

# **European Monetary Union: Evidence from Structural VARs**

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**Abstract:** This paper examines the historical pattern of aggregate demand and supply shocks in several European Monetary System countries in order to assess the desirability of monetary union. Countries with similar patterns of shocks are presumably better candidates for monetary union than those hit by wildly disparate shocks. The historical time series of shocks is identified by estimating a vector autoregressive model while imposing the restriction that demand shocks have no permanent effect on real output. In most cases supply shocks are positively correlated with those of Germany, but the negative correlation of demand shocks suggests that monetary union may not be desirable.

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## **European Monetary Union: Evidence from Structural VARs**

### **I. Introduction**

This paper examines the desirability of monetary union in Europe in terms of its likely effects on macroeconomic stability. As in Bayoumi and Eichengreen (1992a and b), the approach taken involves examining cross-country correlations of fundamental demand and supply shocks. Countries that are subject to similar patterns of shocks (i.e., substantial positive correlations of fundamental demand and supply shocks) are presumably good candidates for monetary union; they derive less benefit in terms of macroeconomic stability from exchange rate changes than countries that have asymmetric shocks, while gaining the other benefits (such as lower transactions costs) from monetary union.

The historical time series of demand and supply shocks is estimated using a structural vector autoregressive model (VAR). As pioneered by Blanchard and Quah (1989), the technique involves imposing a long-run restriction that demand shocks have no permanent effect on real output; this restriction is sufficient to identify the demand and supply shocks. Bayoumi and Eichengreen (1992a) report positive correlations between fundamental shocks in Germany and fundamental shocks in most other EC members; the correlations are particularly large for Denmark, France, Belgium, and the Netherlands, leading Bayoumi and Eichengreen to conclude that those countries form a "core" of relatively good candidates for monetary union with Germany.

Whereas Bayoumi and Eichengreen used annual GNP and deflator data, in this paper fundamental shocks are extracted from data more reflective of the tradable goods sector, namely industrial production and wholesale prices. The results are somewhat different from those of

Bayoumi and Eichengreen. While supply shocks in France, Italy, and the Netherlands show substantial positive correlation with supply shocks in Germany, demand shocks in Italy are almost uncorrelated with German ones, and demand shocks in France and the Netherlands are negatively correlated with German ones. The results in this paper indicate that Canada and the United States may be the best candidates for monetary union among the countries covered; only they have substantial positive correlation of both demand and supply shocks.

The remainder of the paper is as follows: Section II presents background on the movement toward European monetary unification and economic analysis of its desirability. The following section develops the VAR model and discusses the empirical methodology. Section IV describes the data used and various preliminary statistical tests that were done prior to estimating the VAR. Section V presents empirical results for five European countries (Germany, France, Italy, the Netherlands, and Great Britain), as well as three outsiders (the United States, Canada, and Japan). The final section presents conclusions.

## **II. Background**

In the twenty years that have passed since the breakup of the Bretton Woods system of fixed exchange rates, various members of the European Community (EC) have attempted to limit exchange-rate movements within Europe, while maintaining flexibility vis-à-vis outside currencies, notably the U.S. dollar. The effort had its greatest success in the European Monetary System (EMS), which began operation in 1979 and brought down exchange-rate variability among its members, especially in the second half of the 1980s.

Attempting to build on the apparent success of the EMS, leaders of the EC agreed in late 1991 to a proposal for European monetary unification before the end of the century. Under the Maastricht Treaty, exchange rates within Europe will be irrevocably fixed, and a European Central Bank will be created that will take over the monetary policy functions of the national central banks.

While the Maastricht Treaty initially appeared to be a "done deal," in the past several years the movement toward European monetary union has suffered severe setbacks. One blow was struck by Danish voters, who narrowly rejected the treaty in a referendum in June 1992; the rejection cast doubt on the likelihood of ratification by other countries.<sup>1</sup> Continuing political turmoil in Italy, one of the founding members of the EC and its third-largest economy, accentuated doubts that Italy could bring down its inflation rate and budget deficit in time to participate in monetary union.<sup>2</sup> Most importantly, sharp differences within Europe regarding monetary policy strained confidence in the permanence of the EMS exchange rate pegs; in particular, the Bundesbank insisted on maintaining high interest rates to fight inflation in Germany, while other countries, especially Britain, sought lower interest rates in order to stimulate sluggish economies.

These strains set off severe speculative pressures on the EMS exchange rate pegs, which were maintained through the summer of 1992 only by large-scale government intervention. In September 1992, the British pound and Italian lire were withdrawn from the EMS; both currencies immediately depreciated sharply vis-à-vis the Deutschemark.

In the ensuing months, other currencies in the EMS came under severe pressure, notably the French franc. As the French economy weakened, market participants increasingly came to

doubt the willingness of the French government to tolerate continued sluggishness in order to maintain the existing exchange-rate link with Germany. At the end of July 1993, after weeks of heavy intervention in support of the franc as well as several other currencies, the remaining members of the EMS decided to widen the allowable exchange-rate bands drastically, from plus or minus 2-1/4 percent to plus or minus 15 percent; in effect, the EMS was virtually suspended for all members except the Netherlands.<sup>3</sup>

Despite these setbacks, EC governments are continuing to prepare for monetary union in accordance with the Maastricht timetable. Accordingly, the economic desirability of European monetary union remains a live issue.

Moving to a single currency for Europe would obviously reduce transactions costs resulting from exchanging currencies within Europe; the Commission of the European Communities has estimated this benefit to be sizeable, from 0.3 to 0.4 percent of annual community GDP.<sup>4</sup> Another potential benefit would be a gain in seignorage. EC members might reduce their reserve holdings of U.S. dollars and replace them with European Currency Units (ECUs); in addition, ECUs might displace dollars in private and governmental holdings in Eastern Europe, the Middle East and elsewhere. Such a substitution of ECUs for dollars would result in a seignorage gain for EC members as a whole, at the expense of the United States.

Monetary unification would also limit the ability of individual governments to use changes in exchange rates or monetary policy to cushion economic shocks.<sup>5</sup> Various authors have compared the members of the EC with existing monetary unions to try to assess the viability of European monetary unification. Eichengreen (1990) argues that geographic mobility of labor is significantly lower in Europe than in the United States and that this difference makes monetary

union problematic for Europe. Poloz (1990) found that regional real exchange rates within Canada were more variable than national real exchange rates in Europe; considering that Canada has a single currency, he concluded that the Europeans could have monetary union also. Sala-i-Martin and Sachs (1991) compare Europe to the United States; in their view, the United States has a successful monetary union in part because the Federal government, through its tax system and various benefit programs, cushions to a considerable extent the impact of regional economic shocks. Because Europe does not have such a unified fiscal system, they argue that monetary union would be accompanied by severe regional depressions that would be politically intolerable.

