	Percentage of forecast error due to			
1	24	56	0	20
2	19	52	13	16
5	17	21	55	7
10	26	18	49	7

Finland

Years ahead	Oil prices	EMU GDP	EMU interest rate	Finnish GDP
	Percentage of forecast error due to			
1	3	0	4	93
2	1	4	2	94
5	17	12	5	66
10	19	14	7	60

France

Years ahead	Oil prices	EMU GDP	EMU interest rate	French GDP
	Percentage of forecast error due to			
1	1	80	0	20
2	15	57	5	23
5	20	21	48	11
10	16	23	47	13

Germany

Years ahead	Oil prices	EMU GDP	EMU interest rate	German GDP
	Percentage of forecast error due to			
1	1	77	0	22
2	1	59	15	25
5	6	34	43	17
10	10	35	42	14

Ireland

Years ahead	Oil prices	EMU GDP	EMU interest rate	Irish GDP
	Percentage of forecast error due to			
1	0	3	2	95
2	0	7	9	85
5	2	2	16	80
10	1	2	7	91

Italy

Years ahead	Oil prices	EMU GDP	EMU interest rate	Italian GDP
	Percentage of forecast error due to			
1	15	33	13	39
2	14	32	15	39
5	17	10	49	25
10	19	8	44	28

Netherlands

Years ahead	Oil prices	EMU GDP	EMU interest rate	Dutch GDP
	Percentage of forecast error due to			
1	12	49	6	33
2	6	41	20	33
5	3	18	41	37
10	2	20	42	35

Portugal

Years ahead	Oil prices	EMU GDP	EMU interest rate	Portuguese GDP
	Percentage of forecast error due to			
1	1	47	14	38
2	1	44	9	46
5	5	18	46	32
10	7	21	41	30

Spain

Years ahead	Oil prices	EMU GDP	EMU interest rate	Spanish GDP
	Percentage of forecast error due to			
1	2	45	15	38
2	1	36	27	36
5	6	22	46	25
10	11	21	45	24

Notes: Each panel describes the decomposition of the forecast error for the country of interest's GDP. The first column in each block refers to the number of years (s = 1, 2, ..., 10) ahead for the forecast. Columns indicate the percentage of the s-step-ahead forecast error arising from a particular structural disturbance.

Source: Calculations from author's statistical model, using the following annual data series: IMF—world crude oil prices, interest rates, and gross domestic product.

common and idiosyncratic disturbances is largely unchanged. This suggests that responses are fairly similar. A common finding is that unanticipated shocks to aggregate U.S. income are less important at longer horizons.

Are EMU country economic disturbances more alike than those of U.S. regions?

Table 2 reports forecast error decompositions for the income of EMU countries. Concentrating on the one-step-ahead forecast error, countries fall into three groups. Common shocks explain about 80 percent of the one-step-ahead forecast errors of income in Belgium-Luxembourg, France, and Germany. This share is a little above 60 percent for Austria, Italy, the Netherlands, Portugal, and Spain. The outliers are Finland and Ireland, where this share falls below 10 percent.

The decompositions of the first EMU group are similar to the U.S. group comprising the Great Lakes, Southeast, Mideast, and Far West. The second EMU group has forecast error decompositions that are close to those of the U.S. Rocky Mountain and Plains regions. In both cases, oil price shocks are relatively less important than in their U.S. counterpart, while interest rate shocks are relatively more important than in the U.S. regions. Just as in the U.S., aggregate income shocks are the most important economic disturbance to EMU country income. The findings suggest that, with the exception of Finland and Ireland, EMU country economic disturbances are as alike as those of U.S. regions.

Again, ignoring Finland and Ireland, the long-horizon picture of EMU disturbances is also similar to the U.S. This suggests that EMU responses to disturbances may well be as alike as U.S. responses.

Do U.S. regions have similar responses to economic disturbances?

Figures 3–6 describe in detail the responses of the eight BEA regions to common and idiosyncratic shocks. The black lines trace the impulse response functions of regional income: the way regional income responds over time to a one standard deviation shock to world oil prices, aggregate output, U.S. monetary policy, and regional income, respectively. (The colored lines are the 95 percent confidence bands of these impulse response functions.) These figures show that U.S. regions have similar responses to common disturbances (unanticipated shocks to world oil prices, aggregate U.S. output, and U.S. monetary policy) and that they adjust to idiosyncratic shocks over a period of about two years.

Figure 3 shows that an unanticipated increase in the growth rate of world oil prices has a significant negative impact on the income of seven of the eight U.S. regions, which persists for about one year. The exception is the Southwest, which is the largest oil producing region of the U.S. Although the result is not statistically significant, an increase in the growth rate of world oil prices raises Southwest real income.

In contrast, figure 4 reveals that an unexpected positive shock to aggregate U.S. income has an immediate positive impact on the income of all U.S. regions. The effect of this shock on regional income is generally not statistically significant beyond two years. The only exception is the Southwest, where the aggregate income shock has a statistically significant effect six years after the shock.

Figure 5 shows that an unexpected tightening of U.S. monetary policy (an unexpected rise in the U.S. federal funds rate) tends to have a statistically significant effect on U.S. regional income two years after the shock. The exceptions are the Southwest and Far West. In both cases, the impulse response function is virtually identical to those of other U.S. regions, but not statistically different from the zero line.

Turning to idiosyncratic shocks, figure 6 reveals that U.S. regions adjust quickly to region-specific disturbances. The regions can be divided into two groups. The first group, consisting of the Great lakes, Plains, Southeast, and Far West, have responses that are not statistically significant beyond the year in which the shock occurs. The second group, comprising New England, Mideast, Southwest, and Rocky Mountains, have responses that are statistically significant for no more than three years after the shock.

Do EMU countries have responses that are more alike than those of U.S. regions?

Figures 7–10 (pages 15–18) describe in detail the response functions of the EMU countries to common and idiosyncratic disturbances. These figures suggest that, with the clear exceptions of Finland and Ireland, the response functions of EMU countries are at least as alike as those of U.S. regions. In addition, the response functions imply that contrary to the general view, EMU countries adjust to idiosyncratic shocks at the same speed or faster than U.S. regions.

