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SUPPLY-SIDE SOURCES OF INFLATION: EVIDENCE FROM OECD COUNTRIES

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ABSTRACT

We evaluate the merits of the "supply-side" view under which inflation results from sectoral shocks, and compare it with the "classical" view in which inflation results from aggregate factors such as variations in money growth. Using a panel VAR methodology applied to data for 13 OECD countries, we find support for a multi-shock view of inflation: supply-side shocks are statistically significant determinants of inflation, even after taking into account aggregate demand factors. While oil prices are the dominant supply-side influence, other measures such as the skewness of relative price changes are important as well. At short horizons, an innovation to skewness leads to an increase in inflation of 0.5 percentage points. As suggested by the classical view, money growth plays an increasingly important role as the time horizon lengthens.

Supply-side sources of inflation: evidence from OECD countries

Prakash Loungani and Phillip Swagel[1]

"...the debate between the Currency and Banking schools in the first half of the 19th century anticipated, with great accuracy, the debate between monetarists and Keynesians that began in the 1960s. Members of the Currency school, like later monetarists, emphasized the monetary causes of inflation; the Banking School's proto-Keynesians pointed to what are now called supply-side shocks." [The Economist, June 11, 1994]

1. Introduction

In this paper we use data on 13 OECD countries, including the United States, to evaluate the merits of "supply-side" theories of inflation. By "supply-side" we refer to theories in which developments in particular sectors of the economy have a sustained impact on the aggregate price level. Solow (1974) captures the spirit of the supply-side view: "every increase in any price is an example of inflation in action."

In contrast, under the "classical" view of inflation, sectoral developments lead to changes in relative prices but not to changes in the aggregate price level. Aggregate demand factors, primarily money growth, determine inflation, while differences across sectors in the rate of price growth simply provide details about "the specific areas that flooded when the monetary dam broke."[2] Refinements of this view make a distinction between the roles of inside money and outside money in causing inflation.[3]

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[2] Bosworth and Lawrence (1982).

[3] See Fama (1983) and Boschen and Talbot (1991).

The gulf between these two schools of thought was particularly evident during the episodes of sharp increases in oil prices in the 1970's. Friedman (1975) reiterates the classical view of the effect of oil price changes on the aggregate inflation rate:

> *"...why should the average level of all prices be affected by changes in the prices of some things relative to others?"*

In contrast, many others assign an important role to fluctuations in oil prices in accounting for the double-digit inflation of that period; for example, Blinder (1982) states:

> *"...energy prices rose 21.6% during 1974 and 37.4% during 1979. The 1970's were different, and I fail to see why a theory of inflation is more "scientific" if it ignores this fact."*

The positive correlation between inflation and relative price volatility that has been documented in numerous studies is consistent with both classical and supply-side views of inflation.[4] In these studies, relative price volatility is measured by the standard deviation of relative price changes across sectors; in our work this variable is labeled SDEV. Under the supply-side view, movements in SDEV result from developments in particular sectors of the economy, so that the correlation between SDEV and inflation is interpreted as implying causality from SDEV to inflation. In contrast, under the classical view, an increase in money growth leads to increases in both inflation and SDEV, thereby generating a positive correlation between the two variables. Using data for the United States, Fischer (1981) finds some support for both points of view. While price changes in the food and energy sectors are found to be particularly

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[4] See the comprehensive survey by Marquez and Vining (1984). Stockton (1988) develops an interesting model in which there is a nonlinear relationship between relative price variability and inflation. Marquez (1995) models the relationship between relative price variability and inflation in a framework that allows for a long-run relationship between the two variables.

important in generating the positive correlation between inflation and SDEV, monetary shocks play a role as well.[5]

Ball and Mankiw (1995) develop a new theoretical explanation for supply-side inflation. In their model, the existence of menu costs faced by firms in adjusting prices implies that changes in relative prices lead to aggregate inflation. Their theory, which we review in the next section, suggests that the *skewness* of relative price changes across industries can be used as a measure of this supply shock. Ball and Mankiw present several OLS regressions of inflation on skewness and other measures of supply shocks, using annual data for the United States for the period 1948 to 1989; they conclude that their skewness measure is better able to explain movements in inflation than "the traditional measures such as the relative prices of food and energy."

We provide evidence on the relative contribution of money growth and three supply-side measures--oil price shocks, SDEV, and skewness--in accounting for aggregate inflation.[6] Our work offers several advantages over previous work in this area. First, our empirical specification nests alternate views on the determinants of inflation. Second, we construct SDEV and skewness using a consistent source of industry data for the 13 countries. Previous attempts to test the supply-side view with cross-country data have used a small number of countries, and the supply-side measures have not always been consistent across countries.

[5] Debelle and Lamont (1995) show that cities with higher-than-average inflation have higher-than-average relative price dispersion. The city-level correlation cannot be attributed to monetary policy, oil price shocks or other aggregate influences, since the effects of aggregate shocks are already "purged" in constructing city-specific inflation and city-specific relative price dispersion. Hence the authors interpret their finding as evidence in favor of models in which prices are sticky in the face of relative shocks.

[6] Surprisingly, the Ball-Mankiw regressions do not include money growth as a possible determinant of inflation, and hence their empirical work does not nest the classical view.

Third, we take seriously the possibility that causality may run from inflation to skewness. The Ball-Mankiw theory rests crucially on the assumption that skewness in sectoral price changes leads to aggregate inflation rather than the other way around. Ball and Mankiw give descriptive evidence that this is the case, but provide no formal econometric support. We use a panel VAR approach which allows us to examine whether our results on the contribution of skewness to inflation are sensitive to alternate assumptions about the exogeneity of skewness.[7]

The rest of the paper proceeds as follows. In the next section, we summarize the theory and empirical work of Ball and Mankiw. The data set is described in section 3. Section 4 contains the main empirical results of the paper, with sensitivity analysis in Section 5. Section 6 sums up the evidence.

2. Supply-side theories of aggregate inflation

Ball and Mankiw (1995) present a theory under which relative price shocks lead to changes in the overall price level. The key assumption of their theory is that there are fixed costs of adjusting prices ("menu costs"), so that firms adjust prices only when the desired price change exceeds a cutoff value. In the case of a sector-specific shock, more prices will change in industries directly affected by the shock than in industries which are affected only indirectly, so that price changes in one direction will not be completely offset by corresponding decreases in other prices. When the distribution of price changes is not symmetric, then a shock leads to a disproportionate number of relative price changes in one direction, thereby affecting aggregate

[7] Such evidence may be useful in distinguishing the Ball-Mankiw approach from the menu-cost model of Caballero and Engel (1993), in which the cross-section distribution of relative price changes evolves endogenously as a result of firms' responses to aggregate and idiosyncratic shocks.

inflation. If the distribution of price changes is skewed to the right, for example, a shock will lead to more increases in relative prices than decreases, even if the distribution of price changes is centered at zero. The Ball-Mankiw theory thus predicts that the *skewness* of relative price changes will be correlated with aggregate inflation.

A further implication of the theory is that a higher *variance* of price changes magnifies the effect of skewness on aggregate inflation, since a larger variance of shocks leads to more weight in the tails of the distribution of price changes. A given skewness shock then leads to an even greater disparity between the number of price increases and decreases.

Ball and Mankiw provide evidence for their theory in U.S. data in the form of several OLS regressions with the aggregate inflation rate as the dependent variable: first with just lagged inflation as an independent variable, and then with the additions of the standard deviation of sectoral price changes, the skewness of sectoral price changes (calculated from 4 digit industry PPI data), and the interaction of standard deviation and skewness. The results are consistent with their theory--the variance and skewness of sectoral price changes are both statistically significant, as is the interaction. Similar results hold when other measures of asymmetry are used instead of skewness, as well as in Phillips curve regressions in which unemployment and food and energy prices are added as determinants of inflation.

However, these regressions take as given that causality runs from skewness to inflation rather than the other way around. This assumption is justified on the basis of a few historical episodes in which changes in skewness can be traced to exogenous developments in a few sectors of the economy. Though this narrative evidence is consistent with the theory, there are some limitations of this approach. For instance, many of the episodes coincide with increases in oil prices; this limits the extent to which sharp differences can be drawn between their theory and the earlier work on supply-side determinants of inflation.[8] Extending the Ball-Mankiw empirical work to a VAR framework allows us to formally examine how sensitive the skewness-inflation relationship is to alternate assumptions about the causal relationships among oil prices, skewness, inflation and other variables.

3. Description of the cross-country data

We use annual data on aggregate inflation and sectoral price changes for 13 OECD countries for the years 1960 to 1990; the countries are listed in Table 1. Our data on industry prices are from the OECD Intersectoral Database (ISDB), 1993 edition. The ISDB contains data on annual output and prices for 32 industry groups across the OECD for the years 1960-90.[9] For each industry, we use the most disaggregated level of data available; this corresponds to roughly the three digit level of the ISIC classification, and leaves us with 23 industries.[10] These are listed in the table below.

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[8] De Abreu Lourenco and Gruen (1994) use data for Australia to provide additional support for the skewness hypothesis: they use the absolute value of changes in the terms of trade as an instrument for the skewness of relative price changes and find a positive effect of skewness on inflation. Even here, however, the problem remains that aggregate factors may lead to terms of trade shocks, rendering them suspect as an instrument for the skewness of sectoral price changes.

[9] See Meyer zu Schlochtern (1988) for a complete description. We are grateful to Karen Johnson for providing us with an updated version of the data set.

[10] The price data needed to calculate the skewness of sectoral inflation are not available for every sector in each country and year. To obtain reasonable estimates of the skewness of price changes across industries, we exclude those country-years in which prices are available for fewer than ten industries. This leads us to omit Australia, for which prices are available for only five industries.

1. Agriculture	9. Basic metal products	17. Construction
2. Mining and quarrying	10. Metal products ex. machines	18. Wholesale, retail trade
3. Food, beverages, and tobacco	11. Ag. and industrial machines	19. Restaurants and hotels
4. Textiles	12. Office machines	20. Communication
5. Wood and products	13. Electrical goods	21. Finance and insurance
6. Paper, printing & publishing	14. Transport equipment	22. Real estate
7. Chemicals	15. Other manufactured products	23. Community, social and personnel services
8. Non-metallic mineral products	16. Electricity, gas and water	

We calculate weighted moments of sectoral relative price changes, where the weights in each year are the output share of a sector within each country.

The aggregate data for money growth and inflation are from the IMF International Financial Statistics (IFS). Inflation in each country is growth rate of the CPI (line 64), outside money is measured as base money (reserve money, line 14), while inside money is taken as M2 (line 351, the sum of lines 34 and 35). Data on aggregate unemployment are from the OECD Major Economic Indicators, while the world oil price in dollars is from the Federal Reserve Board Multi-Country Model. To obtain country-specific oil prices, we then multiply this world price by each country's exchange rate (IFS line rf).[11]

Table 1 provides summary statistics on the key variables in the data set. There is quite a bit of variation in average inflation rates--the range is from 3% a year in Germany to 11% a year in Italy. Overall, however, the period is characterized by moderate rates of both inflation and money growth.

[11] This neglects the role of domestic oil production in each country, something that might be important for countries such as the UK and Norway.