Bayoumi and Eichengreen (1992a) use structural VARs to extract estimates of the historical demand and supply shocks that have hit various European economies, as well as various regions of the United States. Taking Germany as the anchor country, they find substantial positive correlations between demand and supply shocks in some EC members and similar shocks in Germany. They term countries with high correlations of shocks vis-à-vis Germany "core" countries: these are Germany (trivially, by the choice of anchor), France, the Netherlands, Denmark, and Belgium. In their view, countries with high correlations of shocks are good candidates for monetary union. They conclude that monetary union makes much more sense for the core countries than for the entire EC, as envisaged by the Maastricht Treaty.<sup>6</sup>

This paper, like Bayoumi and Eichengreen (1992a and b), uses structural VARs to estimate the fundamental demand and supply shocks, but instead of using annual data on GDP and the deflator to measure output and prices, monthly data on industrial production and producer prices are used. This choice of data focuses the analysis more closely on the tradable goods sector of

the economy, which would be most directly affected if exchange rates were pegged irrevocably; moreover, monthly data make it possible to examine the timing of historical shocks more precisely than with annual data. In addition, the use of monthly rather than quarterly, or especially annual, data reduces the possibility that time aggregation could result in a commingling of the fundamental demand and supply shocks, as discussed in Faust and Leeper (1994). Correlations of shocks are examined for five European countries (Germany, France, Italy, the Netherlands, and Great Britain); for comparison, three non-European countries (the United States, Canada, and Japan) are included as well.

### Empirical Methodology

This paper uses long-run restrictions on a simple VAR model to identify the fundamental demand and supply shocks that have driven output and prices in each country. Before discussing this methodology, it may be worthwhile to mention two other approaches to this issue.

In the traditional econometric approach derived from the Cowles Commission, the main shocks to the economy are movements in observable variables, such as the money supply or interest rates as measures of monetary policy, and budget deficits as measures of fiscal policy. In addition, there are unobservable shocks, the error terms that are hoped to be small in size and are assumed to be orthogonal to the observable variables.

In the structural VAR approach developed by Bernanke (1986) and Sims (1986), the fundamental shocks to the economy are not directly observable. The variables which *can* be observed are modeled as moving averages of the fundamental shocks. Estimating the VAR of the observable variables yields a vector of estimated residuals, which can be regarded as

one-step-ahead forecast errors. If in addition certain restrictions are imposed on the contemporaneous correlations (essentially the within-period dynamics) of the one-step-ahead forecast errors, it is possible to recover unique estimates of the fundamental shocks from the VAR residuals; that is, the fundamental shocks are said to be identified.

In this paper, the fundamental shocks are recovered from an estimated VAR, but identification is achieved by imposing long-run restrictions while leaving short-run dynamics to be determined by the data. This technique was pioneered by Blanchard and Quah (1989) and has also been used by Bayoumi and Eichengreen (1992a and b), Ahmed et al. (1993) and Tallman and Wang (1992). The advantage of using long-run restrictions is that in many instances, economic theory provides more guidance about long-run relationships than about short-run dynamics.<sup>7</sup>

As in Blanchard and Quah (1989) and Bayoumi and Eichengreen (1992a), I assume that there are two fundamental or structural shocks driving output and prices. The first, which I label as the supply shocks,  $\varepsilon_s$ , can affect both output and prices in both the short and long run. The second, which I label as the demand shock,  $\varepsilon_d$ , can also affect both output and prices in the short run, but in the long run it is restricted to have no effect on output. These assumptions about the effects of demand and supply shocks are rationalized by Bayoumi and Eichengreen (1992a) in terms of an aggregate demand-aggregate supply model with short-run stickiness, though models without wage stickiness such as those discussed in Lucas (1981) or Barro (1981) can have similar implications if demand shocks are interpreted as unanticipated monetary shocks.



To set notation, let  $\Delta y_t$  be real growth (the percentage change in industrial production) in period  $t$  and  $\Delta p_t$  be inflation (the percentage change in producer prices) in period  $t$ . The structural model of output and prices can be written in moving average form as:<sup>8</sup>

$$X_t \equiv \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = C(L) \varepsilon_t, \quad (1)$$

where  $L$  is the lag operator,

$$C(L) \varepsilon_t \equiv \sum_{i=0}^{\infty} L^i \begin{bmatrix} C_{11i} & C_{12i} \\ C_{21i} & C_{22i} \end{bmatrix} \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{dt} \end{bmatrix}, \quad (2)$$

and

$$\text{Var}(\varepsilon_t) = \Sigma. \quad (3)$$

The fundamental shocks  $\varepsilon_{dt}$  and  $\varepsilon_{st}$  are assumed to be orthogonal; hence the variance-covariance matrix  $\Sigma$  is diagonal. Moreover, the restriction that demand shocks have zero impact on real output in the long run implies that the matrix of long-run moving average coefficients,  $C(1)$  is lower triangular; that is,

$$\sum_{i=0}^{\infty} C_{12i} = 0. \quad (4)$$

By algebraic manipulation, the structural model in equation (1) can be rewritten as

$$A(L) D X_t = -C^{-1}(1) X_{t-1} + \varepsilon_t \quad (5)$$

where  $D$  is the difference operator.

The reduced form or VAR representation of the system is

$$F(L)DX_t = GX_{t-1} + u_t \quad (6)$$

where  $u_t$  are the reduced form errors. The matrices  $F(L)$  and  $G$  can be estimated by applying least squares to (6) equation-by-equation; the residuals  $u_t$  are the one-step-ahead forecast errors of this VAR, and may be correlated across equations; let  $\Omega$  denote the estimated variance-covariance matrix of the  $u$ 's.

To calculate the matrix of long-run moving average coefficients and estimates of the fundamental supply and demand shocks, equation (6) can be premultiplied by  $HG^{-1}$ , where  $H$  is constructed to be the inverse of the Cholesky factor of  $[G^{-1}\Omega(G^{-1})']$  yielding

$$HG^{-1}F(L)DX_t = HX_{t-1} + HG^{-1}u_t \quad (7)$$

By construction, the variance of  $[HG^{-1}u_t]$  is the identity matrix. The observable equation (7) is in the same form as the unobservable structural model in (5). If we normalize the structural model to make the variances of the demand and supply shocks one, then the correspondence is complete: the matrix of long-run moving average coefficients is given by  $-H^{-1}$  and the adjusted residuals given by  $[HG^{-1}u_t]$  are estimates of the fundamental shocks  $\varepsilon_s$  and  $\varepsilon_d$ . Moreover,  $-H^{-1}$  is lower triangular by construction, thereby being consistent with the restriction that in the long-run demand shocks have zero effect on real output, and the estimated fundamental shocks are orthogonal to one another.

