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ABSTRACT

The Effects of Exogenous Oil Supply Shocks on Output and Inflation: Evidence from the G7 Countries

Using state-of-the-art methods, this study estimates and compares the effects of exogenous shocks to global oil production on seven major industrialized economies. The main findings are: (1) There is a fair degree of similarity in the real growth responses. An exogenous oil supply disruption typically causes a temporary reduction in real GDP growth that is concentrated in the second year after the shock. (2) Inflation responses are more varied. The median CPI inflation response peaks after three to four quarters. There is clear evidence that exogenous oil supply disruptions need not generate sustained consumer price inflation. Evidence of sustained inflation (as in the case of Germany) therefore must reflect a favourable institutional environment. (3) The evidence of stagflationary responses is strongest for Germany, Japan and Canada, whereas for the US, the UK and Italy there is little or no evidence of stagflationary responses to oil supply shocks. (4) As measured by cumulative inflation and real growth responses, some countries such as Italy, France and Japan have fared well when faced with exogenous oil supply disruptions, whereas others such as Germany have not. (5) A counterfactual historical exercise suggests that the evolution of CPI inflation in the G7 countries would have been similar overall to the actual path even in the absence of exogenous shocks to oil production, consistent with a monetary explanation of inflation. There is no evidence that the 1973/74 and 2002/03 oil supply shocks had a substantial impact on real growth in any G7 country, but for some G7 countries the 1978/79, 1980, and 1990/91 shocks had some impact.

JEL Classification: E31, E32 and Q34
Keywords: counterfactual, dynamic effects, exogeneity, inflation, oil supply and real GDP growth and stagflation

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1. Introduction

There is a large empirical literature on the effects of exogenous variations in the supply of oil on macroeconomic and industry aggregates.[1] Much of that literature has focused on the United States. The experience of other countries has remained understudied, notwithstanding some notable early exceptions such as Bohi (1989) who informally compared the inflation and real output experiences of Japan, Germany, the United Kingdom and the United States during the oil shocks of the 1970s. A more recent example of an international comparison of the effects of oil shocks is Mork et al. (1994). In this paper I focus on the set of G7 countries comprised of the United States, Canada, Japan, France, Germany, Italy and the United Kingdom. One reason is that there is independent interest in understanding the effects of exogenous oil supply shocks on industrialized countries such as Japan, Canada or the four largest European economies. The other reason is that one would hope to gain additional information about the generic consequences of an oil supply shock on output and inflation by studying a wider cross-section of countries.

The analysis in this paper departs from the existing literature along several dimensions. First, whereas much of the existing literature has focused on the effects of oil supply shocks on real output, I put equal emphasis on the responses of output and inflation. Second, I exploit recent methodological advances in measuring oil supply shocks that are exogenous with respect to global macroeconomic conditions. Specifically, I utilize a direct measure of these exogenous oil supply shocks proposed by Kilian (2005) rather than measures based on oil prices. Third, my analysis is based on a recently proposed approach to quantifying the dynamic effects of exogenous oil supply shocks that avoids some of the conceptual and econometric difficulties with earlier analyses (see Kilian 2005). Fourth, because I employ a common methodology across countries and hold fixed the sample period, the results are directly comparable across countries, whereas existing results for different countries tend to be based on mutually inconsistent sample periods and methodologies. Fifth, my data set extends to 2004.III and includes additional exogenous oil supply disruptions not covered by previous studies.

The objective of the regression analysis in this paper is to assess the dynamic effects of exogenous shocks to oil production on output and inflation in the G7 countries. In addition to

[1] See, for example, Balke, Brown and Yücel (2002), Barsky and Kilian (2002, 2004), Bernanke, Gertler and Watson (1997), Bohi (1989, 1991), Burbidge and Harrison (1984), Bruno and Sachs (1982), Darby (1982), Davis and Haltiwanger (2001), Gisser and Goodwin (1986), Hamilton (1996, 2003), Hamilton and Herrera (2004), Hooker (1996, 2002), Hoover and Perez (1994), Lee and Ni (2002), Lee, Ni and Ratti (1995), Mork (1989), Mork, Olsen and Mysen (1994), Rasche and Tatom (1981), Shapiro and Watson (1988), Tatom (1988).

conducting impulse response analysis, I use counterfactual simulations to assess how output and inflation would have evolved in these countries in the absence of exogenous oil supply shocks. The answer to these questions is relevant both for our understanding of the historical record and for the design of policy responses to future exogenous oil supply shocks. Specifically, I am interested in answers to the following questions: Do exogenous oil supply shocks generate sustained inflation? How does real GDP growth respond? How long does it take for the responses to set in? Are the responses similar across countries? Are exogenous oil production shortfalls stagflationary? To what extent can the poor macroeconomic performance of G7 countries during specific historical episodes be attributed to exogenous shocks to oil production?[2]

My starting point is a linear regression model of the relationship between exogenous oil supply variations and macroeconomic aggregates. Based on quarterly data for 1971.I-2004.III, I find a fair degree of similarity in the qualitative features of the estimated real GDP growth responses: First, the evidence suggests that the real GDP responses to exogenous oil supply cuts, while ambiguous in theory (see Barsky and Kilian 2002), tend to be negative in practice. An exogenous oil supply disruption causes a temporary reduction in real growth that is concentrated in quarters 4 through 8 after the shock. Second, inflation responses appear more varied. The median CPI inflation response peaks three to four quarters after the shock. Exogenous oil supply disruptions do not necessarily generate sustained CPI inflation, consistent with the evidence and theory presented in Barsky and Kilian (2002). Third, as measured by real GDP and CPI data, exogenous oil supply disruptions historically have caused stagflation in some, but by no means all countries. The evidence of stagflationary responses is strongest or Germany, Japan and Canada, whereas for the United States, the United Kingdom, and Italy there is little or no evidence of stagflationary tendencies caused by exogenous oil supply disruptions. This result contradicts the popular notion that exogenous oil production shortfalls are by necessity stagflationary. Fourth, as measured by cumulative inflation and real growth responses, some countries such as Italy, France and Japan have fared well when faced with exogenous oil supply disruptions, whereas others such as Germany have not. The German CPI response in particular is consistent with secondary price increases driven by wage-price dynamics. Only for Germany

[2] See Barsky and Kilian (2004) for a review of the channels by which oil supply shocks may affect real GDP and inflation.

is there a statistically significant increase in the CPI level in response to exogenous oil supply shocks, and only for the U.K. and for Canada is there a statistical significant reduction in the level of real GDP at the 5% level. Fifth, a counterfactual historical exercise suggests that the evolution of real GDP growth and CPI inflation in the G7 countries would have been similar overall to the actual path even in the absence of exogenous shocks to oil production. There are some differences during specific historical episodes, however, and some oil supply shocks mattered more than others. For example, a consistent finding is that the 1974/75 decline in real growth had little to do with exogenous oil productions cuts.

The remainder of the paper is organized as follows: Section 2 reviews recent methodological advances in assessing the effects of exogenous oil supply shocks and describes the approach taken in this paper. Section 3 describes the data used in the regression analysis. Section 4 contains the estimation results by country. Section 5 puts the linear regression results into perspective and attempts to draw general lessons from the evidence. Section 6 concludes.

2. Alternative Approaches to Identifying the Effects of Exogenous Oil Supply Disruptions

2.1. Oil-Price Based Measures of Exogenous Oil Supply Disruptions

A common feature of all methodologies designed to learn about the dynamic effects of exogenous oil supply shocks is that they involve a projection of macroeconomic aggregates on some measure of the exogenous oil supply shock. Early studies sometimes treated the price of oil (or positive changes in that price) as the measure of the exogenous oil supply disruption. It is widely understood today that at least since 1973 the price of oil has been fully endogenous to global macroeconomic conditions and cannot be treated as exogenous (see Rotemberg and Woodford 1996; Barsky and Kilian 2002, 2004; Hamilton 2003).

Some studies have noted that at least the major oil price fluctuations in the 1970s and 1980s were arguably driven by exogenous political events in the Middle East (see, e.g., Shapiro and Watson 1988). This insight was subsequently formalized by Hamilton (1996, 2003) who proposed a statistical measure of the net oil price increase relative to the recent past designed to capture those major oil price increases presumably caused by exogenous political events. That measure also produces a time series very similar to fitted values from more sophisticated nonlinear models of the oil price (see, e.g., Lee, Ni and Ratti 1995, Hamilton 2003).

Such measures are problematic, however. First, although three of the largest oil price increases since the early 1970s occurred near periods of large exogenous shocks to oil

production, not all exogenous oil supply shocks have been associated with net oil price increases. For example, the 2002/03 twin shocks associated with civil unrest in Venezuela and the Iraq war were not associated with a net oil price increase in real terms (see Kilian 2005). Second, it would be dangerous to associate the observed net real oil price increases with exogenous political events in the Middle East, because at least part of that net increase may simply reflect strong demand for industrial commodities in general, as documented in Kilian (2005). For these reasons, one would not want to use the net oil price increase as a measure of the exogenous oil supply shock. The same reasoning casts doubt on the view that the innovations to the oil price series or for that matter the innovations to the net oil price increase can be treated as exogenous with respect to global macroeconomic conditions.