4. Evidence from panel vector autoregressions

Use of a vector autoregression methodology (VAR) allows us to formally model the dynamic relationships among the variables in the data set. For our cross-country panel of data, let t denote time, and i index the 13 countries. We pool the data for all countries and estimate a VAR of the form:

$$Z_{it} = A(L)\, Z_{it-1} + \theta_i + \varepsilon_t$$

where $A(L)$ is a one-sided polynomial in the lag operator (L), θ_i denotes a set of country-specific fixed effects and ε_t is a vector of normally distributed errors ("innovations").[12]

4.1 A "parsimonious" specification

To provide a flavor of our basic results without getting mired in a lot of detail, we first estimate a VAR which is parsimonious in terms of the number of variables. The vector Z includes three variables, which are ordered as follows:

1. money growth, measured by M2 growth	[M2]
2. inflation	[INFL]
3. skewness of relative price changes	[SKEW]

We include four lags of each variable. By ordering skewness (SKEW) last in the system, we provide a "lower bounds" estimate of the importance of skewness in accounting for inflation movements.

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[12] It is well-known that least squares estimates are biased in the presence of both fixed effects and lagged endogenous variables. However, as discussed by Nickell (1981) and Hsiao (1989, pp. 73-76), the bias is inversely proportional to the time dimension (T) of the panel; in our data set T is between 20 and 30, so that the size of the bias is likely to be small.

The estimated impulse responses (along with two standard error bands) are shown in Figure 1. The first row of graphs shows the response of the three variables to a one standard deviation innovation in M2 growth. As expected, an innovation in M2 growth leads to an increase in the inflation rate, with the peak impact being an increase in inflation of 0.7 percentage points. Skewness, however, does not show any response to a monetary shock. The middle row shows the response of the three variables to a one standard deviation innovation in inflation. Note again that there is only a modest response of skewness to an increase in inflation.

Finally, the last row of Figure 1 shows the response of the three variables to a one standard deviation *innovation* in skewness, where the innovation is defined as that part of skewness which is orthogonal to current and lagged values of M2 growth and inflation. The key result is that an innovation in skewness leads to a positive, and fairly persistent, increase in inflation. The estimated response is statistically different from zero and is also significant in economic terms: the peak impact of skewness on inflation is 0.5 percentage points.

4.2 An augmented VAR

We next add several variables to the system, and examine the impact of changes in the ordering of variables in the VAR. However, our estimate of the peak response of inflation to skewness turns out to be remarkably robust: across all specifications we find that an innovation in skewness leads to an increase in inflation of about 0.5 percentage points.

We add oil price growth (OIL), the standard deviation of relative price changes (SDEV), and the aggregate unemployment rate (UNEM) to the system presented above. The first two variables are included to test if skewness continues to play a role in accounting for inflation once these other measures of supply shocks are added to the system. Unemployment is added to allow for the possibility that labor market slack influences the inflation rate through a "Phillips curve" relationship.[13]

As before, we pool the data for all countries and estimate panel VAR's which include country fixed-effects. The vector Z now consists of six variables, identified by their mnemonics as OIL, UNEM, M2, SDEV, INFL, and SKEW. As before, we include four lags of each variable.

The numbered columns of Table 2 correspond to the six regressions estimated in our augmented VAR. The table shows values of the F-statistic for the null hypothesis that the four lags of the relevant variable can be excluded from the regression without loss of explanatory power. A large F-statistic (small significance level) indicates a rejection of the null, and indicates instead that the variable in a given row does forecast the variable listed at the top of the column. Two interesting findings emerge. First, looking down column (5), it is apparent that the data support a "multi-shock" view of inflation. With the exception of the standard deviation of relative price changes, SDEV, lags of all variables play a role in accounting for inflation movements. In particular, note that lags of the skewness of relative prices forecast inflation (F-statistic of 2.968, significance level of 0.02). Second, the results in column (6) show that with the surprising exception of UNEM, other variables in the system do not forecast movements in skewness. In particular, lags of inflation do not forecast skewness (F-statistic of 1.044, significance level of 0.39). Combined with the previous finding, this indicates that Granger-

[13] In our initial investigations, we also included an error-correction term, the lagged difference between the log of the price level and the log of M2. The inclusion of this term does not affect any conclusions about the short-run determinants of inflation, which is our primary focus here.

causality runs from skewness to inflation rather than the other way around.

While the F-statistics in Table 2 do not depend on the ordering of variables in the system, this is not true for the variance decompositions and impulse response functions that will be presented shortly. To provide some indication of how sensitive these results will be to the particular ordering chosen, Table 3 shows the correlations among the reduced-form errors, ε_t, of the estimated regressions. The correlations indicate that two choices are likely to be important in the ordering of the variables in the VAR. First, there is a large positive correlation between the innovations in oil price growth and inflation (the point estimate is nearly 0.6) and a smaller positive correlation between innovations in OIL and skewness (the point estimate is 0.2). In our benchmark case, we assume that innovations in OIL represent exogenous shocks driven largely by OPEC's policy decisions. That is, we assume that these correlations represent causality from OIL to inflation and skewness, and place OIL first in the VAR system.

However, it is possible that OPEC's pricing decisions were themselves a response to the erosion in the real purchasing power of oil revenues. Under this story, the inflation of the early 1970's was triggered by easy monetary policy in the United States and then exported to other countries through the Bretton Woods fixed exchange rate system. Since contracts on the world oil market were (and are) to a large extent denominated in dollars, inflation in the U.S. reduced the real value of oil revenues, prompting "corrective" actions by OPEC. We have tried to evaluate the merits of this story by estimating VARs without oil price growth. The idea is to gauge the extent to which measures of monetary policy, as reflected in the growth of monetary aggregates, provide an alternate explanation for the "world-wide" inflation of the 1970's and early

1980's.[14]

The second decision to be made in the ordering of the variables arises from the correlations between inflation and the other supply-side measures. As shown in the last column of Table 3, we find positive correlations between inflation (INFL) and the skewness (SKEW) and standard deviation (SDEV) of relative price changes. We thus present results under two alternate orderings, one in which inflation is placed ahead of one of the supply-side measures, and another where this ordering is reversed. Note that even in the ordering where skewness is placed ahead of inflation, an innovation to skewness is only that part of SKEW which is orthogonal to current and past values of oil price growth, unemployment and M2 growth. The remaining correlations shown in Table 3 are all fairly small, and we have verified that our results are not sensitive to the choice of ordering in these cases.

To summarize, we present results for the following two orderings:

Ordering I: OIL, UNEM, M2, SKEW, INFL, SDEV
("strong" assumptions about exogeneity of skewness)

Ordering II: OIL, UNEM, M2, SDEV, INFL, SKEW
("weak" assumptions about exogeneity of skewness)

As discussed above, we also present results for these two orderings with OIL excluded from the system, giving us a total of four cases to consider.

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[14] We also ran VAR's with oil price growth (OIL) placed after inflation in the ordering. It turned that the results of this specification were quite similar to simply dropping OIL from the VAR.

4.3 Variance decompositions from the augmented VAR

Table 4 presents the forecast error variance decompositions of inflation for the four cases. In describing the results, it will be useful to attach the label "short-run" to the variance decomposition of inflation at horizons of up to two years, and the labels "medium-run" and "long-run" for the three- to five-year and the ten-year horizons, respectively. Focusing first on panel (a) of the table, the following statements summarize the results:

i) Of the three supply-side measures, oil price growth plays a dominant role in accounting for the variance of inflation at all horizons. About a third of the variance of INFL is accounted for by OIL.

ii) Labor market slack, as measured by the aggregate unemployment rate, accounts for between 10 and 20 percent of the variation of inflation, depending on the horizon. The contribution of innovations in UNEM in accounting for short-run inflation is not surprising, but our results show that this contribution remains important even at longer horizons.

iii) The second supply-side measure, the skewness of relative price changes, plays a modest role in the variance decomposition of inflation. In the short-run, the contribution of innovations in SKEW rivals that of innovations in M2 growth, with both variables accounting for about 5 percent of the variance of inflation. As the horizon grows longer, however, the contribution of M2 outstrips that of SKEW. In the long-run, for instance, the contribution of M2 reaches 15 percent, while SKEW only accounts for about 6 percent. An important finding is that the contribution of SKEW is not sensitive to the two alternate orderings of the system.

iv) The performance of the final supply-side measure, the standard deviation of relative price changes, is sensitive to the ordering of the system. When SDEV is placed before inflation it explains about 6 percent of the variance of short-run inflation, but only 1 percent if placed after INFL.

v) Inflation exhibits considerable persistence. In the short-run, 40 percent of the variance of inflation is accounted for by its own lags, and this contribution remains high even in the long-run (33 percent).[15]

Moving next to panel (b) of Table 4, it is clear that when oil is excluded from the system, the major "beneficiary" is lagged inflation itself, rather than any of the other variables. In particular, there is no significant change in the proportion of the variance of inflation accounted for by M2 growth, indicating a lack of evidence for the alternative explanation of world-wide inflation sketched earlier. The contribution of skewness to short-run inflation goes up a bit, with the range now being between 6 percent and 11 percent. This suggests that the impact of oil prices on inflation works through the Ball-Mankiw "menu-cost" channel to some extent.

4.4 Impulse responses from the augmented VAR

The complete set of impulse responses (along with two standard error bands) for the four cases are contained in Figures A.1 to A.4 in the Appendix.[16] With one exception, the response

[15] One possible explanation for the high contribution of the own lags is that there are shocks beyond those considered here; for instance, "exogenous" movements in exchange rates are often mentioned as a source of short-run inflation. Another possibility is that there is substantial inertia in the process of formation of inflation expectations, and this in turn leads to considerable persistence in actual inflation rates.

[16] The standard errors were computed by the Monte Carlo method described in example 10.1 in the 1990 RATS manual, using 1000 draws from the estimated asymptotic distribution of the VAR coefficients and the covariance matrix of the innovations. The point estimate and standard errors are the average and standard deviation across draws of the simulated impulse responses.

of inflation to all the variables in the system is significantly different from zero. The exception has to do with the impact of the standard deviation of relative price changes: in cases where SDEV is placed after INFL, the estimated response is not significantly different from zero.

In figures 2 and 3, we focus on the response of inflation to innovations in oil price growth, M2 growth, and skewness. Standard error bands are omitted from these figures to avoid clutter. We present the results from ordering II, which is least favorable for skewness. From Figure 2 we see that a one standard deviation innovation in oil price growth increases the inflation rate contemporaneously by 1 percentage point. The impact persists at this level for a year before decaying slowly to zero by the fourth year.

From Figure 3 we see that the response of inflation to one standard deviation innovations in M2 growth and skewness is quite similar in the short-run. For example, an innovation in skewness raises the inflation rate in the second year by about 0.5 percentage points. In the medium-term, the impact of M2 growth on inflation is much stronger than that of skewness. Of the variables considered in this study, oil prices best account for the co-movement in inflation rates across countries. Figure 4 shows that the impulse response of inflation to skewness from the augmented VAR is quite similar--both qualitatively and quantitatively--to that from the parsimonious VAR presented at the beginning of this section.

While the variance decomposition shows that the contribution of skewness in explaining inflation is fairly modest, the impulse responses show that the point estimate of the response of inflation to an innovation in skewness is quite large in an economic sense. This means that while "skewness shocks" are not a pervasive feature of the data, in the years in which they do occur such shocks play an important role in accounting for movements in inflation.

