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How large is the risk of asymmetric shocks for Sweden?

Per Jansson*

Summary

■ This paper analyses conditions for Swedish membership in the EMU. A desirable basis for a common monetary policy is that shocks affect member countries similarly, that is, that they are symmetric. Country-specific asymmetric shocks may require a country-specific monetary or exchange-rate policy. This is not an option in a monetary union.

This paper reviews earlier studies and presents new empirical estimates. The principal conclusion is that country-specific shocks largely explain the short-term development of output, employment, and prices in Sweden. The evaluation shows that many shocks, which affect output and employment, originate from supply-side changes. In contrast, it appears that price developments in Sweden are mainly demand determined.

For the optimal composition of the EMU, the picture is ambiguous. Results vary depending on the model, method, time period, and data used. But there is a small group of countries around Germany that seem to be more suitable than Sweden to be included in the currency union.■

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Stage Three of the EU's economic and monetary union, according to present plans, will be introduced on January 1, 1999. Then a common European Central Bank (ECB), with price stability as its primary goal, will assume responsibility for the member countries' monetary policy. At the same time, the current national currencies will be locked irreversibly against each other, and the new common currency (euro) will be introduced.

A European currency union has advantages and disadvantages. The advantages mainly stem from the lowering of transactions and information costs and from reduced risk. The main disadvantage is that the member states must give up their monetary and exchange-rate policy independence. It is also possible that the member states' fiscal policy independence will be significantly limited. So there is a considerable risk that the member countries may become trapped in an economic and political straitjacket, which will largely prevent traditional independent stabilization policy.

A discussion about the consequences of relinquishing the flexibility of monetary and exchange-rate policy must be related to the theory on optimal monetary and exchange-rate policy and to the theory of optimal currency areas. The fundamental question is under what circumstances monetary and exchange-rate policy will be significant for the development of the *real* economy. The conventional view is that monetary and exchange-rate policy is important for output and employment in the short term but not in the long term. If prices and wages do not adjust immediately (that is, if there are nominal rigidities) then changes in *nominal* quantities, including monetary policy and the nominal exchange rate, will lead to changes in relative prices and

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real wages. These real price changes will influence real aggregate demand and therefore output and employment. But in the long term, prices and wages adjust so that real price changes are eliminated. So monetary and exchange-rate policy only have real effects in the short term.

The lack of a long-term relationship between an economy's real and monetary spheres does not imply that the conduct of monetary and exchange-rate policy becomes trivial. Because monetary policy and exchange-rate policy have real effects in the short term, these policy instruments have a role to play for the purpose of the stabilization of the economy. Whether it is desirable to use them for this purpose largely depends on the goals for inflation and short-term variations in output and employment. But it also depends on what perceptions one has of the effectiveness of stabilization policy.

If monetary policy is governed by high ambitions for employment in the short run, then this may lead to unnecessarily high inflation in the long run. This is the main message from research into the credibility or time-inconsistency problem of monetary policy. According to this theory, a country that has low credibility regarding its monetary and exchange-rate policy should be able to reduce its inflation rate by participating in a system of irrevocably fixed exchange rates, such as the EMU. So with this view, the benefits of stabilization policy must be weighed against the benefits to be gained in terms of credibility that joining the monetary union would achieve.

The discussion on the EMU has been much influenced by the theory that deals with the conditions for an optimal currency area. The main message from this theory is that only countries with similar *economic structure* should form a common currency area. Given that nominal prices and wages are slow to adjust, the relative importance of *asymmetric* (country-specific) shocks and *symmetric* (common) shocks becomes a central issue. A desirable basis for a common monetary policy is that shocks are symmetric. Asymmetric shocks may require a country-specific monetary or exchange-rate policy. But in a monetary union this is not an option.

It is not only the degree of symmetry of shocks that plays a role. If the member countries do not make the same weighting between inflation and (short-term) unemployment, then it is also of significance whether the shocks occur on the demand or supply side. With negative *supply shocks*, stagflation can arise. This means that prices rise, while at the same time, output and employment fall. A sudden rise in oil prices or a sudden reduction in productivity are examples of such shocks. Pursuing a strict (demand-orientated) economic policy of price stabilization in this situation would lead to further losses in output and employment. If stabilization policy has price and employment goals, it can be desirable in such a situation to adjust the exchange rate.

If a shock occurs that affects prices and output (and thus employment) in the same direction, the picture becomes quite different. Here, there is no conflict between the goal of stabilizing the price level on one hand, and the goal of stabilizing output and employment on the other. Shocks with this property are *demand shocks*. So it appears that for a country that values stability of prices, output, and employment, participation in a monetary union aimed at price stability is most advantageous if *symmetric demand shocks* predominate.

This paper evaluates the risk for Sweden of being hit by different types of country-specific asymmetric shocks. The analysis uses time-series data to estimate a statistical model. In the model, two different components drive the macroeconomic time series: a symmetric (common) component and an asymmetric (country-specific) component. The components cannot be directly observed. But under certain assumptions, statistical methods can be used to identify them. The model is estimated for quarterly and annual data. Besides Sweden, the analysis includes Belgium, Denmark, Finland, France, Ireland, Luxembourg, the Netherlands, the UK, Germany, and Austria. The evaluation concentrates on three key questions:

1. How important are symmetric and asymmetric shocks, respectively, for the economy's real and nominal development?
2. What is the relative significance of supply shocks and demand shocks?
3. How persistent are the shocks?

The econometric technique used in this paper differs from that used in earlier studies, where the degree of symmetry and asymmetry is generally measured through the degree of correlation between different countries' shocks. There are at least three reasons why the results, which are obtained with this technique, must be interpreted very carefully:

1. A correlation is a *pair-wise measure of covariation.* Thus, it can only capture the covariation between two countries. But because the monetary union will (probably) include more than two countries, a *measure of covariation for a group of countries* should be used.
2. It is difficult to determine the *statistical certainty* in the estimated correlations. In turn, this means that it is difficult to determine whether an estimated correlation should be classified as high or low.[1]
3. In most studies, the usefulness of the results hinge on how well the different shocks (for example, demand and supply shocks) are *identified.* If the identifying assumptions that are made are incorrect, then the results will naturally be dubious.

The remainder of this paper is organized as follows. Section 1 discusses some theoretical and empirical problems that deserve special attention. Section 2 summarizes the results from earlier studies that deal with the effects of different shocks on the Swedish economy. Section 3 presents the empirical model. A more technical description appears in the appendix. Section 4 discusses the data that are being used. Section 5 evaluates the results. Section 6 contains a summary and a concluding discussion.

1. Empirical evidence and theory: some important problems

The theories on the suitability of a common currency largely deal with how countries are hit by, and adjust to, shocks. As previously explained, for a country that values price stability and output and employment stability, both the symmetry of shocks and the relative frequency of supply and demand shocks are of interest. But it is also reasonable to assume that the effects on the economy will be different depending on what *specific type of demand or supply shock* it is subjected to. In an analysis of optimal stabilization policy in a closed economy, Poole (1970) showed that a central bank's choice between stabilizing the quantity of money or stabilizing the interest rate can be

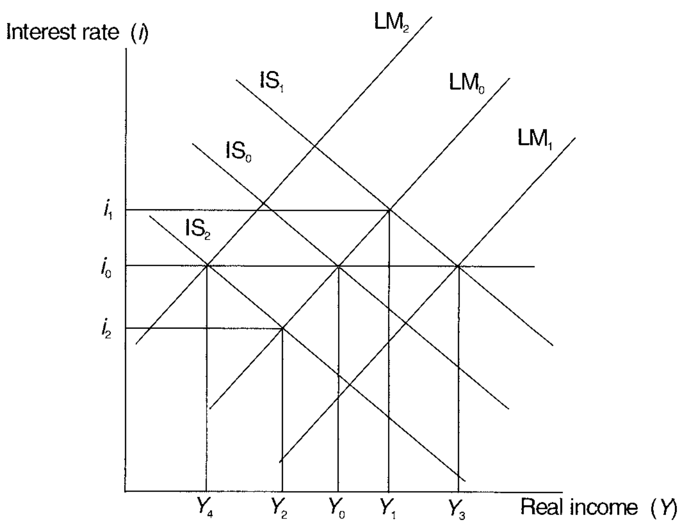
[1] As far as I am aware, no study has attempted to estimate measures of endogenous model-specific uncertainty for the correlations. In Funke (1995), rules of thumb are used.

influenced by the type of demand shocks that predominate. Poole's analysis is based on a traditional Keynesian macro model with a stochastic IS-LM framework.[2] Consequently, the model is driven only by demand shocks and the price level is assumed to be fixed. The IS curve and the LM curve can both be affected by shocks. *Real demand shocks* cause a shift in the IS curve, while *monetary demand shocks* lead to a shift in the LM curve. The objective of monetary policy is to minimize variations in output. I denote a policy to stabilize the quantity of money, a *non-accommodating* monetary policy, and a policy to stabilize the interest rate, an *accommodating* monetary policy.

