SWEDISH ECONOMIC POLICY REVIEW 4 (1997) 411-446

International covariation in manufacturing 1975-1995

John Hassler*

Summary

■ Monetary policy must be identical in all countries of a future EMU. If business cycles in participating countries are well synchronized, there are not likely to be conflicting interests regarding stabilization policy. I analyze manufacturing output and employment in Sweden, a sample of other potential EMU members, and the U.S. to quantify the degree of covariation between Swedish and foreign business cycles. Regardless of whether the focus is on employment or output or on growth rates or underlying innovations, the conclusion is that business cycles in Swedish manufacturing have had a relatively low degree of comovement with business cycles in other countries. I also find that manufacturing business cycles in Belgium, France, the Netherlands, Germany, and Austria correlate well. My results suggest that Sweden must change more to adjust to the monetary union than many of the other potential members. But the results indicate nothing about how costly this may be. Some changes, such as increased integration of goods and capital markets, may occur automatically and without costs. Others may be more painful.

I also analyze some regional aspects of the EMU with respect to Sweden. I find that all Swedish regions appear to have a well-diversified industrial structure. The differences in industrial structures that exist among regions are not of the kind that would generate large differences in the degree of business-cycle comovement with foreign countries. ■

* *Senior research fellow at the Institute for International Economic Studies, Stockholm University, and member of the Economic Council of Sweden.*

SWEDISH ECONOMIC POLICY REVIEW 4 (1997) 411-446

International covariation in manufacturing 1975-1995

John Hassler*

Will a Swedish EMU membership lead to higher unemployment and a more volatile business cycle? Or will it mean that inflation can be kept down at small costs, that uncertainty and interest rates fall, and that investments and employment rise? The only truthful answer is that we do not know. No comprehensive method exists for analyzing the total effects of joining or not joining the EMU. To judge the desirability of a Swedish membership, we must weigh together results from many different approaches.

One method that has been used extensively in this context is to study how well various macroeconomic variables in potential member countries are correlated. Employment, manufacturing output, and GDP are examples of such variables.

The motivation for this approach is straightforward—if these and other macroeconomic variables are well correlated, one may expect that a coordinated stabilization policy can be conducted without divergent interests arising. For example, if Sweden and Germany simultaneously tend to face business-cycle downturns, their interest in a more expansionary monetary policy will tend to coincide. But a low correlation may cause discord within the monetary union. And countries with little influence on the common central bank must accept that monetary policy will not take their interests into account.

This paper analyzes business cycles in several potential EMU members. It focuses on the manufacturing sector for two reasons:

- Data of good quality and high periodicity exist for this sector.
- Manufacturing, with its high exposure to foreign competition, is particularly interesting when the consequences of a common currency is at issue.

* *I thank Lars Calmfors, Nils Gottfries, Per Jansson, Anders Vredin, and Anders Warne for valuable comments. The responsibility for conclusions, opinions, and errors rests fully with me.*

To set a benchmark for the comparison of the degree of comovements, this paper also looks at some OECD countries that are not potential EMU members.

In contrast to other studies that have distinguished between demand and supply shocks, or between nominal and real shocks, no such categorization is done here. Bayoumi and Eichengreen (1992a) provide an example, where separate demand and supply shocks to GDP are identified for several EU and EFTA countries between 1963 and 1988. They find that both types of shocks in Belgium, Denmark, France, and the Netherlands are well correlated with corresponding shocks in Germany. Among the EFTA countries, shocks in Switzerland and Austria are better correlated with shocks in Germany than with shocks in Finland, Sweden, and particularly Norway.

In another similar study, Bayoumi and Eichengreen (1992b) find that the correlation between business-cycle shocks in different regions in the U.S. tends to be higher than the corresponding correlation between countries in Europe. The highest correlation coefficients between supply shocks in U.S. regions (between the Great Lakes, Mid-East, and New England) are around 0.8. The highest corresponding correlations in Europe (between Belgium, Denmark, France, and the Netherlands) are around 0.6. Similar differences are found for demand shocks.

Several studies, similar to this one, have not distinguished between demand and supply shocks. Most often, Sweden is not part of the analyses. Christodoulakis, et al. (1995) analyze business cycles in several EU countries and find a considerable degree of covariation, in particular between GDP in France, Germany, and the UK. Their interpretation of the results is that the potential EMU countries face similar shocks and that they also react in similar fashions to these shocks. Bayoumi and Prasad (1995) compare regions in the U.S. with countries in Europe and find substantial similarities. They study output growth in eight sectors of the economy in eight European countries and eight U.S. regions. The purpose is to quantify the relative importance of country-specific and industry-specific and common shocks. They find that the relative importance of these shocks is similar in Europe and the U.S. But the total explanatory power of these three shocks is higher in the U.S. ($R^2 = 0.72$) than in Europe ($R^2 = 0.52$). This implies that shocks specific to both country (region) and industry are more important in Europe than in the U.S.

Helg et al. (1995) study 11 sectors of manufacturing in 11 EU member countries. They find that country-specific shocks are more important than industry-specific shocks for output growth in manufacturing. Their results indicate that what happens in the home country is more important than what happens in the same manufacturing sector in other countries. But the degree of comovement is larger among some countries. Of the studied countries, the highest correlation is between Belgium, Germany, and the Netherlands, closely followed by Denmark, France, and the UK. A smaller degree of comovement with other countries is Italy, Spain, and Greece. Ireland and Portugal are classified as most peripheral in this sense.

Sardelis (1994) surveys studies that are similar to the ones described above but which include Sweden. Sardelis (1993) finds that GDP growth in Sweden in 1972 to 1991 had a relatively low degree of correlation with growth in the EEC. Baldwin et al. (1992) find a substantially higher degree of Swedish comovement with the EEC when extending the time period to 1961-1991. Tarkka and Åkerholm (1992) evaluate how much of different countries' GDP growth during 1973-1990 can be attributed to a common component. They find that Germany, France, the Netherlands, and possibly Belgium and Austria belong to a *core* of countries where a common component is more important than in other European countries. Sweden does, according to this study, not belong to this core group. Bergman and Jonung (1994) have studied the comovement between Swedish and foreign business cycles in a longer historical perspective. They find that the Swedish business cycle is correlated mostly with the other Nordic countries and only to a substantially smaller degree with other foreign countries.

Several objections can be raised to the use of historical correlations to evaluate the consequences of a currency union. One of the major problems with this approach is that observed historical correlations hardly can be assumed to be stable if a fundamental structural change occurs, such as that of joining a monetary union. The degree of business-cycle comovements can increase due to increased economic integration and trade, which may increase the spillover of disturbances between the countries. Increased integration could also lead to increased regional and national specialization, which might decrease business-cycle comovements. The coordinated monetary policy in a union may increase the degree of comovements because disturbances, which are due to independent national policies, disappear. The alleged Swedish devaluation cycle is an example of such a disturbance. The comovements can also decrease if domestic monetary policy has mainly stabilized domestic and idiosyncratic shocks to the economy, which will be impossible with a common monetary policy.

The previous discussion shows that a high degree of business-cycle covariation *before* the start of a monetary union is neither a necessary nor a sufficient condition for a common currency to be beneficial. But a low degree of covariation might be interpreted as indicating a relatively large need for structural change in the economy. The concluding section of this paper discusses this further.

My discussion is structured as follows: Section 1 describes the data that I use. Section 2 reports various measures of the degree of international business-cycle covariation for the level and the growth of output and employment in manufacturing in Sweden and the other studied countries. Here, I find that Swedish business cycles show a relatively low degree of comovements with business cycles in the other countries. The existing positive correlation is mainly with the smaller potential EMU countries and not with France, Italy, Germany, or the UK. Section 3 shows that this result is strengthened if we focus on the correlation between the underlying shocks that generate fluctuations in output and employment. Section 4 uses regional variations in industry composition to assess whether output and employment in some Swedish regions are less correlated with foreign output and employment. Such regional differences could imply that some regions would face larger potential costs after a Swedish EMU entry. But here, I find surprisingly small regional variation. I also find that underlying business-cycle shocks in different Swedish industries show a low correlation relative to the same correlation in most other examined countries.

1. Data description

The empirical analysis in this study is based on data from *The Indicators of Industrial Activity (IIP),* which is published by the OECD. I use quarterly data on output (value added) and employment in some potential EMU countries (Belgium, Finland, France, the Netherlands, Italy, Spain, the UK, Sweden, and Germany) and in Norway and the U.S. However, I have no data on employment for Belgium, Italy, Spain, and the UK. Most of the series cover the first quarter of 1975 to the third of 1995 and thus contain 83 observations. The analysis is confined to manufacturing. In some parts of the analysis, I also divide manufacturing into 11 subindustries. Table 1 lists these.

Table 1. Manufacturing subsectors

Sector number	Description
310	Food, beverages, and tobacco
320	Textiles, clothing, and leather
330	Wood and wood products
340	Paper and paper products
350	Chemicals
360	Non-metallic mineral products
370	Basic metals
381	Metal products
382	Machinery
383	Electrical machinery
384	Transport equipment

Statistics Sweden has produced data for total value added (gross regional product) and employment for 1991 in each of the 24 Swedish counties (*län*). These data were used in the regional analysis.