5. Sensitivity Analysis

We next examine the sensitivity of our results to several changes in the specification, and test whether the determinants of inflation differ across countries.

5.1 Cross-country differences

We have thus far assumed that the estimated coefficients in the VAR system are identical across all countries. To investigate whether this masks interesting differences across countries, we estimated the augmented VAR separately for the following three country blocs:[17]

1. North America	USA and Canada
2. Nordic bloc	Denmark, Norway, Sweden, Finland
3. Rest of Europe	UK, Belgium, France, Germany, Italy, Netherlands

We report results only for Ordering II (the ordering is OIL, UNEM, M2, SDEV, INFL, SKEW); the main results do not change appreciably for the other orderings.

The response of inflation to skewness for the three country blocs is shown in Figure 5. Note that because SKEW is ordered last in the system, the contemporaneous response is restricted to be zero in all three cases. But some differences emerge in subsequent years. While the overall shape of the response is the same across countries, the impact of skewness on inflation is higher in the Nordic countries than in the other two blocs. For instance, the peak impact of skewness on inflation in the Nordic countries is 0.7 percentage points, compared to 0.4

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[17] Since there is no reason to believe that mere geographical proximity leads to similarity in inflation behavior, these blocs should perhaps be regarded simply as a way of demonstrating that our results are not driven by a few "outlier" countries. We did attempt a couple of more interesting ways of grouping the countries, the first of which involved distinguishing countries that were significant oil-producers from others. As a first pass, we were unable to spot differences between the two groups, for example in the contribution of oil price shocks to inflation. Second, we separated countries that had "high" average inflation over the period from the others, the hypothesis being that nominal rigidities should be less important in the former group. Here again, we could not find evidence in support of the hypothesis, though this may simply reflect the fact that in our sample the "high" average inflation range is only 8% to 11% a year.

percentage points in the other two blocs. In terms of the variance decomposition, skewness accounts for about 15 percent of the short-run variance of inflation in the Nordic countries, compared to only about 6 percent in Europe and North America.

Figure 6 shows that the response of inflation to innovations in M2 growth is also different in the Nordic countries. The contemporaneous impact on inflation is actually negative, and the medium-run impact, while positive, reaches a peak of only 0.3 percentage points. For the other two country blocs, the shape of the impulse response is quite similar to the "average" response across all countries shown in Figure 3. While the peak response of inflation to a monetary innovation is about 0.8 percentage points for both country blocs, Figure 6 shows that M2 growth plays a much more important role in short-run inflation in the U.S. and Canada than in other countries. M2 growth also accounts for a larger portion of the variance of inflation in the North American block--17 percent in the short-run and 28 percent in the long-run, compared with about 12 percent in the short-run and 17 percent in the long-run in Europe.

5.2 Interaction of skewness and standard deviation

As discussed in Section 2, the Ball-Mankiw theory suggests that an increase in SDEV should magnify the effects of skewness on inflation. To test whether this prediction is borne out, we add to the system a variable INTER which is the product of the variables SDEV and SKEW. We use a variant of our ordering II; that is, the variables are ordered: OIL, UNEM, M2, SDEV, INFL, SKEW, INTER. Figure 7 demonstrates that inflation responds positively to innovations in INTER, which is consistent with the theory.[18] However, the quantitative impact of skewness

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[18] Figure A.5 in the Appendix contains the complete set of impulse responses.

on inflation is not altered by the inclusion of INTER--the peak impact is 0.5 percentage points, with the impact of INTER at that horizon only about half as large as that of skewness.

5.3 Inside money vs. outside money

Some extensions of the "classical" approach to inflation make a distinction between the roles of inside and outside money. Fama (1983), for instance, hypothesizes that it is fluctuations in the monetary base that should be the principal determinant of inflation, rather than movements in broader aggregates that include deposits. On the other hand, Boschen and Talbot (1991) argue that "if currency and some classes of deposits are imperfect but still very close substitutes, then changes in the quantity of either deposits or currency can have similar effects on the price level." Boschen and Talbot's careful empirical study suggests that monetary base growth and the growth rate of the multiplier both play important roles in accounting for inflation in post-WWII data for the United States.

To address this issue, we decompose M2 growth into monetary base growth (referred to as BASE) and the growth rate of the multiplier between M2 and the base (labelled MULT). The variables are again ordered as in ordering II, with the exception that BASE and MULT take the place of M2: OIL, UNEM, BASE, MULT, SDEV, INFL, SKEW. As shown from the resulting impulse-responses in Figure 8, the findings from our cross-country data set are similar in spirit to Boschen and Talbot's findings for the U.S. alone. Innovations in base growth as well as innovations in multiplier growth lead to increases in inflation; in fact, the impact of multiplier growth dominates that of base growth.[19] Again, however, the response of inflation to the supply-

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[19] The complete set of impulse responses is shown in Figure A.6 in the Appendix.

side measures--oil price growth, SDEV and skewness--is not affected by the decomposition of M2 growth into inside money and outside money.

5. A summary of our findings

Our evidence suggests that in order to account fully for the short-run behavior of inflation, it is essential to allow for shocks from many different sources. We find that both money growth and supply-side shocks play a role in inflation; in addition, the state of the labor market, measured here by the unemployment rate, plays an important role.

Our study considers three sources of supply-side influences, (i) oil price shocks, (ii) the standard deviation of relative price changes (SDEV), and (iii) the skewness of relative price changes. Oil prices play a key role, accounting for over 30 percent of the variance in short-run inflation. This predominance comes about because oil prices are best able to account for the co-movement in inflation rates across many OECD countries in the 1970s and early 1980s. Our evidence also suggests that the impact of oil prices on inflation works partly through the "menu costs" channel. The contribution of SDEV is less important than that of oil, and it also turns out that it plays a significant role in inflation only under the identifying assumption that causality runs from SDEV to inflation.

Ball and Mankiw (1995) have suggested the use of skewness as a new measure of supply-side influences. An important difference between our empirical work and that of Ball-Mankiw is that we present evidence on the response of inflation to *innovations* in skewness. In most cases, the innovation in skewness refers to the component of skewness that is orthogonal to current and lagged values of the inflation rate itself, as well as current and lagged values of money growth, oil prices, unemployment and SDEV. Hence, the impact of skewness on inflation that we document cannot be attributed to reverse-causality from inflation to skewness; nor can it be easily attributed to the influence of an omitted "third factor," since the impact of the most important candidates for the third factor is already accounted for. Despite these stringent identifying assumptions, innovations in skewness lead to an increase in short-run inflation of 0.5 percentage points. This quantitative estimate is robust to numerous changes in identifying assumptions, as well as changes in the set of variables considered. We also provide evidence on cross-country variations in the impact of skewness on inflation. The differences are modest, with the impact being somewhat larger in the Nordic countries than in others.

Finally, we find that an innovation in M2 growth leads to an increase in inflation of about 0.5 percentage points in the short-run. There are some cross-country differences, with M2 growth more important for inflation in the U.S. and Canada than in the Nordic countries. Contrary to some theories, we find that both outside money (monetary base growth) and inside money (growth rate of the money multiplier) matter for inflation. The importance of money growth, relative to supply-side influences, increases in the long-run.

Overall, the results support a hybrid theory of the determination of inflation, one in which the supply-side sources suggested by menu-cost models play a significant role in short-run inflation, while the money growth suggested by classical models plays an increasingly important role as the time horizon lengthens.

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Table 1: Summary Statistics

Country	obs	base growth	M2 growth	unemploy-ment	skewness	inflation
All	327	0.080 (0.09)	0.107 (0.06)	5.19 (3.24)	-0.091 (1.35)	0.064 (0.04)
US	29	0.062 (0.03)	0.084 (0.03)	6.11 (1.63)	0.117 (1.53)	0.049 (0.03)
UK	27	0.074 (0.09)	0.142 (0.12)	6.15 (3.44)	-0.383 (1.00)	0.082 (0.05)
Belgium	27	0.038 (0.04)	0.082 (0.03)	6.50 (3.94)	-0.191 (1.52)	0.052 (0.03)
Denmark	21	0.081 (0.24)	0.107 (0.06)	6.74 (3.20)	-1.216 (1.81)	0.075 (0.03)
France	27	0.065 (0.09)	0.119 (0.09)	5.50 (3.25)	0.186 (1.04)	0.067 (0.03)
Germany	30	0.067 (0.06)	0.088 (0.03)	4.12 (3.29)	-0.120 (0.65)	0.034 (0.02)
Italy	20	0.137 (0.04)	0.138 (0.05)	8.60 (2.32)	0.324 (1.16)	0.112 (0.05)
Netherlands	21	0.074 (0.03)	0.091 (0.04)	6.71 (3.54)	0.999 (1.87)	0.047 (0.03)
Norway	27	0.067 (0.05)	0.108 (0.04)	2.25 (0.97)	-0.345 (0.99)	0.070 (0.03)
Sweden	20	0.102 (0.10)	0.093 (0.04)	2.26 (0.61)	0.024 (1.56)	0.081 (0.02)
Canada	28	0.077 (0.04)	0.109 (0.05)	7.03 (2.33)	0.201 (1.30)	0.056 (0.03)
Japan	20	0.102 (0.07)	0.111 (0.04)	2.14 (0.50)	-0.157 (1.24)	0.053 (0.05)
Finland	30	0.124 (0.14)	0.125 (0.04)	3.57 (1.75)	-0.492 (1.11)	0.073 (0.04)

Note: 1. standard deviation in parentheses
2. skewness is weighted by industry output

Table 2: F-statistics from Augmented VAR

	(1) oil price growth	(2) unemploy-ment	(3) M2 growth	(4) std dev of relative price changes	(5) inflation	(6) skewness of rel. price changes
	OIL	UNEM	M2	SDEV	INFL	SKEW
oil price growth	4.731 (0.00)	2.832 (0.03)	3.287 (0.01)	0.833 (0.51)	4.476 (0.00)	1.455 (0.22)
unemployment	6.284 (0.00)	381.959 (0.00)	0.189 (0.94)	0.097 (0.98)	8.996 (0.00)	4.535 (0.00)
M2 growth	1.538 (0.19)	2.347 (0.06)	3.267 (0.01)	0.967 (0.43)	4.132 (0.00)	1.267 (0.28)
std deviation of rel. price changes	0.131 (0.97)	0.434 (0.78)	0.550 (0.70)	1.040 (0.39)	1.082 (0.37)	0.516 (0.72)
inflation	3.241 (0.01)	4.087 (0.00)	0.831 (0.51)	1.516 (0.20)	21.676 (0.00)	1.044 (0.39)
skewness of rel. price changes	4.320 (0.00)	0.969 (0.43)	0.725 (0.58)	0.742 (0.56)	2.968 (0.02)	0.963 (0.43)
R^2	0.287	0.950	0.272	0.169	0.806	0.268

Note: significance levels in parentheses.