Diagram A in Figure 1 analyses the effects of a real demand shock.

Figure 1. The effects of real and monetary demand shocks

A. A real demand shock with non-accommodating/accommodating monetary policy



[2] The IS curve shows the combinations of the interest rate and the level of real income that imply an equilibrium in the goods market. The LM curve shows the same thing for the money market. The IS curve is negatively sloped, while the LM curve is positively sloped.

If the quantity of money is held constant, then the equilibrium in the money market is unaffected. So the position of the LM curve remains constant. Real income (output) varies between Y_1 (a positive shock) and Y_2 (a negative shock). A monetary policy that aims to stabilize the interest rate, increases the variability of output. If, for example, the shock is positive so that the IS curve moves from IS_0 to IS_1, then there is pressure for an increase in the interest rate (the equilibrium interest rate is i_1). The increase in the interest rate can only be prevented if the central bank buys bonds so that their price rises and their yield falls. But this open market operation leads to an increase in the quantity of money in circulation. The LM curve then shifts from LM_0 to LM_1.[3] For a negative shock that affects the IS curve, the LM curve instead shifts (for similar reasons) from LM_0 to LM_2. So output varies more in this case (between Y_3 and Y_4).

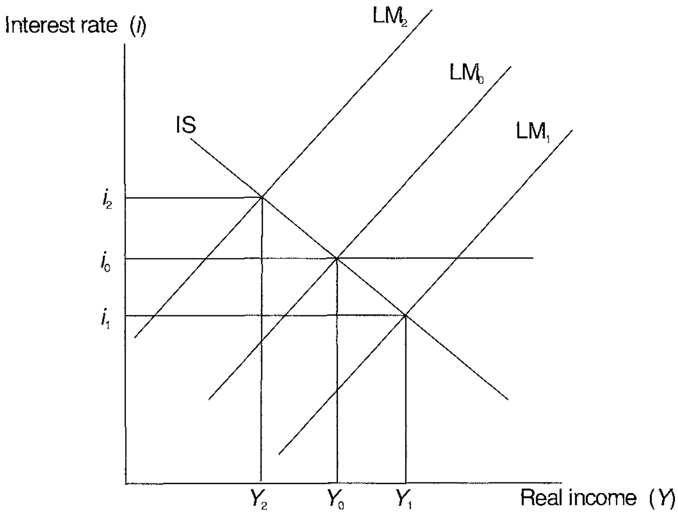
Diagram B in Figure 1 shows the effects of monetary demand shocks. A fixed money supply implies that the central bank refrains from undertaking open-market operations. Consequently, the interest rate is permitted to vary and output fluctuates between Y_1 (a positive shock) and Y_2 (a negative shock). But if the interest rate is stabilized, then the central bank increases (reduces) the money supply when tendencies for interest-rate increases (decreases) arise. In such a way, output can be held constant at Y_0, and here an accommodating policy thus completely stabilizes output.

So from the stabilization-policy viewpoint, it is better to choose a non-accommodating monetary policy (that is, to stabilize the money supply) in a situation where the economy is mainly hit by real demand shocks. When monetary demand shocks are the dominant source of uncertainty, then an accommodating monetary policy (a policy of stabilizing the interest rate) is preferred instead. The deciding factor is whether the adjustment mechanisms in the money market increase or dampen the effects of the shocks.

[3] In this model, the demand for money depends on the interest rate i (negatively), and on output Y (positively). If the money supply increases, then the equilibrium condition for the money market requires that Y, given i, increases. In the same way, the equilibrium condition requires that i, given Y, decreases. So the LM curve shifts to the right when the money supply increases.

Figure 1. continued ...

B. A monetary demand shock with non-accommodating/accommodating monetary policy



This argument can easily be applied to exchange-rate policy in a small open economy. With high capital mobility, a country-specific (asymmetric) *real* demand shock may be more of a problem for a country if it participates in a currency union than if it stays outside, because the shock's output effects can only be counteracted by a change in the exchange rate in the latter case.[4] With a (positive) asymmetric shock, there is a tendency toward an increase in the interest rate (so that the domestic interest rate rises *vis-à-vis* the rest of the world). When the interest-rate differences cannot be counteracted through an exchange-rate change, this leads to an inflow of capital. This increases the quantity of money in the country so that the interest rate is stabilized. Because a shock to the IS curve affects the interest rate and output in the same direction, this increase in the

[4] This assumes that exchange-rate flexibility can be maintained if a country stays outside the monetary union.

quantity of money reinforces the shock's real effects (see diagram A in Figure 1).

If instead, an asymmetric shock hits the economy's *monetary* side, then the same adjustment mechanisms counteract the effects on output. So here, it is actually advantageous to participate in a monetary union. An (positive) asymmetric shock to the LM curve creates a tendency for interest rates to fall (in comparison to the rest of the world). This causes capital to flow out of the country, thereby reducing the quantity of money in the country. Because a shock to the LM curve causes the interest rate and output to move in opposite directions, the change in the quantity of money in the country now counteracts the real effects of the shock instead (see diagram B in Figure 1).

Although the model used in the previous example is extremely stylized, it nevertheless conveys an important message: whether or not asymmetric shocks constitute a problem in a monetary union may depend on of which *specific structural type* they are. As with earlier empirical studies in this area, this study may also be criticized for failing to give the identified shocks a sufficiently *structural content*. But the absence of a theoretical framework, which logically brings together the relevant aspects, makes it difficult in practice to use a more detailed *identification scheme* for the shocks. In addition, to attempt to identify *many* specific structural shocks in an empirical analysis creates theoretical and technical problems. So specific types of supply and demand shocks presumably have a role to play, but the possibility to account for this is limited.

Another problem, which deserves special attention, has to do with the fluctuations that empirical models can handle.[5] In econometric analyses, residuals—that is, the unexplained part of the equations—tend to represent shocks. To obtain reliable estimates, these shocks must fulfill certain conditions. These conditions imply, among other things, that especially large, unique, shocks cannot be allowed to occur. So many estimates are based on data, which have either first been "cleaned" of extreme shocks or are not at all characterized by such shocks. But it has been argued that it is precisely these unusual swings that are really of interest when considering the value of retaining monetary policy independence. War, financial crisis, and other types of powerful and unique historical shocks have more or less

[5] See Jonung (1996).

regularly forced the *Riksbank* (the central bank of Sweden) to abandon different fixed exchange-rate systems.[6] The issue is how common such events will be in the future if the EMU comes into being. Of course, it is impossible to give an answer to this. But seen from a historical perspective, it appears very risky to give up the possibility to handle extreme shocks with exchange-rate adjustments.

A more general problem is associated with the conclusions that the empirical estimates allow regarding economic policy.[7] Many econometrically estimated relationships depend on the economic policy being conducted. So these relationships change when economic policy is changed. This problem is not unique for studies that analyze symmetries in the pattern of shocks among possible EMU member countries. In principle, it is found in all empirical analyses. But one peculiarity of these studies is the size of the change of policy that the EMU would entail. Participation in the monetary union would, as mentioned earlier, not only mean a loss of currency policy independence, but presumably also a significant limitation of fiscal policy autonomy. So the asymmetries that depend on domestic economic policy would largely disappear.[8] This means that studies based on historical data can probably only give a lower boundary as to how symmetric output movements may be in the future.

Empirical studies of the type discussed here thus have many problems and must therefore be interpreted with great caution. But the problems affect different studies in different ways. So the reliability of judgments increases when more studies with different methods are considered.

2. Earlier studies

This section summarizes some of the previous literature that looks at the effects of different shocks on the Swedish economy.

2.1. Supply and demand shocks

The relative importance of supply and demand shocks has been analyzed with the help of both *atheoretical* time-series models and more conventional econometric models, which specify *behavioral* relation-

[6] For a more detailed discussion of the Swedish exchange-rate history, see Jonung (1996).
[7] See Lucas (1976).
[8] For a detailed discussion of this, see Sardelis (1994).

ships. The following summarizes studies that use VAR models (vector autoregressions), which are the most common form of atheoretical time-series models.[9] The reason for this is that very few studies were done in recent years using more conventional econometric models. An advantage with VAR models is that they allow quite a large degree of freedom for data to "speak for themselves", without the complete absence of an economic structure.

Within the framework of the VAR literature one can, roughly speaking, find two different methods of identifying supply and demand shocks:[10]

1. The structural shocks (the supply and demand shocks) are identified by *imposing restrictions only on the contemporaneous relationships* between the shocks and the variables.
2. The shocks are identified by *imposing restrictions on both the contemporaneous and the long-term relationships*. An advantage with using restrictions on the long-term relationships is that they are generally easier to derive from economic theory.