Once the estimates of the fundamental shocks ( $HG^{-1}u_t$ ) are obtained, they can be analyzed to determine whether EMS members faced similar patterns of shocks during the sample; for comparison, the fundamental shocks in several non-EMS countries are examined as well.

### Data

Monthly data on output and prices were gathered for four original EMS members (Germany, France, Italy, and the Netherlands), as well as for Great Britain, which officially joined the EMS in October 1990, though it had been shadowing the system for some time prior to that date. For comparison, three non-EMS countries were also included: the United States, Canada, and Japan. The sample period went from January 1960 to July 1992, thereby leaving out the recent period of turmoil within the EMS that resulted in the departure of Britain and Italy from the system.<sup>9</sup> Because the paper deals with an exchange-rate issue, it seemed appropriate to use data on output and prices in the tradable goods sector, rather than for the entire economy. Accordingly, output was measured by industrial production or industrial production in manufacturing; prices were measured by producer prices or producer prices in manufacturing. Data were obtained from the BIS or Haver Analytics.

Prior to estimating the reduced form of the model (equation (6)), the unit-root test of Hasza and Fuller (1982) was applied to the data, which were not seasonally adjusted by the source; this test allows for both stochastic and deterministic seasonality. In most cases the results favored deterministic seasonality and a single unit root; in no case was this specification rejected strongly. Accordingly, for all countries deterministic seasonal dummies were included in the

estimated reduced form, and estimation was done taking the growth rates of output and prices as stationary. In addition, tests for cointegration were applied to each country's output and price level; the augmented Dickey-Fuller test for cointegration described by Engle and Granger (1987) showed no strong rejections of the hypothesis of non-cointegration. This result is in accord with the structural model of equation (1), which assumes that there are two stochastic trends (permanent shocks) in each country's output and price data.

### Empirical Results

To compare the behavior of the fundamental demand and supply shocks in various countries, some members of the EMS and some not, it is first necessary to estimate the fundamental shocks. The reduced-form model of equation (6) was estimated by least squares for each country individually, thereby yielding estimates of the matrix  $G$ , the vector of residuals (one-step-ahead forecast errors  $u_t$ ), and the variance-covariance matrix of the residuals  $\Omega$ . In estimating the reduced form, the lag length of  $F(L)$  was set at 24 months, comparable to the 8 quarters used by Blanchard and Quah (1989) and two years used by Bayoumi and Eichengreen (1992a). To impose the restriction that the long-run effect of the demand shock on real output is zero, the matrix  $H$  was calculated, and the estimated version of (6) was pre-multiplied by  $HG^{-1}$ , thereby yielding the estimated restricted model, as in equation (7). In addition, the model was normalized to ensure that the coefficient on the current value of the left-hand-side variable ( $DX_t$ ) was 1 in each equation.

Using the estimated restricted model, impulse response functions (IRFs) and variance decompositions (VDCs) were calculated showing the effects of the fundamental demand and supply shocks on output and prices. Figure 1 shows the IRF for German output in response to a one-standard deviation supply shock. The horizon is given on the horizontal axis: 1 to 60 months. The jagged solid line gives the response of the *level* of German output (in logs) to a supply shock. The response shrinks sharply just after impact but then builds gradually until the full positive response is achieved at a lag of about two years. The dotted lines represent 90 percent significance bands around the point estimates. The simulated errors of the IRF were computed by simulation using 50,000 replications of the German model, and the dotted lines equal the point estimates of the IRF plus or minus 1.645 times the simulated standard error.<sup>10</sup>

Figure 2 gives the response of the German price level to a supply shock. Note that the response is negative, implying that when a supply shock raises output, it lowers the price level. The price response builds gradually over a period of about a year and a half before stabilizing.

Figure 3 gives the response of German output to demand shocks; it is positive initially but fades away to zero after about a year and a half, consistent with the long-run theoretical restriction that demand shocks have zero long-run impact on output.

Figure 4 gives the response of German prices to demand shocks; it is positive and gradually builds up, with most of the response coming in the first two years.

Table 1 presents variance decompositions for the effects of demand shocks on output at various horizons.<sup>11</sup> In most cases demand shocks account for over half of the variance of output at a one-month horizon, but their contribution shrinks at longer horizons. Demand shocks are particularly important in explaining output in the United States; at a 12-month horizon,

80 percent of output variance is attributable to demand shocks, and even at a 60-month horizon demand shocks account for over one-third of the variance of output, more than in any other country except Italy. By contrast, in Germany only 65 percent of output variance at a horizon of 12 months is due to demand shocks, and at a horizon of 60 months the percentage is down to 21 percent.

Table 2 presents variance decompositions for the effects of demand shocks on prices. In most cases the fraction of variance attributable to demand shocks increases as the horizon lengthens. Demand shocks are a more important source of price level movements in Germany than in the United States, especially at the shorter time horizons.

The vectors of supply and demand shocks were also extracted from the estimated restricted model by calculating  $[HG^{-1}u_t]$ . The monthly series were quite noisy, but quarterly or annual averages of the monthly data revealed interesting patterns. For example, Figure 5 shows quarterly supply shocks in Germany from 1970 through 1975. A large negative supply shock occurring in late 1973 and early 1974 is quite noticeable and corresponds to the first major oil price shock.<sup>12</sup>

Table 3 gives cross-country correlations of quarterly averages of monthly supply shocks for Germany vis-à-vis the other seven countries; for comparison, the correlations for the United States vis-à-vis the other countries are given as well.<sup>13</sup> Table 4 gives similar correlations for demand shocks. If the true correlation were zero, the usual formula indicates a standard error of the estimated correlations of  $1/\sqrt{N}$ , where  $N$  is the number of observations. In Tables 3

and 4 the standard errors for the correlations involving Great Britain are 0.13, those involving France are 0.11, and those involving other countries are 0.10.

Turning to supply shocks first, three European countries have positive correlations vis-à-vis Germany that are both substantial and statistically significant: France, Italy, and the Netherlands. The three non-European countries (the United States, Canada, and Japan) all have much smaller positive correlations with Germany. By contrast, Great Britain has a small but statistically insignificant negative correlation vis-à-vis Germany.