Table 3: Correlations matrix of innovations

	M2	unemploy-ment	std deviation	skewness	inflation
oil price	-0.019	0.056	-0.047	0.200	0.576
M2		-0.031	-0.069	-0.033	-0.045
unemployment			-0.085	-0.051	-0.056
standard deviation				-0.053	0.212
skewness					0.188

Table 4: Variance decompositions of inflation under alternate orderings of skewness and inflation

(a) with OIL

year	Strong assumptions about exogeneity of skewness						Weak assumptions about exogeneity of skewness					
	OIL	UNEM	M2	SKEW	INFL	SDEV	OIL	UNEM	M2	SDEV	INFL	SKEW
0	33.2	0.8	0.1	0.5	65.4	--	33.2	0.8	0.1	5.4	60.5	--
1	37.4	9.2	0.4	2.1	50.1	0.7	37.4	9.2	0.4	6.2	45.5	1.3
2	33.9	13.7	4.2	5.0	42.0	1.2	33.9	13.7	4.2	6.2	38.0	4.1
3	31.3	15.0	9.4	5.2	38.0	1.1	31.3	15.0	9.4	5.6	34.5	4.2
4	29.2	15.8	11.7	6.2	36.1	1.1	29.2	15.8	11.7	5.2	33.1	5.1
5	28.0	16.4	13.3	6.5	34.6	1.1	28.0	16.4	13.3	5.1	31.8	5.4
10	26.7	17.5	14.9	6.4	33.3	1.2	26.7	17.5	14.9	5.1	30.4	5.4

(b) without OIL

year	Strong assumptions about exogeneity of skewness						Weak assumptions about exogeneity of skewness					
	OIL	UNEM	M2	SKEW	INFL	SDEV	OIL	UNEM	M2	SDEV	INFL	SKEW
0	--	0.1	0.7	2.6	96.7	--	--	0.1	0.7	4.2	95.2	--
1	--	5.6	0.5	6.8	86.6	0.5	--	5.6	0.5	5.3	86.5	2.1
2	--	9.2	4.3	11.3	74.3	1.0	--	9.2	4.3	5.4	75.1	6.0
3	--	10.7	9.7	11.4	67.3	0.8	--	10.7	9.7	4.8	68.4	6.3
4	--	11.6	12.7	12.1	62.8	0.9	--	11.6	12.7	4.5	64.2	6.9
5	--	12.1	14.4	12.5	59.9	1.0	--	12.1	14.4	4.5	61.5	7.4
10	--	13.7	15.8	12.2	57.2	1.2	--	13.7	15.8	4.6	58.6	7.4

Figure 1

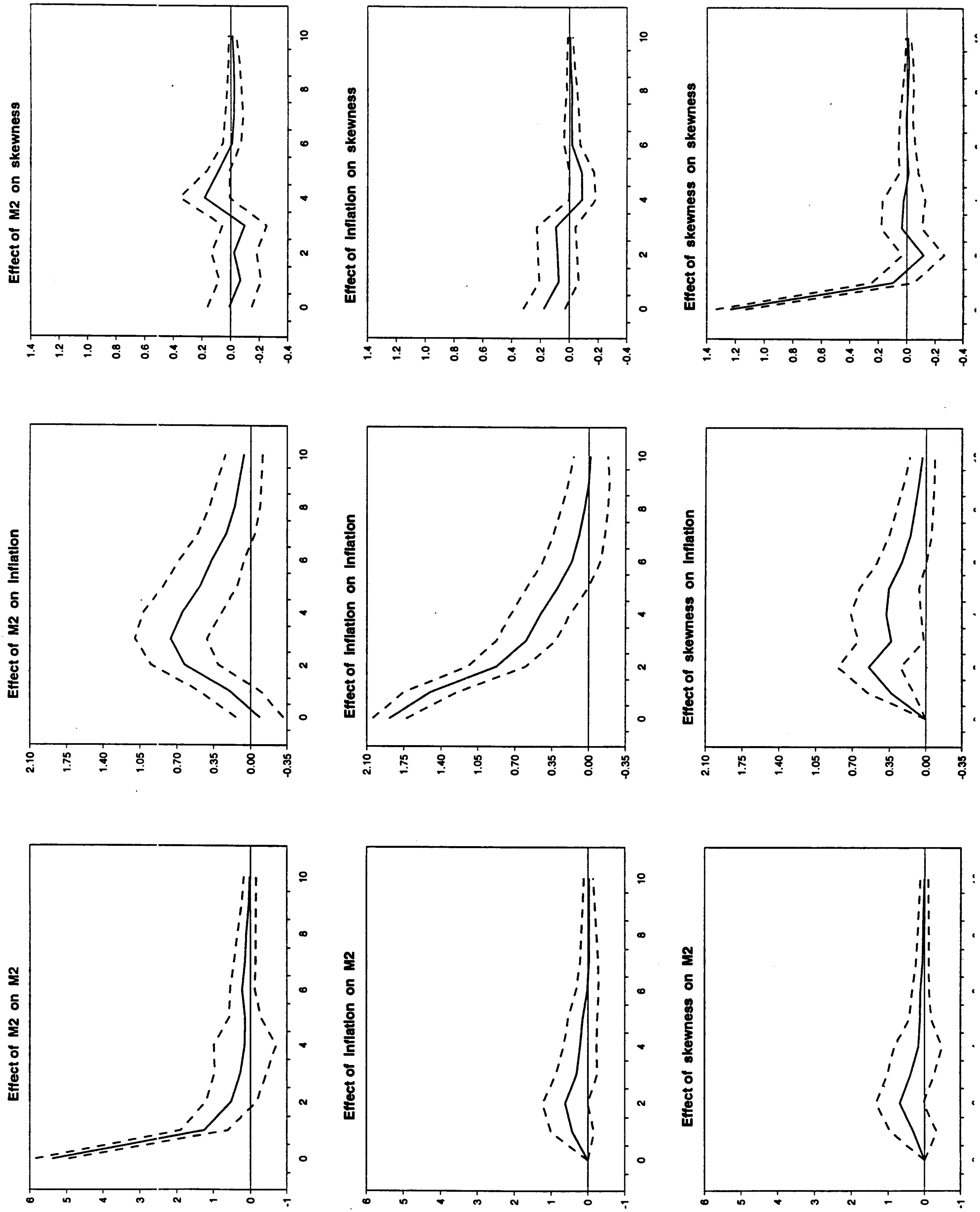
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Figure 2
Response of inflation to oil prices