Most of the used time series show large seasonal variation. To eliminate this in a consistent way, the logarithms for all the series were seasonally adjusted with quarterly dummies.

2. Manufacturing business cycles in different countries

Figure 1, which depicts manufacturing output as deviations from a log-linear trend, provides a first picture of business cycles. We can immediately identify substantial similarities between business cycles in the different countries. There is a relatively large upturn during the latter half of the 1980s in all countries except Finland and Norway. In Finland, output is above trend during the entire 1980s, while output in Norway shows only minor variations during that period. The boom during the 1980s was followed by a downturn in the early 1980s. But the downturn came later in Germany than in the other countries. Besides the similarities, we also find some substantial differences between the countries. Finland, the UK, and Sweden show a clear downward trend from the start of the sample until the mid 1990s. Parallels to the very strong recovery in Sweden that occurred from 1992 can be found mainly in Finland and Spain. In Belgium and Germany, no such recovery can be seen.

Figure 1. Production index for manufacturing—deviations from a log-linear trend

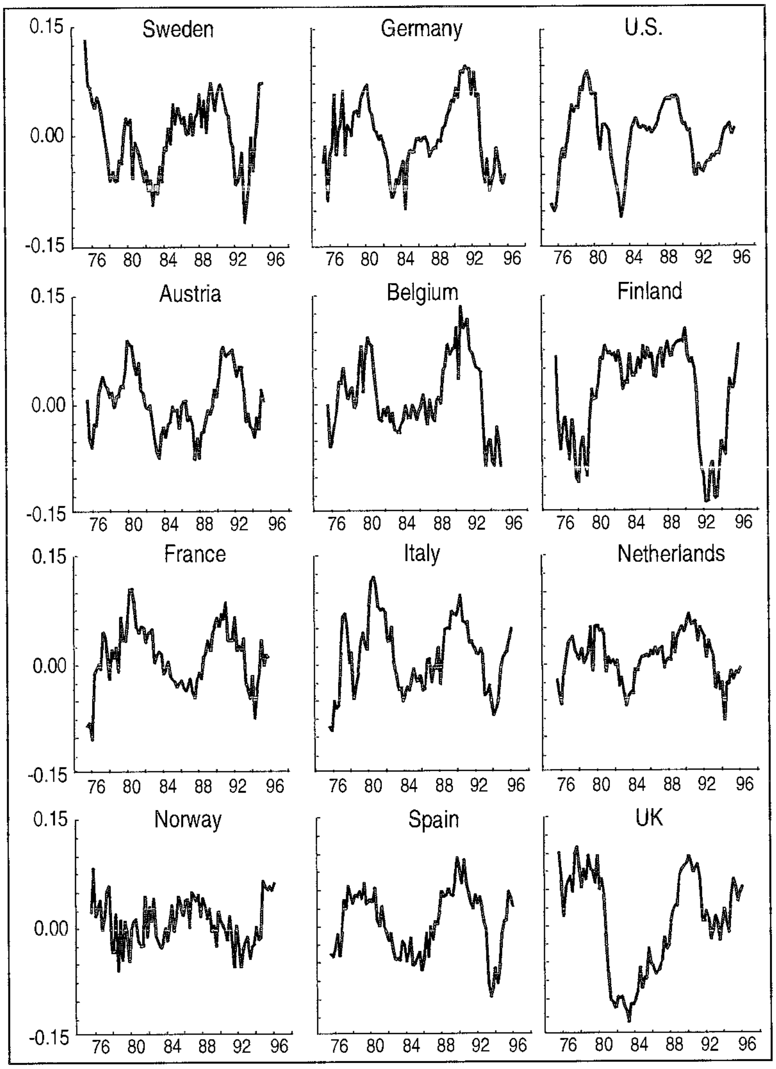


Table 2 provides the correlation coefficients between the series in Figure 1—as a measure of the degree of business-cycle comovements. The last column of the table displays the number of correlations for the country on the rows that are higher than 0.45.[1] The number of correlations above 0.45 that relate to the large countries (France, Germany, Italy, or the UK) are within parentheses.

To facilitate comparison, I include the correlation with the own country (which is unity) for the latter countries. This implies that all countries can have a maximum of four correlations above 0.45 with the large potential EMU countries.

Table 2 shows that Austria, Belgium, France, Germany, Italy, Spain, and the Netherlands, can be classified as a core group. Between these countries all correlations are higher than 0.45—the lowest correlation is as high as 0.54.

Table 2. Correlation coefficients for manufacturing output levels

	Ger.	U.S.	Aus.	Bel.	Fin.	Fr.	Ita.	Ne.	Nor.	Spa.	UK	>0.45
Swe.	0.18	0.16	0.12	0.32	0.40	-0.08	0.13	0.39	0.46	0.32	0.46	2 (1)
	Ger.	0.32	0.83	0.76	-0.13	0.65	0.58	0.78	-0.22	0.68	0.49	7 (4)
		U.S.	0.26	0.42	0.26	0.32	0.48	0.57	0.06	0.55	0.39	3 (1)
			Aus.	0.69	-0.15	0.69	0.64	0.69	-0.28	0.54	0.39	6 (3)
				Bel.	0.15	0.64	0.67	0.85	-0.20	0.78	0.49	7 (4)
					Fin.	0.19	0.30	0.17	0.41	0.11	-0.28	0 (0)
						Fr.	0.78	0.61	-0.20	0.61	0.17	6 (3)
							Ita.	0.69	-0.09	0.66	0.21	7 (3)
								Ne.	-0.05	0.73	0.49	9 (4)
									Nor.	-0.04	0.00	1 (0)
										Spa.	0.60	7 (3)
											UK	4 (1)

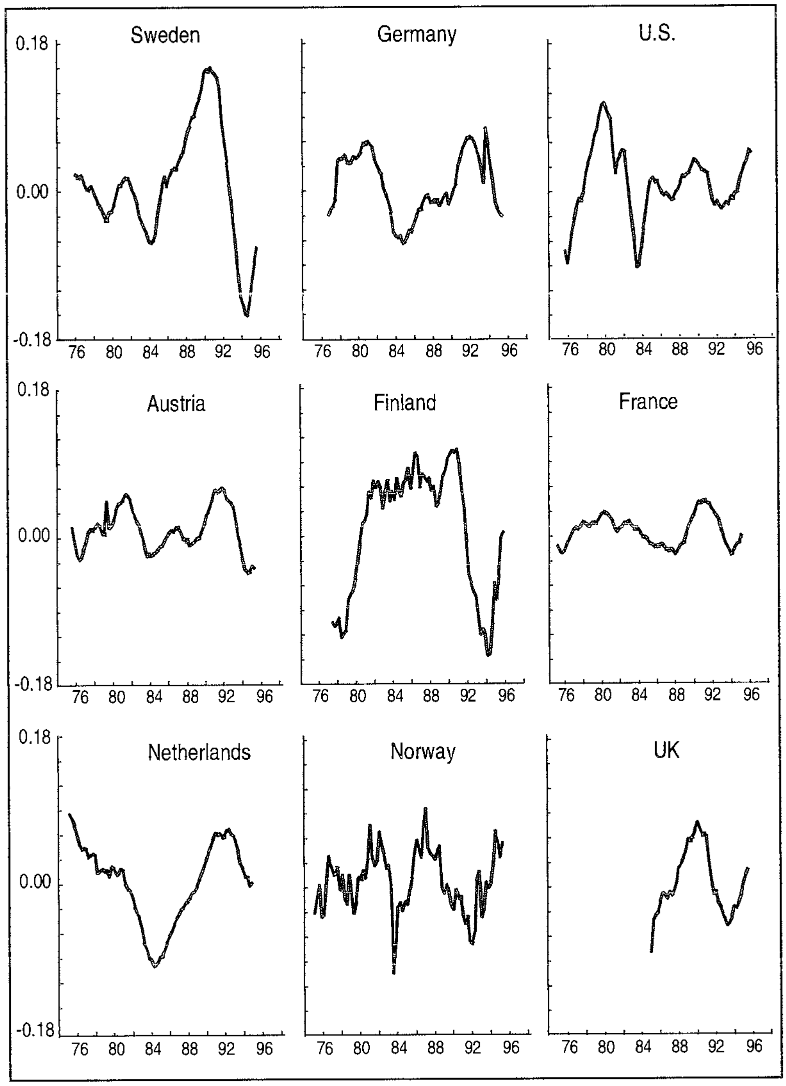
The correlation between these countries and countries outside the core is quite low (except perhaps for the UK). We can also see that the countries outside the described core generally have lower correlations with foreign countries. Finland, Norway, and Sweden, for example, have few correlations above 0.45 and none over 0.50. The

[1] The limit 0.45 is arbitrarily chosen but it means that the two highest Swedish correlations just pass the limit. The autocorrelation is high in these series, which makes statistical inference somewhat unreliable. So I abstain from reporting levels of significance in this case.

correlation between Swedish business cycles and the large countries in the core is particularly low. The other Nordic countries in the sample also have low correlations with the large core countries. But the Swedish correlation with the UK is relatively high.

Figure 2 shows that the general patterns that we found in Figure 1 is also found for employment. But some clear deviations exist.