The correlations for demand shocks are quite different. Italy's demand shocks are almost uncorrelated with Germany's, while the Netherlands and especially France and Great Britain have substantial, statistically significant negative correlations with Germany. This result is quite different from that of Bayoumi and Eichengreen (1992a), who found positive correlations with Germany for all four of these countries.

Bayoumi and Eichengreen (1992a,2) argue that countries that are good candidates for monetary union should have positive correlations of their supply and demand shocks. In such a situation of symmetric shocks, a common response in terms of monetary and fiscal policy should be appropriate. For example, if a negative demand shock hits France and Germany simultaneously, a common response of expansionary policy is appropriate.

By contrast, if asymmetric shocks predominate, then exchange-rate flexibility may be needed to accommodate asymmetric policy responses; otherwise, one country may be constrained from pursuing the policy that would be appropriate to its shock. For example, if Germany has a positive demand shock and at the same time France has a negative one, Germany might want

to tighten monetary policy while France would want to loosen; under monetary union or a fixed exchange rate with a high degree of capital mobility, such a difference in policy is not feasible.

Judged by this criterion, the results in Tables 3 and 4 indicate that none of the European countries are particularly good candidates for monetary union with Germany, because they all have small (Italy) or negative (the Netherlands, France, and Great Britain) correlations of their demand shocks with Germany's. Britain is a particularly poor candidate because its supply shocks are also negatively correlated with Germany's. The only pair of countries that has substantial positive correlations of both demand and supply shocks is the United States and Canada.

### **Conclusion**

This paper has studied cross-country correlations of demand and supply shocks for five possible members of a European monetary union and three outsiders. The historical time series of shocks were estimated using structural VAR models that were identified using a long-run restriction that demand shocks have no permanent effect on real output.

The results indicate that none of the European countries may be good candidates for monetary union with Germany, because asymmetric demand shocks predominate. Britain is an especially poor candidate because both its supply and demand shocks are negatively correlated with Germany's. Of the three outsiders, Canada and the United States alone have substantial positive correlations of both demand and supply shocks, suggesting that they may be better candidates for monetary union on these grounds than any of the European countries studied.



### Notes

1. In May 1993, Danish voters approved a modified version of the treaty.
2. As discussed in Bean (1992), the Maastricht Treaty sets out several criteria that are supposed to be met by countries before they can move to monetary union. One criterion requires convergence of inflation rates; a country's inflation rate is not to exceed the lowest three inflation rates in the EC by more than 1-1/2 percentage points. Two others limit fiscal policy: the annual government budget deficit is supposed to be no more than 3 percent of GDP, and the total outstanding government debt is limited to no more than 60 percent of GDP. In recent years, Italy has consistently violated all three of these criteria by wide margins.
3. Throughout the crisis the Dutch currency was never under heavy pressure, thereby allowing that country to retain the narrow 2-1/4 percent band vis-à-vis the Deutschemark.
4. European Commission (1990, 68).
5. Such a limitation on governments' freedom of action may be beneficial; for example, Giavazzi and Pagano (1988) argue that the EMS is dominated by Germany and that traditionally inflationary countries like Italy can benefit in terms of reducing the cost of disinflation by tying their future monetary policy to Germany's. However, the Bundesbank's caution about monetary union no doubt reflects in part a concern that creation of a European central bank will enable higher-inflation countries to impose their policy preferences on Germany.

6. In another paper, Bayoumi and Eichengreen (1992b) examine demand and supply shocks in six other European countries that are potential candidates for EC membership. They conclude that Austria, Switzerland, and (more marginally) Sweden are comparable to the core countries; they would be good candidates for monetary union. However, Norway, Finland, and Iceland have different patterns of shocks, making them more comparable to Britain, Italy, Spain, etc.
7. For critical appraisals of this technique, see Lippi and Reichlin (1993) and Faust and Leeper (1994); also see Blanchard and Quah (1993).
8. The analysis assumes that  $\Delta y_t$  and  $\Delta p_t$  do not need to be differenced to attain stationarity and that the matrix of moving average coefficients is non-singular; the latter condition rules out cointegration between  $\Delta y_t$  and  $\Delta p_t$ .
9. For some countries, the sample period was shortened because of lack of data. For Japan, the sample was January 1961 to July 1992. For the Netherlands, it was January 1963 to June 1992. For France, it was January 1963 to December 1985. For Italy, it was January 1960 to December 1989. For Britain, it was January 1974 to June 1992. For Canada, it was January 1961 to June 1992.
10. Shapiro and Watson (1988) and Tallman and Wang (1992) employ narrower one-standard error significance bands.
11. Because there are only two fundamental shocks in the model, the contribution of supply shocks is simply 100 minus the contribution of demand shocks.

12. The largest supply shock in the entire sample occurs in 1974Q1; it is approximately five times the standard deviation of the quarterly supply shocks.
13. Using quarterly average shocks in calculating correlations is preferable to using monthly shocks because it allows some scope for the possibility that a common shock may not be observed in different countries in precisely the same month. Even so, the pattern of results using the monthly shocks is similar to those presented here; the size of the correlations tends to be smaller than in Table 3 and 4, but the standard errors are smaller as well. The most notable difference is that using monthly shocks, the negative correlations of demand shocks for the Netherlands and Great Britain vis-à-vis Germany are no longer statistically significant.

### References

- Ahmed, Shaghil, Barry Ickes, Ping Wang, and Byung Sam Yoo. "International Business Cycles." *American Economic Review* 83 (1993), 335-59.
- Barro, Robert J. "The Equilibrium Approach to Business Cycles." In Robert J. Barro, *Money, Expectations, and Business Cycles*, 41-78. New York: Academic Press, (1981).
- Bayoumi, Tamin and Barry Eichengreen. "Shocking Aspects of European Monetary Unification." NBER Working Paper No. 3949. (1992a).
- \_\_\_\_\_. "Is There a Conflict Between EC Enlargement and European Monetary Unification?" NBER Working Paper No. 3950. (1992b).
- Bean, Charles R. "Economic and Monetary Union in Europe." *Journal of Economic Perspectives* 6 (Fall 1992), 31-52.
- Bernanke, B. "Alternative Explanations of the Money-Income Correlation." *Carnegie-Rochester Conference Series on Public Policy* 25 (1986), 49-100.
- Blanchard, Olivier J. and Danny Quah. "The Dynamic Effects of Aggregate Demand and Supply Disturbances." *American Economic Review* 79 (1989), 655-73.
- \_\_\_\_\_. "The Dynamic Effects of Aggregate Demand and Supply Disturbances: Reply." *American Economic Review* 83 (1993), 653-58.
- Eichengreen, Barry. "Is Europe an Optimum Currency Area?" University of California at Berkeley Working Paper 90-151 (October 1990).
- Engle, Robert F. and C.W.J. Granger. "Co-integration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55 (1987), 251-76.
- European Commission. "One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union." *European Economy* 44 (1990), 3-347.
- Faust, Jon and Eric M. Leeper. "When Do Long-Run Identifying Restrictions Give Reliable Results?" Board of Governors of the Federal Reserve System, International Finance Discussion Paper No. 462, March 1994.
- Froot, Kenneth A. and Kenneth Rogoff. "The EMS, the EMU, and the Transition to a Common Currency." NBER Working Paper No. 3684. (1991).