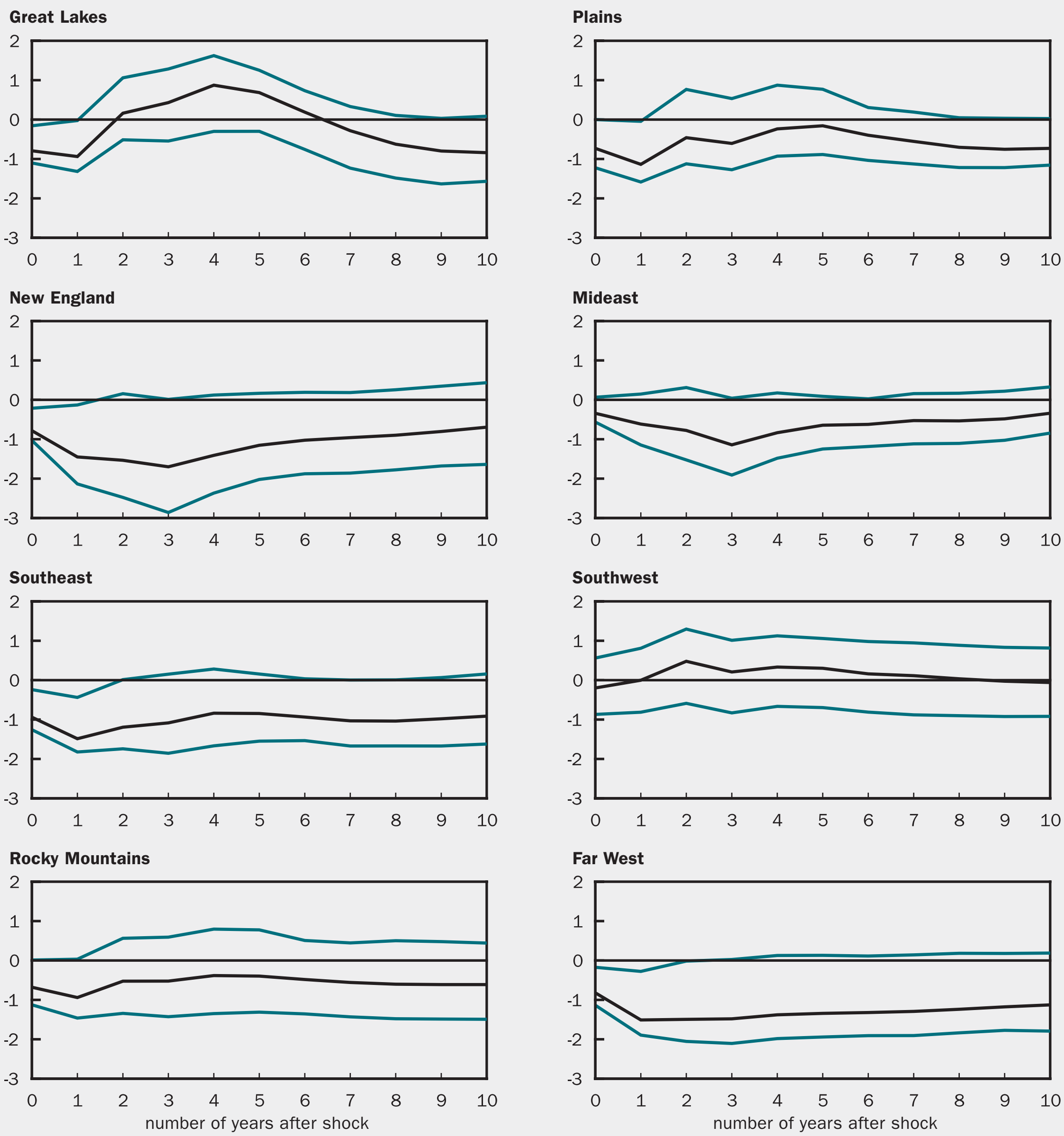
In contrast to the U.S. result, figure 7 shows that an unexpected positive shock to the change in world oil prices does not have a statistically significant effect on the income of all EMU countries.

However, figure 8 shows that an unanticipated positive shock to aggregate EMU output has a statistically significant positive effect on the output of most EMU countries that dies out one year after the shock. Again, the exceptions are Finland and Ireland, where the effects of the aggregate output shock are not statistically significant.

Turning to the regional monetary shock, we see in figure 9 that EMU responses are not only similar across countries, but also quite similar to the U.S. response functions. As in the U.S., an unanticipated tightening in regional monetary policy (an unanticipated increase in the German overnight money market rate) leads to a contraction in regional income two

FIGURE 3

U.S. output response: Shock to world oil prices
(percent)



Notes: All figures report changes in the region of interest's real personal income following a one standard deviation shock to the given variable. The black line represents the point estimates of the impulse response function for the region of interest. The colored lines are the 95 percent confidence bands, computed by Monte Carlo simulation using 1,000 independent draws.

