No. 2001/11

Country-Specific and Global Shocks in the Business Cycle

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CFS Working Paper No. 2001/11

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First Draft, October 2000
Final Draft, January 2001

Abstract:
Industrial production in G7 countries is assumed to be driven by two exogenous disturbances. Those disturbances are identified in a VAR model so they can be interpreted as country-specific and global supply shocks. The dynamic properties of the model are analyzed and the relative importance of each shock is measured. It is shown that the VAR model matches most of the theoretical predictions of standard intertemporal open-economy models. The identified structural disturbances are analyzed with regard to their impact on the current account and investment.

JEL Classification: E32, F41

Keywords: Country-Specific and Global Shocks, VAR, RBC

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This paper is based on the second chapter of my doctoral dissertation at the University of Frankfurt. I am grateful to Matthias Hoffmann and Axel A. Weber for helpful comments and discussions. All remaining errors are my own.

1 Introduction

The economic profession distinguishes between country-specific and global shocks. In each category, one can further discriminate between demand and supply disturbances. The impact of demand and supply disturbances on economic activity has been studied extensively in theoretical closed and open economy models including Mark and Cantor (1988), Mendoza (1991), Baxter and Crucini (1993), Backus, Kehoe and Kydland (1992) and (1994), Cooley (1995), Baxter (1995) and Kollmann (2001) amongst others. Extending Sims's (1982) seminal work, Blanchard and Quah (1989) proposed an identification scheme in a vectorautoregression (VAR) framework by which the researcher is able to discriminate between demand and supply shocks. The method uses the theoretical insight that demand shocks should have no persistent impact on real variables. Many researchers including Galí (1992), Chinn and Lee (1995), Clarida and Galí (1995), amongst others, followed this approach to answer the question to what extent cyclical fluctuations in economic activity are attributable to demand and supply disturbances. Global and country-specific shocks have been studied with at least two different perspectives. One strand of research comprises the theoretical and empirical literature on the intertemporal approach to the current account, pioneered by Sachs (1981), Obstfeld (1986) and canonized in Obstfeld and Rogoff (1996). Tests of this theory generally involve an evaluation of the impact of country-specific and global shocks on the current account. Glick and Rogoff (1995) construct measures of country-specific and global shocks and provide empirical evidence in favor of this theory by confirming earlier results of Sachs (1991). These findings are reinforced by Hoffmann (2000). He identifies country-specific and global shocks in a vector error-correction model. Gregory and Head (1999) come to similar conclusions with a Kalman-filter approach detecting the impact of global and country-specific shocks on the current account. A second strand of research focuses on the importance of global and country-specific shocks for the international business cycle. To the authors knowledge, the theoretical insights and the empirical evidence are somewhat scant. On the one hand, global or common shocks seem to play no prominent role in the international business cycle theory as many models do not consider them in their analyses, e.g. the survey by Baxter (1995). On the other hand, theoretical insights and empirical evidence appear to be unmatched. Canova and Marrinan (1998) provide empirical evidence that country-specific shocks to the US induce co-movements in the output cycles of Germany and Japan which is akin to saying that country-specific shocks to the US spill-over to other countries and thereby produce co-movements in aggregate variables. In the same paper, however, they present a theoretical multi-country model and show that a common component in the shocks best accounts for the empirically observed output dynamics. As far as the empirical evidence is concerned, Kwark (1999) arrives at similar conclusions. He identifies global and country-specific shocks in a vector error-correction framework using the US as domestic country and an aggregate of the other G7 members as foreign country. His findings are that country-specific shocks to the US are most important in explaining domestic and foreign output fluctuations although foreign output fluctuations are partly explained by global shocks. Contrary to these results are the findings by Phillip's (1991). He shows that the effects from global shocks dominate the impact from the transmission of country-specific shocks in a regime-switching model. The previous results are challenged by a recent study of Canova and de Nicoló (2000). In a novel procedure, they identify shocks by matching the cross-correlation pattern of the impulse response functions to the theoretical predictions. Although their focus is primarily on the sources of economic fluctuations, their findings suggest that one is looking at the wrong candidates when analyzing supply shocks as the primary disturbances that drive the business cycle. Following their arguments, it seems that nominal country-specific demand shocks are the primary forces that account for the major part of economic fluctuations in the G7 countries[1].