- Giavazzi, Francesco and Marco Pagano. "The Advantage of Tying One's Hands: EMS Discipline and Central Bank Credibility." *European Economic Review* 32 (1988), 1055-82.
- Hasza, David P. and Wayne A. Fuller. "Testing for Nonstationary Parameter Specifications in Seasonal Time Series Models." *Annals of Statistics* 10 (1982), 1209-16.
- Lippi, Marco and Lucrezia Reichlin. "The Dynamic Effects of Aggregate Demand and Supply Disturbances: Comment." *American Economic Review* 83 (1993), 644-52.
- Lucas, Robert E., Jr. *Studies in Business-Cycle Theory*. Cambridge: MIT Press, 1981.
- Poloz, Stephen S. "Real Exchange Rate Adjustment Between Regions in a Common Currency Area." Mimeo, Bank of Canada. (1990).
- Sala-i-Martin, Xavier and Jeffrey Sachs. "Fiscal Federalism and Optimum Currency Areas: Evidence for Europe from the United States." Yale University, Economic Growth Center Discussion Paper No. 638. (August 1991).
- Shapiro, Matthew and Mark Watson. "Sources of Business Cycle Fluctuations." In Stanley Fischer, ed., *NBER Macroeconomics Annual*, 111-48. Cambridge: MIT Press, 1988.
- Sims, Christopher. "Are Forecasting Models Usable for Policy Analysis?" *Federal Reserve Bank of Minneapolis Quarterly Review* 10 (1986), 2-16.
- Tallman, Ellis W. and Ping Wang. "Money Demand and Relative Prices in Hyperinflations: Evidence from Germany and China." Federal Reserve Bank of Atlanta Working Paper 92-10. (1992).

**Table 1: Variance Decompositions for Output  
Percentage of Variance Due to Demand Shocks**

	Horizon (months)			
	1	12	24	60
Germany	65.4 (25.6)	65.2 (22.5)	42.2 (19.0)	21.0 (11.1)
France	65.2 (20.3)	70.4 (11.8)	47.3 (11.8)	18.7 (6.8)
Italy	84.8 (17.0)	85.1 (11.7)	74.6 (11.6)	46.6 (13.0)
Netherlands	56.6 (27.4)	46.9 (25.5)	33.1 (20.9)	15.0 (11.6)
Great Britain	73.6 (27.5)	55.1 (26.3)	38.0 (25.0)	23.9 (22.1)
United States	83.0 (18.7)	80.3 (18.9)	71.0 (21.5)	36.6 (16.2)
Canada	45.4 (30.8)	43.6 (30.1)	36.4 (28.0)	21.2 (20.5)
Japan	50.8 (27.0)	52.8 (26.1)	31.6 (21.6)	11.9 (11.1)

*Note: Numbers in parentheses represent estimated standard errors of the VDCs. Percentage of variance due to supply shocks is equal to 100 minus the percentage shown here.*

**Table 2: Variance Decompositions for the Price Level  
Percentage of Variance Due to Demand Shocks**

	Horizon (months)			
	1	12	24	60
Germany	38.9 (26.4)	52.6 (26.3)	57.5 (25.4)	60.3 (25.5)
France	31.8 (19.8)	30.7 (18.6)	33.5 (19.4)	34.3 (21.0)
Italy	16.0 (17.5)	25.3 (20.4)	27.5 (20.9)	27.1 (21.1)
Netherlands	43.2 (27.4)	59.0 (26.4)	57.4 (26.6)	58.9 (26.9)
Great Britain	31.4 (29.3)	41.8 (31.1)	44.2 (31.4)	48.6 (31.6)
United States	14.6 (17.2)	27.2 (21.8)	39.9 (23.8)	50.4 (25.5)
Canada	53.5 (30.8)	74.1 (25.6)	77.3 (24.4)	76.5 (24.9)
Japan	46.8 (26.9)	62.9 (25.4)	68.5 (23.9)	68.6 (24.8)

*Note: Numbers in parentheses represent estimated standard errors of the VDCs. Percentage of variance due to supply shocks is equal to 100 minus the percentage shown here.*

**Table 3: Cross-Country Correlations of Supply Shocks  
Quarterly Data: 1965Q2 to 1992Q2**

	<u>Germany</u>	<u>United States</u>
United States	0.22	1.00
Japan	0.19	0.11
Canada	0.03	0.40
France	0.56	-0.05
Italy	0.46	0.16
Netherlands	0.40	0.28
Great Britain	-0.08	-0.02

*Note: Estimated standard errors for the correlations involving Great Britain are 0.13, those involving France are 0.11, and those involving all other countries are 0.10. For France, data on shocks end in 1985Q4. For Italy, data on shocks end in 1989Q4. For Great Britain, data on shocks begin in 1976Q2.*



**Table 4: Cross-Country Correlations of Demand Shocks**  
**Quarterly Data: 1965Q2 to 1992Q2**

	<u>Germany</u>	<u>United States</u>
United States	-0.10	1.00
Japan	-0.16	-0.08
Canada	-0.05	0.41
France	-0.32	0.07
Italy	0.02	-0.10
Netherlands	-0.24	0.10
Great Britain	-0.34	0.17

*Note: Estimated standard errors for the correlations involving Great Britain are 0.13, those involving France are 0.11, and those involving all other countries are 0.10. For France, data on shocks end in 1985Q4. For Italy, data on shocks end in 1989Q4. For Great Britain, data on shocks begin in 1976Q2.*