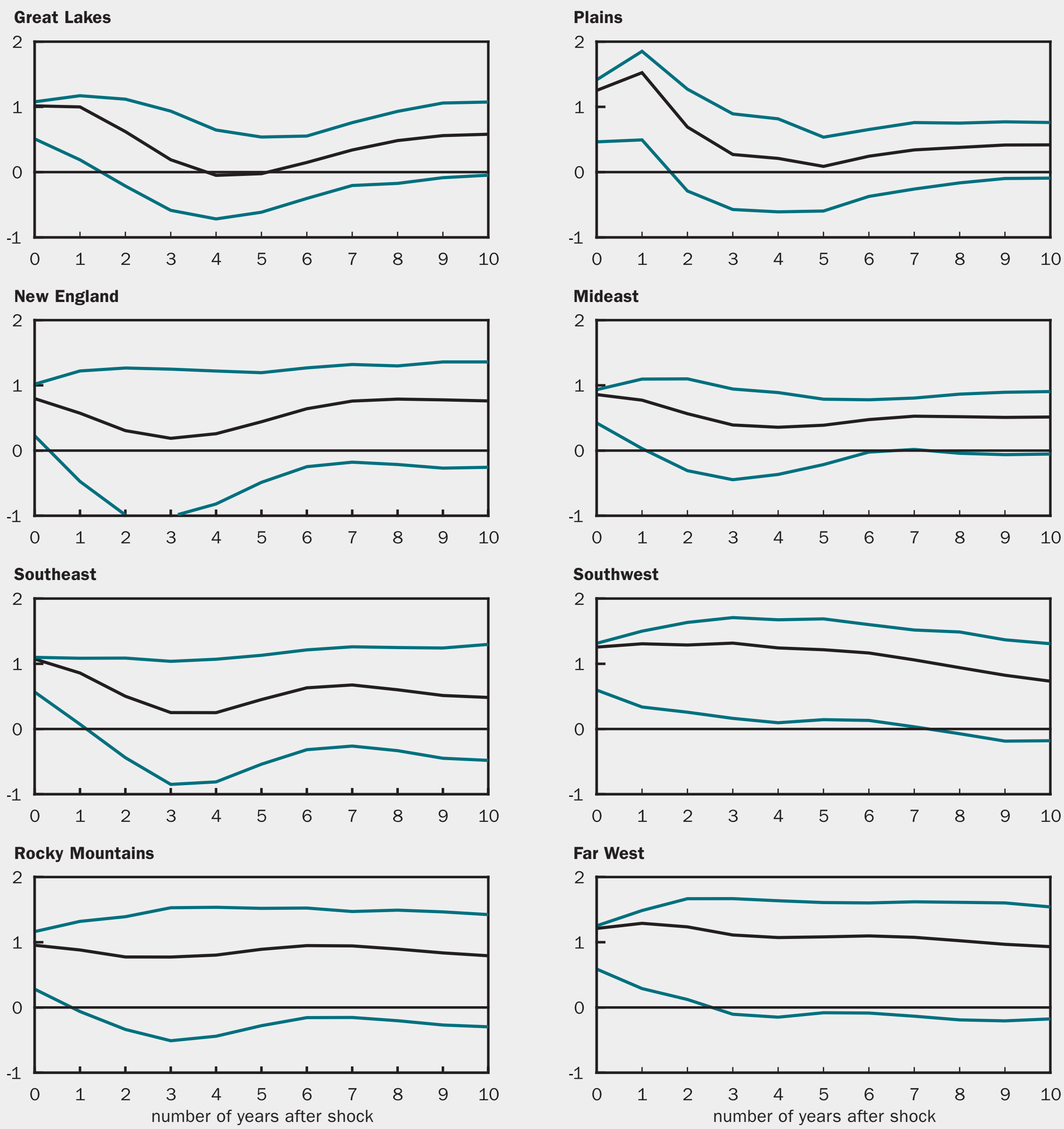
Source: Calculations from author's statistical model, using the following annual data series: International Monetary Fund—world crude oil prices; Bureau of Economic Analysis—personal income by state; and Federal Reserve Board of Governors—federal funds rate.

years after the shock. It is important to note that Finland and Ireland have similar responses to the rest of the EMU, but their responses are not statistically different from zero.

Finally, figure 10 describes the rate at which EMU countries adjust to country-specific shocks. Ignoring Finland and Ireland, there are essentially two groups, just as there are in the U.S. case. The first group, consisting of Austria, Belgium-Luxembourg, France, Germany, and Italy, have response functions that are not statistically different from zero a year after the shock. The second group, the Netherlands, Portugal, and Spain, adjust in under three years. The response functions of Finland and Ireland display considerably longer adjustment periods. In the case of Ireland, idiosyncratic shocks appear to be highly persistent.

FIGURE 4

U.S. output response: Shock to aggregate U.S. income
(percent)