The present paper contributes to the debate by proposing an identification scheme for global and country-specific shocks in a vectorautoregression (VAR) framework. The analysis differs from previous work in at least four aspects. First, we impose a structural identification on a VAR model. The restrictions are derived from a baseline international real business cycle model that explicitly considers global shocks. Second, we distinguish explicitly between country-specific and global supply shocks by means of standard assumptions. Third, we circumvent large scale aggregation of time series in order to avoid measurement errors that might bias the results[2]. Fourth, the present analysis attempts to link the intertemporal approach to the current account and the international business cycle theory by confronting the empirical evidence with both branches of economic theory.

Section 2 motivates why one might care about the existence of global shocks. Section 3

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[1] The general conclusion must be restricted. Their results seems to hold for all G7 countries but Canada and Italy. Also, the interpretation should be taken with care because no explicit distinction between country-specific and global shocks is made. Further, the identified supply shocks appear to have no persistent effects which is a counter-theoretical feature.

[2] Kwark (1999) aggregates the output, consumption, investment and export series across the G7 countries - except the US - using the real exchange rate. Lumsdaine and Prasad (1999) proceed similarly.

presents a version of a two-country international real business cycle model with incomplete markets where both countries are hit by a common productivity shock. It is shown that the shock-symmetry forces the cumulated output responses to be identical across countries regardless of differences in country size. This implication is used in section 4 to identify symmetric and asymmetric shocks where the former are interpreted as global and the latter as country-specific innovations. A VAR model is estimated using monthly data of industrial production for the sample of the G7 countries. Impulse response function analysis and variance decomposition is performed. We extend the VAR model in section 5 by an oilprice variable. It is intended to show that global shocks still matter once we account for the major oilprice crisis. We then check for robustness with respect to data frequency in section 6. In section 7, we look at the impact of country-specific and global shocks on investment and the current account. In section 8, the conclusions are summarized.

2 Global Shocks

Whilst there seems to be consensus in the literature about the meaning of demand and supply shocks, the identification and interpretation of global and country-specific shocks appears to be less clear-cut. Phillips (1991) extension of Hamilton's (1989) work is an example for what is interpreted as global shock. The very low autocorrelations in the innovation processes across industrialized countries are taken as evidence that major movements in the GDP growth rates are caused by world-wide shocks and that any other transmission of business cycles is small in comparison[3]. Glick and Rogoff's (1995) work identifies country-specific shocks as deviations of the Solow-residual from a world aggregate productivity measure. Global shocks capture anything else that is not covered by country-specific shocks. Global shocks are therefore better understood as residuals rather than as structural innovations that are assigned an economic meaning. A major drawback of their approach is that shocks are identified beyond an economic model. Gregory and Head (1999) use similar measures of global and country-specific shocks to identify their impact on the current account. More theory-based identifications of global and country-specific shocks are suggested by Kwark (1999) and Hoffmann (2000). The former identifies global shocks explicitly by assuming that they have no contemporane-

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[3] This conclusion is derived from the analysis of the country-pairs US-Canada, US-Germany and US-UK. It might not be valid for the transmission of business cycles between developed and less-developed or large and small countries.

ous impact on the trade balance. Disturbances that have no contemporaneous effect on foreign variables qualify in this setting as country-specific shocks. Hoffmann (2000) uses similar arguments to identify global and country-specific shocks in bilateral vector error-correction models. Although the theoretical meaning of a global shock is well understood, their intuitive content is rather low. Hence, before introducing another identification scheme, some empirical evidence is presented that shall motivate the idea of a global shock.