2.2. Oil-Production Based Measures of Exogenous Oil Supply Disruptions

A different strand of the literature has instead used as identifying information the observable changes in the production levels of oil-producing countries that are subject to exogenous political shocks. For example, Hamilton (2003) proposes to use the drop in observable oil production following an exogenous event as a measure of the magnitude of the exogenous shock to the supply of oil. Typical examples of the events Hamilton considers exogenous are the Arab oil embargo of 1973/74, the Iranian revolution of 1978/79, the Iran-Iraq war of 1980-88 and the Gulf war of 1990/91. In each case, Hamilton focuses on the oil-producing countries directly involved in the event in question. Given the starting date of the event, he uses the level of oil production in the month prior to this date as a benchmark. He then compares that level to the level of production at some subsequent date. The difference in physical production levels over the period in question is expressed as a share of the average world oil production in the year, in which the exogenous event started (see Hamilton 2003, p. 390). The resulting "production shortfall" is treated as a measure of the magnitude of the shock that occurred in the first quarter of the exogenous event. This approach is in essence a quantitative version of the dummy variable approach used by Hoover and Perez (1994) to model oil shocks.

An alternative measure of exogenous oil supply shocks based on production data for all OPEC countries and for aggregate non-OPEC oil production that are available from the U.S. Department of Energy has been proposed by Kilian (2005). This measure is based on the observation that any attempt to identify the timing and magnitude of these exogenous production shortfalls requires explicit assumptions about the counterfactual path of oil production in the

absence of the exogenous event. The strategy is to generate the counterfactual production level for the country in question by extrapolating its pre-war production level based on the average growth rate of production in other countries that are subject to the same global macroeconomic conditions and economic incentives, but not directly affected by the war. Which countries belong into this benchmark group must be decided on a case-by-case basis drawing on historical accounts and industry sources. This approach allows the construction of a time series of exogenous oil production shortfalls. The change over time in this exogenous production shortfall series (aggregated across OPEC countries and expressed as a percent share of world oil production) provides a natural measure of the exogenous oil supply shock.

The Kilian (2005) method of quantifying exogenous production shortfalls has five distinct advantages compared to the conventional approach based on quantitative dummy variables as discussed in Hamilton (2003): (1) It does not impose the assumption that the level of oil production would never have changed in the absence of the exogenous political event. (2) It allows the response of oil production to the exogenous event to be immediate or delayed. (3) It allows the response to be long-lasting. (4) It allows the response to be time-varying. (5) It allows the response to an exogenous political event to be negative or positive, possibly changing sign over time. This point is important as my analysis shows that wars in the Middle East, for example, may actually cause higher oil production, when the parties involved resort to oil exports to finance the war.

The analysis in this paper will utilize the baseline time series of exogenous oil supply shocks developed in Kilian (2005). For a comparison of the implications of this measure to the quantitative dummy approach the reader is referred to Kilian (2005). That paper also contains extensive sensitivity analysis of the assumptions made in constructing the counterfactuals.

2.3 Inference based on Production Based Measures of Exogenous Oil Supply Disruptions

Given a production-based measure of the exogenous oil supply shock, there are two alternative approaches to quantifying the dynamic effects of exogenous fluctuations in oil production on macroeconomic aggregates. The first approach due to Hamilton (2003) is to use lags of the exogenous oil supply shock as identifying instruments in regressions that relate the macroeconomic aggregate of interest to past oil price changes and past values of the macroeconomic aggregates. While this approach is quite appealing, Kilian (2005) documents that such instrumental variable regressions in practice tend to suffer from a weak instrument

problem that renders point estimates unreliable and standard inference misleading (see Stock, Wright and Yogo 2002). In response to this problem, Kilian (2005) proposed an alternative regression approach that will form the basis of the analysis in this paper.

That approach follows the convention in the literature of treating changes to oil production induced by political events such as wars or revolutions in the Middle East as exogenous with respect to the macroeconomic aggregates in G7 economies. Specifically, it treats the oil supply shock series as strongly exogenous in the sense that there is no feedback from current or lagged values of the dependent variable to the exogenous variable. Let x_t denote the date t observation of the exogenous oil supply shock series, Δy_t the corresponding percent growth rate in real GDP and π_t the percent change in the consumer price index. The object of interest are the impulse responses $\partial \Delta y_{t+i} / \partial x_t$ and $\partial \pi_{t+i} / \partial x_t$, $i = 1, 2, 3...$ For each country, the first-order effect of a given increase in x_t on Δy_{t+i} and π_{t+i}, respectively, may be computed based on the fitted value of the linear ordinary least squares (OLS) regressions:

$$\Delta y_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta y_{t-i} + \sum_{j=1}^{8} \gamma_j x_{t-j} + u_t \tag{1}$$

and

$$\pi_t = \delta + \sum_{i=1}^{4} \lambda_i \pi_{t-i} + \sum_{j=1}^{8} \eta_j x_{t-j} + v_t, \tag{2}$$

where the error terms u_t and v_t are serially uncorrelated, given the inclusion of four lags of the dependent variable and eight lags of the exogenous oil supply shock.[3] Provided that the exogenous oil supply shock regressors are not correlated with any omitted exogenous variables, the implied impulse responses will measure the causal effects of the exogenous variations in oil supply. Level responses for real GDP and the level of consumer prices may be obtained by cumulating the estimated impulse responses. Confidence intervals for these impulse responses may be constructed by drawing from the asymptotic normal distribution of the slope parameters and simulating the standard errors of the impulse response estimators.

The estimated responses provide a measure of the expected response of macroeconomic aggregates to exogenous oil production shortfalls based on historical data. They represent consistent estimates of the causal effects of a unit change in the exogenous oil supply shock

[3] This lag structure corresponds to the assumptions used by Hamilton (2003) and Kilian (2005).

measure. It is important to keep in mind that these impulse response estimates are reduced-form in that they will capture the average effect of country-specific endogenous policy responses and other propagation mechanisms that prevailed at the time of the exogenous oil supply shocks. In this sense, the estimated responses do not reflect inevitable facts, but empirical regularities. They are designed to quantify the historical tendency of the G7 economies to perform poorly as a consequence of exogenous oil supply disruptions.

3. Data

3.1. Exogenous oil supply shocks

Table 1 lists the major political events that for the purpose of this study will be considered exogenous with respect to inflation and real output growth in the G7 countries. Barsky and Kilian (2002) observe that there is reason to be skeptical about the exogeneity of the 1973/74 oil embargo decision (see Hamilton (2003) for a different view). Here I will follow the convention in the literature in treating this event as exogenous. Figure 1 shows the quarterly exogenous oil supply shock series derived by Kilian (2005) on the basis of the dates in Table 1 and a detailed analysis of the monthly oil production data provided by the Department of Energy. The major oil dates have been imposed as vertical lines. As expected, the most important spikes in the series occur near those dates. For further discussion of the derivation of this series the reader is referred to Kilian (2005).[4]

The starting date of 1971.I ensures that the regression model can be used to construct counterfactuals starting as early as 1973.I (before the first major oil supply shock). Since the value of the exogenous oil supply shock is zero prior to 1973.IV, the possibility of a structural change in the transmission of exogenous oil supply shocks induced by the rise of OPEC in late 1973 has no effect on the regression analysis. The ending date of 2004.III is dictated by the availability of oil production data from the Department of Energy.

3.2. Real GDP and CPI Inflation

The regression analysis will be based on seasonally adjusted quarterly real GDP growth and CPI inflation rates for 1971.I-2004.III. The CPI data are from the IFS with the exception of the U.S. CPI which was obtained from the Bureau of Labor Statistics. The German inflation series was

[4] The data are publicly available at http://www-personal.umich.edu/~lkilian/oilshock.txt.

obtained by combining West German CPI inflation data for 1973.I-1991.I with CPI inflation rates for the unified Germany starting in 1991.II.

The GDP data for Canada, Germany, and Italy are from the IFS website. The French GDP data are from the Banque of France, as detailed in Knetsch (2005). Missing observations for the last one or two quarters of Italian, German and French data were replaced by the quarter-on-quarter seasonally adjusted real GDP growth rates provided on the *Eurostat* website. The Japanese real rates of growth have been computed based on the consistent quarterly real GDP series (in 1990 prices) provided by the Economic and Social Research Institute, Cabinet Office, Japan. That series ends in 2000.IV. The growth rates for the subsequent quarters are based on seasonally adjusted IFS data in 1995 prices. For the United Kingdom, I used the quarter-on-quarter real GDP growth series provided on the website of *U.K. National Statistics*, which unlike the IFS data is seasonally adjusted. The seasonally adjusted U.S. real GDP data were obtained from the Bureau of Economic Analysis.

4. Estimation Results by Country

This section contains a description of the estimation results for each G7 country. All results are based on OLS estimates of models (1) and (2). The discussion of the lessons to be drawn from the evidence is deferred to section 5.

4.1 Impulse Responses and Counterfactual Simulations

Given estimates of models (1) and (2) it is straightforward to assess the impact of an exogenous 10% reduction in global oil production or to simulate the path of CPI inflation and real GDP growth under the counterfactual assumption that the political events responsible for exogenous fluctuations in the supply of oil never occurred. A natural starting point is the case of the United States.

United States

Figure 2 shows the responses caused by an exogenous 10% reduction in world oil production. There is a sharp reduction in U.S. real GDP growth between five and seven quarters after the shock that is significant at the 10% level. After cumulating the growth rate effects, I find a significant reduction of the level of real U.S.GDP in the second and third year following the shock at the 10% level. There also is a sharp increase in consumer price inflation three quarters

after the shock (significant at the 10% level), but no significant effect on the level of consumer prices.