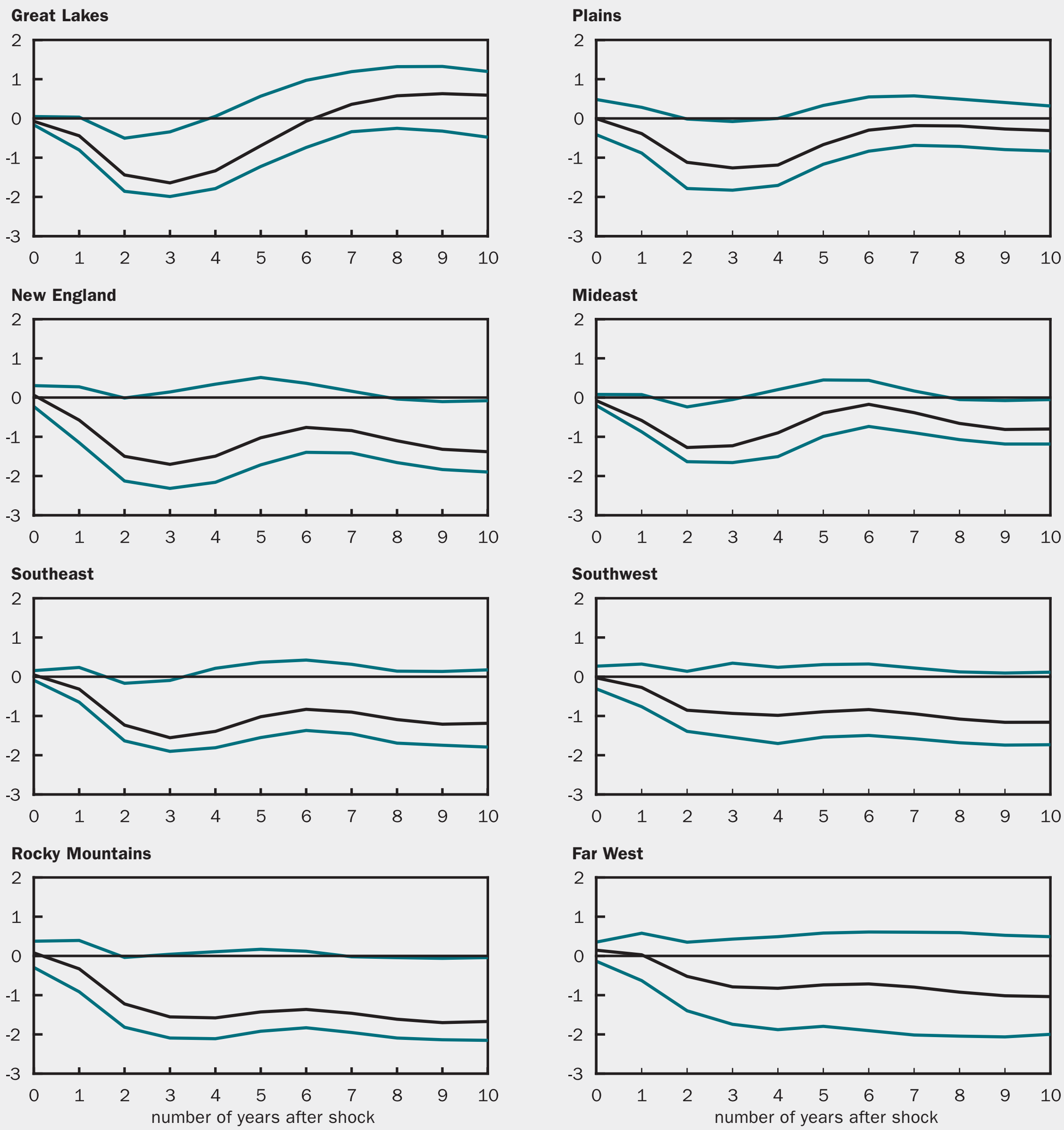


Notes and source: See figure 3.

The lessons learned from the simple business cycle analysis of the previous section carry over to the VAR analysis. The EMU is characterized by a highly symmetric center—Austria, Belgium-Luxembourg, France, Germany, Italy, the Netherlands, Portugal, and Spain—and an asymmetric periphery—Finland and Ireland. As noted earlier, the center countries have highly correlated business cycle fluctuations. The VAR analysis shows that these correlations are supported by common sources of disturbance and similar responses to these shocks. The VAR analysis also reveals that EMU countries and U.S. regions behave similarly along both these dimensions. Finally, in contrast to anecdotal evidence, the VAR analysis suggests that EMU countries adjust to idiosyncratic shocks at roughly the same speed as U.S. regions.

FIGURE 5

U.S. output response: Shock to U.S. federal funds rate
(percent)



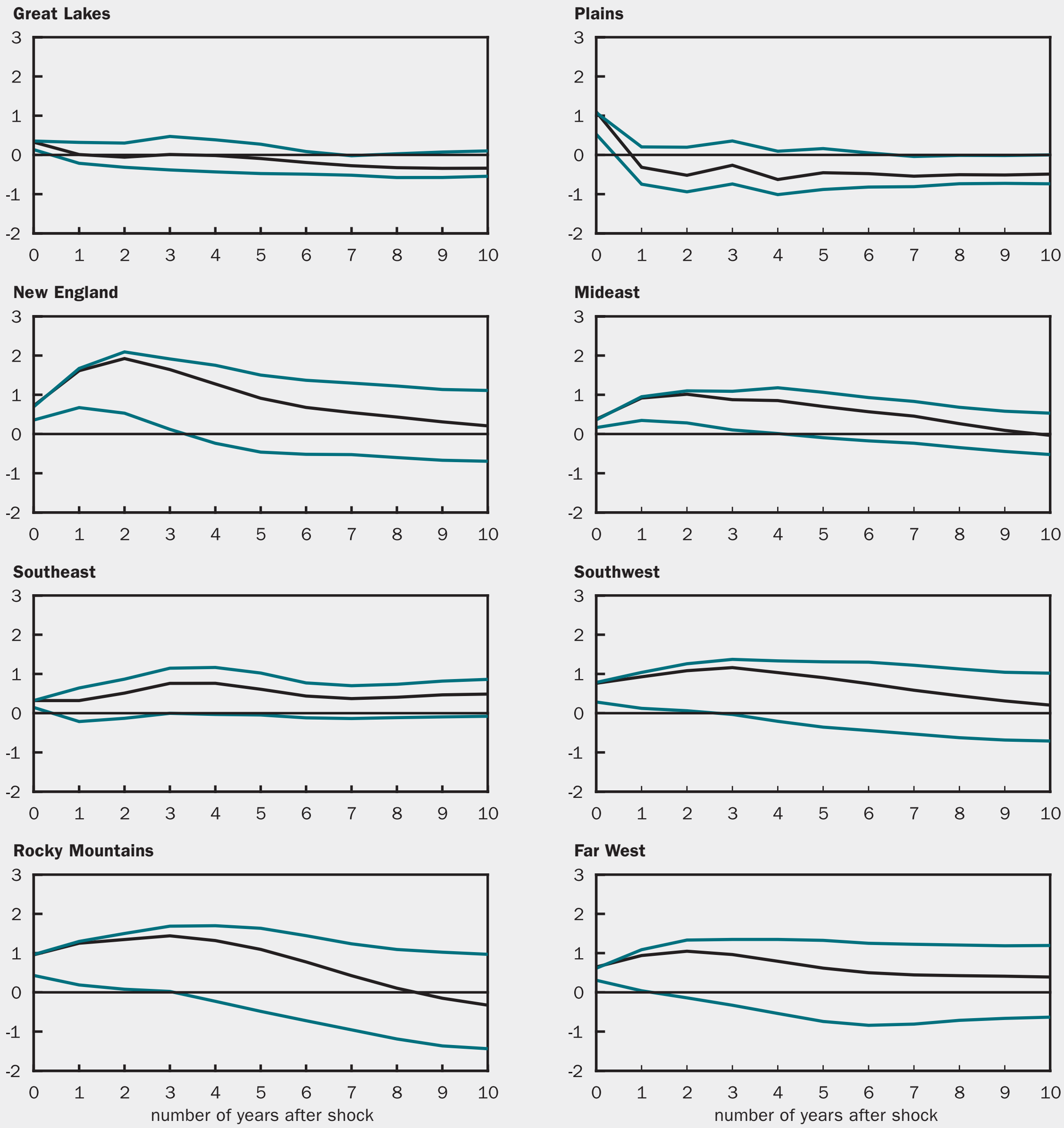
Notes and source: See figure 3.