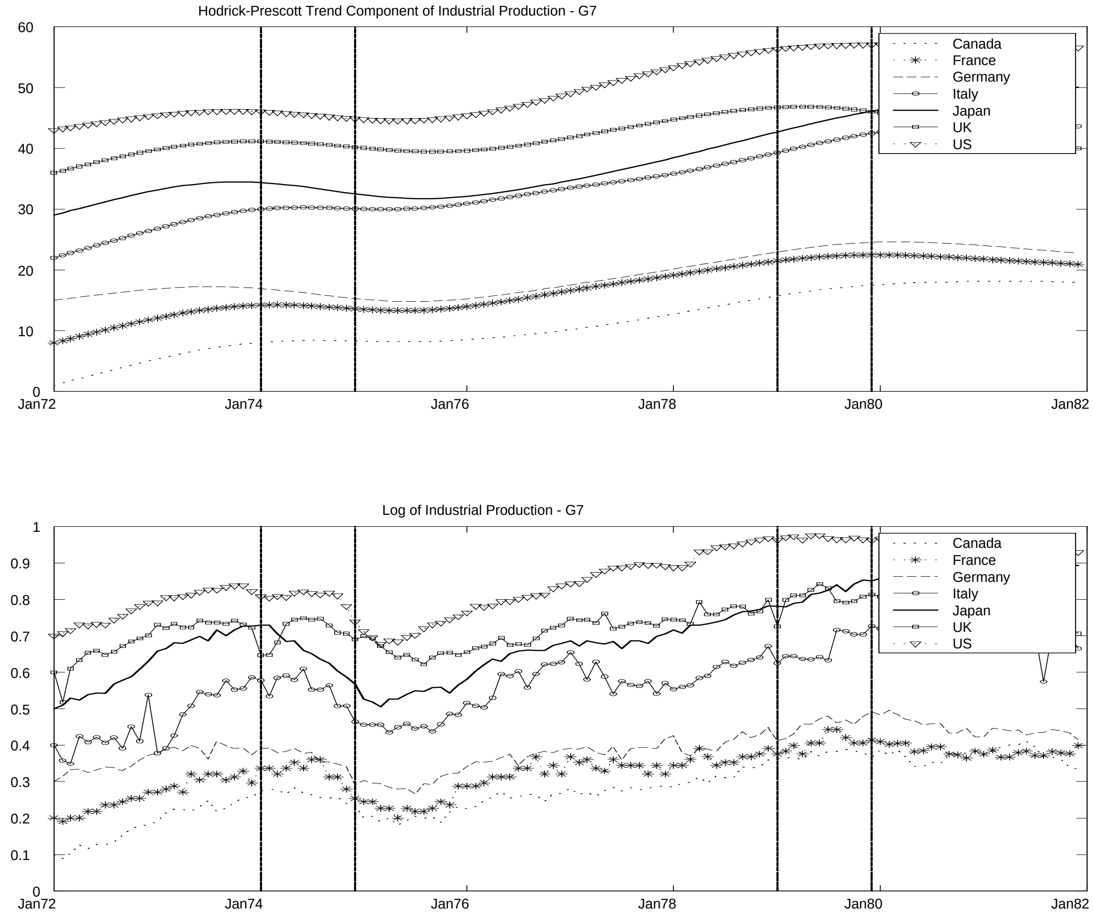

Figure 1: Industrial Production in G7 Countries

A straight-forward example of a shock that was perceived to be global in nature is the first oilprice shock in 1974[4]. The lower panel of figure 2.1 shows monthly observations

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[4] Many undergraduate textbooks (see Barro and Grilli (1994), Mankiw (1994), Barro (1997), Blanchard (1997)) discuss the impact of the oilprice crisis with the slowdown in economic activity in the

of real industrial production[5] for the G7 countries. Visually, real industrial production declines in all G7 countries in response to this negative (oil-) supply shock in 1974. This impression is reinforced by looking at the trend-components that are shown in the upper panel of figure 2.1. Trend-growth of industrial production has been slowing across all G7 countries in response to the increase in oilprices. A rough glance also suggest that the impact of oil price increase differs in terms of size and duration across countries. The decline in Japanese total domestic production appears to be more severe than the response of the Canadian economy. Whilst the economy in France seems to enter the recession in August 1974, Japan has already been experiencing the recession for 7 months. Even if the extent to which a country is hit by the oilprice shock differs across countries, the OPEC-driven increase in the oilprice has become an example *par excellence* for an adverse global supply shock. Presumably this is not only because the directions of changes in the growth of total domestic production have been similar across the G7 countries[6] but also that a single source was unambiguously identified and that the same mechanisms[7] were at work leading to a decline in total production across countries.

The coincidence of a common exogenous shock and simultaneous output movements is not as self-evident as one might expect. To demonstrate this point, figure 2.1 also highlights the period January - December 1979 in which the second oilprice crisis fell. Although the causal origin is identical to its predecessor in 1974, industrial production does not show any systematic behavior across the G7 countries. Partly, this might be accounted for by different policy reactions to the oilprice increase. However, it raises the question if a global shock is characterized by a common exogenous disturbance, by simultaneous output movements or by both of them. Interestingly, we are able to identify a substantial negative global supply shock in 1979 by assuming that the output responses are equal across countries.

In general, episodes in which global shocks are so evident and undoubtedly identified - like in 1974 - are rare[8]. More likely, one has to think about global shocks as unobserved

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major industrialized economies in the 1970's, implicitly assuming that the oilprice increase had similar effects across countries.

[5] The data has been taken from the International Financial Statistics publication of the IMF.

[6] Phillips (1991) estimates high probabilities that the economies of Canda, Germany, the UK and the US are in a recession in 1974. Growth rates in 1974 had been very low (in some cases even negative) compared to the pre - 1974 GDP growth.