Impulse responses are useful measures of the dynamic effects of shocks, but they do not reveal the importance of shocks for particular historical episodes. To answer the latter question, I conduct a counterfactual exercise, in which I set the variation in the exogenous shock to zero and simulate the implied path of the U.S. economy. This historical decomposition is plotted in Figure 3. The plot shows how U.S. real GDP growth and CPI inflation would have evolved from 1973.I until 2004.III in the absence of exogenous oil supply shocks. Although the counterfactual path of inflation and real growth overall is similar to the actual path, there are some important differences. In 1992 real U.S. growth was clearly lower as a consequence of the disruptions associated with the Persian Gulf War, and there is evidence of a temporary fall in growth in 1980 and 1982 associated with the 1978/79 and 1980 oil shocks. At the same time, exogenous oil supply shocks are responsible for at least a partial reversal of this reduction in real growth in subsequent years. Perhaps surprisingly, the 1973/74 oil crisis had comparatively little effect on real U.S. growth nor has there been much of an effect from the 2002/2003 oil shocks. Compared to the effects on real growth, the effects on U.S. consumer price inflation tend to be even smaller. Here as well there is evidence that the initial increases in inflation caused by oil supply disruptions are subsequently reversed. The main effect appears to be slightly increased volatility in U.S. CPI inflation in the early 1980s.

Italy

Figure 4 shows that Italy as well experienced a significant temporary reduction in real GDP growth at the 10 percent significance level (between six and nine quarters after the shock), and again there is a significant reduction of the level of real GDP (between eight and twelve quarters after the shock). At the same time, there is a significant spike in consumer price inflation four quarters after the shock, but no significant increase in the price level. These results are qualitatively very similar to those in Figure 2 for the United States. The same holds true for the counterfactual results in Figure 5a.

France

Figure 4 shows a significant reduction in French real GDP growth at the 10 percent level between seven and ten quarters after the exogenous oil supply disruption. The effect on the level

of real GDP is not significant. Exogenous oil supply disruptions also cause a sustained and significant increase in consumer price inflation that extends from the second to the fifth quarter following the shock, before inflation reverts to zero. This hump in the inflation response implies a significant increase in the level of consumer prices at horizons of three to nine quarters. Figure 5b shows that once again mainly the 1978/79, 1980 and 1990 oil shocks caused French real growth to fall temporarily. As far as inflation is concerned, the 1980 and 1990 episodes stand out.

Germany

The German data pose special problems due to German re-unification in 1990.IV. It is not obvious how to account for the effects of this event on German inflation and real growth, since it coincided with the effects of the Persian Gulf War. I model the transition dynamics following re-unification using dummies representing level shifts and slope shifts. Similar results were obtained under a number of alternative dummy specifications.

The baseline regressions for German GDP growth account for a one-time increase in growth in 1991.I due to the re-definition of the German GDP series and allow for a change in the average growth rate after 1990.IV. The implied response of real growth is very similar to that obtained for data up to 1999.II only (excluding the re-unification period). In contrast, there is no evidence of a mean shift in inflation due to unification, but there is evidence of a temporary increase in inflation after 1990.IV. My baseline regression estimates include one level dummy each for 1991.I-IV intended to account for the inflationary pressures immediately following re-unification. The shape of the resulting impulse response estimate is very similar to that of the response estimated on data up to 1990.II only, but the magnitude of the responses is somewhat lower than based on the pre-1990.II data. Adding dummies for the 1993.I VAT increase and the1994.I mineral oil tax increase, which arguably were related to the cost of financing unification and which coincided with sharp spikes in inflation, does not affect the results appreciably.

The baseline results for Germany are shown in Figure 4. There is evidence of a temporary reduction in real GDP growth between the fourth and eight quarter, most of which is significant at the 10% level. Additional significant reductions in real growth at horizons ten and eleven are too small in magnitude to have much of an effect. The implied output response is significantly negative at horizons 7 through 12.

A clear anomaly of the German case is the implication of Figure 4 that an exogenous oil supply disruption causes a statistically significant *increase* in real GDP growth after one quarter (and a significant increase in real GDP for the first three quarters). It can be shown that this result is *not* driven by the fact that the 1990/91 oil crisis coincided with temporarily high German real growth driven by German re-unification. In fact, the same anomaly arises when I estimate the responses on German data up to 1990.II only (excluding the 1990.III oil crisis). Thus, this implausible result is likely to reflect a spurious sample correlation between economic expansions in Germany and exogenous oil supply disruptions, as may be verified in Figure 5c below. One would expect this correlation to vanish, as the sample size increases. Apart from this anomaly, the German real growth and real GDP responses are qualitatively very similar to those for Italy, France and the United States.

German CPI inflation shows at significant peak at horizons 2 through 4, similar to France, Italy and the United States, but that peak is followed by sustained increases in inflation from horizon 6 through 12 with additional peaks after 6 and 10 quarters. This pattern is suggestive of additional wage-price dynamics not present in the U.S., Italian or French data. The level response shows a significant increase in consumer prices for all but the first quarter. This pattern is also unique in the sample of G7 countries. Again it can be shown that this result is robust to excluding the post 1990.II data.

Subject to the aforementioned caveats, Figure 5c plots the counterfactual historical data for Germany. Notwithstanding the anomalous impulse response pattern, the qualitative pattern for real growth is similar to the other countries studied so far. For inflation, Figure 5c indicates a somewhat bigger effect of exogenous oil supply shocks in general. In 1979, 1981, and 1991/92 in particular, inflation would have been much lower in the absence of exogenous oil supply shocks.

United Kingdom

The analysis of the U.K. data is complicated by a possible structural break in the relationship between oil supply shocks and macroeconomic aggregates in the late 1970s, when U.K. domestic oil production gained momentum. Oil production data from the Department of Energy show that U.K. crude oil production, after being negligible until early 1975, reached 10,000 barrels a day in 1975.III, 500,000 barrels a day in 1977.I and finally 1 million barrels a day in 1978.II. The estimated inflation and output responses based on post 1975.III and post-1977.I data, however,

are very similar to the full-sample estimates, suggesting that the possibility of a structural break in the U.K. regression model can be ignored. I therefore focus on the full-sample results in Figure 4, although I will report additional results based on a possible 1978.II break in section 5.1.

Figure 4 indicates a significant reduction in U.K. real GDP growth two, four, five, seven and eight quarters after the shock. Although the growth response appears somewhat erratic, it is broadly consistent with earlier results for other countries. There is a significant and persistent reduction in the level of real GDP starting two quarters after the shock. CPI inflation spikes two quarters after the shock, followed by a secondary spike six quarters out. This pattern again is consistent with wage-price dynamics that propagate the initial shock. Unlike in the German data, the two spikes are separated by periods of falling consumer prices, however, preventing a significant change to the price level.

Figure 5d confirms that exogenous oil supply shocks were mainly responsible for raising the variability of U.K. inflation in the 1970s and 1980s. There is no evidence that subsequent shocks affected inflation in important ways. In contrast, exogenous oil shocks caused unusually large reductions in real growth in 1980-1982 and1991-1992, followed by smaller reversals.

Canada

The Canadian real growth response in Figure 4 shows the familiar pattern of a temporary reduction in growth at horizons of 4 to 9 quarters, accompanied by a significant reduction in real GDP in the second and third year after the shock. CPI inflation shows significant increase in the first two quarters, a pattern unique to Canada, and another significant peak after six quarters. With the exception of the first three quarters, the increase in the price level is not significant at the 10% level.

Figure 5e shows a large reduction in Canadian GDP growth in 1991/92 caused by the 1990 oil shock and somewhat reductions following the 1978/79 and 1980 oil shocks (the latter partially reversed). The remaining oil shocks had only minor effects on Canadian real growth. Apart from increased volatility in inflation in 1974-1975 and 1979-1982, and a small increase in 1990/91, Canadian inflation hardly responded to exogenous oil supply shocks.

Japan

Figure 4 shows that apart from a drop six quarters after the shock, the response of Japanese real growth to exogenous oil supply disruptions is not significant nor is there a significant effect on

the level of real GDP. The inflation response is continuously positive for the first seven quarters, but only the first quarter response is significantly positive at the 10% level. Given the apparent imprecision of the estimate, it is unclear whether there are multiple peaks or just one hump as in the case of France. For the remaining quarters the response is mostly negative. The implied increase in the level of consumer prices is marginally significant for the first six quarters.

Figure 5f shows that Japanese real growth was remarkably little affected by exogenous oil supply shocks, although the country has been heavily dependent on imported oil. Similarly, Japanese consumer price inflation did not move very much as a result of exogenous oil supply shocks even in the 1980s.

5. Analysis

Although the sample available for this study is small, there is a fair degree of similarity in the real growth responses across G7 countries. In all seven countries there is significant evidence that an exogenous oil supply disruption causes a decline in real growth. This effect with the exception of the U.K. is delayed until at least the fourth quarter after the shock. With the exception of Germany and France there are no significant reductions in real growth after the ninth quarter. Moreover, only in one of seven countries is there significant evidence that exogenous oil supply disruptions cause a reduction of real GDP within the first year following the shock. In contrast, in five of the seven countries exogenous oil supply disruptions cause a significant reduction of real GDP in the second and third year following the shock.

Turning to CPI inflation, there is some heterogeneity among G7 countries in that in the United States and Italy exogenous oil supply disruptions tend to cause sharp spikes in CPI inflation, in France the response is hump-shaped, and in Canada, the U.K., Germany (and to a much lesser extent Japan) the responses are characterized by repeated spikes. Only for Germany (and possibly to a lesser extent for Japan) is there evidence of sustained inflation increases caused by exogenous oil supply disruptions. The existence of secondary and tertiary peaks in the estimated responses is suggestive of wage-price setting dynamics that amplify the initial price shock. There also is evidence of a significant increase in the German CPI level three years after the shock. For the United States and the U.K. the price level three years after the oil supply disruption is no higher than before the shock. For all other countries the price level rises as a consequence of the disruption, but not significantly so.