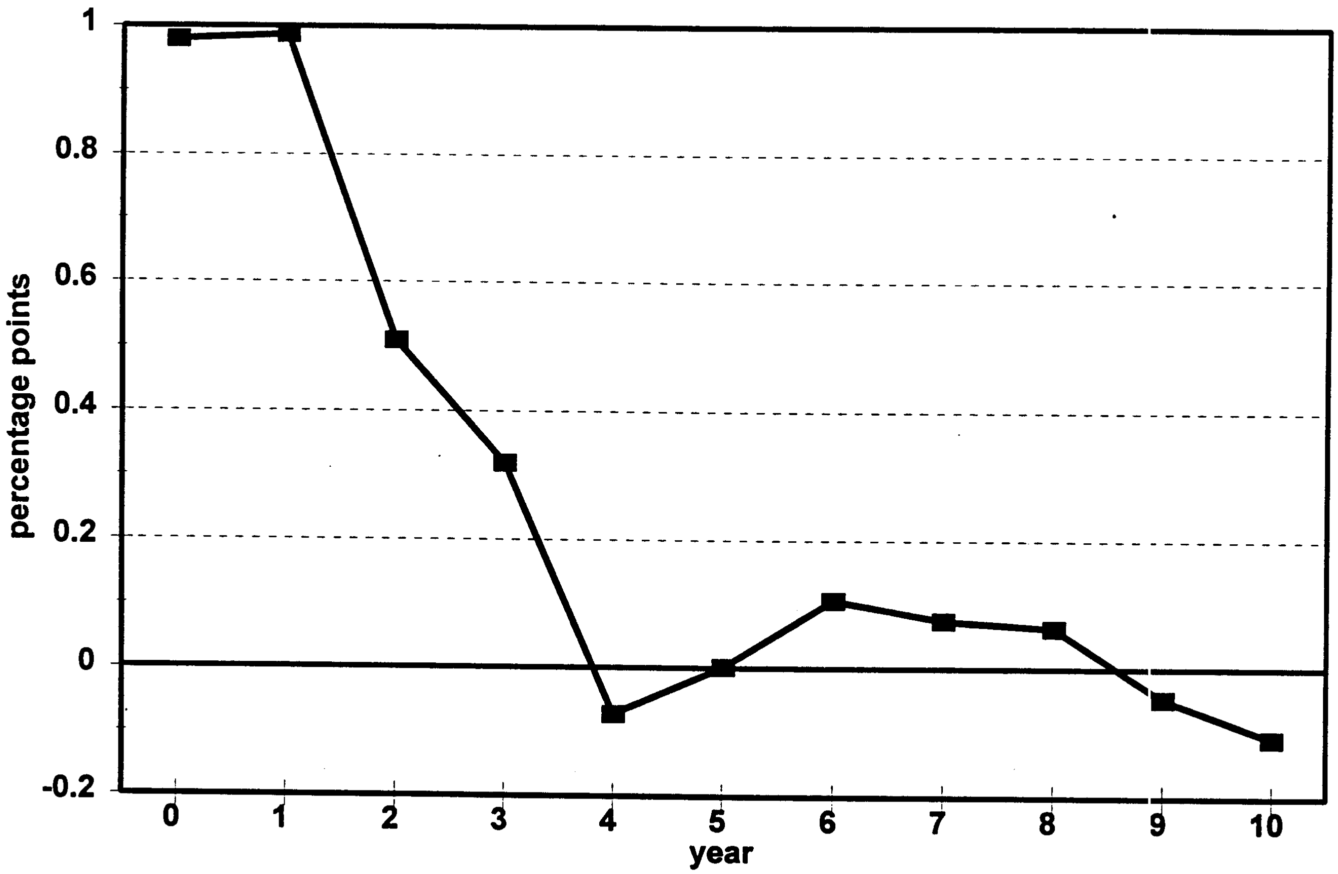


Figure 3
Response of inflation to M2 & skewness

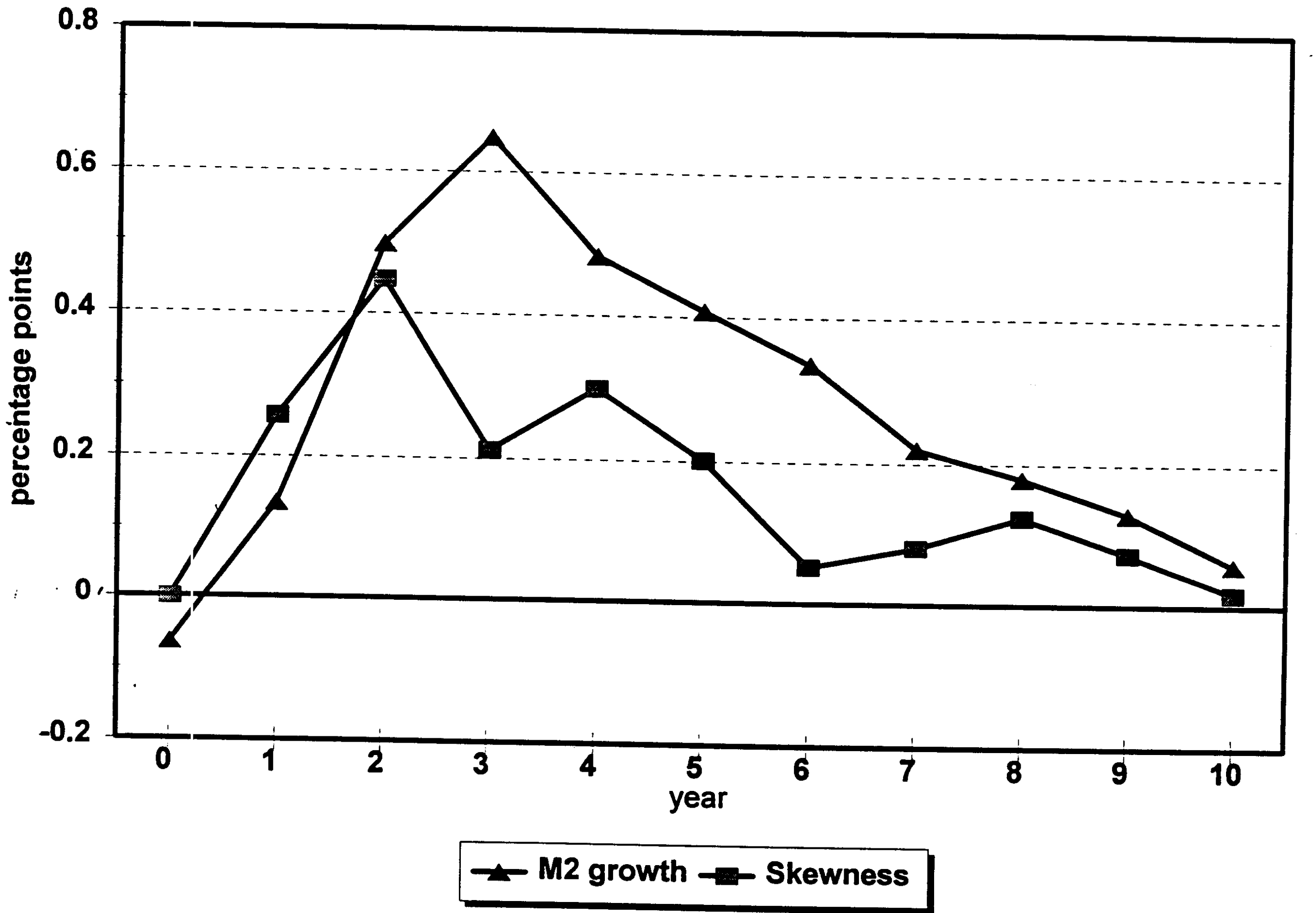


Fig. 4: Response of INFL to skewness
Parsimonious vs. augmented VAR

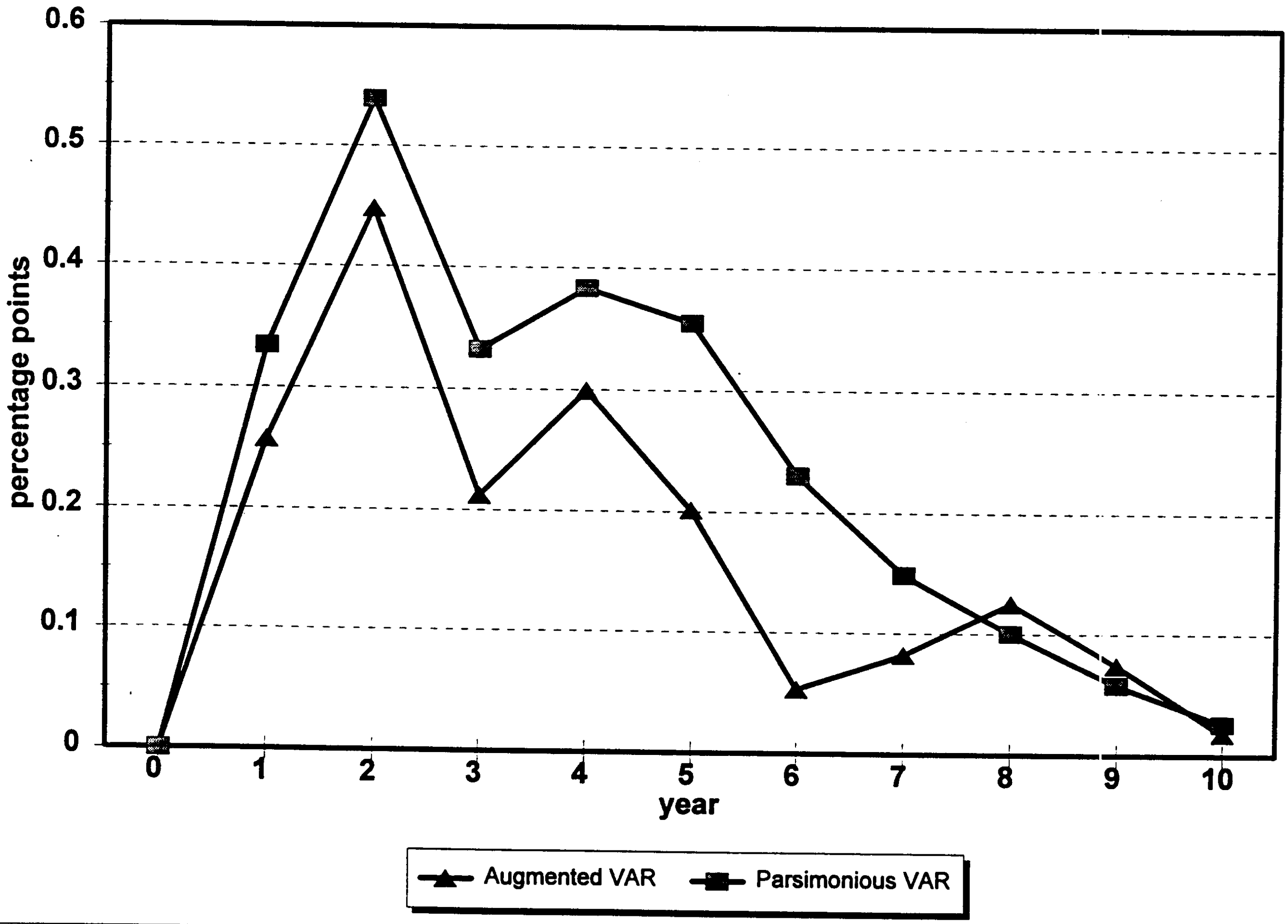


Fig. 5: Response of INFL to skewness
Cross-country comparison