Figure 2. Employment index—deviations from log-linear trend



In Finland, the Netherlands, Norway, and Sweden employment is at least as volatile as output. But in Austria and particularly in France, employment is substantially less volatile than output.

Table 3 provides more support for the picture of a high degree of business-cycle comovement among Austria, France, Germany, and the Netherlands. All correlations between these countries' employment levels are high. The lowest correlation is 0.52. Finland and Sweden have a large positive correlation only with each other. The U.S. has no correlation above 0.45.

As an alternative to studying correlations between deviations from a log-linear trend, we might study correlations between growth rates. Some statistical problems noted in footnote 1 then become less important. But note that growth-rate correlations, to a larger extent than trend deviations, are measures of short-run comovements. This is a disadvantage, if the focus is on the extent to which business-cycle conditions tend be synchronized. Tables 4 and 5 report the correlations between growth rates for output and employment in the different countries. Correlations above 0.30 are underlined and correlations above 0.45 are in addition shaded.

Table 3. Correlation coefficients for manufacturing employment levels

	Ger.	U.S.	Aus.	Fin.	Fra.	Ne.	Nor.	>0.45
Swe.	0.04	0.18	0.45	0.69	0.23	0.06	0.07	2 (0)
	Ger.	0.40	0.72	-0.40	0.61	0.87	-0.16	3 (2)
		U.S.	0.22	-0.27	0.09	0.30	0.04	0 (0)
			Aus.	0.21	0.78	0.56	-0.14	4 (2)
				Fin.	0.05	-0.48	0.17	1 (0)
					Fra.	0.52	-0.44	3 (2)
						Ne.	-0.18	3 (2)

As a rule, we can consider underlined correlations as significant at about 1 percent. Because the actual sampling error is difficult to compute, I use the term *nominal significance* for this level.[2]

[2] Correlations at 0.29 and 0.22 produce F(1,75) statistics with a marginal significance level of 1 and 5 percent in an F test of the significance of a regression between the variables. But note that the variables are autocorrelated, which affects the actual significance level. In the following analysis, the correlations are also computed in several steps. This implies that we should interpret the reported sig-

The last columns of the tables report the number of correlations above 0.30 for each country. The number within parentheses indicates how many of these nominally significant correlations are with the large potential EMU countries (as previously mentioned, these are France, Germany, Italy, and the UK).

Table 4 shows that output growth rates in Italy seem the least correlated with other countries—no correlation is nominally significant.

Table 4. Correlation coefficients for manufacturing output growth rates

	Ger.	U.S.	Aus.	Bel.	Fin.	Fra..	Ita.	Ne.	Nor.	Spa.	UK	No. of sign
Swe.	0.22	0.11	0.34	0.15	0.45	0.29	0.06	0.32	0.04	0.30	0.10	4 (0)
Ger.		0.27	0.36	0.22	0.17	0.53	-0.12	0.40	0.17	0.26	0.40	4 (3)
U.S.			0.22	0.15	0.19	0.27	0.03	0.24	0.16	0.19	0.44	1 (1)
Aus.				0.41	0.19	0.37	0.27	0.48	-0.01	0.29	0.16	5 (2)
Bel.					0.17	0.32	0.12	0.47	-0.04	0.26	0.13	3(1)
Fin.						0.47	-0.09	0.12	0.29	0.13	0.39	3 (2)
Fra.							0.05	0.58	0.39	0.37	0.42	8 (3)
Ita.								0.19	-0.04	0.08	-0.08	0 (1)
Ne.									0.02	0.26	0.28	5 (2)
Nor.										0.30	0.29	2 (1)
Spa.											0.25	3 (1)
UK												4 (3)

The finding that output levels (deviations from trend) had a substantially higher correlation can be interpreted as indicating that there is either an idiosyncratic source of disturbances in Italy with a relatively high frequency or that the short-run dynamics of the Italian economy differ a lot from the other countries. There are some similar indications for the Belgian economy. But growth rates in France are well correlated with foreign growth rates. Eight of 11 correlations are nominally significant and three are higher than 0.45. It is noteworthy that Sweden and the U.S. are among the few countries with non-significant correlations with France. All correlations between France, the Netherlands, Germany, and Austria are nominally significant.

nificance levels as approximations. To remind the reader about this, I use the term *nominal significance.*

Sweden belongs to a middle group with its four nominally significant correlations. But none of these four is with a large potential EMU member. Germany and the UK have the same number of nominally significant correlations. But an important difference is that France, Germany, and the UK all are correlated with each other. Sweden is not correlated with any of these countries.

Table 5 shows that employment growth rates, especially in France, the Netherlands, and Austria are well correlated with growth rates in other countries including the large potential EMU countries. Note that employment growth rates in Sweden and Finland are correlated with growth rates in France but not in Germany. The highest Swedish correlation is with Finland but the correlation with Germany is about zero.

We can get another perspective on the character of international business-cycle comovements by calculating the composition of the *basket* of countries, which would have the highest correlation with domestic business cycles. Take Sweden as an example. Let us form a weighted average of the growth rates of all other eight potential EMU countries in the sample by using weights w_1 through w_8.

Table 5. Correlation coefficients for manufacturing employment growth rates

	Ger.	U.S.	Aus.	Fin.	Fra.	Ne.	Nor.	No. of sign.
Swe.	0.02	0.25	0.35	0.46	0.40	0.23	0.13	3 (1)
	Ger.	0.02	0.30	-0.11	0.23	0.46	-0.27	2 (1)
		U.S.	0.07	0.05	-0.15	-0.09	-0.03	0 (0)
			Aus.	0.33	0.50	0.37	0.21	5 (2)
				Fin.	0.31	-0.05	0.27	3 (1)
					Fra.	0.33	0.01	4 (1)
						Ne.	-0.07	3 (2)

We then calculate the set of weights that maximize the correlation between the growth rates for the weighted average and Sweden. I also allow negative weights.[3] If the weights are relatively similar in size and the correlation with the average is high, then this is a sign of high and well-diversified international covariation. Large weights for only a

[3] Computationally, this procedure is identical to running a regression of the Swedish growth rate against the other countries' growth rates. But the assumptions necessary to interpret the calculation as a regression are not necessarily satisfied.

few countries indicate that most of the international comovements are with these countries. Table 6 reports results of the computations.

Table 6. Weights that maximize international correlation—manufacturing growth rates

	Swe.	Ger.	Aus.	Bel.	Fin.	Fra.	Ita.	Ne.	Spa.	UK	Correlation
Swe.	–	0.15	0.17	-0.17	0.68	-0.28	0.02	0.42	0.30	-0.28	0.62
Ger.	0.20	–	0.39	0.01	-0.42	0.76	-0.37	0.02	-0.03	0.44	0.65
Aus.	0.13	0.22	–	0.18	0.07	-0.04	0.21	0.20	0.08	-0.04	0.62
Bel.	-0.24	0.01	0.33	–	0.29	-0.11	-0.01	0.63	0.23	-0.14	0.55
Fin.	0.68	-0.32	0.10	0.21	–	0.83	-0.15	-0.57	-0.28	0.49	0.71
Fra.	-0.13	0.25	-0.02	-0.04	0.36	–	0.04	0.37	0.16	0.00	0.78
Ita.	0.29	-3.75	3.82	-0.08	-2.03	1.26	–	1.62	0.31	-0.44	0.41
Ne.	0.26	0.01	0.16	0.28	-0.35	0.52	0.07	–	-0.12	0.16	0.74
Spa.	0.44	-0.03	0.16	0.25	-0.40	0.54	0.03	-0.29	–	0.30	0.51
UK	-0.35	0.41	-0.07	-0.13	0.61	-0.01	-0.04	0.32	0.26	–	0.58

Note that Finland has the largest weight in Sweden's optimal basket.[4] France and the UK have *negative* weights in Sweden's basket. Also note that Austria stands out as a country with relatively well-diversified international comovements although France and the UK have fairly small weights. But Italy has a low correlation with its optimal basket and weights vary substantially between different countries. France seems somewhat more well diversified than Germany.

3. The correlation between underlying business-cycle shocks

The analysis in the previous section does not consider that the transmission mechanism in the case of a shock can be different in different countries. Say, for example, that a common positive shock occurs in an industry that is represented in two countries. Now assume that the time lag between this shock and the impact it has on output is different in the two countries, for example, due to different labor-market institutions. We may then observe a low correlation between the two countries output growth despite the fact that the original shocks were identical in the two countries. Another example could be a common change in money demand. If the transition mechanisms are different in the two countries, such common shocks cause a low degree of covariation of growth rates.

[4] The result for Sweden is not changed much if Norway and the U.S. are also included in the basket. The weights for Norway and the U.S. are -0.14 and 0.00.

In these examples, apparently the correlation between growth rates is a bad measure of to what extent the business cycles in the two countries are driven by a common source. But it is of interest to study the underlying shocks because a high degree of correlation between the shocks potentially could lead to common interests regarding stabilization policy.