A popular notion is that exogenous oil supply shocks can be held responsible for triggering stagflation, defined as the coincidence of rising price levels and falling output. For example, *The Economist* (November 27, 1999) writes:

"Since OPEC agreed to supply-cuts in March, the price of crude oil has jumped to almost $26 a barrel, up from less than $10 last December and its highest since the Gulf war in 1991. This near-tripling of oil prices evokes scary memories of the 1973 oil shock, when prices quadrupled, and 1979-80, when they also almost tripled. Both previous shocks resulted in double-digit inflation and global recession […] Even if the impact will be more modest this time than in the past, dear oil will still leave some mark. Inflation will be higher and output will be lower than they would be otherwise."

The evidence in section 4 suggests that this assertion, while not completely without basis, is not a necessary consequence of exogenous oil supply cuts. As Figures 2 and 4 show, exogenous oil supply disruptions cause stagflation (defined as negative co-movement in the level of real GDP and the level of consumer prices) in some, but not all countries in the second year following the shock. The evidence for stagflationary responses to such shocks is clearest for Germany, Japan and Canada. For the United States, the United Kingdom, and Italy, however, there is little or no evidence of stagflationary tendencies, contradicting the popular notion that exogenous oil production shortfalls are by necessity stagflationary. For France there is only slim evidence of stagflation.

5.1. Median responses

One way of summarizing these data is to focus on the median peak of CPI inflation responses and median trough of the responses of real GDP in the G7 countries. The upper panel of Table 2 suggests that exogenous oil supply disruptions cause a trough in G7 real growth 7 quarters after the shock. The median magnitude of the trough caused by a 10% reduction in world oil supplies is -1.7%. Real GDP reaches a trough about 11 quarters after the shock. The median cumulative effect on real GDP is -5.9%. The median inflation peak comes three quarters after the exogenous oil supply disruption with a median magnitude of 1.25%. The CPI level peaks after 7 quarters with a median cumulative effect of about 4%.

I also report separate results for the four European G7 countries ("Europe") to address the question of whether there are important differences in the European experience compared to the United States, Canada and Japan. The timing and magnitude of the growth and output responses is very similar. For the inflation responses as well the differences are small. For price level

responses, in contrast, the data at first seem to suggest a 9.5 quarter lag for the peak response in Europe compared with only 7 quarters for the G7. Upon inspection, this result is driven by the French CPI response which exhibits a primary (statistically insignificant) peak of magnitude 4.09 after 12 quarters, as well as a secondary, but statistically significant peak of magnitude 4.07 after 6 quarters. If we focus on the secondary peak instead of the primary peak, the median delay shrinks from 9.5 to 6.5 very close to the G7 median peak time, with virtually no change in the median cumulative effect. These results suggest that there is no systematic difference in the response of the European G7 countries from the United States, Canada, and Japan.

As mentioned earlier, the U.K. responses, while still similar to the baseline case, change somewhat when the sample is reduced to the post 1978.III period, effectively eliminating the 1973/74 oil shock episode from the sample. I therefore present additional results in which these alternative U.K. results have been substituted for the baseline results. Table 2 shows that this substitution somewhat lowers the estimated median impact of exogenous oil supply disruptions on real growth and inflation, but otherwise the median results are quite similar.

5.2. How Similar are the Response Patterns across G7 Countries?

While the evidence of a temporary reduction in real GDP growth is consistent across all G7 countries, the inflationary consequences of an oil supply shock are far less clear-cut. An important lesson of the earlier analysis by country is that it is possible for countries to fare comparatively well when faced with exogenous oil supply shocks. For example, in the United States exogenous oil supply disruptions historically caused only a brief spike in CPI inflation after 3 quarters rather than a sustained increase in CPI inflation. Qualitatively similar results also were obtained for Italy with a spike after 4 quarters and to a lesser extent for France, which historically experienced a hump in CPI inflation from the second through the fifth quarter. This evidence contrasts with the pattern of repeated spikes in CPI inflation responses found in German data, and to a lesser extent Canadian, Japanese and U.K data. Only for Germany there is clear evidence of sustained inflation being caused by exogenous oil supply shocks. This pattern is also reflected in the estimated cumulative effect on the price level after three years. Whereas the cumulative effect for the United States and the United Kingdom is negative (although not significantly so), Italy (2.69), Japan (2.63), Canada (4.38) and France (4.09) experienced

moderate price level increases after three years. The only G7 country with a significant long-run increase in consumer prices is Germany (8.03).

Similarly, the estimated cumulative output responses after three years suggest that countries such as Italy (-3.80), France (-3.45) and Japan (-2.82) suffered less severe reductions in real GDP growth due to exogenous oil supply disruptions than the U.K. (-7.87), Canada (-7.60), Germany (-5.93), or the United States (-6.21). This is further evidence that policy responses and institutional characteristics matter in dealing with exogenous oil supply shocks.

5.3. Comparing the Effects of Exogenous Oil Supply Shocks Across Countries and Time

The historical decompositions allow some generalizations about the effects of specific historical exogenous oil supply shocks. Tables 3a and 3b present average real GDP growth and average CPI inflation rates (normalized relative to the average for 1973.I-2004.III) for selected subperiods following the exogenous events of Table 1. It also shows the average change in real growth and inflation caused by exogenous oil supply shocks over the same subperiods. The corresponding time plots are shown in Figures 6a and b.

5.3.1 Real GDP Growth

There is a presumption that periods following exogenous oil supply shocks tend to be characterized by unusually low real growth. Table 3a shows that this is true for the aftermath of the 1973/74 shock and – with the exception of Japan – for the 1980 shock. It also is true for the 1990 shock, abstracting from Germany which was subject to the effects of German re-unification at the time. On the other hand, after the 1978/79 and 2002/03 shocks three of seven countries were able to maintain average or above average real growth rates.

There also is a presumption that the observed unusually low real growth may be attributed to the effects of the preceding exogenous oil supply shocks. As expected, Table 3 shows that the estimated effect of exogenous oil supply shocks on real growth is negative in each instance. There are, however, important differences across episodes and countries that become readily apparent in Figure 6a. For example, in all six countries that experienced distinctly below average growth after the 1973/74 shock, the effects of the oil shock appear negligible. The same is true for Canada.

For the 1979/79 shock there is some evidence in Figure 6 that the oil shock contributed to a small extent to fluctuations in real growth in the United States and the United Kingdom, but for

most countries the contribution is again negligible. Stronger evidence is obtained for the 1980 oil shock. Especially for the United States, the oil shock contributed to the decline in real growth in 1982. Similarly, this shock contributed to lower Canadian real growth in late 1981 and in 1982. The evidence is strongest for Germany, where the effect of the oil shock seems to account for most of the growth fluctuations during 1980.IV-1983.I. There also is some apparent effect in the Italian, French, and British data, but hardly any for Japan.

Exogenous oil supply shocks also seem to matter in the period after the 1990 shock, although this effect does not explain the immediate drop in real growth during late 1990 and early 1991 observed in all countries but Germany (for the reasons alluded to above) and Japan. Rather the cumulative effect of exogenous oil supply shocks on real growth makes itself felt only in 1992 and 1993. A possible explanation of the initial drop in real growth could be a temporary increase of fears of future oil supply disruptions in late 1990. Those fears never materialized and hence are not reflected in the production-based measure of the exogenous oil supply shock used in this paper. That explanation would be consistent with the observed behavior of the real price of oil (see Kilian 2005), although it is unclear why Japan would not have been affected by the same phenomenon.

Finally, following the 2002/03 shocks, there is hardly any evidence of a reduction in real growth being caused by oil supply. The consistently negligible magnitude of the effect of exogenous oil supply shocks on real growth after 1973/74 and again after 2002/03 is consistent with the view that the sharp real oil price increases during those times were driven by strong demand for oil rather than exogenous oil production reductions. As noted by Kilian (2005), similarly rapid real price increases occurred in many other industrial commodities over these periods. To a lesser extent this explanation applies after 1978/79 as well.

5.3.2 CPI Inflation

There is a presumption that periods following exogenous oil supply shocks are periods of abnormally high inflation. Table 3b suggests otherwise. While the shocks of 1973/74 and 1978/79 and – with the exception of Japan – that of 1980 were indeed followed by unusually high CPI inflation rates, all subsequent shocks have been followed by periods of below average low rates. Although these shocks usually caused higher CPI inflation, in some cases the estimated average effect is negative (although close to zero in all but one of these cases).

Figure 6b shows that after 1973/74 the increase in CPI inflation that can be attributed to exogenous oil supply cuts is negligible compared to existing levels of CPI inflation (which leaves open the possibility of course that higher oil prices due to endogenous factors such as high global demand for oil may have played a more important role). This is true for all G7 countries. As noted by Bohi (1989), the striking differences in economic performance across the United States, Japan, and Germany, in particular, when faced with the same exogenous shock, are suggestive of an important role for domestic economic policies. Qualitatively similar results hold for the 1978/79 and 1990 shocks. After the 1980 shock there is some effect on CPI inflation, notably in Germany and in the U.K., but again oil supply cuts are not the primary cause of higher inflation. Finally, the effects of the 2002/03 shock on inflation are negligible. These results underscore the earlier point that the unusual inflation experience of the 1970s and early 1980s was not caused by exogenous oil production cuts, but is likely to have been the consequence of countries' macroeconomic policy choices, which would help explain both the wide variation in inflation experiences across countries over the same subperiod and the wide variation across different episodes in the same country (as in the case of Japan, for example).

6. Conclusion

Building on recent work in Kilian (2005), this study estimated and compared the effects of exogenous shocks to global oil production on inflation and real output in major industrialized countries since the 1970s. Linear regression analysis suggested the following main findings:

● An exogenous disruption of global oil production typically causes a temporary reduction in real GDP growth that is concentrated in the second year after the shock. The median CPI inflation response peaks three to four quarters after the shock. There is clear evidence that exogenous oil supply disruptions need not generate sustained consumer price inflation. Evidence of sustained inflation (as in the case of Germany) therefore must reflect a favorable institutional environment.