Conclusion

The answer to the question of whether a currency union will be viable in the long run depends to a large extent on how far the union is from being an OCA. With this in mind, I assess the long-run viability of the EMU by comparing the EMU with a viable currency union (the U.S.) based on critical OCA criteria. My working hypothesis is that if the EMU is as close as the U.S. is to being an OCA, then there could be no presumption that the EMU would not be viable in the long run. Alternatively, if the EMU is much further from being an OCA than the U.S. is, then the adoption of a single currency could be problematic for some EMU countries and would call into question the viability of this monetary union. My analysis suggests that the behavior of countries at the center of the EMU is very similar to that of U.S. regions for all OCA criteria. In contrast, I find that

FIGURE 6

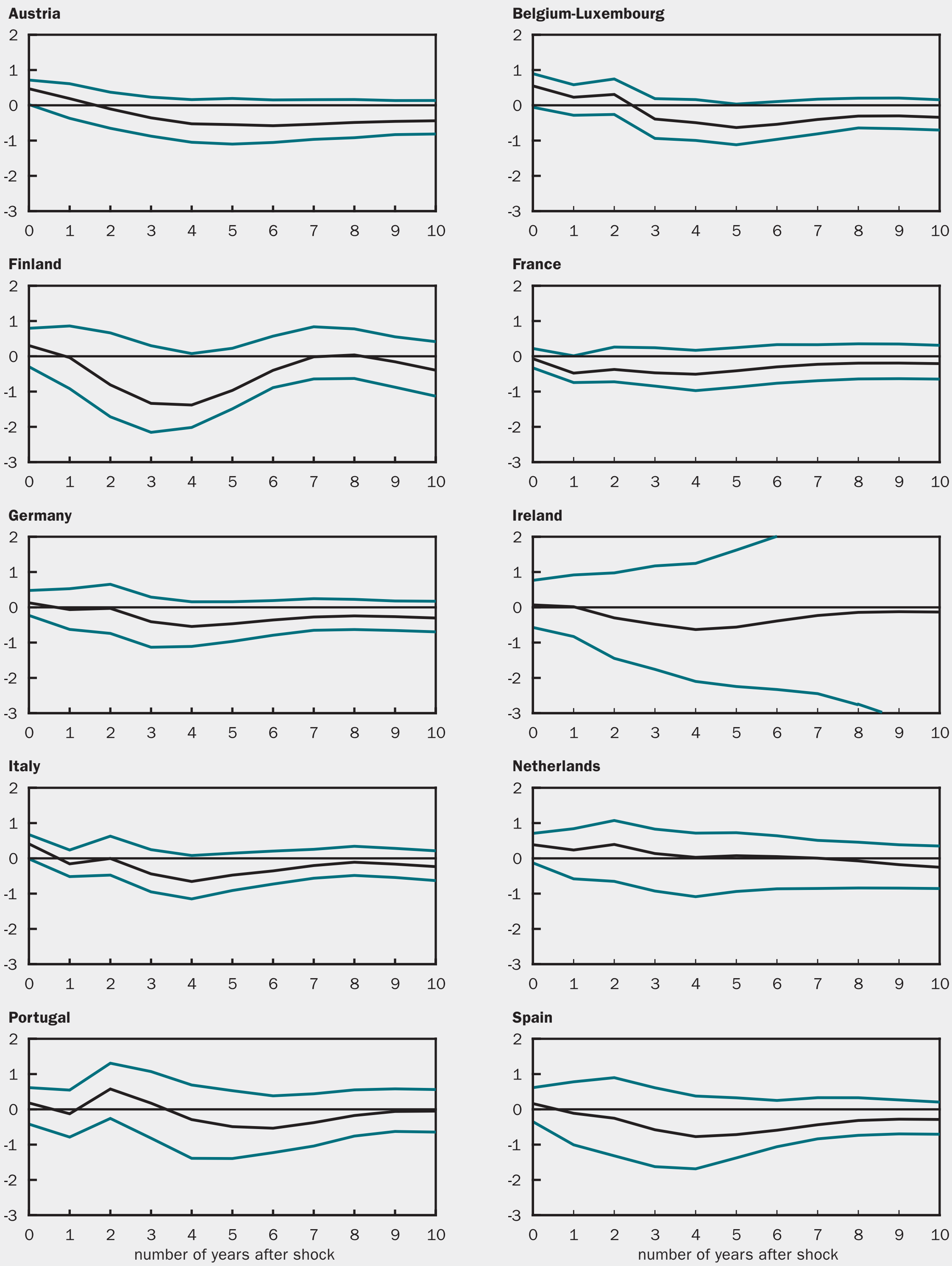
U.S. output response: Shock to U.S. regional income
(percent)



Notes and source: See figure 3.