Blanchard and Quah (1989) is an often-cited case in which such restrictions on long-term relationships are used for the purposes of identification. They show how a variant of a Keynesian model with nominal-wage contracts can be used to derive the identifying restric-

[9] A VAR model is a system of equations with time-lagged observations of all the variables on the right-hand side. The equations $X_t = \alpha_0 + \alpha_1 X_{t-1} + \ldots + \alpha_p X_{t-p} + \beta_1 Y_{t-1} + \ldots + \beta_p Y_{t-p} + \varepsilon_t^X$ and $Y_t = \gamma_0 + \gamma_1 X_{t-1} + \ldots + \gamma_p X_{t-p} + \delta_1 Y_{t-1} + \ldots + \delta_p Y_{t-p} + \varepsilon_t^Y$ together form a bivariate VAR(p) model. Because X_t and Y_t are only functions of historically determined values, the VAR model can be interpreted as a reduced form (that is, as the solution to an underlying structural model in which $X_t = f(Y_t, Y_{t-1}, \ldots, Y_{t-p}, X_{t-1}, \ldots, X_{t-p}, u_t^X)$ and $Y_t = g(X_t, Y_{t-1}, \ldots, Y_{t-p}, X_{t-1}, \ldots, X_{t-p}, u_t^Y)$, where u_t^X and u_t^Y are uncorrelated structural error terms (for example, supply and demand shocks)). This implies that the coefficients α_i, β_i, γ_i, and δ_i and the random terms ε_t^X and ε_t^Y are complicated functions of the structural coefficients and the random terms in $f(\cdot)$ and $g(\cdot)$.

[10] If ε_t^X and ε_t^Y in the example in the previous footnote are correlated, then we cannot interpret changes in them as genuine structural shocks. Technically speaking, we can say that the identification problem then consists of transforming the VAR model in such a way that the uncorrelated structural shocks, u_t^X and u_t^Y, can be computed.

tions. The model identifies two types of shocks—supply and demand shocks. The restriction imposed is that only supply shocks influence output in the long run. But the model imposes no restrictions on how both types of shock influence the economy in the short run. To introduce theoretically well-founded identifying assumptions via restrictions on the immediate or short-term effects of different shocks is generally very difficult. In many cases, these are motivated by atheoretical assumptions on the decision and information structure, for example, that information about a certain variable is not directly available so that decision-makers cannot react to it in the same period.

Table 1 summarizes the results from nine different studies for Sweden that use VAR models based on either the identifying methods (1) or (2).[11] The table shows the shares of price and output fluctuations that arise from supply and demand shocks after one year and after (about) five years, that is, over a normal business cycle.

For each model in the table, this information is specified:

- Selected period of study
- Identification scheme (identification method 1 = 1; identification method 2 = 2)
- Types of variables: R = real variables; N = nominal variables

In four cases, inflation (the logarithmic change in the price level) is used instead of the price level.[12] In addition, two models use unemployment instead of output.[13]

From the table, most of the studies clearly point to supply shocks as having, on average, the most significance for fluctuations in Swedish output in the medium term (roughly five years). But Löf (1993) and Englund et al. (1994) are two exceptions. With a horizon of one year, the picture is less clear, but supply shocks still seem to play a very central role.

[11] The studies are Gerlach and Klock (1990, 1991), Bergman (1992), Löf (1993), Assarsson and Olsson (1993), Mellander et al. (1992), Englund et al. (1994), Jansson (1994), and Hokkanen (1995). The table is a generalization of Table 3.2, page 66, in Bergman and Jonung (1994).

[12] Gerlach and Klock (1990, 1991), Bergman (1992), and Assarsson and Olsson (1993).

[13] Assarsson and Olsson (1993) and Hokkanen (1995).

Table 1. The relative importance (in percent) of supply and demand shocks

Study	Time horizon in years	Demand shocks		Supply shocks		Period	I method
		Price level %	Output %	Price level %	Output %		
Gerlach & Klock (1990)	1 5	20 20	20 5	**80** **80**	**80** **95**	1950 - 1988	2 N, R
Gerlach & Klock (1991)	1 5	**81** **80**	5 2	19 20	**95** **98**	1864 - 1988	2 N, R
Bergman (1992)	1 5	**89** **89**	8 0	11 11	**92** **100**	1970 - 1990	2 N, R
Löf (1993)	1 5	26 **55**	**85** **79**	**73** 45	14 21	1965 - 1988	1 N, R
Assarsson & Olsson (1993)	1 6	**79** **62**	**83** 28	21 38	17 **72**	1965 - 1991	1 N, R
Mellander et al. (1992)	1 4	- -	17 9	- -	**83** **91**	1871 - 1986	2 R
Englund et al. (1994)	1 4	**79** **66**	**87** **61**	21 34	13 39	1871 - 1990	2 N, R
Jansson (1994)	1 5	46 23	**50** 21	**55** **77**	**50** **79**	1870 - 1991	2 N, R
Hokkanen (1995)	1 5	- -	18 33	- -	**76** **46**	1970 - 1989	1 R

Notes: The figures in the table (columns 3-6) show the shares of the econometric models' variance in forecast errors that supply and demand shocks can account for. The results in Gerlach and Klock, Bergman, and Assarsson and Olsson are for inflation (the logarithmic change in the price level). In Assarsson and Olsson and Hokkanen, they use unemployment rather than output. Hokkanen also identifies a foreign shock, which is influenced by foreign-demand and foreign-supply changes. This shock explains roughly 6 percent (21 percent) of output fluctuations after 1 year (5 years). Gerlach and Klock, Mellander et al., Englund et al., and Jansson use annual data, while Bergman, Löf, Assarsson and Olsson, and Hokkanen use quarterly data. Columns 3-6 state the sum of the influence of demand and supply shocks, independent of their source (independent of whether they are domestic or foreign). Column 7 shows the selected study period. Column 8 indicates which identification scheme is used (see Section 2.1) with what types of variables are included (R = real variables; N = nominal variables).

However, for variations in prices and inflation, the conclusion is the opposite: demand shocks dominate according to most of the studies, in the short and the medium term. The exceptions here are Gerlach and Klock (1990), Jansson (1994): one and five years and Löf (1993): one year.

2.2. Symmetric and asymmetric shocks

Recently, several empirical studies have been undertaken that aim at analyzing the symmetry properties of various macro shocks. It is difficult to give a comprehensive overview of these, because their number is increasing rapidly. Again, the following only summarizes the literature that uses atheoretical time-series models. Hassler (1996) contains a list of earlier studies that use completely non-structural approaches.[14] Assarsson (1996) contains an overview of earlier analyses that are based on structural macro models (simulation models).

Bayoumi and Eichengreen (1992a) (BE), a frequently cited work, provides a good illustration of the standard method. The study uses VAR models with long-run restrictions for identification (identification scheme 2) to estimate correlations between countries for supply and demand shocks. The analysis is based on annual data for 18 countries in the 1960-88 period. BE's fundamental identifying assumption is that only supply shocks influence output in the long run (see the previous discussion). With the assumption that Germany would be the anchor in the EMU, BE start with the assumption that a high degree of correlation of shocks with Germany is desirable for countries that wish to participate in the EMU. By this criterion, the countries that seem to have the best conditions for joining, are Denmark, France, and the Netherlands. Sweden belongs to a middle group, which also includes Finland, Italy, and Portugal. These countries have a somewhat lower correlation with Germany than Belgium, Iceland (!), Switzerland, and Austria, but a higher correlation than Greece, Ireland, Norway, Spain, and the UK. (The shocks in Norway, Ireland, and Spain are mostly negatively correlated with shocks in Germany.)

Funke (1995) reiterates BE's analysis using annual data for the 1964-92 period. Except for Iceland and Switzerland, the same coun-

[14] These are characterized by the fact that there is no explicit identification of structural shocks. They instead choose to directly analyze (systematic and unsystematic) *fluctuations* in variables. See also Sardelis (1994).

tries are included. The general impression is that BE's correlations are not especially robust when changes are made to the observation period. According to Funke's estimates, the countries that show the greatest similarities to Germany, are the Netherlands, the UK, and Austria, followed by Belgium, Denmark, and Luxembourg. Sweden ends up together with Finland, France, Greece, Ireland, Norway, and Portugal in a large heterogeneous middle group. The Swedish supply shocks are fairly well correlated with German supply shocks (about 0.35). But for demand shocks, the correlation is negative (about -0.09). Only Italy has a lower correlation than Sweden for demand shocks.