● Exogenous oil supply disruptions cause stagflation (defined as negative co-movement in the level of real GDP and the level of consumer prices) in some, but not all countries in the second year following the shock. For the United States, the United Kingdom and Italy there is little or no evidence of stagflationary tendencies, contradicting the popular perception that exogenous oil supply shocks are by necessity stagflationary.

● As measured by cumulative inflation and real growth responses, some countries such as Italy, France and Japan have fared well when faced with exogenous oil supply disruptions, whereas others such as Germany have not. Some of the differences appear to be determined by wage-price dynamics, as evidenced by secondary spikes in the inflation response to a shock. There is no evidence that these differences are driven by whether a country produces oil domestically (as in the case of the United States, the U.K. and Canada) or not (as in the case of France, Germany, Italy and Japan). Nor is there evidence of a systematic difference between European and non-European G7 countries.

● An important additional question that cannot be answered by impulse response analysis is how much of an effect exogenous oil supply shocks have had in shaping economic history. A counterfactual historical exercise revealed that the evolution of CPI inflation (and to a lesser extent of real GDP growth) in the G7 countries would have been quite similar overall to the actual path even in the absence of exogenous shocks to oil production. There are some differences, however, when it comes to interpreting specific historical episodes. For example, in all G7 countries the 1990/91 oil supply shock caused by the Persian Gulf War contributed to somewhat reduced real growth, albeit with a considerable delay. The oil shocks of 1978/79 and 1980 also left a mark in the data of some G7 countries. In contrast, the 1973/74 oil supply shock had hardly any impact on G7 real growth. Similarly, the effect of the 2002/03 oil supply shocks was negligible for all G7 countries.

● Nonlinearities could in principle account for a larger contribution of exogenous oil supply shocks to real GDP growth and CPI inflation than the baseline linear model. The nature of such nonlinearities and their impact, if any, on the empirical results is left for future research.

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Table 1: Key Oil Dates

Date	Political Event
October 1973	Yom-Kippur war
October 1973	Arab Oil Embargo
October 1978	Iranian Revolution
September 1980	Iran-Iraq War
August 1990	Persian Gulf War
December 2002	Civil Unrest in Venezuela
March 2003	Iraq War

Table 2: Median Peaks and Troughs of the Responses

		Baseline		Same as baseline, except U.K. sample starts in 1978.III	
Trough		Real GDP Growth	Real GDP	Real GDP Growth	Real GDP
Timing (quarters)	G7	7	11	7	11
	Europe[a]	7	10	7	10.5
Magnitude (%)	G7	-1.73	-5.93	-1.52	-5.93
	Europe	-1.69	-5.02	-1.51	-5.02

		Baseline		Same as baseline, except U.K. sample starts in 1978.III	
Peak		CPI Inflation	CPI Level*	CPI Inflation	CPI Level*
Timing (quarters)	G7	3	7 (7)	3	9.5 (7)
	Europe	3.5	9.5 (6.5)	4	12 (7)
Magnitude (%)	G7	1.25	4.09 (4.07)	1.03	4.24 (4.23)
	Europe	1.30	3.52 (3.51)	1.14	4.09 (4.07)

NOTES: * Numbers in parentheses are based on secondary peak for France after 6 quarters that unlike the primary peak after 12 quarters is statistically significant and of only marginally lower magnitude.

[a] Europe here refers to the European G7 countries France, Germany, Italy and the U.K.

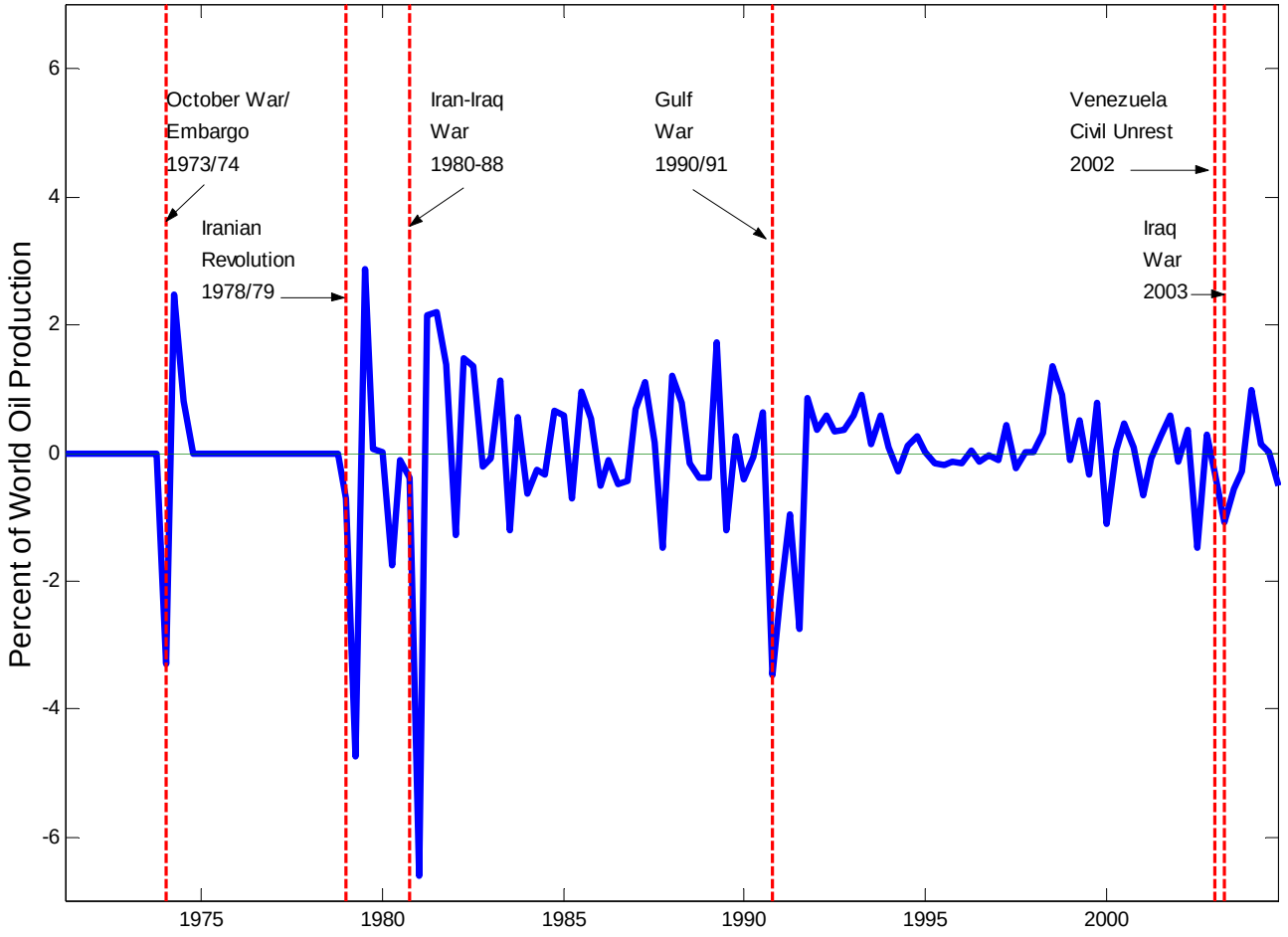
Table 3a: Average Real GDP Growth Rates and Average Estimated Effect of Exogenous Oil Supply Shocks

		Episodes of Exogenous Oil Supply Shocks				
		1973.IV-1975.II	1978.IV-1980.III	1980.IV-1983.I	1990.III-1993.III	2002.IV-2004.III
United States	Growth	-0.96	-0.66	-0.47	-0.32	0.17
	Effect	-0.07	-0.19	-0.27	-0.35	-0.20
Italy	Growth	-0.50	0.52	-0.42	-0.49	-0.38
	Effect	-0.07	-0.09	-0.25	-0.24	-0.08
France	Growth	-0.27	-0.06	-0.09	-0.43	-0.22
	Effect	-0.02	-0.05	-0.22	-0.21	-0.05
Germany	Growth	-0.84	0.04	-0.50	0.58	-0.34
	Effect	-0.06	-0.06	-0.38	-0.34	-0.13
U.K.	Growth	-0.87	-0.61	-0.28	-0.50	0.13
	Effect	-0.05	-0.27	-0.26	-0.41	-0.23
Canada	Growth	-0.06	-0.10	-0.64	-0.68	-0.12
	Effect	-0.09	-0.19	-0.38	-0.45	-0.20
Japan	Growth	-0.44	0.25	0.04	-0.30	0.04
	Effect	-0.04	-0.04	-0.11	-0.14	-0.06

Table 3b: Average CPI Inflation Rates and Average Estimated Effect of Exogenous Oil Supply Shocks

		Episodes of Exogenous Oil Supply Shocks				
		1973.IV-1975.II	1978.IV-1980.III	1980.IV-1983.I	1990.III-1993.III	2002.IV-2004.III
United States	Inflation	1.23	1.73	0.39	-0.33	-0.58
	Effect	-0.01	0.02	-0.16	-0.04	0.04
Italy	Inflation	2.46	2.23	2.02	-0.74	-1.42
	Effect	0.00	0.10	0.05	0.13	0.11
France	Inflation	1.81	1.60	1.48	-0.65	-0.77
	Effect	0.04	0.16	0.10	0.21	0.15
Germany	Inflation	1.08	0.50	0.57	0.35	-0.37
	Effect	0.06	0.21	0.32	0.34	0.11
U.K.	Inflation	3.59	2.09	0.26	-0.80	-0.95
	Effect	0.06	0.11	-0.25	-0.07	0.11
Canada	Inflation	1.33	1.20	1.21	-0.51	-0.72
	Effect	0.04	0.15	0.16	0.18	0.03
Japan	Inflation	3.22	0.67	-0.13	-0.23	-0.81
	Effect	0.04	0.19	-0.09	0.12	0.13