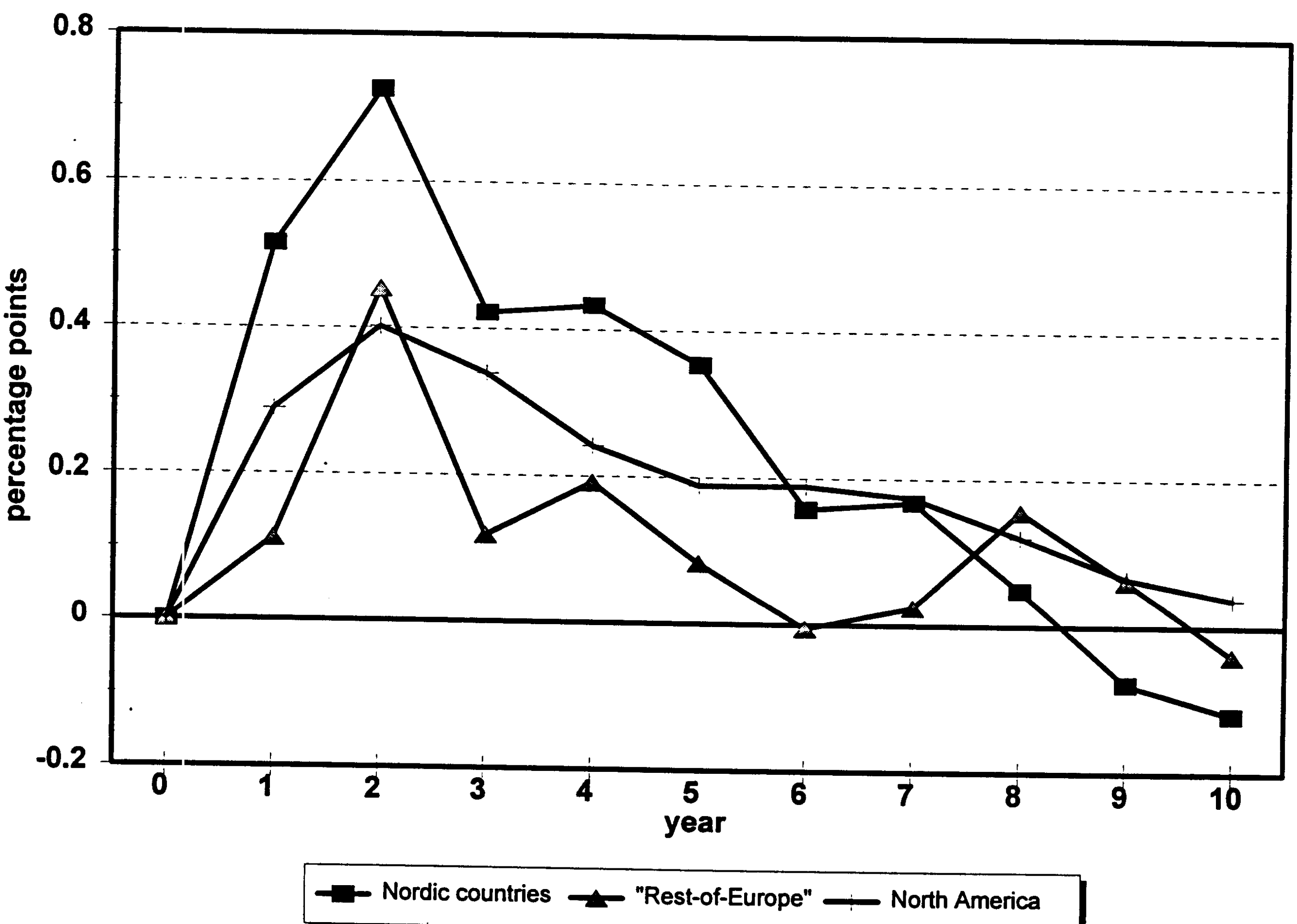


Fig. 6: Response of inflation to M2
Cross-country comparison

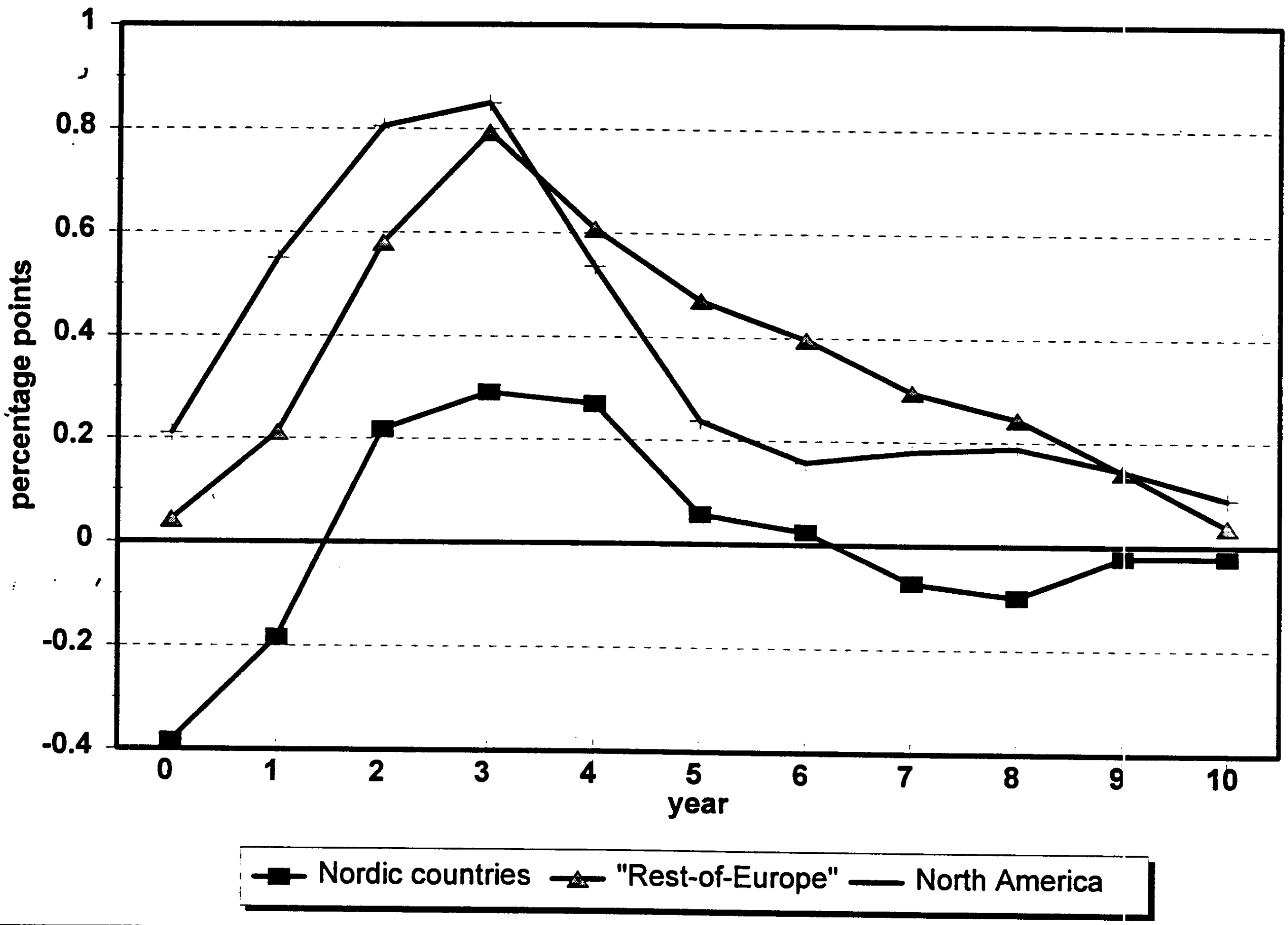


Fig. 7: Response of inflation

Interaction of skewness and SDEV

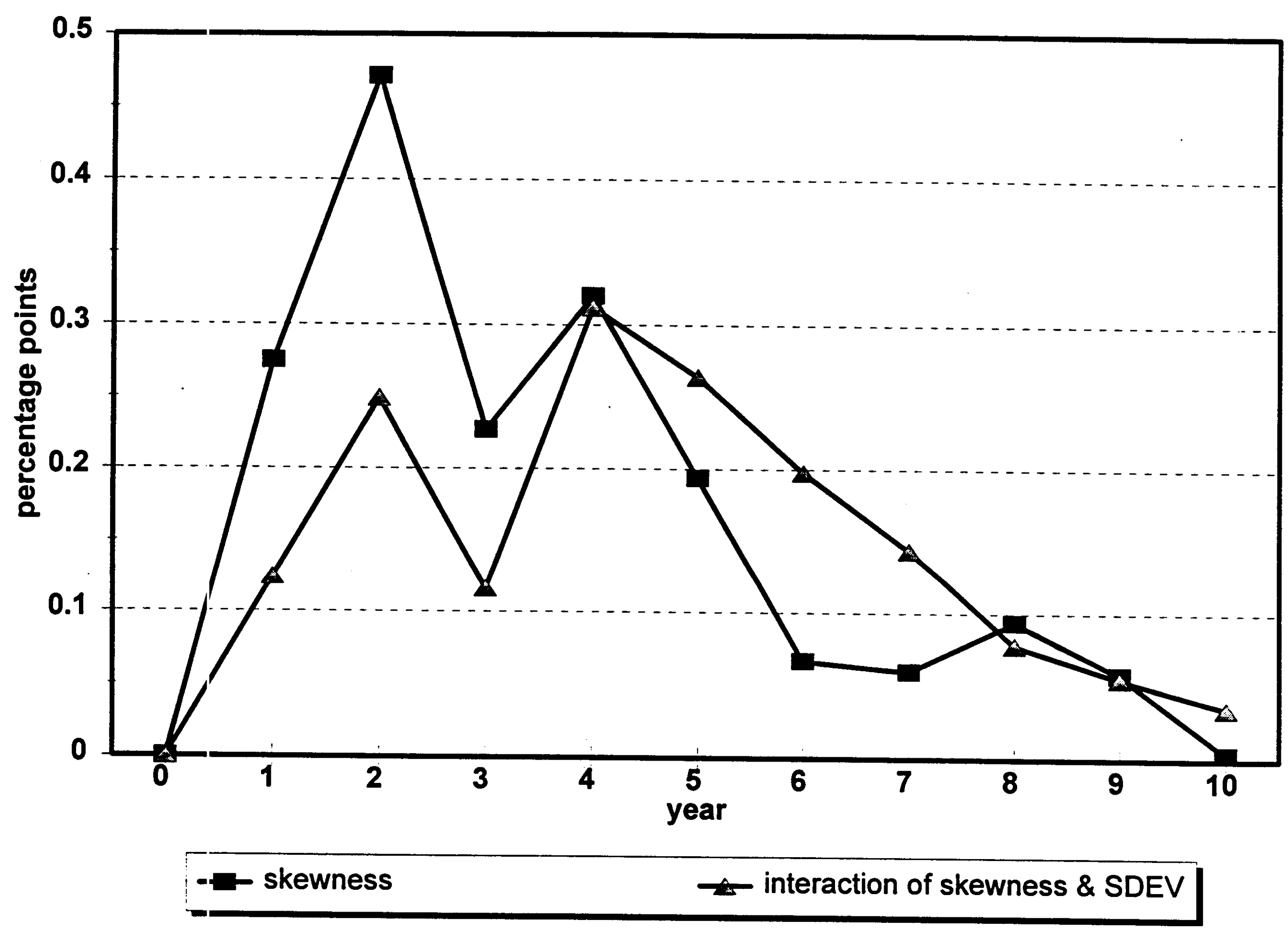


Fig. 8: Response of inflation