Differences in transmission mechanisms might exist because the economy reacts differently to similar shocks. A common international shock, for example, the oil price shock, can result in different patterns of response in different countries. As an example of this, Sardelis (1994) takes the Swedish "bridging" policy that was pursued between 1973-76. During this period, Sweden—in contrast to many other countries—pursued an expansionary monetary and fiscal policy. This led to higher inflation and lower unemployment in Sweden, while most other European countries experienced the opposite development. With a more coordinated economic policy in a monetary union, such differences in transmission mechanisms may diminish. This is another argument for why it is important to analyze how much asymmetry is left when we control for differences in transmission mechanisms.

This section looks at the correlation of shocks to output and employment in different countries when we allow for different structures of transmission mechanisms under as weak assumptions as possible. The analysis builds directly on Helg, et al. (1995). A structurally identical VAR model is estimated separately for output and employment growth.

The model consists of one equation for each country. The growth rate in a country's manufacturing industry (for output and employment) is first assumed to be correlated over time. If growth has been high in a particular quarter, this has effects on growth during the next quarter. I allow a separate influence from each of the preceding four quarters. Growth rates may also be affected by two internationally common components—growth in the U.S. and in the entire EU. Lastly, I allow for a long-run stable relationship between output levels in the different countries. This means that I allow for the existence of stable market shares for different countries. Deviations from these would then tend to diminish over time.[5] For each country, I thus es-

[5] Formally, I allow a cointegrating relationship in each country regression between that country and the EU and/or the US.

timate an equation where the percentage increase in manufacturing output between two quarters depends on:

- Growth rates during each of the previous four quarters in the same country, the U.S., and the EU.
- Deviations from long-run stable market shares (provided that they exist).

The part of the growth rate between two consecutive quarters that cannot be accounted for by these factors is defined as the shock or the VAR residual for that period and country. In the end, correlations between these residuals are used to evaluate the degree of symmetry between different countries.

A shock (residual) should be interpreted as a change in output that is unexpected given previous output in the same country, the U.S., and the EU as a whole. Rather than aggregating the EU, we could certainly imagine to let the international influence on, for example, Swedish output from other countries to vary in other ways than in proportion to its size. But to model this would require large amounts of data or strong *a priori* assumptions about how the dependence varies.

The estimated VAR model should be examined before the correlations between its residuals are analyzed. The model assumes that the residuals are normally distributed and not correlated over time. A first informal test is to plot the residuals as shown in Figures 3 and 4. The amplitude of the residuals is normalized to the interval [-1,1]. The figures show no clear indication of an incorrect specification. There might be a tendency toward a decreasing volatility of the U.S. residuals, and there are some outliers for some countries' employment. The latter can be of special importance for the correlations, which should be noted in the subsequent analysis.

In addition to the plots, I perform two formal tests—one which tests that no autocorrelation remains in the residuals and one which tests that the variance is not correlated over time. The appendix describes the test and the results in more detail. We can see that the model seems to be acceptably specified in most cases. I have also checked that the results are not altered when the first or last five years of observations are excluded. We may now analyze VAR residuals with the same tools as in the previous section.

Figure 3. VAR residuals—manufacturing output

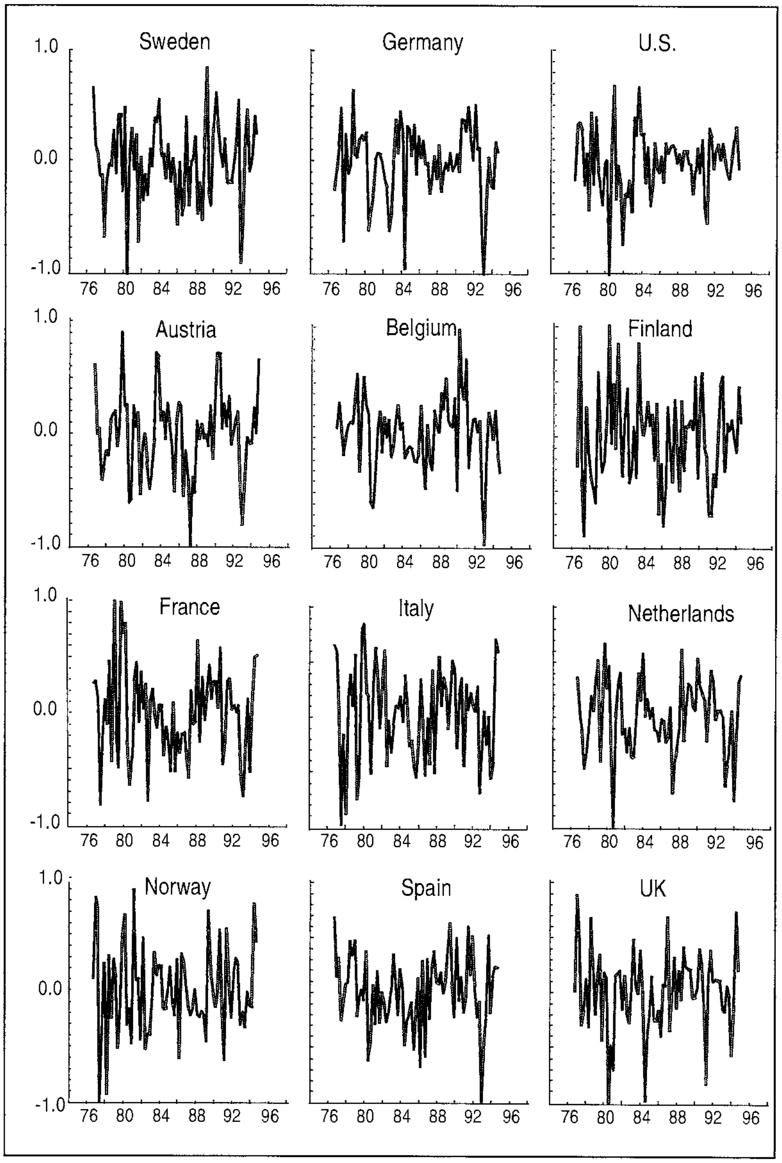
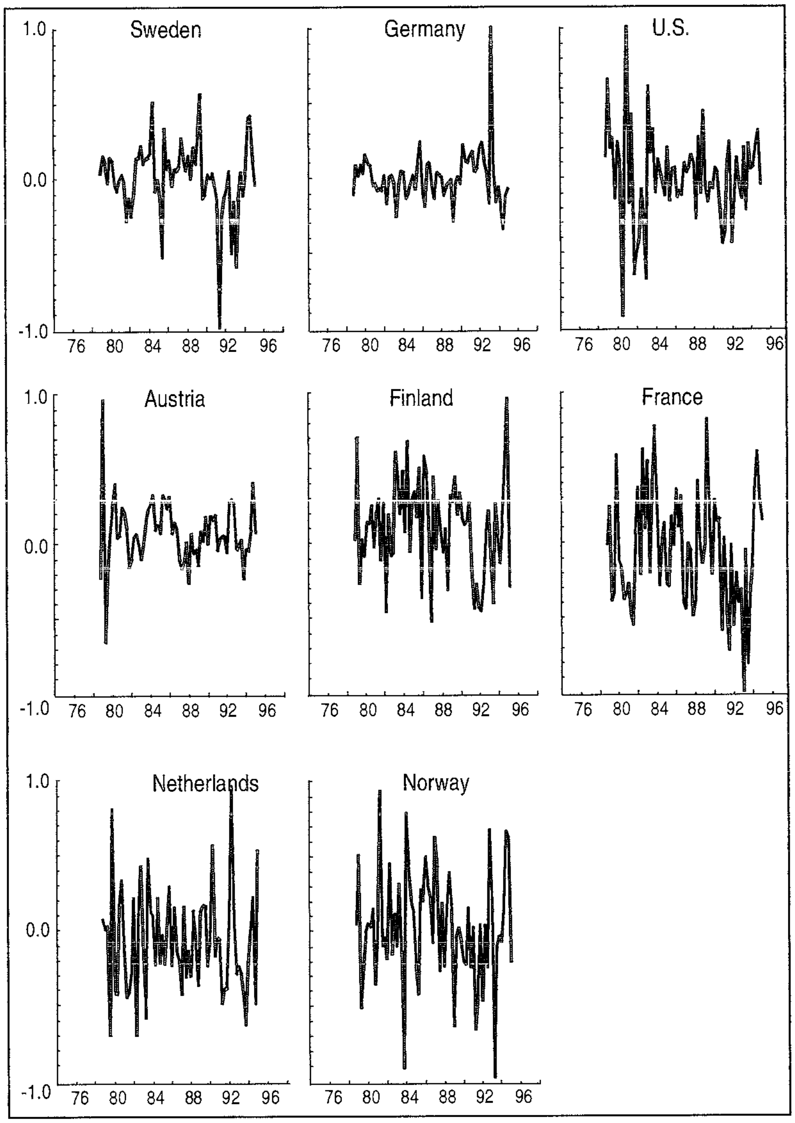


Figure 4. VAR residuals—employment



Tables 7 and 8 report estimated residuals for manufacturing output and employment. The layout is the same as in Tables 4 and 5. We find a much higher number of nominally significant observations, i.e., correlation larger than 0.30 in Table 7 than in Table 4.