Figure 1: Measure of Exogenous Oil Supply Shocks
1971.I-2004.III



Source: Kilian (2005)

Figure 2: Dynamic Effects of a 10% World Oil Supply Disruption on the United States
OLS Point Estimates with One- and Two-Standard Error Bands

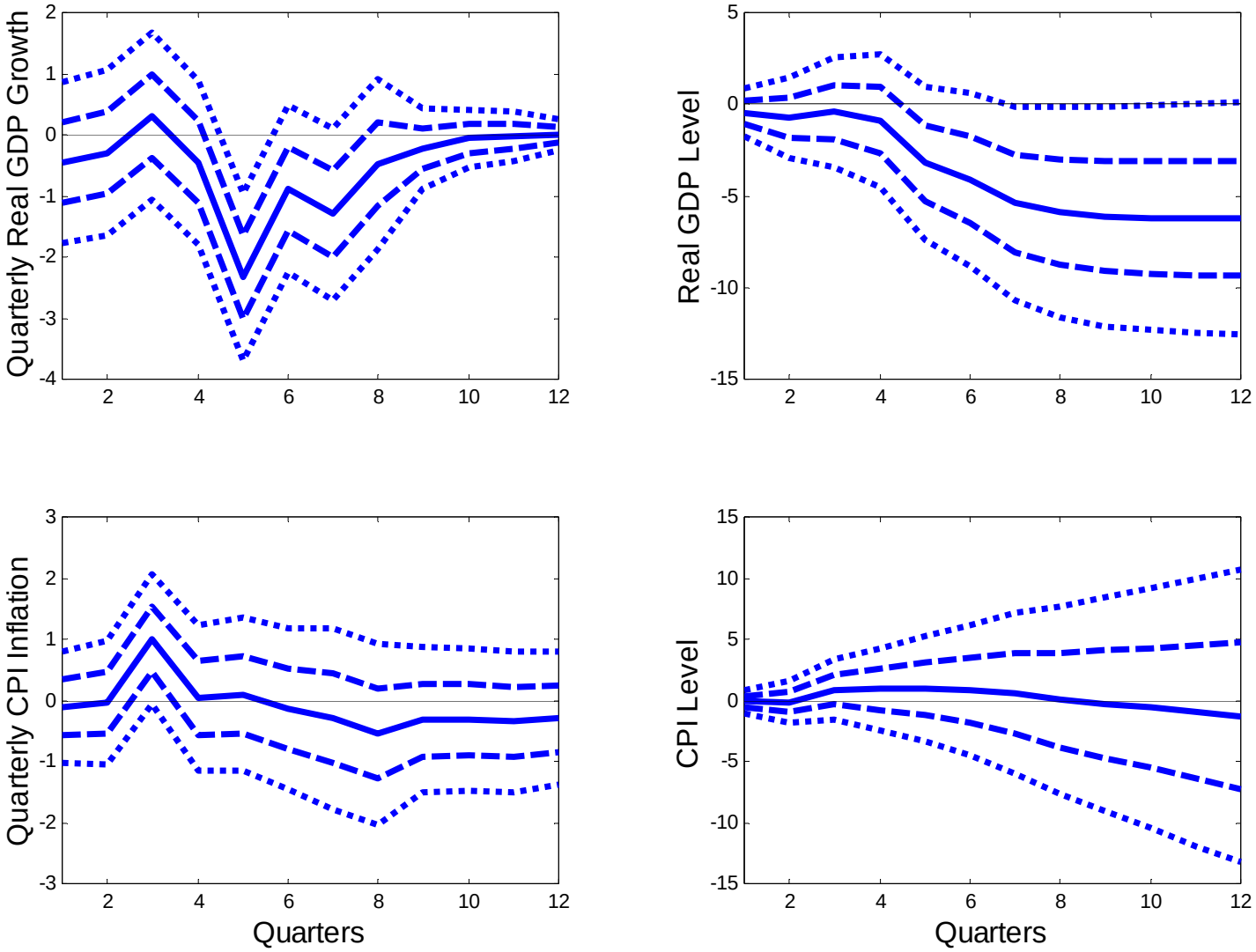


Figure 3: Counterfactual Economic History without Exogenous Oil Supply Shocks
United States

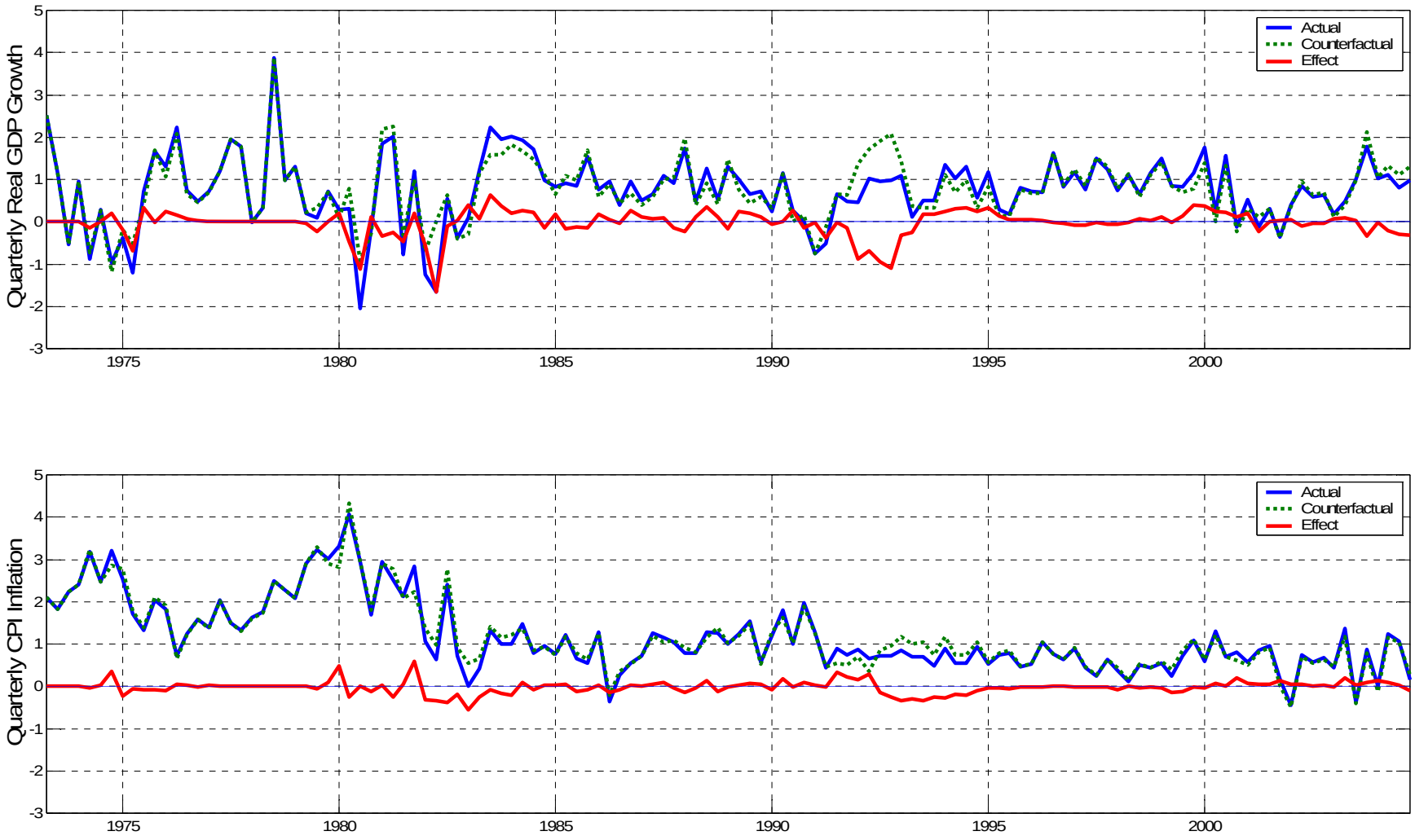


Figure 4: Dynamic Effects of a 10% World Oil Supply Disruption
OLS Point Estimates with One- and Two-Standard Error Bands