[7] Rotemberg and Woodford (1996) examine the mechanisms by which a rise in energy prices leads to a decline in GDP.

[8] Of course, the war periods 1914-1918 and 1939-1945 also give rise to identify global shocks. But these kinds of events have fortunately become rare in our recent history.

innovations to the production process that are neither immediately felt nor necessarily are large in size. Evaluating the quantitative importance of global shocks requires first their identification in time series data, which becomes even more complex when one has to account for the simultaneous presence of country-specific shocks. The identification could even be further complicated by distinguishing demand and supply shocks that can be global or country-specific in nature respectively. However, preliminary tests suggest that temporary components in time series that are generally associated with demand-side innovations are quite low compared to the permanent components and that they do not seem to matter much in the analysis[9]. Hence, for the remainder of this paper, we will only refer to supply-side innovations that are either global or country-specific in nature. To distinguish one from the other, the help of economic theory is invoked.

3 Theoretical Background

3.1 A Basic Two-Country Model

We derive the theoretical formulation of our identification from a standard open-economy real business cycle model as described by Baxter (1995). The model consists of two countries that will be referred to as home and foreign. The preferences of the representative consumer in each country are characterized by an expected lifetime utility function of the form

$$U_i = E_0 \left[\sum_{t=0}^{\infty} \beta^t u \left(c_{it}, 1 - n_{it} \right) \right] \tag{1}$$

with $i = h$, f denoting home (h) and foreign variables (f). Further, c_{it} and n_{it} represent consumption and hours worked in country i at period t. β is a constant discount factor of future period utility. Preferences are assumed to be identical across countries and can be described by the period utility function

$$u \left(c_{it}, 1 - n_{it} \right) = \theta \log c_{it} + (1 - \theta) \log \left(1 - n_{it} \right) \tag{2}$$

where θ is a constant parameter weighting leisure and consumption in period utility. There are representative firms in each country that are assumed to operate so as if the

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[9] We estimated the subsequent regressions i) using the first-differences of the series; ii) using the first-difference of the permanent component of that series only after applying the Beveridge-Nelson decomposition. The results were only marginally different which we interpreted as evidence that a further discrimination of demand and supply shocks in the present analysis is negligible. Nevertheless, we recognize the evidence suggested by Canova and di Nicoló who precisely challenge this view.

environment were perfectly competitive using a Cobb-Douglas production function

$$y_{it} = z_{gt} z_{it} k_{it}^{\alpha} n_{it}^{1-\alpha}. \tag{3}$$

Here, y_{it}, z_{it} and k_{it} denote output, the state of technology and physical capital in country $i = h,\ f$ as before. In contrast to standard specifications of production functions, an additional global shock to productivity z_{gt} is included that is common to both countries and that is interpreted as global supply shock[10]. Capital accumulates in both countries according to

$$k_{it+1} = (1 - \delta)\, k_{it} + x_{it} \tag{4}$$

where x_{it} is gross investment in country i at period t. δ is a constant parameter representing the depreciation rate of the physical capital stock. Both countries are linked by financial markets which are assumed to be incomplete. We do not assume complete Arrow-Debreu financial markets that would allow agents to engage in perfect risk-pooling across countries since this notion has been rejected by several studies including Backus, Kydland and Kehoe (1992), Stockmann and Tesar (1995) and Attanasio and Davis (1996) amongst others. The only asset that is traded internationally is a riskless bond b_t that yields a real return of r_{t-1} at period t. Denoting π and $(1 - \pi)$ the size of home and foreign country respectively, the world market-clearing condition for the riskless bond implies

$$b_t = \pi b_{ht} + (1 - \pi)\, b_{ft} = 0 \tag{5}$$

where b_{ht} and b_{ft} indicate home and foreign country's stocks of bonds. To close the model, the resource constraint for the representative consumers need to be specified. Given the assumptions made above, the period budget constraints take the following forms:

$$y_{it} + (1 + r_{t-1})\, b_{it} = c_{it} + x_{it} + b_{it+1}. \tag{6}$$

Home, foreign and global productivity are assumed to be exogenous and follow stochastic process. In particular, home, foreign and global productivity are assumed to follow the first-order vectorautoregressive process

$$\begin{pmatrix} z_{ht+1} \\ z_{ft+1} \\ z_{gt+1} \end{pmatrix} = \begin{pmatrix} \rho_{11} & \rho_{12} & 0 \\ \rho_{21} & \rho_{22} & 0 \\ 0 & 0 & \rho_g \end{pmatrix} \begin{pmatrix} z_{ht} \\ z_{ft} \\ z_{gt} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ht+1} \\ \varepsilon_{ft+1} \\ \varepsilon_{gt+1} \end{pmatrix} \tag{7}$$

where $\varepsilon = (\varepsilon_h, \varepsilon_f, \varepsilon_g)'$ and $\varepsilon \sim N(0, \Sigma)$. Apart from the inclusion of a global productivity component, equations (1)-(7) are rather standard specifications in the literature on