In Table 7, half of the 66 correlations are above 0.30. But only 21 are at least that large in Table 4. The number of correlations above

0.45 increases from five to 18. So differences in transmission mechanisms between countries seem to reduce business-cycle comovements relative to the correlation of underlying shocks. But this does not seem to apply to Finland and Sweden—the only countries for which the number of correlations above 0.30 falls when we control for differences in transmission mechanisms. VAR residuals, for example, in the Netherlands, Italy, Norway, and Spain are much more correlated with shocks in other countries than their growth rates are.

Table 7. Output correlations—VAR shocks

	Ger.	U.S.	Aus.	Bel.	Fin.	Fra.	Ita.	Ne.	Nor.	Spa.	UK	No. of sign.
Swe.	0.25	0.21	0.50	0.25	0.26	0.28	0.15	0.46	0.06	0.43	0.20	3 (0)
Ger.		0.20	0.38	0.32	-0.09	0.34	0.01	0.47	0.29	0.38	0.37	6 (3)
U.S.			0.16	0.05	0.07	0.11	-0.02	0.09	0.29	0.21	0.38	1 (1)
Aus.				0.53	0.13	0.45	0.42	0.66	0.26	0.38	0.12	7 (3)
Bel.					0.23	0.47	0.24	0.45	0.10	0.48	0.32	6 (3)
Fin.						0.36	0.27	0.17	0.46	0.00	0.18	2 (1)
Fra.							0.58	0.68	0.49	0.51	0.38	9 (4)
Ita.								0.60	0.34	0.27	0.15	4 (2)
Ne.									0.30	0.48	0.30	9 (4)
Nor.										0.31	0.53	6 (4)
Spa.											0.48	8 (3)
UK												7 (3)

Generally, Table 7 shows the same picture as Table 4. France is well correlated with most other countries, including all other large potential EMU members but not with Sweden. The Netherlands is also well correlated with most other countries, including Sweden and the large potential EMU members. Austria, Belgium, France, Germany, and the Netherlands, which formed a core group with relatively large mutual comovements, have all VAR residual correlations nominally significant. France, Spain, the UK, and Germany also form a group where all pair-wise correlations exceed 0.30. Sweden has only three nominally significant correlations and none with the large potential EMU countries.[6]

Table 8 reports correlations between VAR residuals from the employment equations. Here, results differ from Table 5 in two respects:

1. The Swedish and Finnish employment VAR residuals are substantially more negatively correlated with the German than the observed growth rates.
2. The results for Austria differ between the two tables. Most of the Austrian correlation with other countries disappears when we study VAR residuals instead of growth rates. An explanation for this could be that Austrian business cycles are driven by other countries' (German) business cycles via the Austrian transmission mechanism rather than by a direct influence of common shocks.

Table 8. Employment correlations—VAR shocks

	Ger.	U.S.	Aus.	Fin.	Fra.	Ne.	Nor.	No. of sign.
Swe.	-0.25	0.19	0.01	0.42	0.50	0.24	0.33	3 (1)
	Ger.	-0.05	0.11	-0.41	-0.14	0.06	-0.46	2 (1)
		U.S.	0.23	0.14	-0.03	-0.15	-0.01	0 (0)
			Aus.	0.39	0.17	0.08	0.33	2 (0)
				Fin.	0.28	-0.19	0.41	4 (1)
					Fra.	0.43	0.09	2 (1)
						Ne.	-0.10	1 (0)

4. Regional and industry comovements

This section analyzes some regional aspects of international business-cycle comovements. It is *a priori* reasonable to assume that the degree of correlation with business cycles in other countries varies between regions. One reason for this is that different industries may show different patterns of correlations. And because the industrial composition varies between regions, this is going to cause regional dispersion in this respect. Because of this, regional variations in industrial composition and industry differences in international comovements are examined in this section.

Regional variation in international business-cycle comovements can certainly be due to factors other than different industrial compo-

[6] In some cases, the correlation between Swedish and other countries' VAR residuals is highly unstable over time, possibly due to some particular episodes. See Section 5.

sition, for example, differences in the importance of idiosyncratic regional shocks to output or employment. To analyze such causes, we need time series of regional output, which is not available. Statistics Sweden has, however, recently started to produce such data for Swedish counties (*län*). The length of these series is still only three or four years, which makes statistical inference impossible.

To quantify the differences in regional industry composition, I estimate a VAR with one equation for each of the 11 subindustries in manufacturing in each of the studied countries. As explanatory variables, I include lagged dependent variables, growth rates in the same industry in the entire EU, and in the U.S. I also include the aggregate (output or employment) growth in the same country. Lagged explanatory variables in, for example, the equation for the Swedish chemicals industry, are thus output in this sector in Sweden, the U.S., and the EU, and total manufacturing output in Sweden. I allow a separate effect from four lags of the explanatory variables. As in the previous VAR, I also allow deviations from long-run stable market shares, if such exist, to affect growth. The appendix contains a more formal description of the model.

Each estimated equation produces a series of residuals for a particular industry in a particular country. I then take the 11 series of residuals for the Swedish industries. For each of the 24 Swedish counties, I construct a weighted average of the 11 series. The weights for each county are given by the industry composition in the particular county in 1991. Table 9 reports these weights.

Following this procedure, I construct a series of residuals (shocks) for each of the Swedish counties' manufacturing industry. The estimation is done separately for employment and output. Table 10 shows the weights for employment.

Table 11 reports the correlations between the regional shocks and shocks in other countries. I report correlations with Germany, the U.S., and weighted averages of the shocks in some sets of potential EMU members. The weights are 1995 GDP from *OECD Main Economic Indicators*. I use three sets of countries. The first is a small core group with Austria, Belgium, Germany, and the Netherlands (I have no employment data for Belgium). In the second, I add France. And in the third, the sample includes all potential EMU countries.

Table 11 shows that regional differences in industry composition seem to have small effects on correlations with shocks in other countries.

Table 9. Regional industry weights in percent for output

County	FBT	TCL	PP	PPP	C	NMP	BM	MP	M	EM	TE
Stockholm	14.5	0.4	1.1	22.7	19.4	1.5	0	4.8	15.6	11.9	7.9
Uppsala	10.7	1.0	2.7	11.9	12.5	7.2	4.6	37.3	8.9	1.9	1.3
Södermanland	8.8	3.3	3.0	8.6	12.8	4.0	21.6	14.5	15.2	4.5	3.7
Östergötland	8.0	2.2	2.5	14.7	6.5	2.1	4.9	8.1	20.7	11.6	18.7
Jönköping	3.8	2.4	21.3	9.6	13.2	1.4	3.3	21.6	16.8	3.1	3.6
Kronoberg	4.5	1.4	13.5	12.3	3.7	4.9	2.0	14.5	26.4	7.1	9.8
Kalmar	8.2	0.3	17.0	12.9	3.7	7.0	1.2	8.7	11.1	9.2	20.8
Gotland	32.2	1.2	7.0	9.9	4.0	7.8	0	4.6	3.2	30.0	0
Blekinge	18.0	1.5	3.5	9.0	6.0	1.0	1.8	8.9	25.3	-5.3	30.3
Kristianstad	18.9	2.1	18.1	12.7	12.7	6.1	0.6	8.1	7.3	5.3	8.1
Malmöhus	26.1	1.4	1.5	18.5	18.0	5.6	1.9	8.2	13.4	2.1	3.2
Halland	17.3	7.2	6.4	24.6	7.7	9.1	2.3	9.6	6.0	3.6	6.3
Göteborg & Bohus	12.6	1.3	1.5	10.9	38.9	1.2	0.1	7.6	11.7	3.6	10.5
Älvsborg	3.5	14.1	6.4	12.5	11.0	3.6	0.4	10.6	7.3	9.8	20.8
Skaraborg	9.3	2.4	17.7	6.5	5.5	5.6	0.2	11.6	13.6	1.5	26.1
Värmland	10.2	0.6	5.5	29.9	9.2	0.8	9.2	9.4	18.4	2.6	4.2
Örebro	12.0	3.0	3.5	15.3	10.9	4.1	1.3	11.2	21.9	9.0	7.8
Västmanland	2.3	0.5	3.2	8.7	6.0	5.0	9.6	15.4	13.4	12.1	23.7
Kopparberg	7.5	1.6	10.8	23.5	2.4	1.5	17.2	12.8	6.0	9.5	7.2
Gävleborg	7.9	0.3	10.2	27.2	4.5	0.6	18.1	7.4	10.1	11.1	2.6
Västernorrland	8.2	0.7	5.0	29.0	16.1	3.0	2.1	7.0	15.9	7.2	5.8
Jämtland	16.0	3.9	22.0	10.4	2.5	3.4	1.1	12.3	13.0	13.0	2.2
Västerbotten	5.6	0.4	18.2	11.1	11.3	1.7	13.5	7.6	16.8	1.9	11.8
Norrbotten	6.5	0.6	15.8	17.7	3.9	2.4	15.3	17.0	5.3	0.9	14.6

FBT = Food, beverage, tobacco
TCL = Textiles, clothing, leather
PP = Paper & paper products
PPP = Pulp, paper, printing industry
C = Chemicals
NMP = Non-metallic mineral products
BM = Basic metals
MP = Metal products
M = Machinery
EM = Electrical machinery
TE = Transport equipment