FIGURE 7

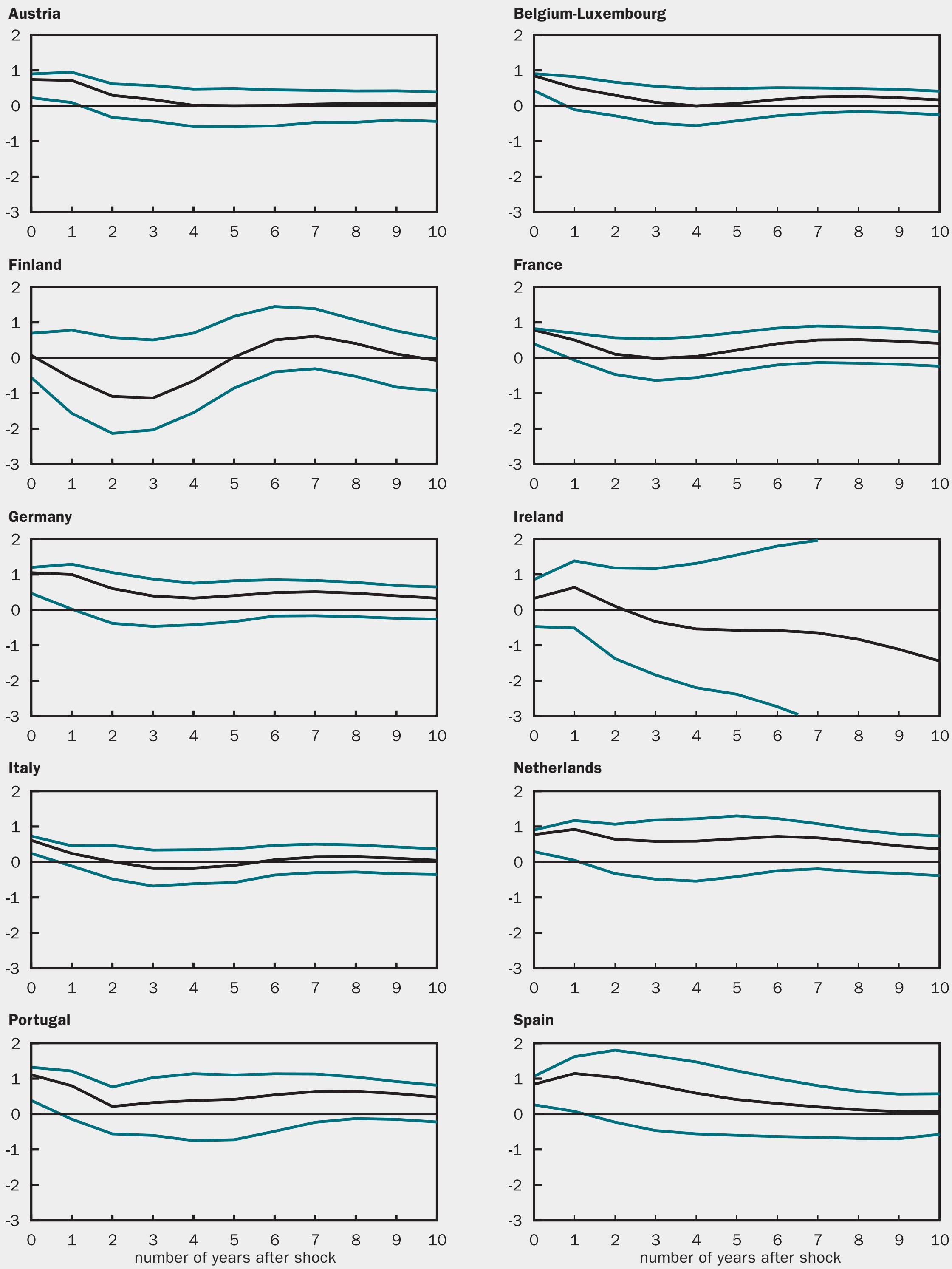
EMU output response: Shock to world oil prices
(percent)



Notes: See figure 3.
Source: Calculations from author's statistical model, using the following annual data series:
International Monetary Fund—world crude oil prices, short-term interest rates, and gross domestic product.

FIGURE 8

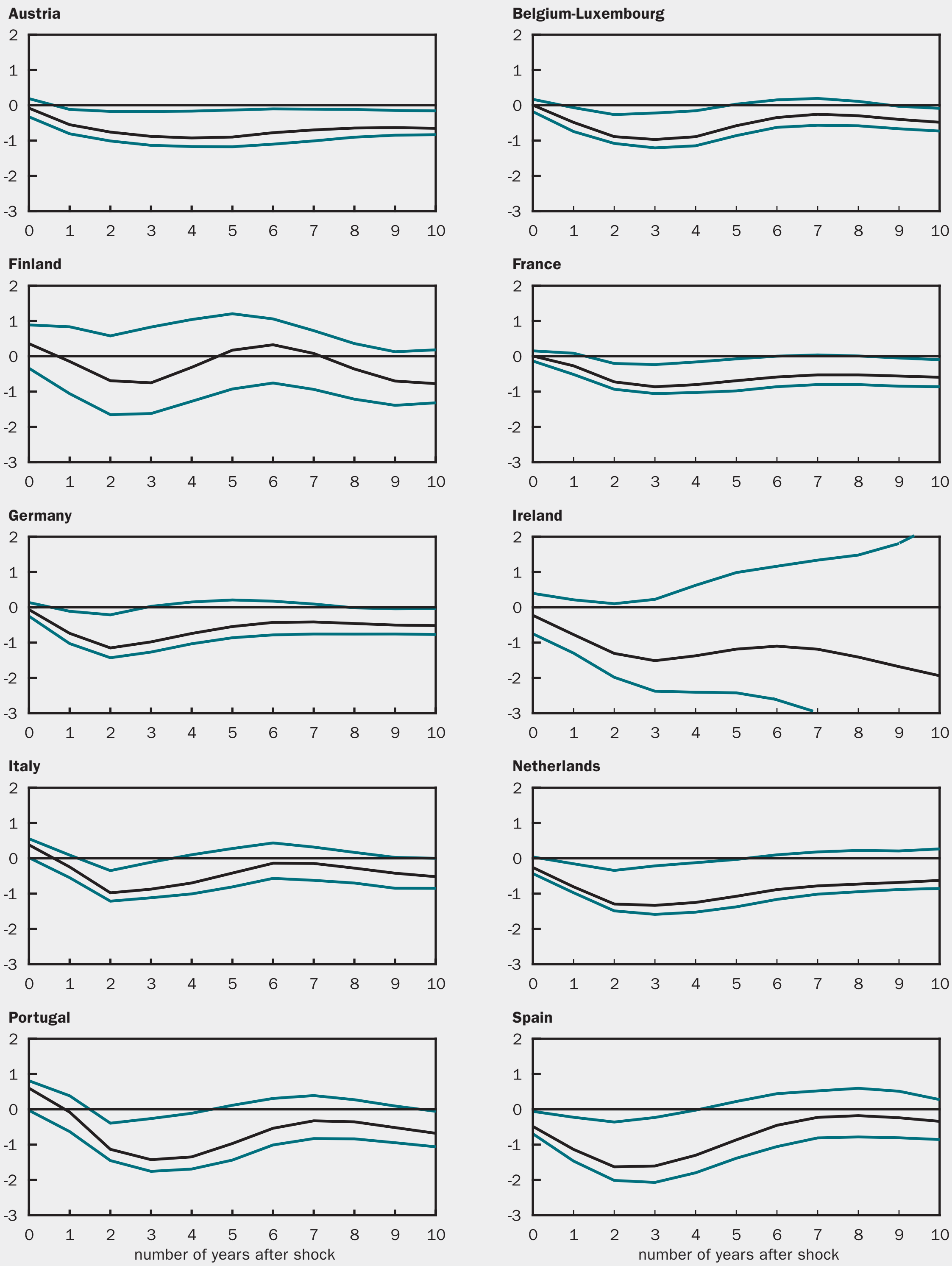
EMU output response: Shock to aggregate EMU output
(percent)