# GERMANY: IND-SUPPLY SHOCK

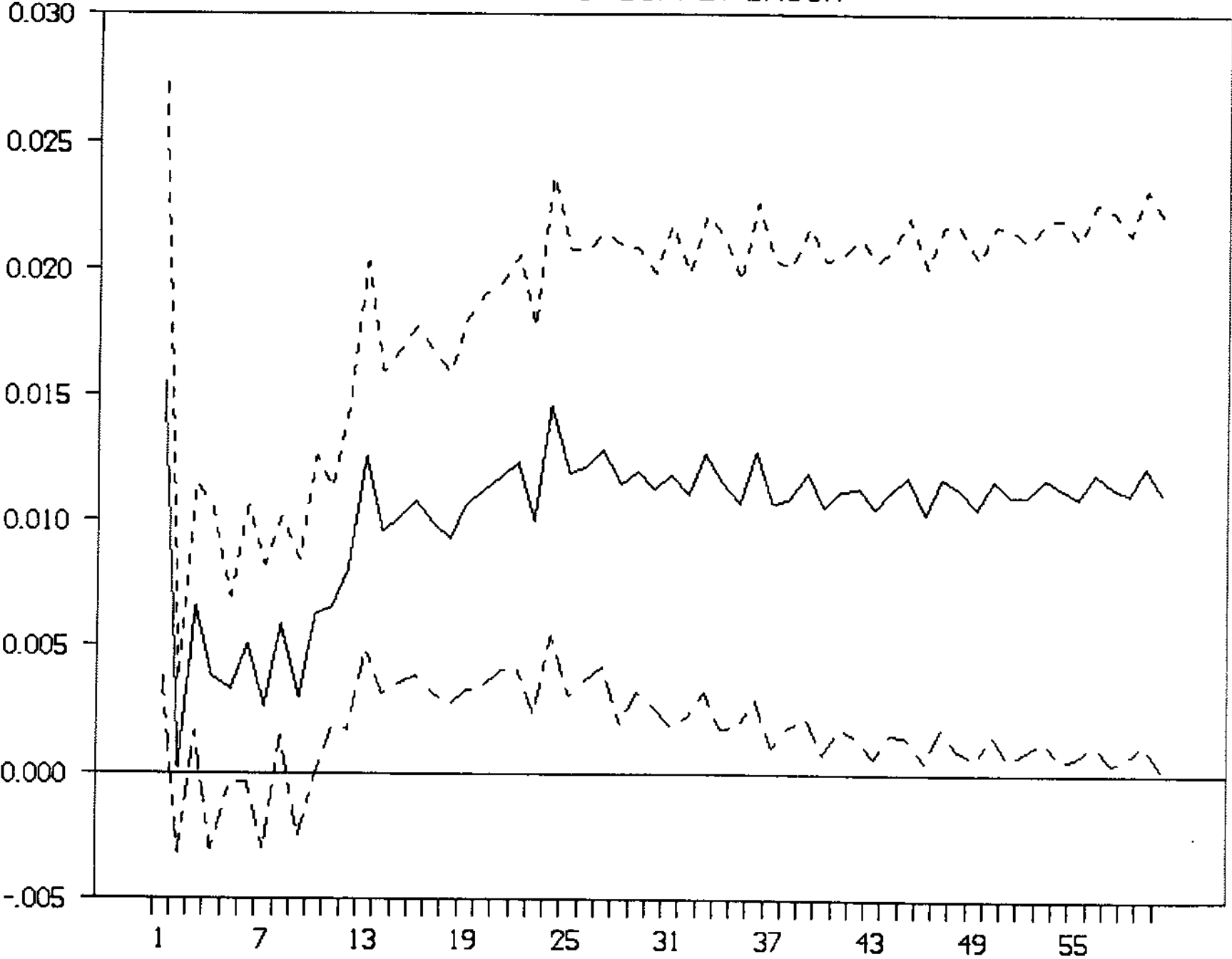


FIGURE 1: Response of German Output to Supply Shock

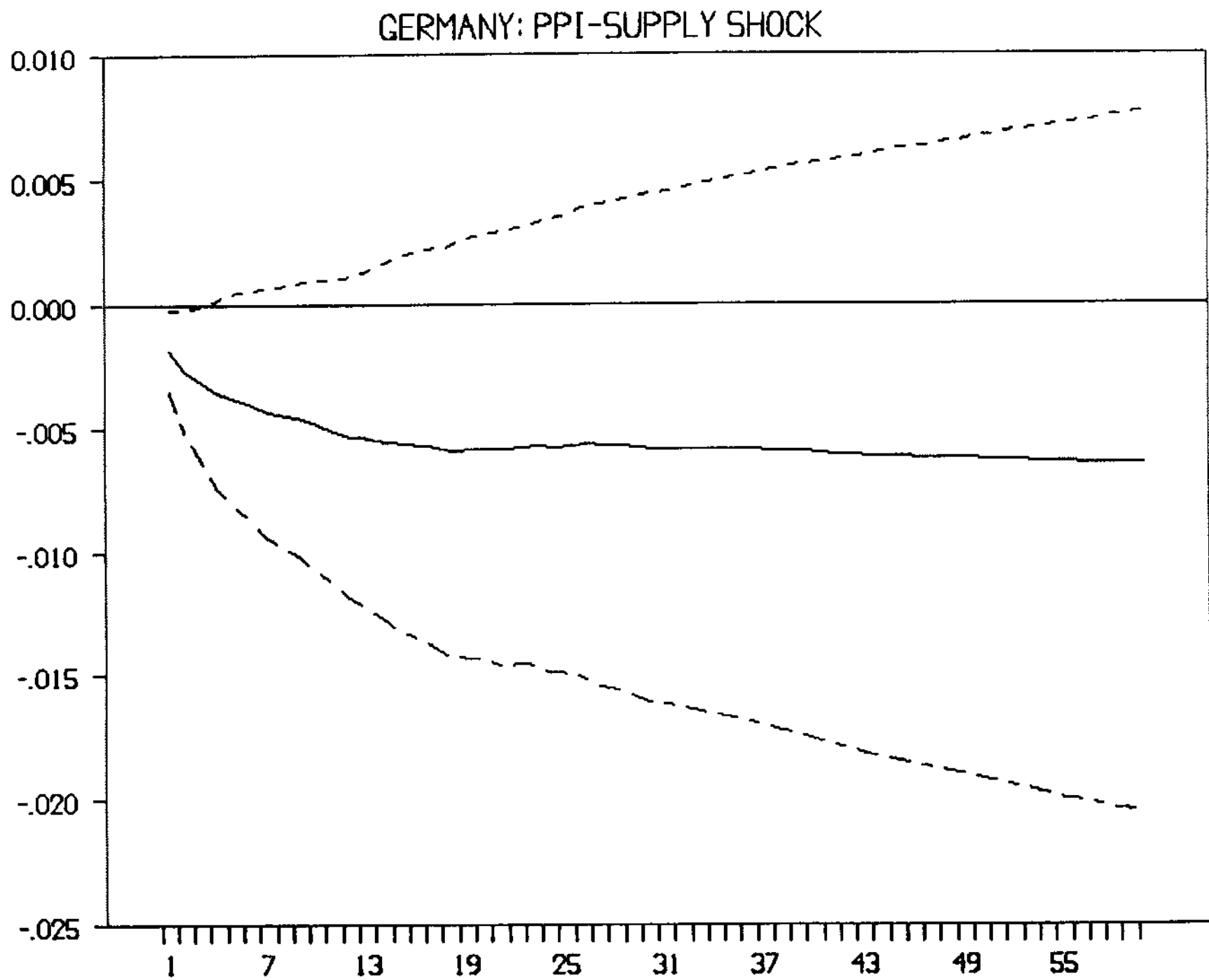