Comparison of base and multiplier

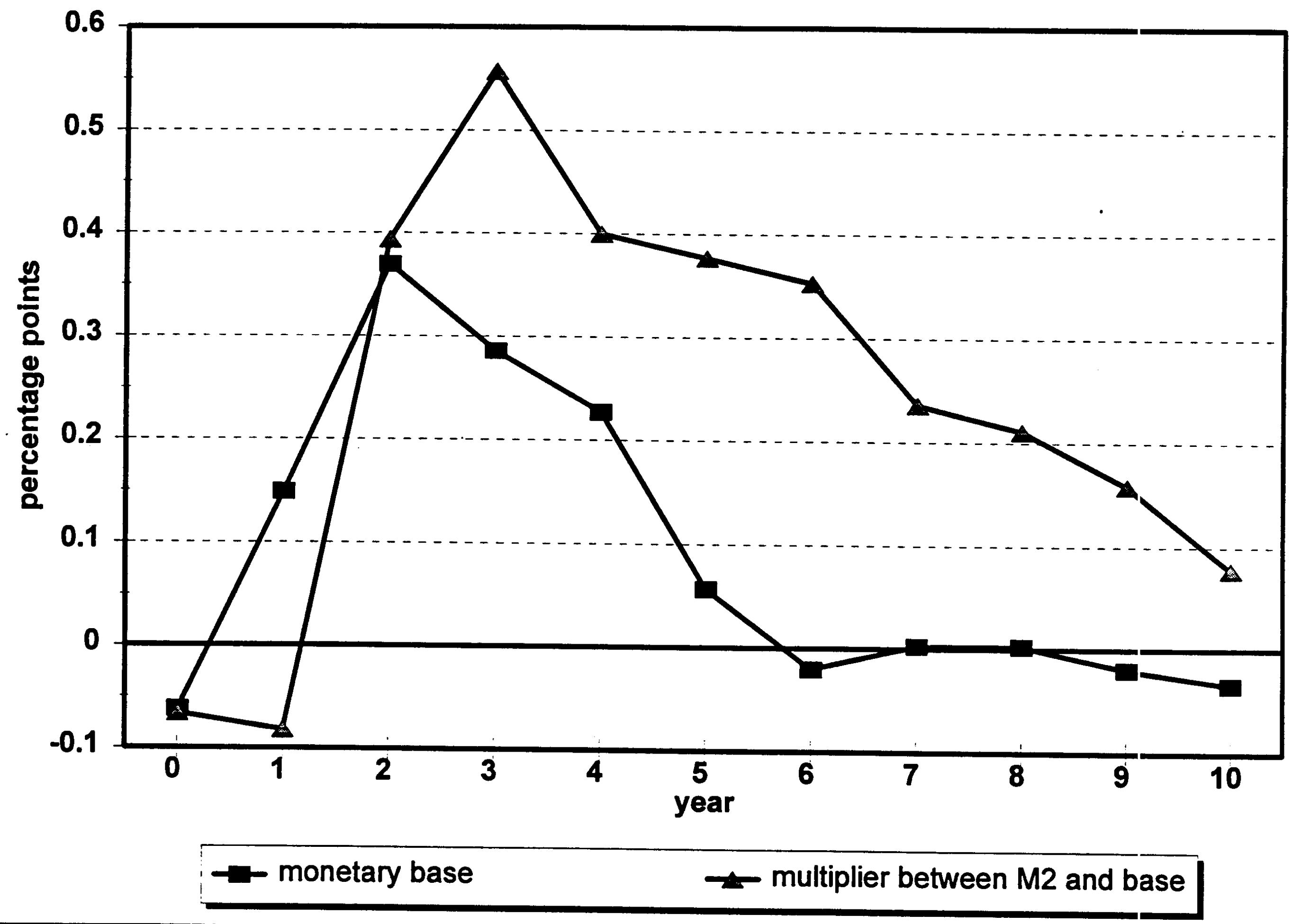


Figure A.1: ORDERING I

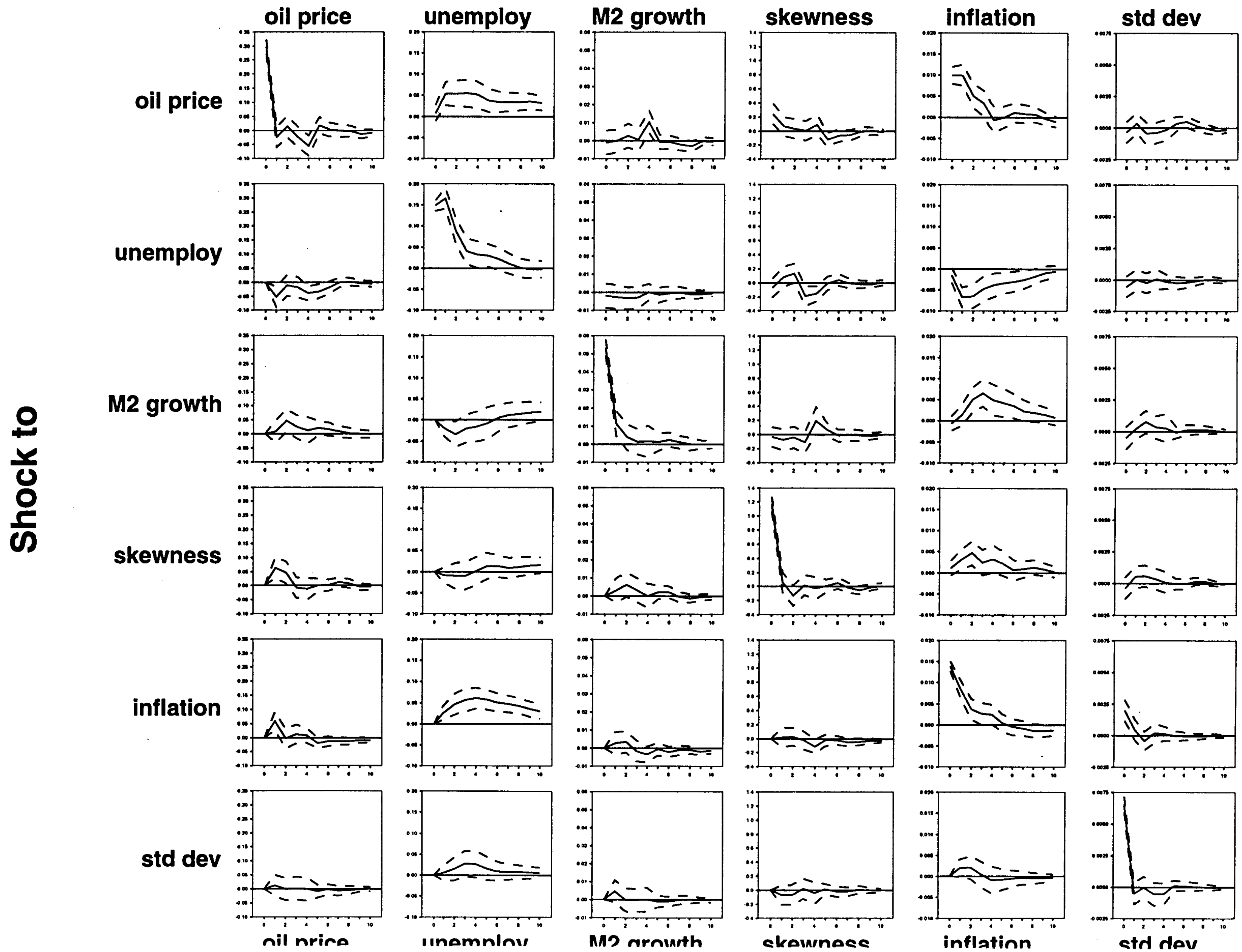


Figure A.2: ORDERING II

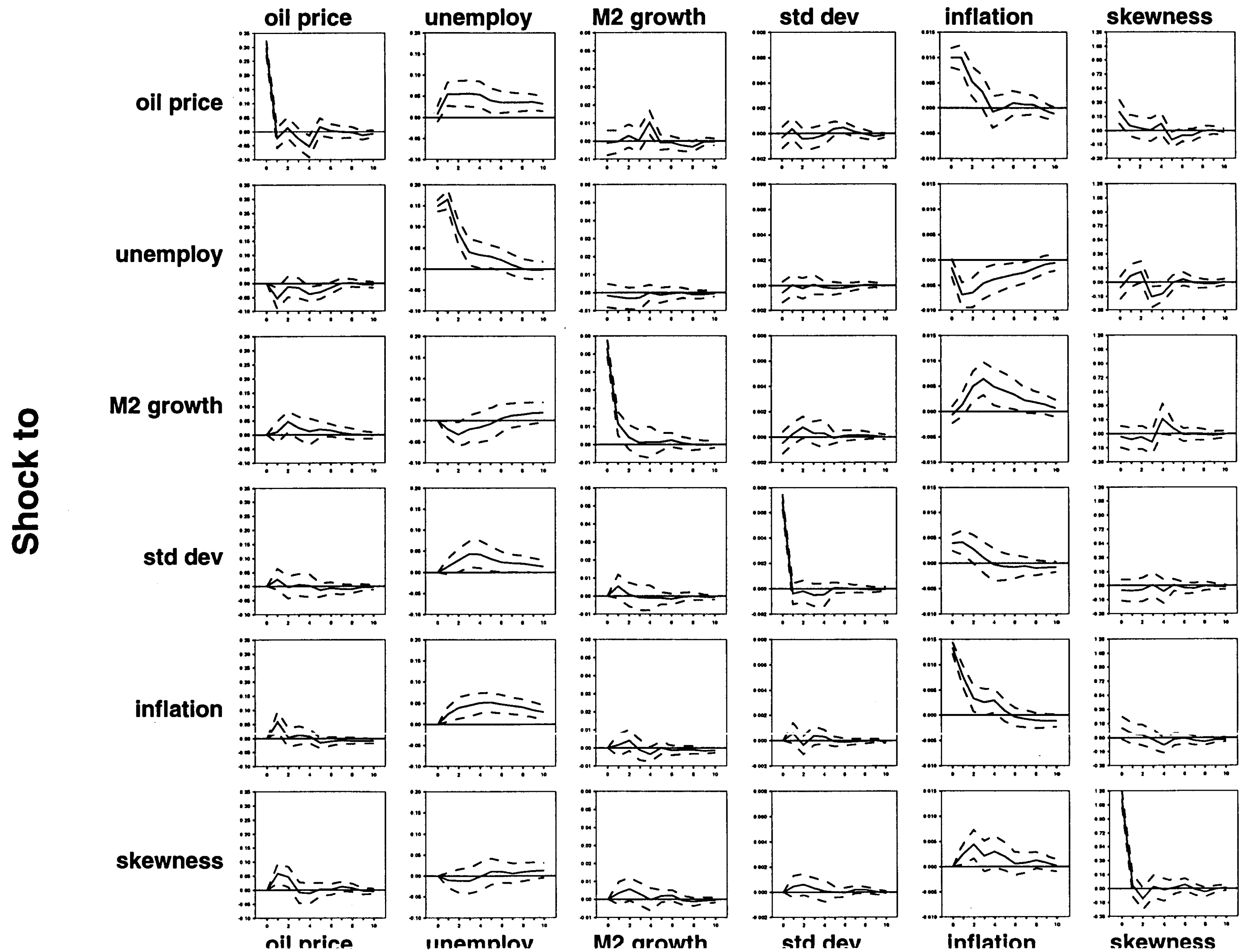


Figure A.3: ORDERING I, without OIL

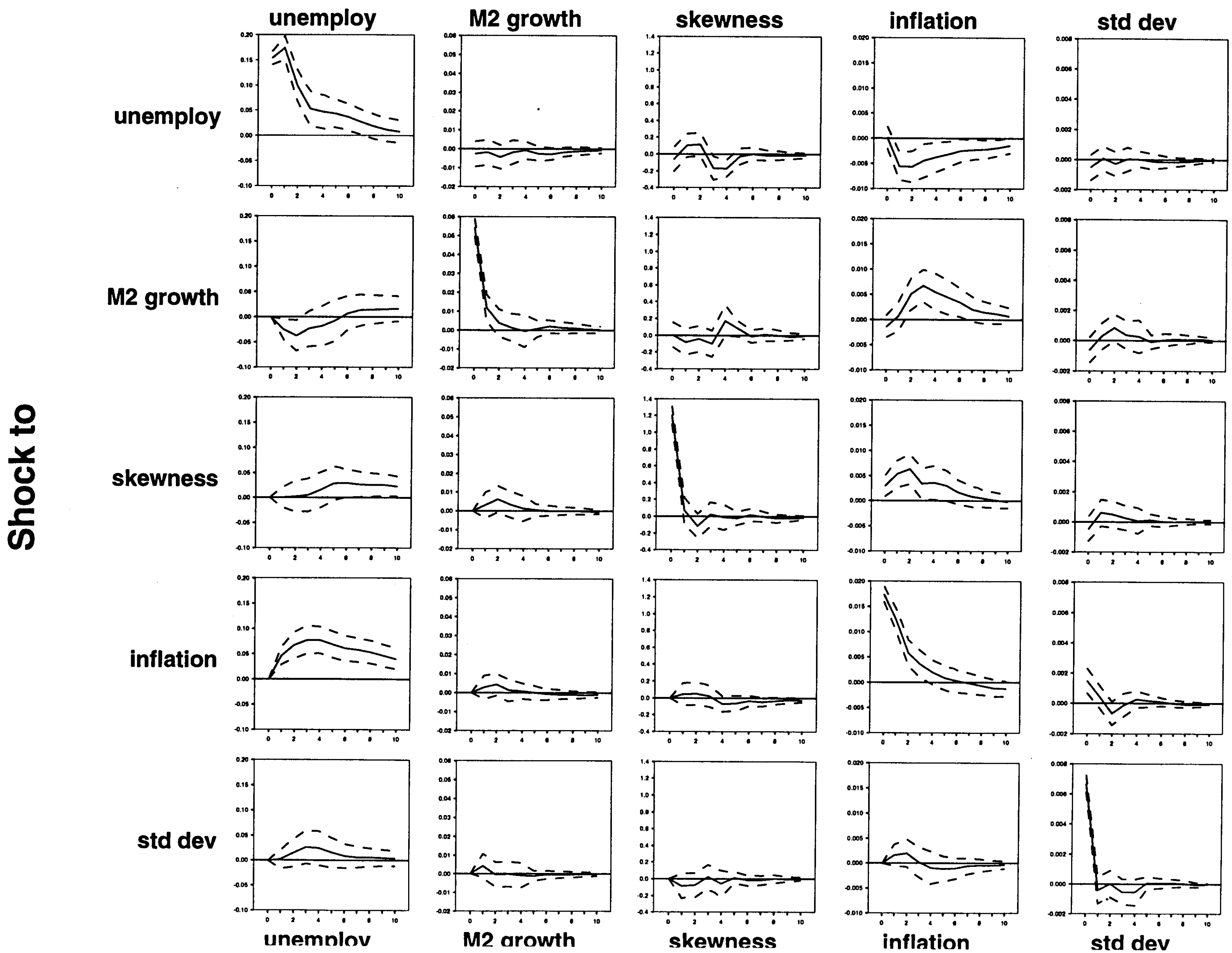


Figure A.4: ORDERING II, without OIL