A criticism against the BE method is that it only measures covariations between two countries at a time, and thus cannot capture the mutual dependency among economies in a larger group of countries.[15] With the aim of dealing with this criticism, Helmenstein and Url (1995) (HU) develop a model that can be used to estimate a measure of covariation for a group of countries. Like BE and Funke, HU derive their empirical shocks by using a VAR analysis based on identification scheme 2. The study is based on annual data for the 1960-93 period for 18 European countries (the same countries as in BE). HU distinguish between two types of shocks: permanent and temporary. Only permanent shocks influence the level of output in the long term. The results from HU's analysis indicate that symmetric shocks are important mainly in Belgium, the Netherlands, and Austria. In these countries, at least 60 percent (in the Netherlands, 45-55 percent) of all shocks are symmetric. In Sweden, many of the temporary shocks are symmetric (about 50 percent) but most of the permanent shocks are asymmetric (about 75 percent). The model indicates that there are three different symmetric components among the permanent shocks and two among the temporary shocks. When one studies the significance of the different symmetric components for each country, one can see that Sweden exhibits the most similarities with Denmark, Finland, and the UK regarding permanent shocks. But for temporary shocks, Sweden covaries mainly with Belgium, Luxembourg, the Netherlands, Germany, and Austria. However, for temporary shocks, the covariation is not especially strong.

Url (1996) did another interesting study that analyzes the significance of domestic and foreign shocks in 12 small open economies.

[15] Bayoumi and Eichengreen (1992a, 1992b).

The shocks are again estimated with the help of VAR models, and the selected identification scheme is type 2. The observations are yearly, and the study period is 1960-94. Each model identifies four types of shocks: domestic-permanent, domestic-temporary, OECD, and EU shocks. Permanent and temporary shocks are calculated in the same way as in HU. To distinguish between domestic and international OECD and EU shocks, Url introduces the assumptions that domestic shocks influence the development of output neither within the OECD nor within the EU and that only about 20 percent of an EU shock directly affects the path of output within the OECD area. (The latter assumption is motivated with reference to an earlier study.) Url's results indicate that the effects of OECD shocks are limited in all countries. But EU shocks are important in certain countries, especially in Belgium where they explain about 60-70 percent of the fluctuations in real GDP. But they are also important in the Netherlands, Switzerland, and Austria (about 30-50 percent) and Luxembourg, Portugal, and Sweden (20-30 percent). Regarding domestic shocks, permanent shocks are generally more important than temporary shocks. In Norway and Ireland, domestic-permanent shocks explain nearly all variations in real GDP. Denmark, Finland, Greece, Sweden, and Portugal form a middle group where country-specific permanent shocks have an explanatory value of about 60-85 percent for output fluctuations. In Luxembourg, the Netherlands, and Austria, these shocks explain about 50-60 percent of the variations in output. For Switzerland, the figures are about 35-45 percent. To see whether the results are stable over time, Url tests to see if any difference exists between the 1960-78 and 1979-94 periods (1979 was the year that the EMS was formed). The general conclusion is that the results are not especially stable. For Sweden, domestic (especially temporary) shocks dominate during the 1960-78 period (about 70-90 percent) and international shocks (especially EU shocks) dominate during the period 1979-94 (about 70-90 percent).

Cheung and Hutchison (1995) (CH) point out that high correlations between VAR shocks can also occur when shocks are asymmetric if the shocks are transmitted among countries. According to CH, the significance of the latter mechanism mainly depends on the exchange-rate system. With the aim of removing the effects of German monetary and exchange-rate policy, the authors introduce information on German output and money supply into the analysis. The study is based on monthly data for the 1960-90 period and separate analyses are undertaken for the 1960-70 (Bretton Woods) and 1974-90 (post-Bretton Woods) periods. Belgium, Finland, the Netherlands, Norway, Germany, and Sweden are studied. A disadvantage with CH's analysis is that the identification of shocks is based on a type-1 identification scheme, which often is difficult to interpret economically (see the previous discussion). Four types of shock are identified. These are called external oil-price, German-monetary, German-output, and country-specific shocks. CH's results do not support the hypothesis that German shocks are important for the path of output in the other countries. This is the case irrespective of whether the 1960-70 period or the 1974-90 period is analyzed. Throughout, the correlations between the output shocks are relatively low, especially for Finland, Norway, and Sweden. The highest correlations are between the Netherlands and Germany during and after the Bretton Woods period (about 0.47 and 0.28, respectively) and between Belgium and Germany during the Bretton Woods period (about 0.25). All other correlations are clearly lower than 0.2.

Assarsson and Olsson (1993) (AO) is the last study discussed here. As shown in Table 1, AO use quarterly observations for the 1965-91 period. Germany, Belgium, the Netherlands, France, Austria, and Sweden are analyzed. Each country is influenced by two international shocks (a demand and a supply shock) and three domestic shocks (a demand, a supply, and a monetary policy shock). Like CH, AO choose to introduce identifying assumptions via contemporaneous relationships between shocks and variables.[16] The results of AO suggest that domestic shocks are the most important ones for Swedish output (unemployment) in the short term. After a quarter (one year), domestic shocks explain about 90 percent (65 percent) of the variations in output. But in the medium and long term, international shocks dominate (especially international supply shocks). With a three (12) year horizon, these explain about 60 percent (70 percent) of the variations.

However, for variations in the Swedish inflation rate, AO's estimates indicate that international shocks are the most important. This holds independently of the time horizon (one year: about 60 percent; three years: about 55 percent; 12 years: about 60 percent). For fluctuations in output in the other countries, domestic shocks generally dominate in the short term (except in Germany, where domestic and

[16] See Bernanke (1986) for a detailed description of this identification scheme.

international shocks are about equally important). With a time horizon of 3-12 years, domestic shocks dominate in only the Netherlands and Germany (in France and Austria, domestic and international shocks have about the same importance in the medium term). Regarding movements in inflation, Austria is the only country in which domestic shocks dominate irrespective of the time horizon. (Throughout, domestic and international shocks are about equally important in Germany. In the short term (medium term), this is also the case in France (the Netherlands)).

2.3. Summary

For Sweden, what general conclusions can be drawn from the previous overview of the literature? Perhaps not too many. It seems as if the real side of the Swedish economy (at least in the short term) is influenced to a relatively high degree by domestic shocks. And it seems that these are mainly permanent shocks on the supply side of the economy. In contrast, the path of prices and inflation in the Swedish economy seems to be mainly demand determined (even in the short run). Here, the literature also indicates that international factors may play a larger role. Even if the "core group" is not especially stable, the general impression is that Sweden, irrespective of what countries it is compared with, is not a prime candidate for this group. Many studies indicate that Sweden would fit in better in a middle group, perhaps with Finland and Portugal (and Denmark and the UK).

3. The empirical model

This section develops a statistical model to help in quantitatively measuring the significance of symmetric and asymmetric shocks for different countries' fluctuations in prices and output.[17] (See the appendix for a detailed mathematical description of the model.)

Section 1 explained that the model is based on the assumption that the fluctuations in prices and output consist of two distinct components: one *country-specific* and one *common*. Each is independent of the other. The components cannot be directly observed. But under certain conditions, they can be estimated using statistical methods. Both components can be subjected to shocks, that is, they are

[17] Variants of the model were previously used in different contexts by Gerlach and Klock (1988), Bergman et al. (1990), and Bergman and Jonung (1994).

stochastic. In that way, the common component captures the importance of *symmetric shocks*, while the country-specific component captures the significance of *asymmetric shocks*.

The model does not specify *a priori* the extent to which the common (symmetric) shocks influence the different countries' fluctuations in prices and output. An important aim of the empirical analysis in this paper is to measure this influence and to investigate whether it varies among the countries.

The estimated model can also be used to study the explanatory value that country-specific and common shocks have for variations in a country's fluctuations in prices and output. Such a *variance decomposition* shows the shares of variations in a country's fluctuations in prices and output that the two types of shocks can explain.[18] If, for example, the common output component has the relative value 0.2 in the calculations for Sweden, this indicates that symmetric shocks explain 20 percent of the variations in Swedish output, while asymmetric shocks explain the remaining 80 percent.

As previously explained, the model uses one observable time series to generate two unobservable components: one country-specific and one common. This means that asymmetric and symmetric shocks are identified. But supply and demand shocks are not identified. Despite this, it seems reasonable that certain information on supply and demand shocks can be obtained via the model. Section 2 suggested that *the direction of covariation* between the fluctuations in prices and output should say something about the relative importance of supply and demand shocks. A demand shock implies that the price and output levels are influenced in the same direction (a positive covariation). But a supply shock implies that the price and output levels are influenced in opposite directions (a negative covariation). So a positive covariation between price and output shocks could be interpreted as an indication that demand shocks dominate. A negative covariation should, for the same reason, imply that supply shocks dominate.