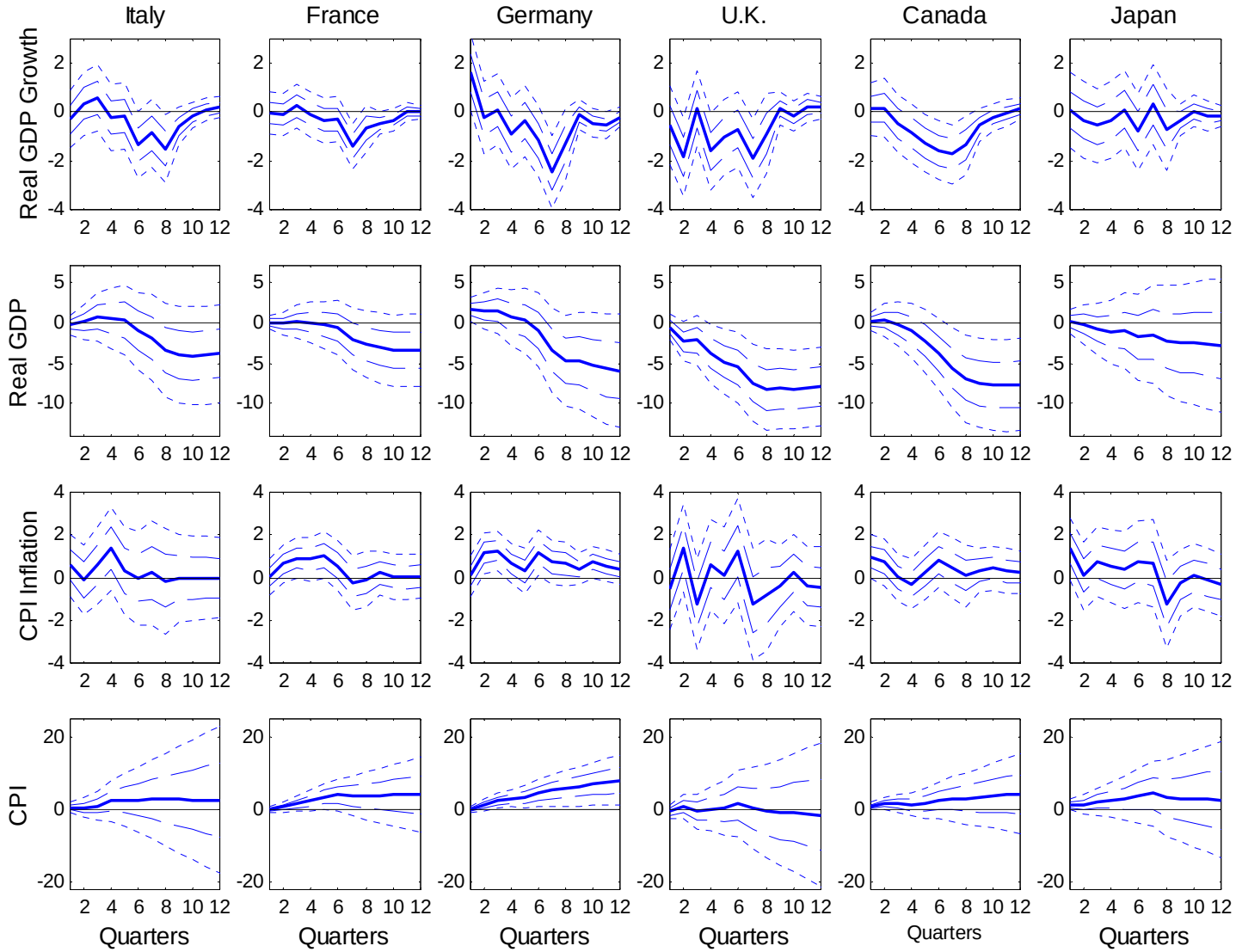
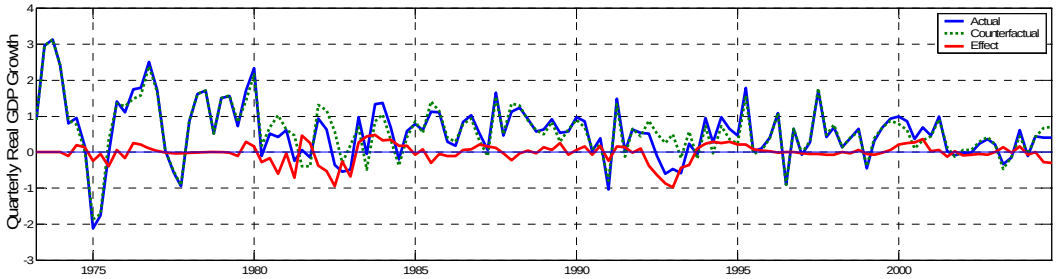
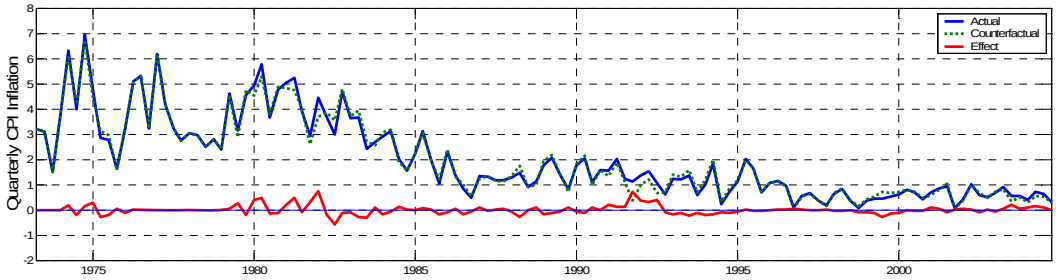


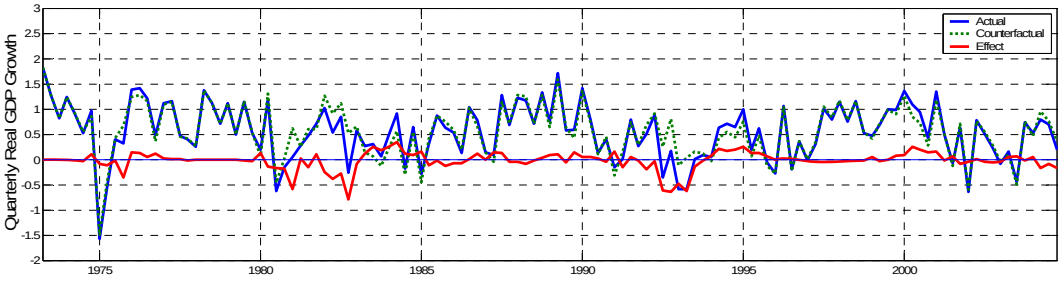
Figure 5: Counterfactual Economic History without Exogenous Oil Supply Shocks

(a) Italy





(b) France



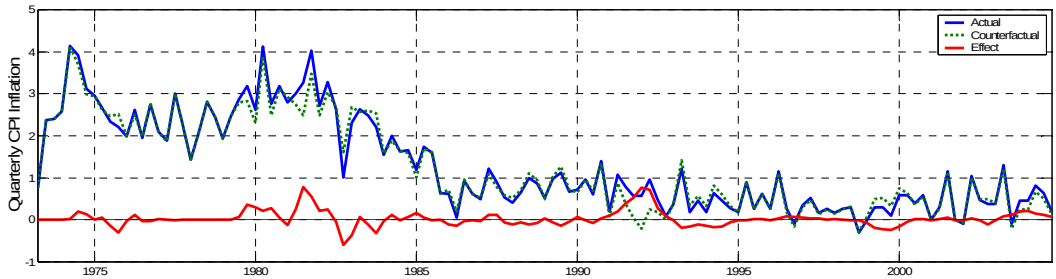
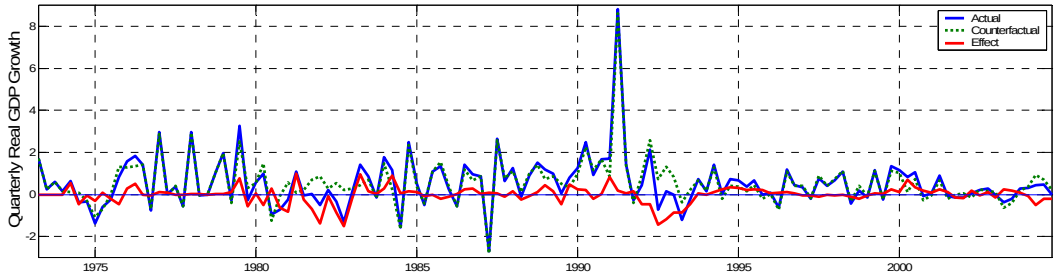
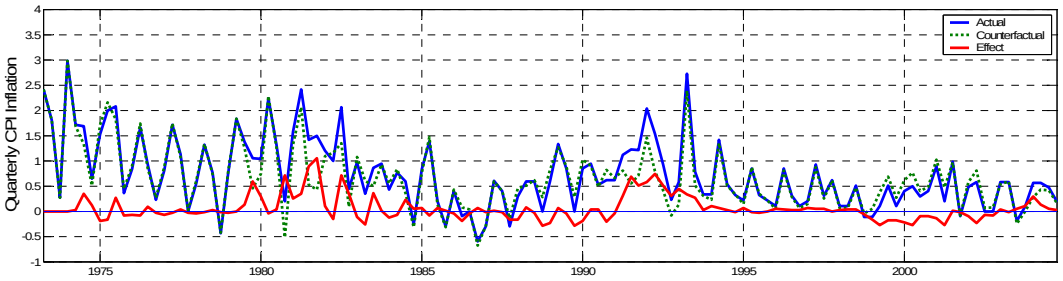


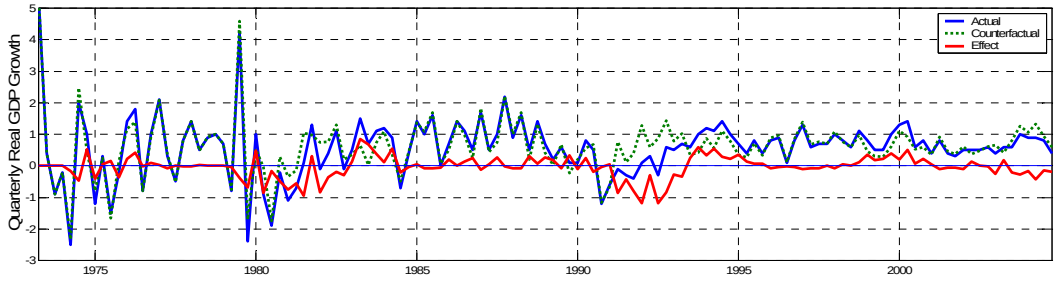
Figure 5: Counterfactual Economic History without Exogenous Oil Supply Shocks (contd.)