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[10] This specification of the production technology is analogous to Glick and Rogoff (1995).

international real business cycles. Yet, we do not intend to claim the integration of a global productivity shock component in international business cycle models. Rather, it is thought of as an experiment to study what happens to economic activity across countries if there is a global component that dominates country-specific shocks?

The representative consumers maximize their expected lifetime utility (1) subject to (3)-(7). The resulting equilibrium conditions do not allow an analytical solution of the model. Therefore, we take a log-linear approximation of the model around the steady state and solve it by applying the Blanchard-Kahn (1982) algorithm.

The numerical analysis of the model requires to calibrate the parameters of the model so that long run properties of the data are matched. We follow closely the parameterization in Baxter (1995) to preserve comparability. In the steady state, one-fifth of total time is devoted to market work, fixing n to 0.2. The discount factor β is set to 0.9875 to arrive at an quarterly real interest rate of 1.012 percent. Capital depreciates at a rate of 2.5 percent per quarter implying $\delta = 0.025$. Labor income is estimated to absorb 58 percent of total GNP suggesting that α is equal to 0.42. Noting that the capital-output ratio averages empirically around 11.8, we set the steady state capital-output ratio equal to 11.8. The weight of leisure in period utility is set to 0.8216 following King, Plosser and Rebelo (1989). The autoregressive coefficients in the shock processes are calibrated as follows: ρ_{11}, ρ_{22} and ρ_g are set to 0.93 paying tribute to the high serial correlations found in the Solow-residuals by Reynolds (1993) and Backus, Kydland and Kehoe (1992). The evidence on the spillover effects of productivity shocks is somewhat scant. Therefore ρ_{12} and ρ_{21} are set to 0.05. These values are perfectly in line with standard parameterization, e.g. Backus, Kehoe and Kydland (1992), Baxter (1995) or Kollmann (2001). In contrast to standard specifications, the innovation variances differ across countries. The smaller home country which accounts for 10 percent of world output ($\pi = 0.1$) is assumed to experience a higher variance in productivity growth $\sigma_{11}^2 = 0.004$ than the foreign country with $\sigma_{22}^2 = 0.0004$ - accounting for 90 percent of world output. The distinction in the innovation variances seems to be justified on empirical grounds. Principally, for a sample of 9 OECD countries, the innovation variances differ by a factor of 10 with Norway at the top ($\sigma_{NO}^2 = 0.003787$) and the US at the lower end ($\sigma_{US}^2 = 0.000419$)[11]. The variance of innovations to global productivity is assumed to dominate. It is set to $\sigma_g^2 = 0.07$ so

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[11] We derived the innovation variances from the residual variance-covariance matrix of a VAR with one lag. The data was provided by Zimmermann (1999). The ranking in terms of innovation variance took the following shape: Norway, Australia, UK, Sweden, Germany, Japan, Canada and the US.

as to induce a cross-country output correlation equal to 0.78[12]. The empirically observed positive correlations amongst the innovations to productivity are fully captured by the dominance of the global shock. For that reason, the covariance between the country-specific shocks is set to zero. Further, the innovations to country-specific and global productivity are assumed to be orthogonal. There are two reasons for this assumption. First, assigning both shocks a structural economic interpretation, there is no justification why their occurrence should systematically coincide[13]. The second argument has a practical background. We later attempt to identify global and country-specific shocks by imposing an orthogonality assumption. In order to be logically consistent, the shock processes are generated by drawing from a normal distribution with global and county-specific shocks to be uncorrelated.

3.2 Impulse Response Functions

The dynamic properties of the model are evaluated by means of simulation and impulse response functions. The panels a), c) and e) of figure 3.1 show the impulse response functions of domestic output and consumption in response to a domestic supply shock, a foreign supply shock and a global supply shock . The panels b), d) and f) display the responses of the same variables for the foreign country. Consider first the responses to a permanent productivity shock in the home country. The productivity shock raises the marginal product of labor permanently and induces the domestic agent to substitute away from leisure to labor. The improvement in technology and the change in labor supply also stimulate investment by increasing the marginal product of capital. Both, the increase in labor and capital induce a permanent increase in output implying a wealth effect. The domestic agent perceives the wealth effect as permanent and immediately adjusts its consumption plan to the new long run level. The domestic productivity shock induces a drain in capital from the foreign to the domestic country because the marginal product of capital is higher in the home country. This is accompanied by a temporary decline of foreign output.