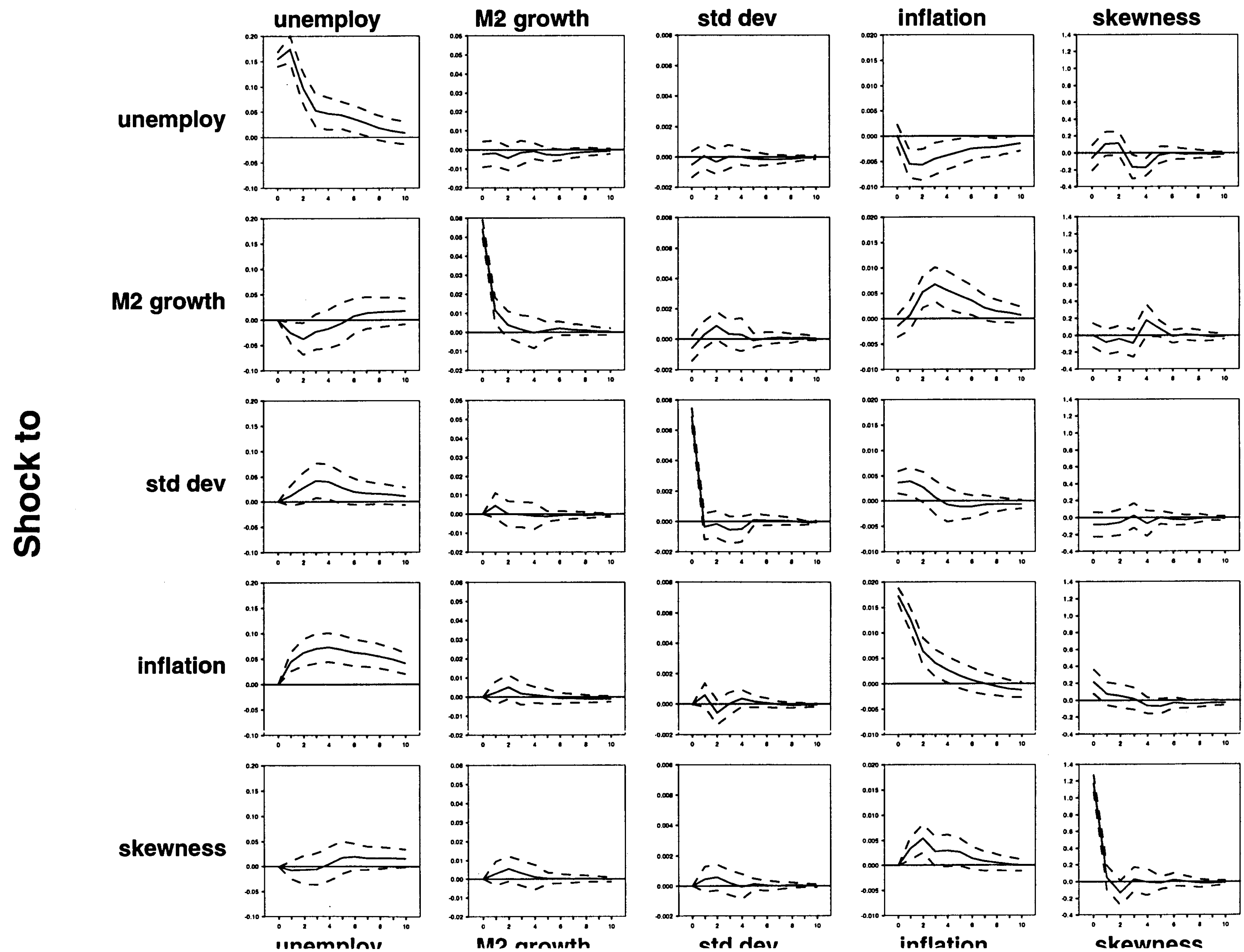


Figure A.5: ORD. II, with interaction of SDEV and SKEW

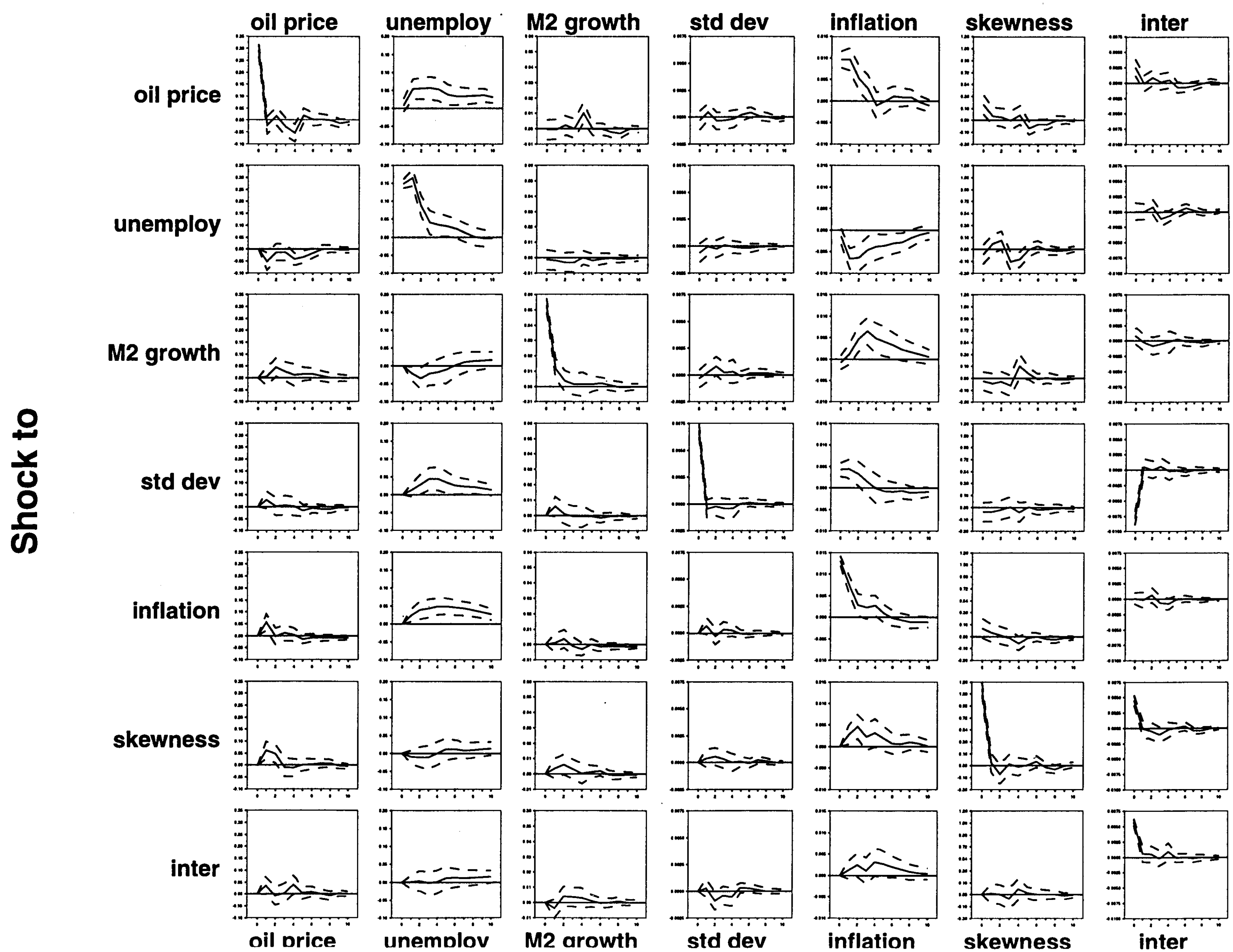
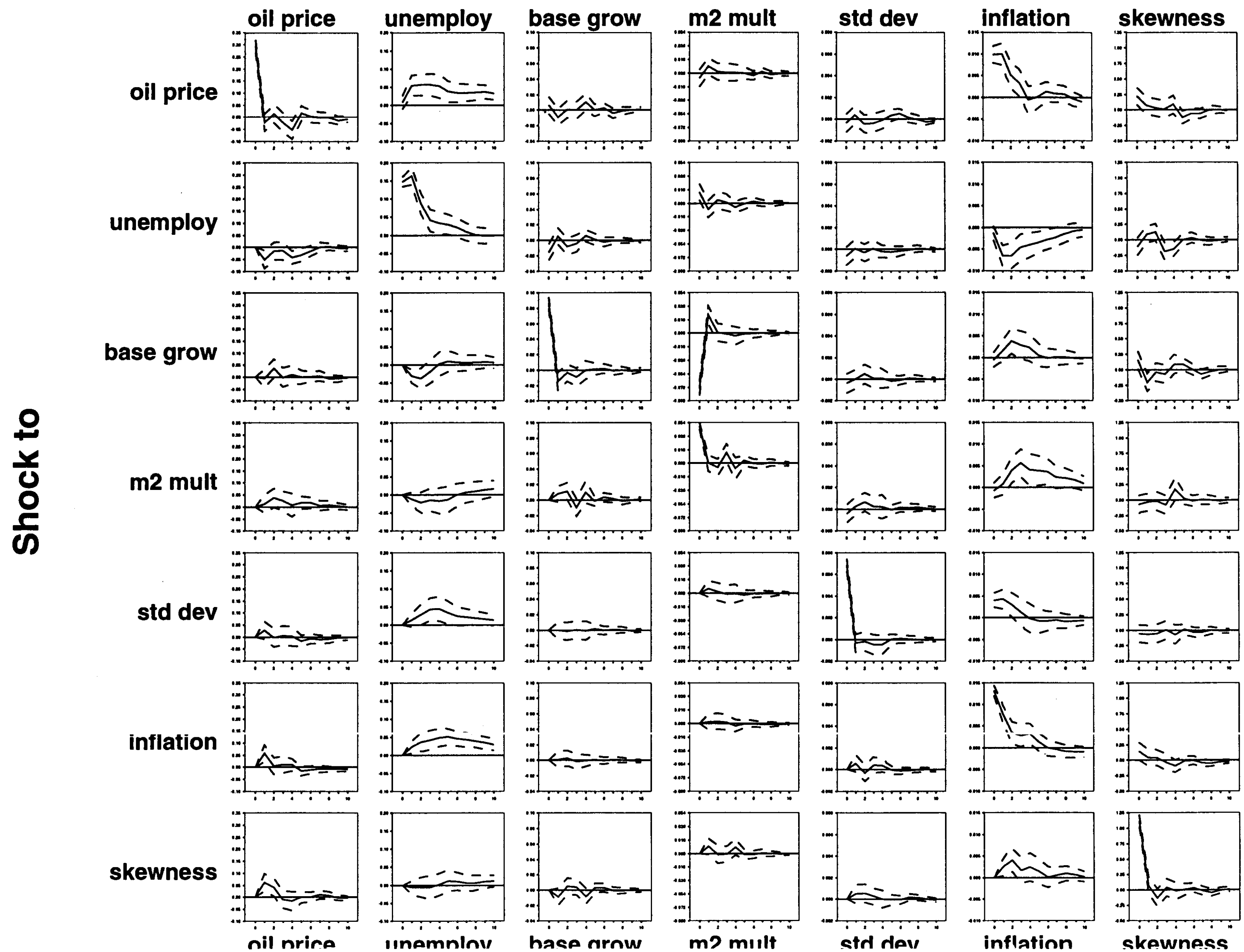


Figure A.6: ORD. II, with Base Growth and M2 Multiplier



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