(c) Germany





(d) U.K.



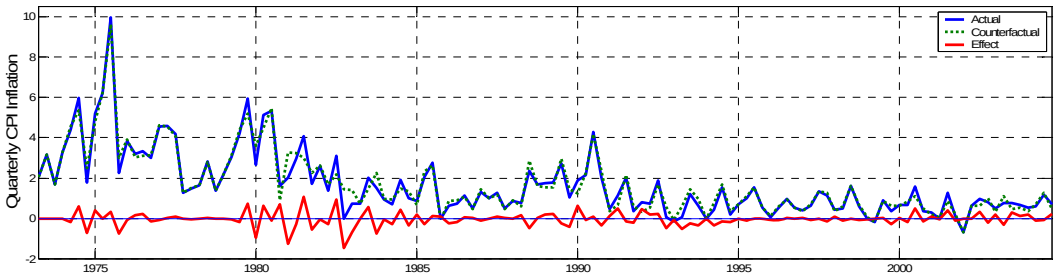
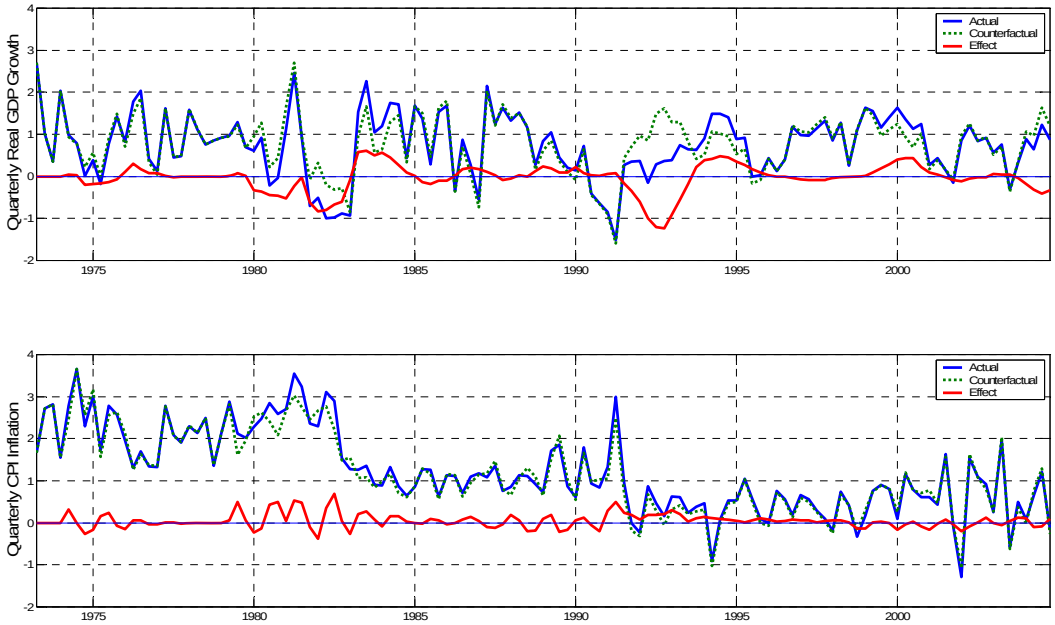


Figure 5: Counterfactual Economic History without Exogenous Oil Supply Shocks (contd.)

(e) Canada



(f) Japan

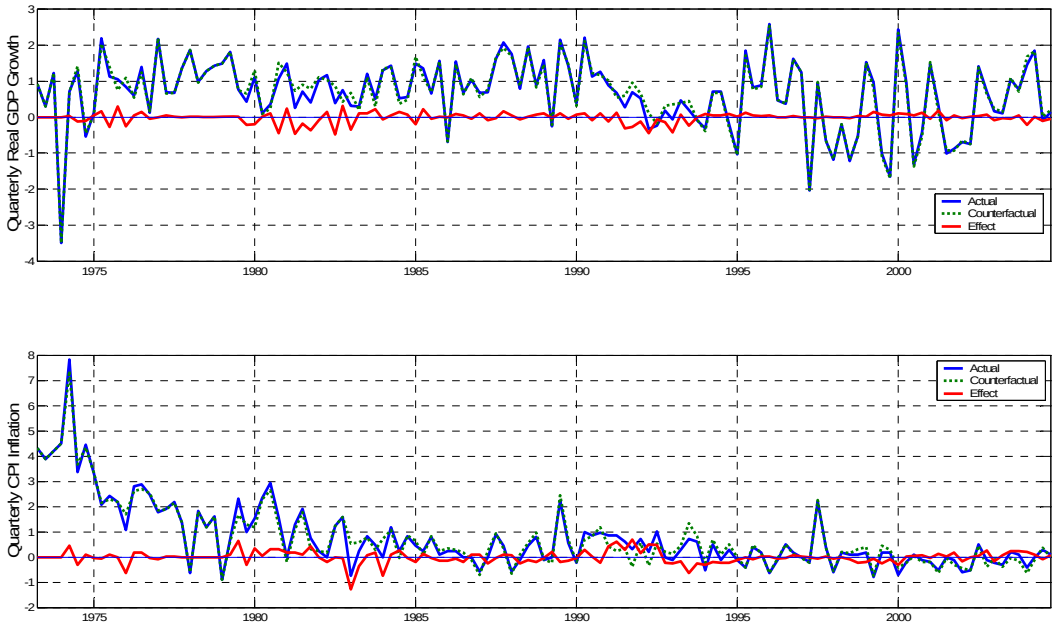


Figure 6a: Comparison of Real Growth Experience by Oil Shock Episode

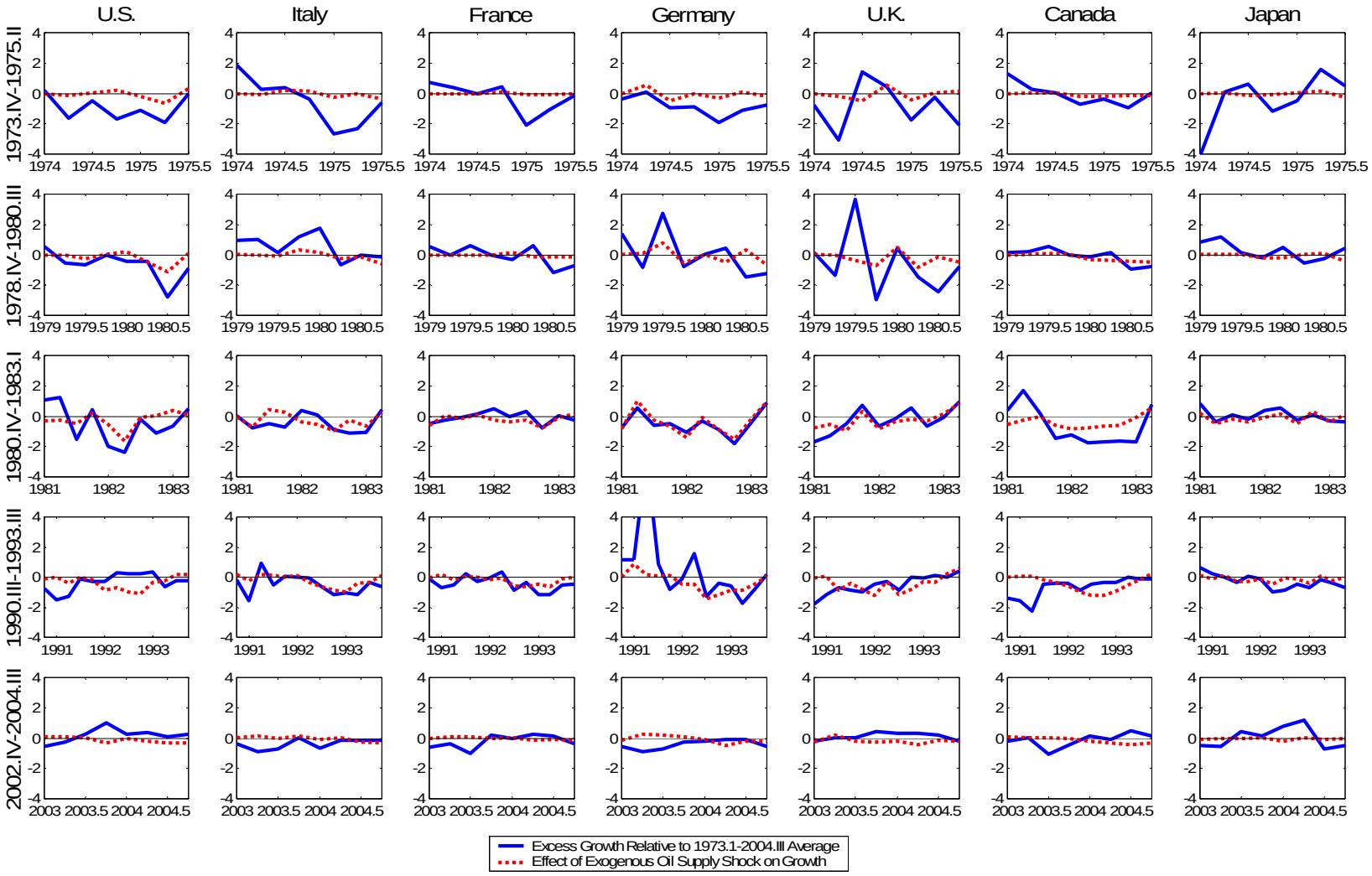


Figure 6b: Comparison of CPI Inflation Experience by Oil Shock Episode