Table 10. Regional industry weights in percent for employment

County	FBT	TCL	PP	PPP	C	NMP	BM	MP	M	EM	TE
Stockholm	11.6	1.1	2.0	22.8	9.3	1.7	0.5	6.2	15.0	19.2	10.7
Uppsala	8.8	1.5	4.3	20.8	18.7	4.8	3.9	20.0	13.2	2.5	1.6
Södermanland	6.8	3.5	3.5	8.9	6.3	3.6	16.5	14.8	21.7	7.8	6.6
Östergötland	7.7	2.2	3.4	11.5	5.0	1.5	3.6	8.7	22.3	15.3	18.8
Jönköping	3.7	2.4	19.9	9.8	12.4	1.6	3.4	21.6	17.6	4.0	3.5
Kronoberg	6.0	2.1	15.2	13.2	3.1	6.3	3.4	10.9	28.0	3.9	8.0
Kalmar	9.4	0.6	18.2	13.5	2.7	8.0	1.9	11.0	11.5	9.9	13.2
Gotland	28.6	2.1	9.2	8.9	4.5	18.3	0.4	3.6	3.5	20.8	0.0
Blekinge	12.4	2.3	3.8	12.0	5.2	0.9	1.2	8.0	15.4	8.4	30.2
Kristianstad	16.0	3.5	18.7	13.4	14.4	5.5	0.3	10.9	9.0	2.9	5.4
Malmöhus	21.1	2.4	2.0	19.4	16.2	5.5	1.9	9.7	14.7	3.3	3.7
Halland	13.3	7.5	7.9	23.3	6.9	5.6	1.5	16.5	6.7	3.4	7.3
Göteborg & Bohus	11.0	2.7	2.3	12.5	9.1	1.2	0.1	8.2	14.5	5.8	32.6
Älvsborg	3.4	15.6	6.0	10.7	7.0	3.2	0.9	11.9	8.2	5.8	27.3
Skaraborg	11.6	2.9	16.8	7.4	6.1	4.4	0.3	11.8	18.1	1.3	19.4
Värmland	10.0	1.0	6.9	20.2	8.7	1.6	12.0	11.2	17.9	5.0	5.4
Örebro	9.8	3.6	4.7	11.4	9.5	4.0	7.6	11.0	23.7	8.7	5.9
Västmanland	3.2	0.9	3.1	7.9	3.1	2.6	10.0	14.5	17.5	17.3	19.9
Kopparberg	7.3	2.7	13.8	15.5	3.0	1.6	20.7	15.7	6.7	8.4	4.4
Gävleborg	5.7	0.8	11.8	21.6	1.9	1.1	18.8	12.7	12.8	9.7	3.1
Västernorrland	6.5	1.4	6.8	30.6	8.0	2.9	3.6	10.3	17.5	6.0	6.4
Jämtland	16.1	4.7	19.9	10.3	2.3	5.3	1.1	14.3	9.8	10.5	5.6
Västerbotten	8.1	0.8	18.1	11.1	8.4	2.2	8.5	8.9	17.5	4.4	11.9
Norrbotten	8.6	1.4	19.7	15.2	3.5	2.4	17.6	15.6	6.8	1.8	7.5

FBT = Food, beverage, tobacco
TCL = Textiles, clothing, leather
PP = Paper & paper products
PPP = Pulp, paper, printing industry
C = Chemicals
NMP = Non-metallic mineral products
BM = Basic metals
MP = Metal products
M = Machinery
EM = Electrical machinery
TE = Transport equipment

Table 11. Regional correlations—VAR shocks

	Output					Employment				
Counties	D	D, B, NL, A	D, B, NL, A, F	D, B, NL, A, F, SF, I, GB, E	US	D	D, NL, A	D, NL, A, F	D, NL, A, F, SF	US
Stockholm	.33	.39	.40	.43	.23	-.28	-.27	-.22	-.20	.21
Uppsala	.20	.27	.29	.32	.21	-.22	-.21	-.16	-.14	.24
Södermanland	.22	.30	.34	.36	.22	-.34	-.34	-.29	-.27	.24
Östergötland	.32	.38	.39	.40	.19	-.27	-.26	-.21	-.19	.24
Jönköping	.28	.35	.36	.39	.24	-.24	-.23	-.17	-.15	.25
Kronoberg	.33	.40	.41	.42	.22	-.24	-.24	-.18	-.17	.29
Kalmar	.28	.34	.33	.35	.13	-.31	-.30	-.24	-.22	.24
Gotland	.29	.34	.36	.39	.07	-.40	-.38	-.34	-.32	.17
Blekinge	.27	.32	.30	.31	.15	-.21	-.21	-.14	-.13	.25
Kristianstad	.27	.34	.34	.37	.17	-.24	-.22	-.17	-.15	.25
Malmöhus	.29	.36	.37	.40	.22	-.24	-.23	-.18	-.16	.26
Halland	.28	.34	.36	.38	.19	-.24	-.22	-.16	-.14	.20
Göteborg&Bohus	.27	.33	.34	.37	.24	-.16	-.15	-.09	-.08	.26
Älvsborg	.30	.32	.36	.38	.20	-.11	-.09	-.02	-.01	.18
Skaraborg	.26	.32	.31	.32	.14	-.21	-.20	-.14	-.12	.28
Värmland	.29	.36	.38	.39	.25	-.31	-.31	-.25	-.23	.26
Örebro	.34	.41	.42	.44	.23	-.28	-.27	-.22	-.20	.26
Västmanland	.26	.32	.33	.34	.15	-.34	-.33	-.28	-.27	.21
Kopparberg	.23	.30	.32	.34	.18	-.43	-.41	-.36	-.35	.19
Gävleborg	.25	.32	.35	.37	.21	-.41	-.40	-.35	-.33	.21
Västernorrland	.31	.38	.39	.42	.25	-.24	-.23	-.18	-.16	.26
Jämtland	.32	.39	.40	.42	.18	-.32	-.30	-.24	-.23	.22
Västerbotten	.26	.33	.34	.35	.20	-.28	-.27	-.21	-.20	.28
Norrbotten	.20	.26	.27	.29	.15	-.38	-.37	-.31	-.29	.23
Total manufacturing	**.25**	**.33**	**.36**	**.39**	**.21**	**-.25**	**-.23**	**-.15**	**-.12**	**.19**

Country abbreviations: A = Austria, B = Belgium, D = Germany, E = Spain, F = France, GB = UK, I = Italy, NL = Netherlands, SF = Finland, US = United States

For output, correlations with Germany range from 0.20 (Uppsala and Norrbotten) to 0.34 (Örebro). A similarly narrow range of correlations can be found for country aggregates and for the U.S. There seems to be no tendency that regional correlations with other countries vary with geographical distance to the continent or to Stockholm. Norrbotten (most northern county) tends to have a somewhat weaker correlation than the average, while other northern counties such as Jämtland and Västernorrland lie above the average.

For employment, the correlations are in all cases negative, except with the U.S. Note that Kopparberg and Älvsborg (western counties) have the lowest (-0.45) and the highest (-0.11) correlations with Germany. A similar range is found for the correlations with the aggregates, from -0.35 for Kopparberg to -0.01 for Älvsborg.

A study of growth rates or trend deviations, rather than VAR residuals, supports the conclusion that differences in regional industry composition seem to have small consequences for business-cycle comovements.[7] For trend deviations, output in Södermanland has the lowest correlation with Germany (0.13), while the highest is found in Jämtland (0.31). For growth rates, Uppsala has the lowest correlation (0.06) and Göteborg, the highest (0.28).

The last row in Table 11 shows that there are no dramatic differences in correlations between Swedish shocks and the different country aggregates. The tendency seems to be that the correlations increase as the aggregate becomes larger. This also holds for individual Swedish counties. To depict the degree of comovement without each country, I calculated the correlation between the shocks in each of the 11 industries with aggregate manufacturing output in the same country. This is done for all countries in the dataset. Table 12 shows the results; the last row is an unweighted average of correlations of each column.[8]

Table 12 shows that correlations between subindustries in a country are far from perfect. Here, variation also exists between the countries. France, Germany, and the U.S. tend to have a higher degrees of correlation between output shocks in domestic subindustries than, for example, in Sweden and Finland. For employment shocks, the variation is even larger.

[7] Tables for these results are not included but can be requested from the author.
[8] In some cases, the VAR does not pass some of the diagnostic tests here. Full results of these tests can be requested from the author.

Table 12. Subindustry correlation with manufacturing—VAR shocks

Output

	Swe.	Ger.	U.S.	Aus.	Bel.	Fin.	Fra.	Ita.	Ne.	Nor.	Spa.	UK
Food, beverages, tobacco	.25	.45	.56	.23	.19	.28	.31	.37	.29	.51	.28	.32
Textiles, clothing, leather	.31	.63	.71	.48	.22	.25	.56	.60	.53	.58	.56	.62
Wood, wood products	.32	.40	.76	.38	.25	.46	.44	.54	.19	.58	.43	.52
Paper, paper products	.42	.69	.68	.34	.49	.47	.57	.40	.25	.66	.16	.64
Chemicals	.40	.67	.81	.49	.51	.40	.44	.59	.61	.49	.61	.47
Non-metallic minerals	.32	.37	.69	.34	.37	.35	.69	.26	.44	.43	.51	.44
Basic metals	.30	.60	.64	.46	.58	.19	.68	.56	.46	.36	.26	.39
Metal products	.46	.73	.84	.66	.41	.27	.78	.62	.38	.65	.68	.21
Machinery	.61	.54	.75	.52	.42	.44	.57	.61	.49	.54	.36	.26
Electrical machinery	.43	.74	.64	.42	.35	.27	.42	.46	.48	.47	.34	.40
Transport equipment	.32	.61	.72	.28	.28	.30	.72	.49	.23	.43	.25	.44
Average	**.43**	**.62**	**.73**	**.47**	**.42**	**.39**	**.60**	**.54**	**.45**	**.56**	**.45**	**.48**

Table 12. continued ...