FIGURE 2: Response of German Price Level to Supply Shock

# GERMANY: IND-DEMAND SHOCK

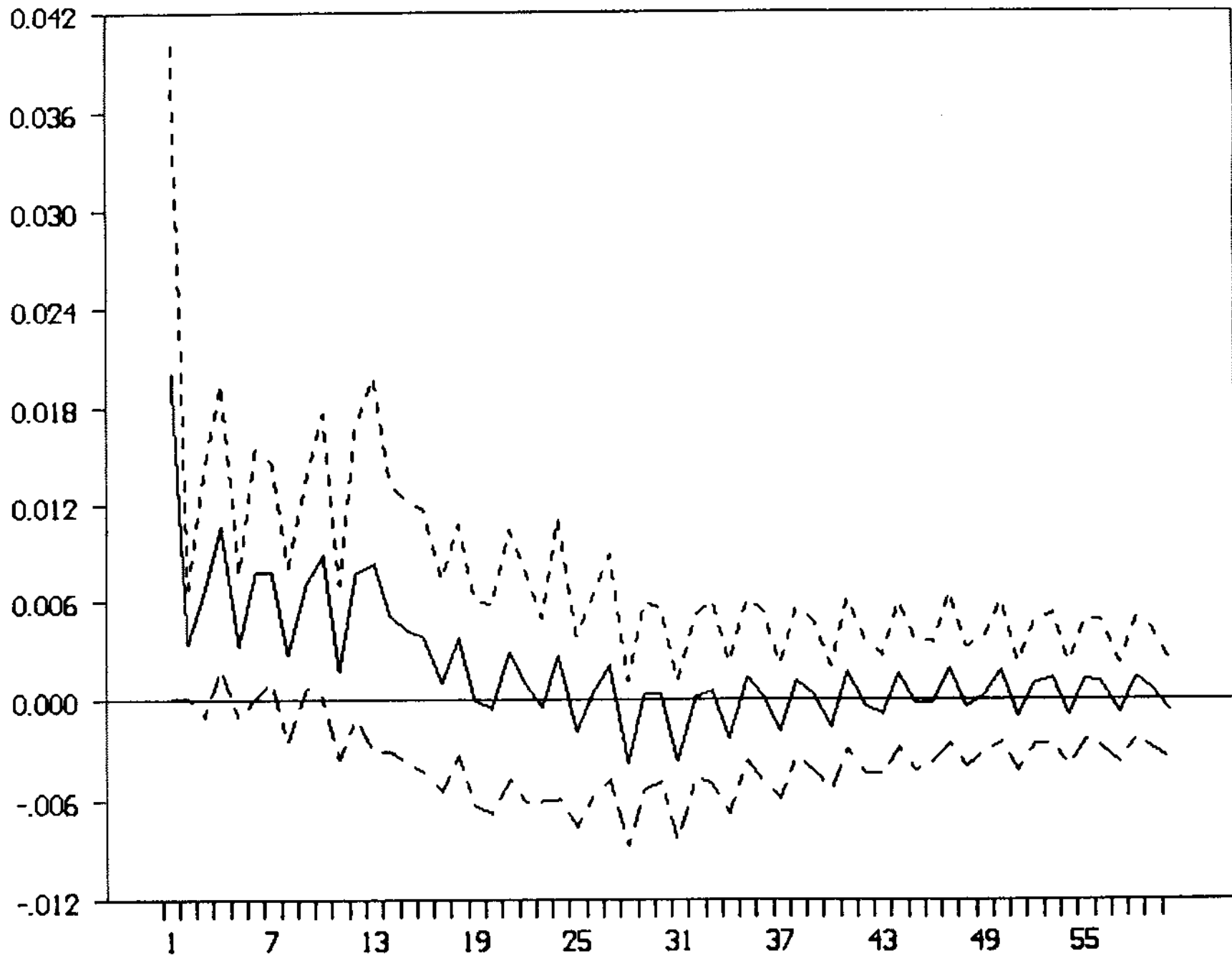


FIGURE 3: Response of German Output to Demand Shock