4. Data

The quarterly and annual data, which are used, are taken from the IMF's *International Financial Statistics* and the OECD's *National Accounts*, Volume 1. The sample periods are 1957:1 - 1994:4 (quarterly

[18] See equation (A.4) in the appendix for the formula used for these calculations.

data) and 1960-94 (annual data). Belgium, Denmark, Finland, France, Ireland, Luxembourg, the Netherlands, the UK, Sweden, Germany, and Austria are included. Estimates were obtained under the assumption that the EMU will include all of these countries. But in most cases, the comparisons are based on a smaller system, which includes Belgium, France, the Netherlands, Sweden, Germany, and Austria.

The same definitions of price and output variables were used in all of the countries. In the calculations using annual data, real GDP and the implicit GDP deflator are used (the ratio between nominal and real GDP). Quarterly data for real and nominal GDP were not available for all countries for the entire period. So when quarterly data are used, the consumer price index and the industrial production index are used instead. All variables are used in logarithmic form.

As stated in Section 3, the empirical model aims to analyze macroeconomic fluctuations. This means that all analyzed variables must be detrended before estimation. In the reference model in this study, I used annual data, which are detrended through (logarithmic) differencing, that is, through $\log(X_t)-\log(X_{t-1})$, where X_t represents the raw-data series. The appendix evaluates the effects of using alternative methods of detrending for both annual data and quarterly data.

5. Results[19]

Tables 2 and 3 show the estimation results for the reference model. Table 2 presents the results for output data, while Table 3 presents the results for price data.

Let us start by examining the results in Table 2. The figures without parentheses in column 2 of the table's top section measure the influence of the common output component on the different countries' GDP fluctuations. For technical reasons, the specified values were normalized (see the appendix). The sensitivity of German fluctuations in output to symmetric variation was used as a basis and is therefore set equal to one. This implies that if, for example, the estimate for Sweden is less (greater) than one, then the Swedish real economy is less (more) sensitive to symmetric variation than the German one. The reported figures within parentheses in this column can be interpreted as (empirical) probabilities that GDP fluctuations

[19] See Harvey (1989) for a detailed description of the statistical estimation method used. All calculations were made using the RATS statistical package, version 4.10c. The data and the program are available from the author.

in a particular country are completely uninfluenced by the symmetric output component, that is, they are only characterized by asymmetrical, country-specific swings.[20]

From the table, all countries' GDP fluctuations are clearly influenced by changes in the common output component: all probabilities are clearly less than 1 percent. This implies that a certain symmetry exists in the output fluctuations of the countries analyzed (Belgium, France, the Netherlands, Sweden, Germany, and Austria). How similarly do the real economies of the countries react to shocks in the common output component? This question can be illustrated through estimating the probability of whether the common output component has an equal influence on all countries' fluctuations in GDP. The probability for this hypothesis amounts to about 8 percent. This means that we cannot rule out that the hypothesis is correct with absolute certainty. An interesting result is that the probability increases by about 7 percentage points if Sweden is excluded from the test.

Columns 3 and 4 in the top section of Table 2 display the estimates of persistence in symmetric and asymmetric output shocks, respectively. Here, values relatively close to plus or minus one imply that it takes a long time for the unobservable output components to return to their initial values after a shock (high persistence). As we can see, the country-specific output shocks in Belgium are characterized by the highest persistence. Sweden ends up in a middle group with the Netherlands and Austria. Country-specific output shocks with relatively low persistence are recorded for France and (especially) Germany. The persistence of the typical symmetric output shock—in absolute and relative terms—is very low. The estimated value is about 0.05, and the probability that the true value is zero (that symmetric output shocks are completely temporary) is about 79 percent.

Table 3 shows the probabilities that the fluctuations in the implicit GDP deflator in each of the countries are completely uninfluenced by the symmetric price component (figures in parentheses in column 2 in the table's top section).

[20] All empirical probabilities (p values) that concern the model parameters were estimated using LR tests (see, for example, Harvey, 1990, pages 162-66).

Table 2. The reference model: annual data, 1960-94—real GDP

	Sensitivity to the symmetric component model parameter: γ_i	Persistence of symmetric shocks model parameter: α_1	Persistence of asymmetric shocks model parameter: $\beta_{1,i}$
Germany	1.00000 [-]	.05207 [.7921]	.10463 [.5435]
Belgium	1.23406 [0]	.05207 [.7921]	-.88129 [.0017]
Netherlands	.86236 [0]	.05207 [.7921]	.39313 [.0343]
France	.91257 [0]	.05207 [.7921]	.19557 [.3536]
Austria	1.01645 [0]	.05207 [.7921]	-.32609 [.1096]
Sweden	.63705 [.0060]	.05207 [.7921]	.33448 [.0766]

The relative contribution of different components to variations in fluctuations (variance decomposition)

	Without restrictions		With restrictions	
	Symmetric component	Asymmetric component	Symmetric component	Asymmetric component
Germany	.614	.386	.599	.401
Belgium	.817	.183	.809	.191
Netherlands	.555	.445	.554	.446
France	.696	.304	.680	.320
Austria	.689	.311	.685	.315
Sweden	.221	.779	.230	.770

Notes: The appendix contains a mathematical description of the model. The calculations are based on $p = 1$ in equations (A.2) and (A.3). Figures within parentheses are p values. A p value can be interpreted as the empirical probability that the null hypothesis in a particular test is true. The null hypotheses that are being tested are:

$H_0: \gamma_i = 0$ (column 2 in the table's top section),

$H_0: \alpha_1 = 0$ (column 3 in the table's top section), and

$H_0: \beta_{1,i} = 0$ (column 4 in the table's top section).

The figures in the table's lower section are based on formula (A.4). The restricted model assumes that only shocks in Belgium and the Netherlands are characterized by persistence. The p value for these restrictions is about 0.24.

As with the output data, we can reject the hypotheses that the countries are not sensitive to symmetric variation with quite large certainty throughout. But note that the probabilities for Sweden and Austria are both greater than 1 percent. The probability that the common price component influences the price fluctuations in all countries by the same amount is about 33 percent. So the conclusion is that common price shocks lead to a more similar adjustment process than common output shocks. If Sweden (and Austria) are excluded from the test, then the probability falls to about 22 percent (about 19 percent), which indicates that Sweden and Austria both contribute positively to making the effects from common price shocks more similar.

Belgium and France are the countries in which country-specific price shocks have the highest persistence (top section, Table 3, column 4). Sweden again ends up in a middle group, this time with Germany (and possibly Austria). Domestic Dutch price shocks are, on average, almost completely temporary. Compared with symmetric output shocks, symmetric price shocks display a higher persistence. The value is about 0.29. But the probability of incorrectly rejecting the hypothesis that symmetric price shocks are completely temporary is still relatively large (about 22 percent).

As Section 3 explains, the estimated model can be used for computing the shares of variations in countries' price and output fluctuations which can be explained by symmetric and asymmetric shocks, respectively. (See formula (A.4) in the appendix.) Columns 2 and 3 in the lower sections of Tables 2 and 3 show the results for the unrestricted reference model.

For output data (Table 2), symmetric shocks are clearly most important in Belgium, France, Germany, and Austria. For the Netherlands, symmetric and asymmetric shocks are about equally important, while asymmetric shocks clearly dominate in Sweden. So here, Sweden stands out from other countries: country-specific shocks explain about 78 percent of the variations in Swedish output fluctuations.

For price data (Table 3), the picture is less clear. In France, symmetric shocks still dominate, but in Belgium, the Netherlands, Austria, and (especially) Germany, asymmetric shocks now have much larger significance. In Sweden, asymmetric price shocks have about the same significance as asymmetric output shocks, that is, they dominate and explain about three-quarters of the variations in the fluctuations.

Table 3. The reference model: annual data 1960-94—implicit GDP deflator

	Sensitivity to the symmetric component model parameter: γ_i	Persistence of symmetric shocks model parameter: α_1	Persistence of asymmetric shocks model parameter: $\beta_{1,i}$
Germany	1.00000 [-]	.28885 [.2178]	.15691 [.4374]
Belgium	2.64559 [.0007]	.28885 [.2178]	-.34968 [.1170]
Netherlands	1.77490 [.0012]	.28885 [.2178]	-.01442 [.9487]
France	2.71091 [.0001]	.28885 [.2178]	.36295 [.2940]
Austria	1.24985 [.0230]	.28885 [.2178]	-.21861 [.2886]
Sweden	2.30908 [.0138]	.28885 [.2178]	-.12024 [.5403]

The relative contribution of different components to variations in fluctuations (variance decomposition)

	Without restrictions		With restrictions	
	Symmetric component	Asymmetric component	Symmetric component	Asymmetric component
Germany	.123	.877	.091	.909
Belgium	.409	.591	.298	.702
Netherlands	.417	.583	.304	.696
France	.768	.232	1.000	.000
Austria	.201	.799	.119	.881
Sweden	.233	.767	.184	.816

Notes: The appendix contains a mathematical description of the model. The calculations are based on $p = 1$ in equations (A.2) and (A.3). Figures within parentheses are p values. A p value can be interpreted as the empirical probability that the null hypothesis in a particular test is true. The null hypotheses that are being tested are:

$H_0: \gamma_i = 0$ (column 2 in the table's top section),

$H_0: \alpha_1 = 0$ (column 3 in the table's top section), and

$H_0: \beta_{1,i} = 0$ (column 4 in the table's top section).