Due to spill-over effects, a domestic country-specific shock to productivity also raises foreign output permanently. The implied wealth effect induces an immediate adjustment in consumption plans abroad. Define the current account of country i as the change in net foreign assets, $CA_{it} = b_{it+1} - b_{it}$. Then the capital inflow in the home country implies

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[12] This figure correponds approximately to the average cross-correlation in output of 9 OECD countries with respect to US output. For reference, see Baxter (1995).

[13] This logic also underlies the distinction of demand and supply shock.

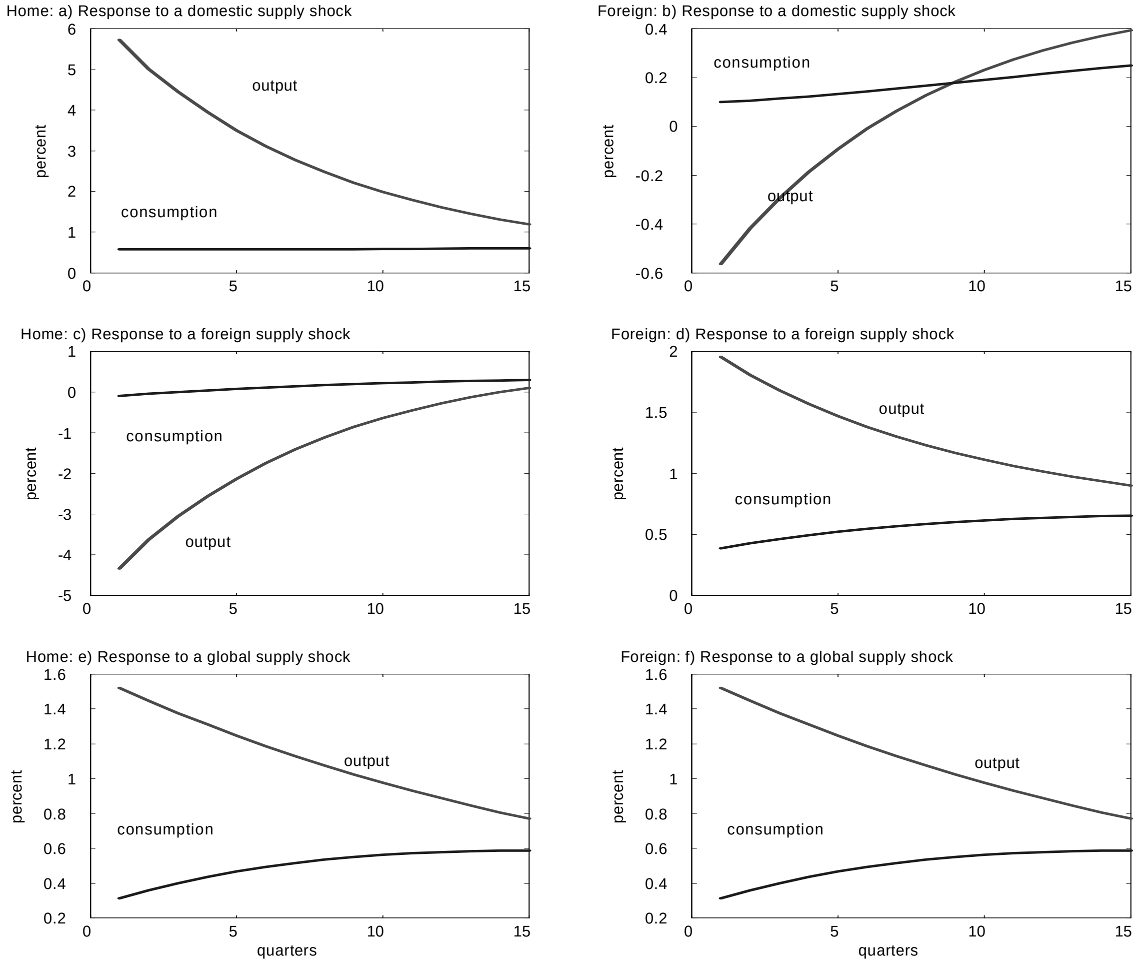

Figure 2: Impulse Response Functions

a deterioration of the current account on impact. The same mechanisms are at work if the foreign country experiences a permanent shock to productivity. Qualitatively, the dynamic responses of the model are simply mirrored. However, the responses differ in terms of deviations from the steady states which results from the larger impact of the foreign country on the world interest rate. On the one hand, domestic agents reallocate relatively more of their capital to the foreign country implying a more severe decline in domestic output. On the other hand, the increase in world interest rates crowds out investment abroad which explains why output increases less in the foreign country.