Notes: See figure 3.
Source: See figure 7.

FIGURE 9

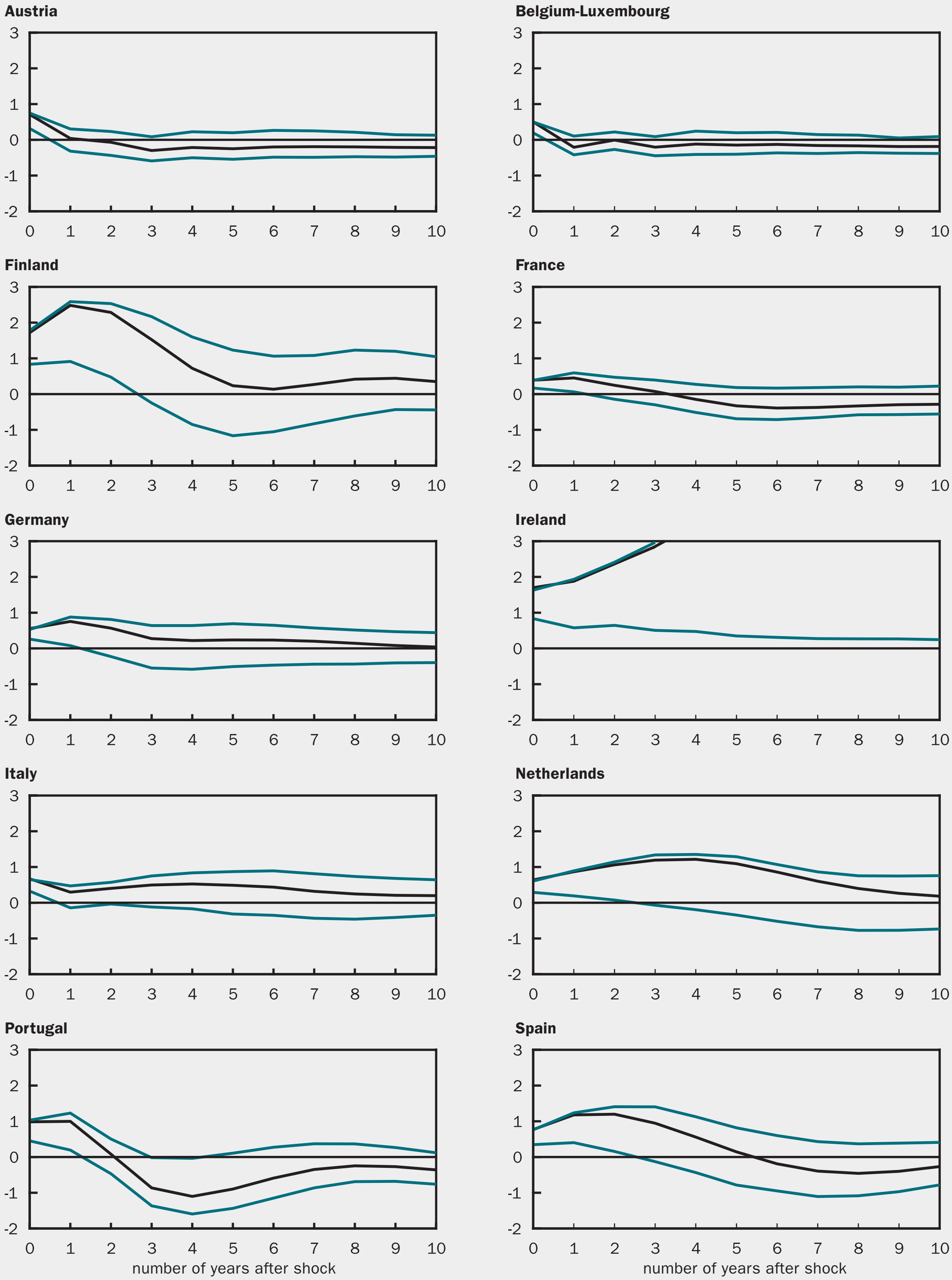
EMU output response: Shock to EMU interest rates
(percent)



Notes: See figure 3.
Source: See figure 7.

FIGURE 10

EMU output response: Shock to EMU country income
(percent)



Notes: See figure 3.
Source: See figure 7.

countries in the periphery of the EMU, Finland and Ireland, are quite different from their EMU partners with regard to the OCA criteria. On the basis of this statistical analysis, I conclude that the EMU will likely be a viable currency union for the center countries, but question the viability of a union with countries in the periphery.

APPENDIX

A VAR analysis of regional business cycles

This appendix describes my methodology in greater technical detail. To isolate the various exogenous shocks, including monetary policy shocks, I use the vector autoregression (VAR) procedure developed by Christiano, Eichenbaum, and Evans (1994). Let Z_t denote the 4 × 1 vector of all variables in the model at date t. This vector includes changes in the log of world oil prices ($POIL$), log levels of aggregate U.S. (or euro-zone) income (YA), log levels of one of the eight U.S. regions (or 10 euro-zone countries) income (YR), and the level of the U.S. federal funds (or German overnight money market) rate (R), which I assume is the U.S. (or euro-zone) monetary policy indicator. The order of the variables is:

1) $Z_t = (POIL_t, YA_t, R_t, YR_t)$.