The figures in the table's lower section are based on formula (A.4). The restricted model assumes that all shocks are completely temporary and that the symmetric component completely explains the French price fluctuations. The p value for these restrictions is about 0.46.

The analysis of the results in the top sections of Tables 2 and 3 indicates that one cannot reject with certainty the hypothesis that some of the parameters in the model have a value of zero. Columns 4 and 5 in the bottom sections of Tables 2 and 3 show the results when the non-significant parameters are set equal to zero from the outset.

As we see, the results are not significantly affected. As expected, the biggest change is for French price fluctuations. The restrictions for France imply by definition that the symmetric price component must explain all variations in the French implicit GDP deflator's fluctuations (see Table 3 and the appendix).

In Table 4, the directions of the covariation between the symmetric and country-specific price and output shocks are shown as simple correlations. The results indicate that supply shocks are very important in most of the countries. Belgium is an extreme example with a negative correlation of almost 0.5. Austria and Germany, with Sweden, form a middle group. The correlations for these countries are negative but in absolute value, much smaller than the correlation for Belgium. In France, it appears that supply and demand shocks are about equally important. The Netherlands is the only country for which a positive covariation can be noted. Here, the correlation amounts to about 0.4. For common shocks, the covariation is negative and similar in size to the figures obtained for country-specific

Table 4. The reference model: annual data 1960-94—correlations between shocks

Price and output shocks for:	Value of correlation coefficient
Common component	-.20
Germany	-.22
Belgium	-.48
Netherlands	.41
France	.00
Austria	-.27
Sweden	-.14

Note: The figures in the table are sample correlations between common and country-specific price and output shocks.

shocks in Sweden, Germany, and Austria.[21]

To summarize, the results for the reference model imply that of the countries studied, Sweden must be judged to be the country whose historical price and output patterns are most characterized by asymmetrical movements. An important question is whether the results depend on which countries are in the analysis. This question is important because there is considerable uncertainty about which countries will participate in Stage Three of the EMU. So I extended the analysis to both 9 countries (the countries in the reference model and Finland, Ireland, and Luxembourg), and 11 countries (countries in the reference model and Denmark, Finland, Ireland, Luxembourg, and the UK). Tables 5 and 6 show the results.

Table 5. The model with nine countries: annual data 1960-94

The relative contribution of different components to variations in fluctuations (variance decomposition)

	Real GDP		Implicit GDP deflator	
	Symmetric component	Asymmetric component	Symmetric component	Asymmetric component
Germany	.680	.320	.143	.857
Belgium	.787	.213	.389	.611
Netherlands	.626	.374	.294	.706
France	.719	.281	.886	.114
Austria	.674	.326	.199	.801
Sweden	.203	.797	.223	.777
Finland	.083	.917	.236	.764
Luxembourg	.504	.496	.040	.960
Ireland	.044	.956	.040	.960

Notes: The figures in the table are based on formula (A.4) in the appendix. The estimates are based on $p = 1$ in equations (A.2) and (A.3). The detrending method is logarithmic differencing (see Section 4).

21 Note that the formulae (equations (A.9) and (A.10) in the appendix), unlike those used for calculating the figures in Table 1, cannot be used to separately study the importance of supply and demand shocks for price and output fluctuations. That supply shocks in a country are most important for output variations but demand shocks dominate for price movements (see Section 2.1) is consistent with both a positive and a negative covariation between asymmetric price and output shocks in that country.

Table 6. The model with 11 countries: annual data 1960-94

The relative contribution of different components to variations in fluctuations (variance decomposition)

	Real GDP		Implicit GDP deflator	
	Symmetric component	Asymmetric component	Symmetric component	Asymmetric component
Germany	.734	.266	.238	.762
Belgium	.748	.252	.375	.625
Netherlands	.698	.302	.301	.699
France	.763	.237	.906	.094
Austria	.702	.298	.149	.851
Sweden	.189	.811	.255	.745
Finland	.065	.935	.199	.801
Luxembourg	.554	.446	.019	.981
Ireland	.069	.931	.030	.970
UK	.123	.877	.265	.735
Denmark	.265	.735	.349	.651

Notes: The figures in the table are based on formula (A.4) in the appendix. The estimates are based on $p = 1$ in equations (A.2) and (A.3). The detrending method is logarithmic differencing (see Section 4).

Clearly, the earlier qualitative conclusions for the countries in the reference model are not changed. These hold irrespective of whether or not Denmark and the UK are included. Like Sweden, the UK, Denmark, Finland, and Ireland are characterized by the fact that asymmetric shocks are the most important for both output and price movements. In Luxembourg, symmetric and asymmetric shocks are about equally important for output movements, but asymmetric shocks almost completely dominate when it comes to price movements.[22]

6. Summary and conclusions

This study analyzes conditions for Swedish membership in the EMU regarding characteristics of shocks that occur. A desirable basis for a common monetary policy is that the shocks, which hit countries in the monetary union, are symmetric. Asymmetric shocks may require

[22] Another important question is whether the model fulfills the statistical assumptions that must be made for the estimates to be reliable. The appendix contains an evaluation of the statistical properties of the model.

a country-specific monetary policy. But in a monetary union, this is not an option. The relative importance of supply and demand shocks is also an area of interest. To pursue a strict price-stabilizing economic policy, when a negative supply shock occurs, will lead to even greater losses in employment and output than otherwise.

In the analysis, I looked at several previously undertaken studies and estimated a new empirical model. Synthesizing the evidence, I conclude that country-specific asymmetric shocks largely explain the short-term real macroeconomic development in Sweden. It also appears that disturbances on the supply side of the economy are the most important. The short-term price and inflation paths in the Swedish economy, however, mainly seem to be demand determined. Despite the fact that international disturbances seem to have greater significance for short-term price developments than for short-term output developments, even the former are mainly explained by country-specific shocks.

Regarding the optimal composition of the EMU, the picture is ambiguous. Results vary depending on which model, method, time period, and data are used. But there is clearly a small group of countries around Germany which seem to fit better into a currency union with Germany than Sweden.

On the basis of a study of this type, one should be careful in drawing far-reaching conclusions. The characteristics of the disturbances that occur are only *one* of many important criteria that should be considered when making a decision on the EMU. Furthermore, there are serious theoretical and empirical problems with an analysis of this type. The lack of a theoretical framework that makes it possible to analyze *specific structural shocks* (that is, different types of supply and demand shocks), clearly constitutes a limitation on the ability to draw conclusions.

One must also question the value of an analysis of *historical data* in this context. Membership in the EMU implies a radical change in all aspects of economic policy. So it is questionable as to how well the economic relationships in the past will tally with the relationships that will exist in the future. For a country to give up the exchange rate as a stabilization instrument and to also have less access to fiscal policy, very likely implies that earlier patterns of disturbances will be changed. This may mean that studies based on historical data, which seek to analyze countries' business-cycle covariations, can only give a lower boundary as to how symmetric the covariation will be in the future.

An additional problem is that the *normal business-cycle swings* might not be the most interesting ones when looking at the value of maintaining exchange-rate independence. It has been claimed that exchange-rate autonomy is especially important when extremely large non-business-cycle disturbances occur. But because these seldom occur and are very different from the more normal shocks, they are difficult to handle empirically.

Appendix

The empirical model—a technical description

Let $X_{t,i}^{C}$ represent the detrended (stationary) data for real output or the price level in country *i* at time *t*. As previously mentioned, $X_{t,i}^{C}$ is assumed to consist of two distinct components: one common ($X_{t}^{C,G}$), and one country-specific ($X_{t,i}^{C,L}$).

The decomposition that is made is

$$X_{t,i}^{C} = \gamma_i X_{t}^{C,G} + X_{t,i}^{C,L}, \tag{A.1}$$

where the parameter γ_i (the factor loading) measures the influence that the common component has on $X_{t,i}^{C}$.