Employment

	Swe.	Ger.	U.S.	Aus.	Fin.	Fra.	Ne.	Nor.
Food, beverages, tobacco	.62	.77	.21	.03	-.09	.44	.14	.07
Textiles, clothing, leather	.20	.74	.58	.20	-.31	.48	.24	.22
Wood, wood products	.63	.62	.70	.06	.22	.57	.20	.53
Paper, paper products	.37	.71	.49	.33	.25	.65	.15	.10
Chemicals	.33	.79	.53	.29	.41	.50	.11	-.20
Non-metallic minerals	.23	.69	.73	.12	.08	.62	.10	.17
Basic metals	.22	.44	.63	.28	-.09	.34	.43	.23
Metal products	.30	.23	.80	.45	.10	.68	.38	.42
Machinery	.56	.76	.62	.35	.07	.63	.27	.29
Electrical machinery	.26	.58	.55	.16	.06	.45	.28	.17
Transport equipment	.33	.75	.48	.25	-.26	.55	.07	.10
Average	**.42**	**.67**	**.61**	**.29**	**.12**	**.57**	**.28**	**.26**

Here, Sweden is in an intermediate position between France, Germany, and the U.S., with higher degrees of correlation and some other countries with lower. But note that the correlation between the business cycles in different industries, measured as trend deviations, is much higher. For Sweden, the average is 0.72 for output. This aligns with most of the other countries, and also with those where VAR residuals are more correlated than for Sweden.[9]

5. Conclusion

This paper shows that manufacturing output in Sweden during the last two decades has had a relatively low correlation with the other potential EMU countries. A special concern is that the correlation with France, Italy, and Germany has been low. We find this low correlation regardless of whether we focus on the activity level, measured as deviations from a logarithmic trend, measure quarterly rates of change, or use shocks derived from a VAR model.

The highest correlation between the level of activity in Swedish manufacturing and other countries is around 0.4 and is found with Finland, the Netherlands, Norway, and the UK. In quarterly growth rates, Swedish manufacturing has a correlation above 0.30 with only Austria, Finland, Spain and the Netherlands. For VAR shocks, the correlation is above 0.30 with only Austria, Spain, and the Netherlands. Sweden and Finland stand out as two countries with particularly low foreign correlations. Sweden is also alone in having no correlation of VAR shocks above 0.30 with France, Germany, Italy, and the UK.

In the study of manufacturing employment, the picture is more ambiguous. Here the correlations between the continental countries are generally lower than for output. Swedish VAR shocks for employment have been relatively strongly correlated with the corresponding French shocks. In some cases, the correlations are negative. This is, for example, the case for the Swedish and German VAR shocks.

The relatively weak Swedish correlation with the large potential EMU countries may be interpreted as indicating that the Swedish economy may face larger demands for structural change in the case of EMU entry than, for example, the French, Dutch, Belgian, or Austrian economies. But this interpretation can be challenged. A

[9] Tables for these results are not included but can be obtained from the author.

more unambiguous conclusion would have been possible to draw if we had found the opposite, that is, a high degree of correlation with Germany and other potential EMU countries. In that case, the findings could be taken as a clear indication of small potential problems in the area of stabilization policy with a Swedish EMU membership. But several reasons exist for why strong conclusions are more questionable in the present case.

This paper says nothing about the costs of potential necessary structural changes associated with an EMU membership. I have also stressed in the introduction that business-cycle correlations cannot be taken as constants. Both the Swedish EU membership and a potential EMU membership affect trade, capital flows, and industry composition. Business-cycle correlations are likely to be affected by such changes. The creation of common currency areas may actually make the participants more suited to participate than they appeared *ex ante*. Frankel and Rose (1997) evaluate this mechanism in their report to the Swedish Government Commission on the EMU. In theory, it is not clear that the increased integration following membership in the monetary union has to increase business-cycle comovements. Higher integration may increase specialization, which could reduce covariations, in particular if industry specific shocks are important. For example, Bayoumi and Eichengreen (1994) and Krugman (1993) stress this argument. But Frankel and Rose (1997) provide empirical support for the opposite hypothesis—that increased integration increases business-cycle comovements.

I also want to emphasize that some possibly important sources of business-cycle fluctuations may disappear after an EMU membership. It is, for example, not at all unlikely that the Swedish monetary and exchange-rate policy, in itself, has created asymmetric fluctuations in employment and output. A casual glance at the development of Swedish and EU GDP shows that when the Swedish business cycle has moved in an opposite direction from the European, this has often been associated with devaluations or other differences in monetary policy. The recurrent Swedish devaluations during the last two decades and the extreme fight to defend the crown in 1992 are examples of asymmetric sources of fluctuations that would disappear automatically with EMU participation.

The Swedish business-cycle asymmetry could have been caused by Sweden reacting differently to common international shocks. In that case, the Swedish asymmetry would have been reduced when measured by the correlation of VAR residuals, because the VAR is designed to control for systematic differences in such transmission mechanisms. The results in this paper are, however, rather the opposite—the Swedish asymmetry is stronger for VAR residuals than for growth rates. This indicates that the Swedish asymmetry is not principally due to a different pattern of reaction to common international shocks—but rather to genuinely domestic sources. The results in this paper cannot be used to make inferences about what these sources are. But I believe it is more likely that they are due to particularities in Swedish economic policy and labor markets than to idiosyncratic technology shocks.

A low correlation of the growth rates of output and employment is not a sufficient condition for diverging stabilization-policy interests to arise. Changes in productivity, export demand, or labor supply affect output but should and cannot be neutralized by monetary policy. But there is a role a role for monetary policy because prices and wages often do not adjust fast enough to these and other economic changes.

In this context, it must be acknowledged that the degree of price and wage stickiness is not independent of monetary policy. The extent of nominal rigidities in the labor market—how long a time is required to adjust disequilibrium wages is of central importance in an analysis of the costs of an EMU membership. Unfortunately, the knowledge of the basic causes of such rigidities is limited. So it is difficult to predict how they may change after an EMU membership. If on one hand, the international competitiveness can no longer be improved through devaluations, this will increase the output and employment costs of nominal rigidities. So the incentives for the agents in the labor market to achieve more flexibility will increase. This could reduce nominal rigidity. On the other hand, an EMU membership may lead to a low and stable inflation rate. This could reduce the costs of fixing nominal prices and wages for long periods and thus increase nominal rigidity. The conclusion here depends crucially on whether Swedish monetary policy has mainly corrected for exogenous domestic shocks and thus facilitated longer nominal contracts or if it has added a source of uncertainty about future price levels. In the latter case, nominal rigidity may increase if this source of uncertainty disappears through an EMU membership. But this may not be particularly dangerous because an important source of disturbances, domestic monetary policy, then disappears.

Note that a lower degree of nominal rigidity may decrease *relative-wage rigidity*. Assume, for example, that there is a floor of zero nominal-wage increases. This in combination with an ambitious target for inflation clearly inhibits fast changes in relative wages. If the nominal floor would disappear after an EMU membership, this increases relative-wage flexibility. Assume similarly that the nominal rigidity (partly) is due to long wage contracts. If a less accommodating monetary policy reduces the length of the wage contracts, this may increase the responsiveness of the labor market to relative changes in labor demand in different sectors of the economy. In this respect, an independent exchange-rate policy is not a working substitute for flexible prices and wages.

This study mainly focuses on business-cycle fluctuations on fairly high frequency. The economy is often assumed to have transmission mechanisms that transform stochastic high-frequency shocks to business cycles of, say, three to five years' average length. A single shock, for example, an oil shock, creates a dynamic response that may last several years. In theory, it would be possible to stabilize the business cycle by neutralizing these shocks immediately when they are realized. An analysis of the potential costs of a common monetary policy should then focus on the underlying high-frequency shocks.

But in practice, it is hardly possible to stabilize shocks as they arise. To do that would require policy instruments that have effects and can be executed with very short time lags. Monetary policy hardly satisfies this requirement—it is generally believed that it affects economic activity with a lag of one to two years. So an analysis of the need for a domestic monetary policy should possibly be focused on more long-run fluctuations than quarterly innovations. But to enable statistical power, a study of business-cycle comovements on longer horizons would require a longer time series than the two decades of data I have had access to. But as a *Catch-22*, longer time series make the inference more susceptible to the consequences of the fact that the economy continuously changes, which makes many economic relationships variable over time.

Figure 1 permits us to separate three Swedish business-cycle upturns and three downturns. Two of the downturns (the early 1980s and the early 1990s) and the long upturn from around 1983 coincide reasonably well with the corresponding business-cycle phases in Germany. Somewhat naively we could say that we only have six observations of distinct Swedish business-cycles phases in the sample and that three of them coincide with the German. But one cannot draw strong statistical conclusions from only six observations.