I assume that Z_t follows a second-order VAR:

2) $Z_t = A_0 + A_1 Z_{t-1} + A_2 Z_{t-2} + u_t$,

where A_0, A_1, and A_2 are 4 × 4 coefficient matrices, and the 4 × 1 disturbance vector u_t is serially uncorrelated. I assume that the fundamental exogenous process that drives the economy is a 4 × 1 vector process $\{\varepsilon_t\}$ of serially uncorrelated shocks, with a covariance matrix equal to the identity matrix. The VAR disturbance vector u_t is a linear function of a vector ε_t of underlying economic shocks, as follows:

$$u_t = C\,\varepsilon_t,$$

where the 4 × 4 matrix C is the unique lower-triangular decomposition of the covariance matrix of u_t:

$$CC' = E[\,u_t u_t'\,].$$

This structure implies that the jth element of u_t is correlated with the first j elements of ε_t, but is orthogonal to the remaining elements of ε_t.

In setting policy, the U.S. Federal Reserve (or the euro-zone member central banks) both reacts to and affects the economy; I use the VAR structure to capture these cross-directional relationships. I assume that the feedback rule can be written as a linear function, Ψ, defined over a vector, Ω_t, of variables observed at or before date t. That is, if I let R_t denote the U.S. federal funds rate (or German overnight money market rate), then U.S. (or euro-zone) monetary policy is completely described by:

3) $R_t = \Psi(\Omega_t) + c_{3,3}\varepsilon_{3t}$,

where ε_{3t} is the third element of the fundamental shock vector ε_t, and $c_{3,3}$ is the (3, 3) element of the matrix C. (Recall that R_t is the third element of Z_t.) In equation 3, $\Psi(\Omega_t)$ is the feedback-rule component of U.S. (or euro-zone) monetary policy, and $c_{3,3}\varepsilon_{3t}$ is the exogenous U.S. (or euro-zone) monetary policy shock. Since ε_{3t} has unit variance, $c_{3,3}$ is the standard deviation of this policy shock. Following Christiano, Eichenbaum, and Evans (1994), I model Ω_t as containing lagged values (dated $t-1$ and earlier) of *all* variables in the model, as well as time t values of those variables the monetary authority looks at contemporaneously in setting policy. In accordance with the assumptions of the feedback rule, an exogenous shock ε_{3t} to monetary policy cannot contemporaneously affect time t values of the elements of Ω_t. However, lagged values of ε_{3t} can affect the variables in Ω_t.

I incorporate equation 3 into the VAR structure described by equations 1 and 2. Variables $POIL$ and YA are the contemporaneous inputs to the monetary feedback rule. These are the only components of Ω_t that are not determined prior to date t. With this structure, I can identify the right-hand side of equation 3 with the third equation in VAR equation 2: $\Psi(\Omega_t)$ equals the third row of $A_0 + A_1 Z_{t-1} + A_2 Z_{t-2}$, plus $\Sigma_{i=1}^{2} c_{3,i}\,\varepsilon_{it}$ (where $c_{3,i}$ denotes the (3, i) element of matrix C, and ε_{it} denotes the ith element of ε_t). Note that R_t is correlated with the first three elements of ε_t. By construction the shock $c_{3,3}\varepsilon_{3t}$ to U.S. (or euro-zone) monetary policy is uncorrelated with the monetary policy feedback rule Ω_t.

I estimate matrices A_0, A_1, A_2 and C by ordinary least squares. The response of any variable in Z_t to an impulse in any element of the fundamental shock vector ε_t can then be computed by using equations 1 and 2.

The standard error bounds in figures 3 through 10 are computed using the following bootstrap Monte

Carlo procedure. First, I construct 1,000 time series of the vector Z_t each of length T, where T denotes the number of observations in my data sample. Let $\{\xi_t\}_{t=1}^{T}$ denote the vector of residuals from the estimated VAR. I construct 1,000 sets of new time series of residuals, $\{\xi_t(j)\}_{t=1}^{T}$, $j = 1, ..., 1{,}000$. The tth element of $\{\xi_t(j)\}_{t=1}^{T}$ is selected by drawing randomly, with replacement, from the set of estimated residuals vectors $\{\xi_t\}_{t=1}^{T}$. For each $\{\xi_t(j)\}_{t=1}^{T}$, I construct a synthetic time series Z_t, denoted $\{Z_t(j)\}_{t=1}^{T}$, using the estimated VAR and the historical initial conditions on Z_t. Next, I reestimate the VAR using $\{Z_t(j)\}_{t=1}^{T}$ and the historical initial conditions and calculate the implied impulse response functions for $j = 1, ..., 1{,}000$. For each lag, I calculate the 25th lowest and 975th highest value of the corresponding impulse response coefficient across all 1,000 synthetic impulse response functions. The boundaries of the confidence intervals in the figures correspond to a plot of these coefficients.

NOTES

[1]See Corden (1993), chapters 7–9, for an extended discussion of the EMS and events surrounding the 1992 breakdown of the system.

[2]In general, time-series data are nonstationary. Nonstationary data do not have well-defined standard deviations or correlations. One way of overcoming this problem is to filter the data using a filter that removes the nonstationary components and renders the data stationary. There is a range of filtering techniques available, including linear time trends and first differencing. Baxter and King (1995) have designed a filter that isolates components of the data that policy analysts are interested in, the so-called business cycle frequencies of one and a half to eight years. I use a Baxter–King filter to isolate cyclical movements in U.S. and EMU time series.

[3]Consumer price indexes do exist for metropolitan areas in the various BEA regions. However, there is a very high degree of correlation in consumer price fluctuations across these metropolitan areas. In addition, using region-specific price series would impose a further limit on the analysis since many metropolitan indexes are not available after 1986.

[4]The gross product by state is available from 1977 to 1997.

[5]See Carlino and DeFina (1998a), appendix A, for a listing of states by BEA region.

[6]For examples, see references in Kouparitsas (1998).

[7]Carlino and DeFina (1998a) assume a similar recursive information ordering in their analysis of the regional impact of U.S. monetary policy.

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