One problem with this decomposition is that neither the country-specific component nor the common component can be directly observed. So they must be estimated with the help of a statistical method. It has been shown that this, for example, is possible if the components are independent of each other, and the dynamic behavior of the components is known. The estimates in this paper are based on the assumption that all non-observable components allow themselves to be written as autoregressive (AR) processes

$$X_{t}^{C,G} = \alpha_1 X_{t-1}^{C,G} + \alpha_2 X_{t-2}^{C,G} + \ldots + \alpha_p X_{t-p}^{C,G} + \varepsilon_t^{C,G}, \tag{A.2}$$

$$X_{t,i}^{C,L} = \beta_{1,i} X_{t-1,i}^{C,L} + \beta_{2,i} X_{t-2,i}^{C,L} + \ldots + \beta_{p,i} X_{t-p,i}^{C,L} + \varepsilon_{t,i}^{C,L}, \tag{A.3}$$

where $\varepsilon_t^{C,G}$ and $\varepsilon_{t,i}^{C,L}$ represent the common (symmetric) and the country-specific (asymmetric) shocks, respectively.[23]

The shocks are considered to be normally distributed with constant variances and $E(\varepsilon_t^{C,G}) = E(\varepsilon_{t,i}^{C,L}) = 0$. That the components are independent of each other is equivalent here to $\text{Cov}(\varepsilon_{t,i}^{C,L}, \varepsilon_{t,j}^{C,L}) = 0$ for all $i \neq j$ and $\text{Cov}(\varepsilon_{t,i}^{C,L}, \varepsilon_t^{C,G}) = 0$ for all *i*. So asymmetric shocks are defined (identified) as shocks, which are both uncorrelated with each other and uncorrelated with the symmetric shocks.

It can be shown that the parameters on the lagged observations in an AR process contain information about the persistence of the shocks. The effect that an asymmetric (symmetric) disturbance equivalent to 1 unit of measurement has on $X_{t,i}^{C,L}$ ($X_t^{C,G}$) after $h = 0$, 1, 2,... periods, can be written as $\text{resp}(t + h) = \beta_{1,i}\text{resp}(t + h - 1) + \beta_{2,i}\text{resp}(t + h - 2) + \ldots + \beta_{p,i}\text{resp}(t + h - p)$, $(\text{resp}(t + h) = \alpha_1\text{resp}(t + h - 1) + \alpha_2\text{resp}(t + h - 2) + \ldots + \alpha_p\text{resp}(t + h - p))$, where $\text{resp}(t + h - k) = 1$ for $h = k$ and $\text{resp}(t + h - k) = 0$ for $h < k$.

The functions $\text{resp}(\cdot)$ are complicated non-linear functions of the parameters $\beta_{1,i}$, $\beta_{2,i}$,..., $\beta_{p,i}$ (α_1, α_2,..., α_p). In the case when $\beta_{j,i} = 0$ ($\alpha_j = 0$) for $j \geq 2$, that is, when we have an AR(1) process, we find that $\text{resp}(t + h) = \beta_{1,i}^h$ ($\text{resp}(t + h) = \alpha_1^h$). So in this case, the absolute value of $\beta_{1,i}$ (α_1) can be used as a simple measure of the persistence of asymmetric (symmetric) shocks. Values close to one imply that it takes a long time for $X_{t,i}^{C,L}$ ($X_t^{C,G}$) to return to its initial value after a disturbance.[24]

[23] Stationarity requires that all the roots of $1 - \alpha_1 z - \alpha_2 z^2 - \ldots - \alpha_p z^p = 0$ and $1 - \beta_{1,i} z - \beta_{2,i} z^2 - \ldots - \beta_{p,i} z^p = 0$ lie outside the unit circle.

[24] Note that stationarity in the AR(1) case is equivalent to $-1 < \beta_{1,i} < 1$ $(-1 < \alpha_1 < 1)$.

With the help of equations (A.1) – (A.3), we can decompose the variance in $X_{t,i}^{C}$ according to the formula:

$$\mathrm{Var}(X_{t,i}^{C}) = \gamma_i^2 \mathrm{Var}(X_t^{C,G}) + \mathrm{Var}(X_{t,i}^{C,L}), \qquad \text{(A.4)}$$

where

$$\mathrm{Var}(X_t^{C,G}) = \mathrm{Var}(\varepsilon_t^{C,G}) + \alpha_1 \mathrm{Cov}(X_t^{C,G}, X_{t-1}^{C,G}) + \ldots + \alpha_p \mathrm{Cov}(X_t^{C,G}, X_{t-p}^{C,G}),$$

$$\mathrm{Var}(X_{t,i}^{C,L}) = \mathrm{Var}(\varepsilon_{t,i}^{C,L}) + \beta_{1,i} \mathrm{Cov}(X_{t,i}^{C,L}, X_{t-1,i}^{C,L}) + \ldots + \beta_{p,i} \mathrm{Cov}(X_{t,i}^{C,L}, X_{t-p,i}^{C,L}).$$

It can be shown that the covariances in these expressions are completely determined in terms of the estimated parameters. So given the model's parameters, it is possible with the help of this formula to indicate in percentage terms how much of the variations in $X_{t,i}^{C}$ that are explained by symmetric and asymmetric shocks, respectively.[25]

Although the model (A.1) – (A.3) does not explicitly identify supply and demand shocks, it still appears reasonable that certain information on these could be obtained via the disturbance terms in the model. For common and country-specific output shocks (denoted by $\varepsilon_t^{C,G}(y)$ and $\varepsilon_{t,i}^{C,L}(y)$, respectively), it should generally hold that

$$\varepsilon_t^{C,G}(y) = \alpha^y E_t^{C,G} + \beta^y U_t^{C,G}, \qquad \text{(A.5)}$$

$$\varepsilon_{t,i}^{C,L}(y) = \delta_i^y E_{t,i}^{C,L} + \gamma_i^y U_{t,i}^{C,L}, \qquad \text{(A.6)}$$

25 From a statistical viewpoint, a significant value of a factor loading, γ_i, can both depend on country *i* being important for and being influenced by the symmetric component. So the direction of causality is not determined. But for the studied countries, it appears reasonable to assume that (possibly except for Germany) significant factor loadings signify causality from $X_t^{C,G}$ to $X_{t,i}^{C}$.

where $E_t^{C,G}$ ($E_{t,i}^{C,L}$) represent symmetric (asymmetric) demand shocks and $U_t^{C,G}$ ($U_{t,i}^{C,L}$) represent symmetric (asymmetric) supply shocks. Because these shocks are structural, it holds that when $Z_t \neq Y_t$, $\text{Cov}(Z_t,\ Y_t) = 0$, where $Y_t,\ Z_t = E_t^{C,G},\ E_{t,i}^{C,L},\ U_t^{C,G},\ U_{t,i}^{C,L}$. In the same way it should hold for corresponding price shocks that

$$\varepsilon_t^{C,G}(p) = \alpha^p E_t^{C,G} + \beta^p U_t^{C,G}, \tag{A.7}$$

$$\varepsilon_{t,i}^{C,L}(p) = \delta_i^p E_{t,i}^{C,L} + \gamma_i^p U_{t,i}^{C,L}. \tag{A.8}$$

Because the parameters on the right-hand side in equations (A.5) - (A.8) are not known, supply and demand shocks are not identified in the general sense. But the discussion in Section 4 suggests that we can determine the sign of $\alpha^j,\ \beta^j,\ \delta_i^j,\ \gamma_i^j$: $\alpha^y,\ \beta^y > 0$, $\delta_i^y, \gamma_i^y > 0$, $\alpha^p, \delta_i^p > 0$, and $\beta^p, \gamma_i^p < 0$. Armed with this information, it is easily seen that because

$$\text{Cov}(\varepsilon_t^{C,G}(y),\ \varepsilon_t^{C,G}(p)) = \alpha^y \alpha^p \,\text{Var}(E_t^{C,G}) + \beta^y \beta^p \,\text{Var}(U_t^{C,G}) \tag{A.9}$$

and

$$\text{Cov}(\varepsilon_{t,i}^{C,L}(y),\ \varepsilon_{t,i}^{C,L}(p)) = \delta_i^y \delta_i^p \,\text{Var}(E_{t,i}^{C,L}) + \gamma_i^y \gamma_i^p \,\text{Var}(U_{t,i}^{C,L}) \tag{A.10}$$

the signs of the correlations between the error terms estimated in the model give information on the importance of symmetric and asymmetric supply and demand shocks. Note that the formulae not only depend on the size of the supply and demand disturbances, but also on the effect that these actually have on symmetric and asymmetric output and price fluctuations.

A statistical problem with the model (A.1) - (A.3) is that it contains one parameter too many for all the parameters in the model to be simultaneously estimated. This means that it is necessary to introduce a non-testable identifying restriction. One way to do this is to measure the common components' influence relative to the influence on country *j* (that is, to introduce the restriction $\gamma_j = 1$). In this paper, I set $\gamma_j = 1$, where *j* = Germany. This implies that if, for example, the estimate for the γ parameter in Sweden is smaller (greater) than 1, then Sweden is less (more) sensitive to symmetric variation than Germany.