Consider then the responses to a common permanent productivity shock. The common shock raises the marginal product of labor symmetrically across countries inducing increases in domestic and foreign employment as agents substitute labor and leisure. Capital is more productive in either country. Therefore, agents in both countries wish to borrow from the rest of the world to finance their investment needs. The increase in the world interest rate defers capital imports in the home and foreign country. Consequently, the output responses in both countries are lower than under asymmetric productivity shocks as a comparison of panels a) - e) and b) - f) reveals. If agents at home and abroad attempt to borrow, world interest rates must rise to clear the international credit market. In equilibrium, there will be no intertemporal reallocation of resources. Then domestic and foreign consumption have to increase gradually - proportional to the output responses. The described mechanisms are rather conventional wisdom in intertemporal open-economy macroeconomics.

A further characteristic that we consider crucial in our analysis refers to the symmetry in the output responses. A global shock produces identical responses in output across countries in terms of deviations from their steady state although country sizes may differ substantially. In other words: if the asset market structure is incomplete, two economies experience the same adjustment path to a global shock regardless of the size of the economies. To enforce this result, two requirements must be met. First, a global shock affects the marginal products of capital and labor symmetrically across countries. This is assured by assuming equality in the steady state labor input and in the per-capita capital stock across countries. Second, initial current account imbalances must not be "too" large. If there is a significant wealth effect for at least one country, then the output responses to a global shock will differ. For minor current account imbalances, the involved wealth effects are quite small and hardly drive a wedge between the output responses. Glick and Rogoff (1995) impose similar conditions on their model arguing that it is a reasonable approximation for the major G7 countries.

Noteworthy, the output symmetry is robust to variation in country sizes. It can be shown that the response symmetry extends to models where goods are traded internationally as in Backus, Kehoe and Kydland (1994). However, it cannot be maintained that this feature is to hold generally. When international financial markets are assumed to be complete, a global shock generates symmetric output responses only if countries are of equal size. When consumers are allowed to perfectly pool their risk against all possible states of nature, the larger consumer always dominates her smaller neighbor leading to asymmetric output and consumption responses. Before the symmetry characteristic is employed to identifying global shocks empirically, we look at the model's ability to replicate important stylized facts of the business cycle.

3.3 Simulation Results

We simulate the model by drawing 100 times from the standard normal distribution. The random realizations of the three shock processes are transformed by the Cholesky factor of Σ^*, where Σ^* denotes the variance-covariance matrix of all structural shocks. Prior to the statistical analysis, the artificially generated data is Hodrick-Prescott filtered with $\lambda = 1600$. The reported standard deviations and correlations are averages over 100 draws. The parameter π is set to 0.1 in order to match on average the differences in size between the US economy and other G7 countries.

Theoretical and Empirical Standard Deviations

	Model		Empirical stylized facts						
	Small	Large	Canada	France	Germany	Italy	Japan	UK	US
y	1.09	1.00	0.78	0.47	0.79	0.88	0.70	0.83	1.00
c	0.26	0.24	0.66	0.46	0.70	0.68	0.76	0.95	0.75
n	0.66	0.60	0.67	1.39	0.48	0.38	0.25	0.57	0.61
x	26.46	10.64	2.18	0.26	2.30	1.71	1.69	1.99	3.27

Table Ia) Model predictions and stylized facts

i) Empirical standard deviations are relative to US output

ii) Theoretical standard deviations are relative to the large country's output

iii) Stylized facts are according to Backus, Kehoe and Kydland (1994)

Table I a) reports the standard deviations for output, consumption, investment and employment relative to US output, table I b) displays the cross-country correlations, each with respect to the same US variable. We distinguish between the small and large country when reporting the standard deviations for the model. Generally speaking, the model is able to replicate important stylized facts of the international business cycle. Investment appears to be more volatile than output which in turn is more variable than employment and consumption. Most importantly, output, consumption, employment and investment are positively correlated within and across countries, a feature that many open-economy real business cycle models fail to replicate (see Baxter (1994) and Cooley (1995)). Clearly, the model with global shocks is at odds with the stylized facts in several respects. First, it tends to underestimate the empirically observed consumption variability. Second, the model overestimates the variability in output and investment in the small country. Third, it also fails to explain the Backus-Kehoe-Kydland output-consumption correlation puzzle in that consumption is theoretically much higher correlated across countries than output. As far as the consumption-output correlation is concerned, this is general failure of open economy real business cycle models with perfectly-flexible prices which we do not attribute to the integration of a common shock. The comparatively high volatility in the small country's investment plan is also precluded by the model's arithmetic rather than a result of the model calibration[14].