# GERMANY: PPI-DEMAND SHOCK

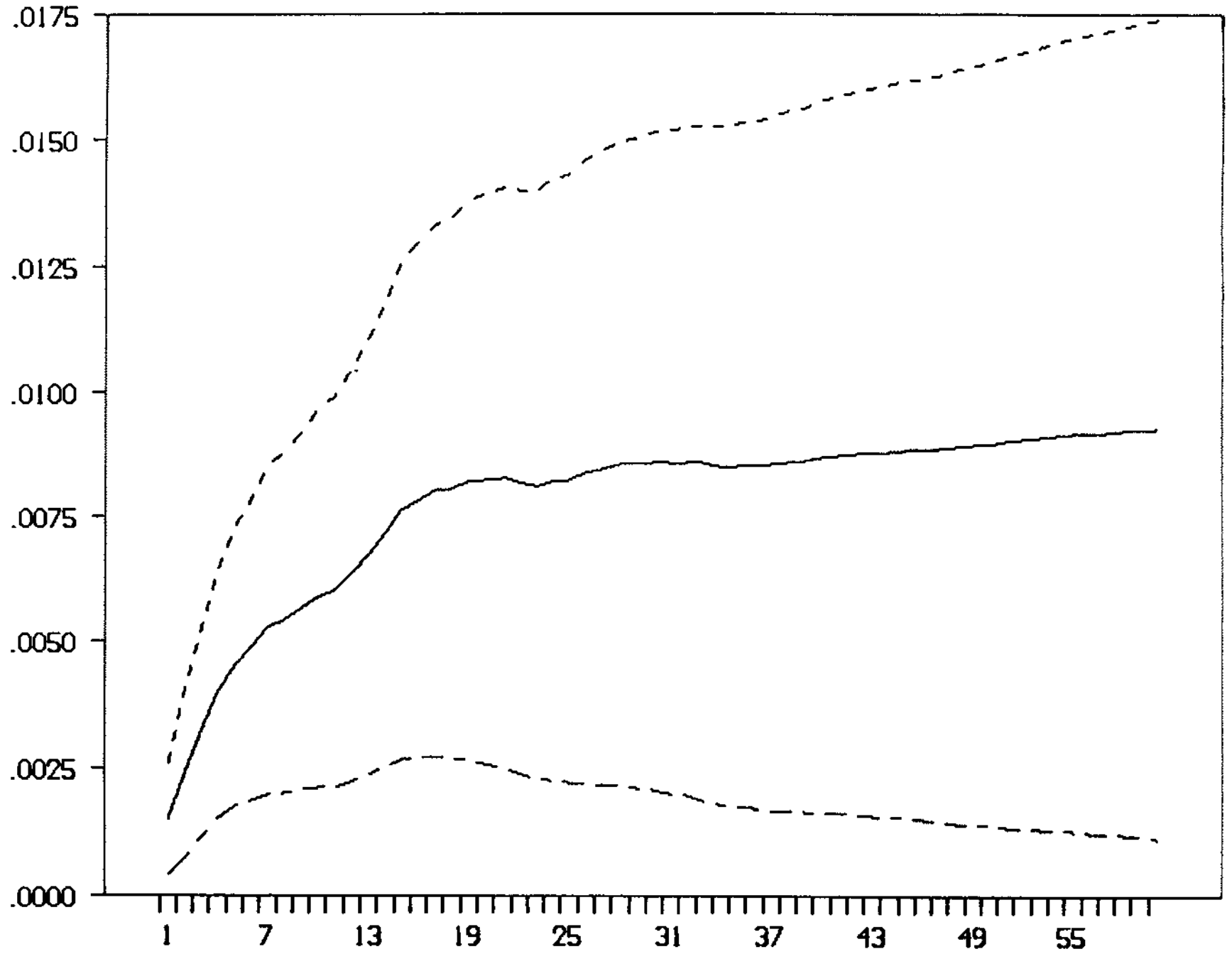


FIGURE 4: Response of German Price Level to Demand Shock

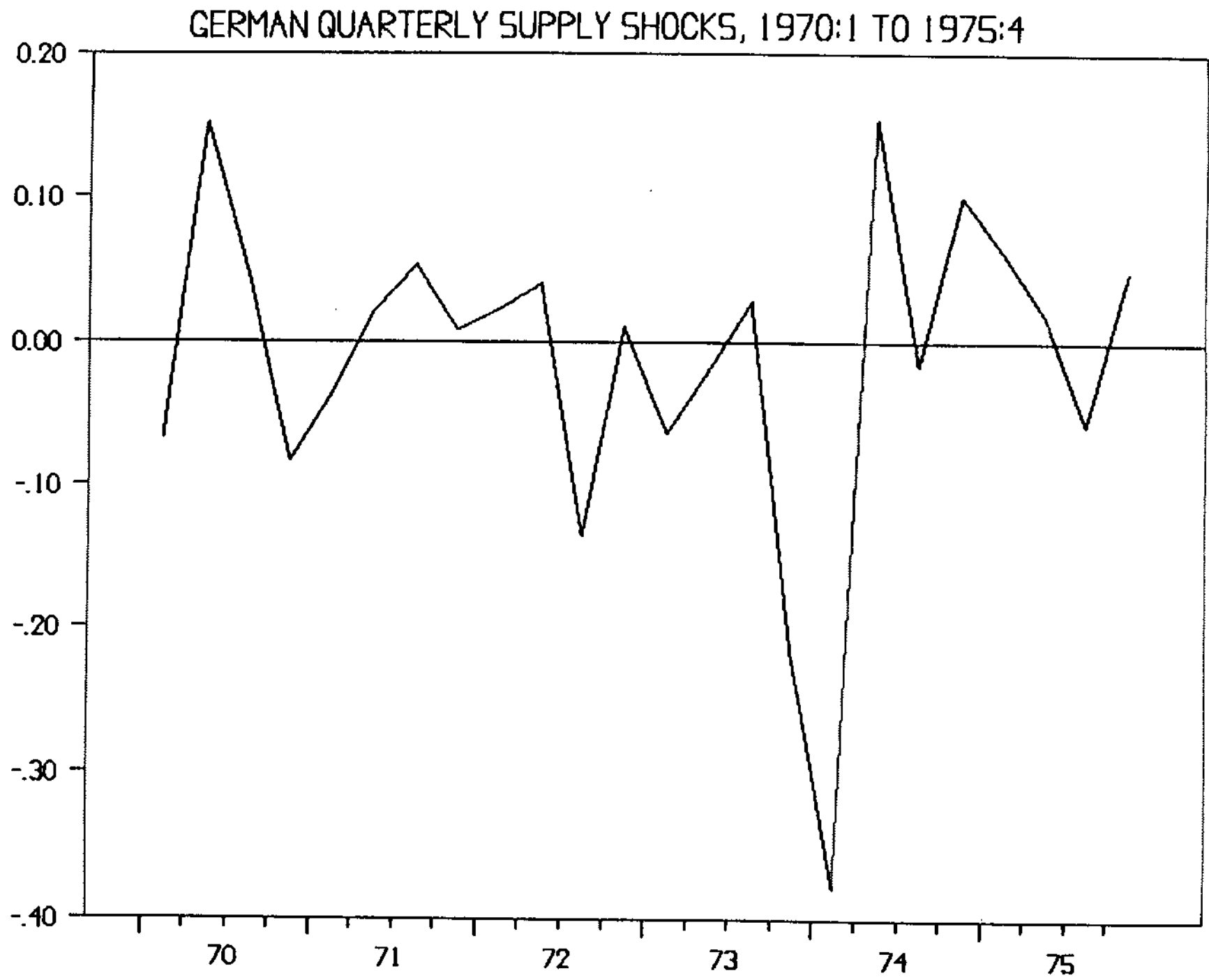


FIGURE 5: German Supply Shocks, 1970 - 1975