So the result in this study, that Swedish business cycles have a low degree of comovement with most of the other potential EMU members, must be interpreted with great caution. Results in Hassler (1994) suggest that degree of comovement between Swedish and international business cycles is higher on lower frequencies (over longer horizons) than on higher frequencies.

Another result in this study is that the variation in industry composition between different Swedish regions is of a size that does not generate large differences in comovements of output and employment with other countries. This indicates that the risk that some regions would be particularly hard hit by an EMU membership is not high. The results also indicate that the different subindustries in manufacturing have relatively low degree of covariation in an international comparison. Subindustries in most of the other countries in the sample, for example, in the U.S., Germany, and France, have a substantially higher degree of comovement. A low degree of covariation between output disturbances in different sectors of the economy reduces the applicability of aggregate monetary policy.

So the overall result of this paper is inconclusive. The statistical analysis *cannot* be taken as an indication that Sweden belongs to a group of countries with a high degree of suitability for a common currency. The analysis provides no firm evidence that Sweden is outside this group. The statistical analysis must be supplemented with other tools that can answer the question of how likely it is that the Swedish asymmetry may be reduced at low costs after entry into the EMU. One such tool is an economic and political case study of the causes behind the episodes when Swedish and European business cycles have diverged. But this is outside the scope of this paper.

Appendix

VAR model for manufacturing

Let y_t^i denote the log of manufacturing output (or employment) in country i at time t and let Δy_t^i denote $y_t^i - y_{t-1}^i$. Δy_t^i is then assumed to follow

$$\Delta y_t^i = \alpha_0^i + \sum_{l=1}^{4} \alpha_l^i \Delta y_{t-l}^i + \sum_{l=1}^{4} \beta_l^i \Delta y_{t-l}^{USA} + \sum_{l=1}^{4} \gamma_l^i \Delta y_{t-l}^{EU} + \phi_1^i y_{t-1}^i + \phi_2^i y_{t-1}^{USA} + \phi_3^i y_{t-1}^{EU} + \varepsilon_t^i \tag{1}$$

plus quarterly dummies to control seasonal variation. The shocks ε_t^i are assumed to be have an i.i.d. distribution over time. Because the shocks ε_t^i may be correlated between countries, I estimate the 12 equations simultaneously.[10]

Diagnostic tests

I perform two formal tests—one to check for remaining residual auto-correlation (AR-test) and one to check for residual variance autocorrelation (ARCH-test).[11] Table 13 reports the test results.

Table 13 shows that we can reject absence of autocorrelation for manufacturing output residuals in Austria. So some caution when interpreting the Austrian results is warranted. Because I estimate the VAR system simultaneously, an incorrect specification could cause inconsistencies in the estimation of the other equations. So I checked that the results are robust to the exclusion of Austria. I estimated the VAR with five lags of all RHS variables. All tests are then passed on the 1 percent level and the results are practically identical.

[10] Here, I perform a SURE—a stacked iterated FGLS (see Hamilton, 1994). I use OLS estimates of the residuals to calculate the starting value of the covariance matrix.

[11] The first test is a univariate variant of the Portmanteu test (see Lütkepohl, 1991). The maximum number of lags in the test use the number of observations over four. The ARCH test uses a regression of squared residuals on its own lag. The test statistic is the regression R^2 times the number observations, which is assumed to be $\chi^2(1)$ if no ARCH is present.

Table 13. Diagnostic test—marginal p-values

	Swe.	Ger.	U.S.	Aus.	Bel.	Fin.	Fra.	Ita.	Ne.	Nor.	Spa.	UK
Output												
AR test	.70	.89	.55	.00	.37	.36	.53	.79	.09	.43	.35	.43
ARCH test	.83	.75	.16	.39	.02	.34	.42	.42	.32	.13	.90	.77
Employment												
AR test	0	.59	.91	.92	–	.43	.04	–	.01	.92	–	–
ARCH test	.93	.92	.71	.00	–	.31	.07	–	.03	.91	–	–

We can also see that we can reject no autocorrelation of the employment residuals in Sweden and the Netherlands. This turns out to be due to an extreme observation in both cases. If the Swedish residual for 1991:1 and the Dutch for 1992:2 are set to zero, the tests are passed. The ARCH test is not passed by Austria. Here, the problem is also due to one single observation—in this case 1978:4. If this is set to zero, the test is passed. I do not attempt to respecify the model to handle these few extreme cases. Because these are all either in the beginning or in the end of the sample, I instead check that correlations are robust to exclusion of the first and last five years of observations.

VAR for subindustries

Let $\Delta y_t^{i,c}$ denote the differenced log of output (or employment) in industry *i* and country *c* and let Δy_t^c denote the differenced log of total manufacturing output (or employment) in country *c*. I assume that

$$\Delta y_t^{i,c} = \alpha_0^i + \sum_{l=1}^{4} \alpha_l^{i,c} \Delta y_{t-l}^i + \sum_{l=1}^{4} \beta_l^{i,c} \Delta y_{t-l}^{i,USA} + \sum_{l=1}^{4} \gamma_l^{i,c} \Delta y_{t-l}^{i,EU} + \sum_{l=1}^{4} \theta_l^{i,c} \Delta y_{t-l}^{c} + \phi_1^{i,c} y_{t-1}^{i,c} + \phi_2^{i,c} y_{t-1}^{i,USA} + \phi_3^{i,c} y_{t-1}^{i,EU} + \phi_4^{i,c} y_{t-1}^{c} \varepsilon_t^{i,c}. \tag{2}$$

It is computationally impossible to estimate (2) simultaneously for all industries and countries. Therefore, I limited estimation so that I simultaneously estimate the 11 subindustries in three countries at the time.[12] Germany and the U.S. are always included in this group of three countries.

Regional weights

I let Statistics Sweden calculate value added and employment in 1991 in each of the 11 subindustries in each of the 24 Swedish counties. By dividing these levels with total output (employment) in each county, I get a set of industry weights for each county. That is, let $y_{1991}^{i,j}$ denote output (employment) in industry i and county j and the corresponding weight for $w_{i,j}$. Then

$$w_{i,j} = \frac{y_{1991}^{i,j}}{\sum_{i=1}^{11} y_{1991}^{i,j}} \tag{3}$$

which produces a set of 11 industry weights for each of the 24 counties.

References

Baldwin, R., Begg, D., Dantine, J-P., Grilli, V., Haaland, J. I., Neumann, M., Norman, V., Venabels A. and L. A. Winters (1992), Is Bigger Better? - The Economics of EC Enlargement, Center for Economic Policy Research.

Bayoumi T. and B. Eichengreen (1992a), Is There a Conflict Between EC Enlargement and European Monetary Unification?, NBER Working Paper No 3950.

Bayoumi T. and B. Eichengreen (1992b), Shocking Aspects of European Monetary Unification, CEPR Working Paper No 643.

Bayoumi T. and B. Eichengreen (1994), One Money or Many? Analyzing the Prospects for Monetary Unification in Various Parts of the World, Princeton Studies in International Finance No 76, Princeton.

Bayoumi T. and E. Prasad (1995), Currency Unions, Economic Fluctuations, and Adjustments: Some Empirical Evidence, Mimeo, International Monetary Fund, Washington.

Bergman, M. and L. Jonung (1994), Svenskt och internationellt konjunkturbeteende, bilaga 13 till Långtidsutredningen 1995, Fritzes, Stockholm.

[12] The diagnostic tests show that the model is well specified with few exceptions. Employment residuals in Swedish ISIC 330 and output residuals in US ISIC 370 do not pass the AR test on the 1 percent level.

Christodoulakis, N., Dimelis, S. P. and T. Kollintzaz (1995), Comparison of Business Cycles in the EC: Idiosyncrasies and Regularities, Economica 62.

Frankel, J. and A. Rose (1997), The endogeneity of the optimum currency area criteria. Swedish Economic Policy Review, 4.

Hamilton, J. D. (1994), Time Series Analyses, Princeton University Press, Princeton, New Jersey.

Hassler, J. (1994), Effects of Variations in Risk on Demand and Measures of Business Cycle Comovements, doctoral dissertation, MIT and IIES, Monograph Series No 24, Stockholm University.

Helg, R., Manasse, P., Monacelli, T. and R. Rovelli (1995), How Much Asymmetry in Europe? Evidence from Industrial Sectors, European Economic Review 39.

Krugman, P. (1993), Lessons of Massachusetts for EMU, in Giavazzi, F. and F. Torres (eds.), Transition to Economic and Monetary Union in Europe, Cambridge University Press, New York.

Lütkepohl, H. (1991), Introduction to Multiple Time Series Analysis, Springer-Verlag.

Sardelis, C. (1993), EC Enlargement and the EFTA Countries, Commission of the EC, Economic Paper No 100. Brussels.

Sardelis, C. (1994), EMU och svensk stabiliseringspolitik, Ekonomisk Debatt 6.

Tarkka, J. and J. Åkerholm (1992), Fiscal Federalism and the European Monetary Integration, Bank of Finland Discussion Papers No 2/92.