Statistical properties of the reference model

Table A1 shows whether the error terms in the model pass the requirement of being serially uncorrelated (rows 3 and 9), homeoskedastic (rows 4 and 10), and normally distributed (rows 5 and 11). Qualitative conclusions from tests for parameter non-constancies are also given (rows 6 and 12).[26] As can be seen, the statistical properties of the reference model are quite impressive. Most of the probabilities for correct specification are clearly larger than 20 percent; only in two cases must the significance level be reduced to about 2 percent for the tests to not reject the hypothesis that the model is correctly specified (row 11 in Table A1: normality for Belgium and Sweden). So the conclusion from these tests is that there is no (strong) indication that the reference model is specified incorrectly.

Alternative methods of detrending

The analyses in Tables 2 – 6 are based on annual data, which were detrended (made stationary) using logarithmic differencing. More specifically, if $BNP_{t,i}$ = real BNP for country i at time t, and $PDEF_{t,i}$ = the implicit GDP deflator for country i at time t, then either $X^{C}_{t,i} = [\Delta \log(BNP_{t,i}) -$ mean value$]$ (with different mean values before and after the first oil crisis of 1973) or $X^{C}_{t,i} = [\Delta^2 \log(PDEF_{t,i}) -$ mean value$]$ is used, where Δ is the difference operator.

Many alternative models, which use different methods to make the data stationary, were estimated to check the robustness of the results. In these, both annual and quarterly data were used. It can be shown that making the data stationary by logarithmic differencing assumes that the underlying trends are stochastic. Basically, a variable contains a stochastic trend if its variance has a continuous linear

[26] For details concerning the tests, see Table A1. The formulae for the tests are in Harvey (1989: page 259: serial correlation; pages 241-42: heteroskedasticity; page 257: parameter constancy) and Doornik and Hansen (1994, pages 2 and 7: normality).

trend. If, in addition, the level has a continuous linear trend, then the variable contains a stochastic trend with drift. Certain studies question whether one can get a good description of all non-stationarities that can occur in a time-series variable by using these assumptions. Many argue that in many cases *deterministic shifts* might exist in growth paths and/or in individual observations.[27] Then simple differencing of a variable is not sufficient to gain stationarity: too small a share of the variance of the variable is assigned to the non-stationary component.

An alternative to (many) discrete deterministic shifts is a continuously varying trend. The existence of such a trend component implies, as does the existence of different shifts, that it becomes possible to assign a larger share of the variance of the variable to the non-stationary component. But depending on one's view of cyclical variations, it can sometimes also be desirable to let the non-stationary component capture a smaller share of the variance of the variable. The Hodrick-Prescott filtering method (HP filter) then becomes a suitable method for making the data stationary. The method generates a flexible trend component by using a moving average. By choosing a value of a certain parameter, one can decide on the smoothness of the trend: a high value for the parameter means that the trend almost becomes linear; a low value implies that the trend and the variable almost coincide with each other.[28]

The results, which are compiled for Sweden in Table A2, are based on HP-filtered data and data that were adjusted for several different deterministic shifts.[29] A complication for the analysis that is based on quarterly data is that the time series may be characterized by seasonal variations. These variations are often interpreted as being determined outside the empirical model, which then allows the data to be seasonally adjusted beforehand. The seasonal dummy variable

[27] See, for example, Perron (1989).

[28] For a more detailed description and critical examination of the HP filter, see King and Rebelo (1993) and Jaeger (1994).

[29] Models that are rejected by the previously mentioned diagnostic tests are not included. But generally, the results for these do not differ substantially from the results for the models that are accepted.

Table A1. The reference model: annual data, 1960-94—diagnostic tests

			Real GDP			
Country	**D**	**B**	**NL**	**F**	**A**	**S**
Serial correlation	3.7598 [.5845]	6.7894 [.2368]	1.8666 [.8673]	3.1498 [.6769]	7.4057 [.1922]	7.6393 [.1773]
Hetero-skedasticity	.2536 [.6145]	.2850 [.5934]	.8297 [.3624]	.4390 [.5076]	.3622 [.5473]	.0155 [.9009]
Normality	.8368 [.6581]	1.3380 [.4996]	.1558 [.9250]	2.1745 [.3371]	2.9079 [.2336]	1.1302 [.5683]
Parameter constancy	yes	yes	yes	yes	yes	yes
			Implicit GDP deflator			
Country	**D**	**B**	**NL**	**F**	**A**	**S**
Serial correlation	4.9608 [.4207]	4.5894 [.4680]	.9324 [.9678]	.6892 [.9836]	5.6625 [.3405]	5.7671 [.3295]
Hetero-skedasticity	.0001 [.9924]	1.3644 [.2428]	1.3399 [.2471]	.9140 [.3391]	.0195 [.8889]	.1319 [.7165]
Normality	.0675 [.9668]	7.2770 [.0263]	2.5315 [.2820]	.4373 [.8036]	4.4190 [.1098]	8.0273 [.0181]
Parameter constancy	yes	yes	yes	yes	yes	yes

Notes: The figures within parentheses are p values. A p value can be interpreted as the empirical probability that the null hypothesis in a particular test is true. The null hypotheses that are tested are

H_0: no serial correlation (rows 3 and 9),

H_0: no heteroskedasticity (rows 4 and 10), and

H_0: normality (rows 5 and 11).

The test for serial correlation is Ljung's and Box's Q test, based on five autocorrelations. The test for heteroskedasticity is Engle's ARCH test based on one ARCH term under the alternative hypothesis. The test for normality is Doornik's and Hansen's E test. The test for parameter constancy is Brown's, Durbin's, and Evans' CUSUM test. "Yes" means that the null hypothesis of constant parameters in the equations for a particular country cannot be rejected at a significance level of 5 percent or greater. D=Germany, B=Belgium, NL=Netherlands, F=France, A=Austria, S=Sweden.

Table A2. Alternative models: annual data, 1960-94 and quarterly data, 1957-94

Annual data. The relative contribution of different components to variations in fluctuations (variance decomposition).

	Real GDP		*The implicit GDP deflator*	
	Symmetric component	Asymmetric component	Symmetric component	Asymmetric component
Model 1.Y	.305	.695	.032	.968

Quarterly data. The relative contribution of different components to variations in fluctuations (variance decomposition).

	Industrial production index		*Consumer price index*	
	Symmetric component	Asymmetric component	Symmetric component	Asymmetric component
Model 1.Q	.061	.939	-	-
Model 2.Q	-	-	.113	.887
Model 3.Q	-	-	.098	.902
Model 4.Q	.213	.787	-	-
Model 5.Q	-	-	.241	.759

Notes: The figures in the table are based on formula (A.4). Model (1.Y) = method of making data stationary (StM): HP filter (with $\lambda = 1600$; see King and Rebelo (1993) or Jaeger (1994)) applied to log levels. The model for real GDP is based on $p = 1$ (see equations (A.2) and (A.3)). The model for the implicit GDP deflator is based on $p = 2$. Model (1.Q) = method of seasonal adjustment (SeM): X11; StM: mean-value adjusted log differences with different mean values for 1957:1 - 1974:3 and 1974:4 - 1994:4. Break: France 1968:2, 1968:3. Austria 1961:1, 1972:4, 1973:1. The model is based on $p = 2$. Model (2.Q) = SeM: X11; StM: detrended log differences with different growth rates for 1957:1 - 1974:3 and 1974:4 - 1994:4. Break: Belgium, France 1974:1, 1974:2, 1974:3. The model is based on $p = 3$. Model (3.Q) = SeM: seasonal dummy variables with varying parameters for the Netherlands and Austria; StM: detrended log differences with different growth rates for 1957:1 - 1974:3 and 1974:4 - 1994:4. Break: Belgium, France 1974:1, 1974:2, 1974:3. The model is based on $p = 3$. Model (4.Q) = SeM: X11; StM: HP filter (with $\lambda = 1600$) applied to log levels. Break: France 1968:2. The model is based on $p = 3$. Model (5.Q)= SeM: seasonal dummy variables with varying parameters for the Netherlands and Austria; StM: HP filter (with $\lambda = 1600$) applied to log levels. The model is based on $p = 3$.

method and the X11 method for seasonal adjustment were used.[30] (A good and relatively simple account of the X11 method is found in Hylleberg (1992). The seasonal dummy variable method can be found in basic text books on econometrics, for example, Gujarati (1988).)

The general impression is that the results, regarding the symmetric properties of Swedish shocks, are remarkably robust when changes are made in the specification of the non-stationarities. Symmetric output shocks explain, at most, about 30 percent of variations in the fluctuations of Swedish output. The corresponding share for price data is about 24 percent.

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