Theoretical and Empirical Cross-Correlations

	Model	Empirical stylized facts						
		Canada	France	Germany	Italy	Japan	UK	US
y	0.78	0.78	0.41	0.69	0.41	0.60	0.55	1.00
c	0.97	0.49	0.39	0.69	0.02	0.44	0.42	1.00
n	0.72	0.53	0.26	0.52	-0.1	0.32	0.69	1.00
x	0.17	$-.01$	0.22	0.55	0.31	0.56	0.40	1.00

Table Ib) Model predictions and stylized facts

i) Empirical correlations are with respect to US variables

ii) Stylized facts are according to Backus, Kehoe and Kydland (1994)

The small country hardly affects the world interest rate when acting in international financial markets. Therefore, most of its capital requirements will be met to expand production capacities in boom phases, implying a high investment volatility. In contrast, a large country raises the world interest rate by borrowing from world financial markets which in turn dampens investment demand. Because this "crowding-out" mechanism is more pronounced for larger countries, they appear to display less volatile investment responses than smaller countries.

In contrast, the low consumption variability is a consequences of the inclusion of a common shock. The dominance of global shocks lowers the extent to which agents are able to substitute their consumption intertemporally, implying more gradual adjustments in the consumption plans. This in turn renders consumption less volatile over time. Despite these deficiencies, the model is able to replicate the positive cross-country correlations amongst important macroeconomic variables. We therefore believe the model's implication to be helpful in exploring the extent to which co-movements in macro-variables are accounted for by common shocks.

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[14] Recall that we assumed a shock variance for the domestic country that is 10 times higher compared to the foreign (large) country.

4 Identification of Global Shocks in a Vectorautoregression Model

The impulse response functions in panels e) and f) of figure 3.1 bear strong implications that can be explored to identify country-specific and global supply shock components. First, a global shock produces identical percentage output increases on impact across countries. Second, the limiting impulse responses in the level of output are identical across countries. The first implication focuses on an instant of time, namely on the period in which the shock occurs. Since the model does not account for cross-country structural asymmetries[15], the identification of global shocks on the basis of realizations in a single period is believed to be too restrictive[16]. The second alternative essentially restricts the long run output responses. Explicitly, the limiting impulse responses of the levels of output are identical across countries which is akin to stating that the differential in the output levels must be zero in the long run. This restriction allows for asymmetries in output adjustments over the time span considered and is therefore given preference over the first alternative[17].

4.1 The Data Properties

Implicit to the analysis is the maintained hypothesis, that one is able to discriminate between country-specific and global shocks. There is no economic rational to assume that either type of shock only triggers temporary changes in output. Therefore, both country-specific and global shocks are admitted to have lasting effects on either countries output. Hypothetically, consider a situation in which domestic and foreign output variables are cointegrated, that is, domestic and foreign output share a common trend. This draws two alternative implications. First, any shock that has lasting effects on either country's output will occur perfectly symmetric. For example, if a domestic supply shock raises domestic output permanently, it will do so with foreign output. In this case, the definition of a global supply shock is observationally equivalent to the nature

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[15] Market asymmetries may be present due to informational costs, labor market or price rigidities that differ across countries.

[16] Additionally, there are already studies by Kwark (1999) and Hoffmann (2000) who investigated the role of country-specific and global shocks using on-impact restrictions. Because employing the same restrictions is believed to merely replicate their results, we do not follow this approach.

[17] Surprisingly, a short-run restriction - drawing on the first alternative - identifies shock components that a very similar to those from a long-run restriction across the sample countries. This is taken as evidence in support of our model.

of the country-specific supply shock in the presence of cointegration. Country-specific and global shocks are indistinguishable by the proposed identification scheme. Second, country-specific shocks exert only temporary effects on output, having the global supply shock to explain the cointegrating relationship alone. As this seems hardly justifiable economically, one would rather have to adopt the first implication and conclude that this approach is not tractable. The limitations implied by data properties are rigorously worked out in the appendix A.

As a preliminary step and in order to specify the model correctly, the long run properties of the data are characterized. Unless otherwise indicated, the data used in the remainder of this paper are taken from the June 2000 International Financial Statistics tape. We use monthly observations of industrial production for the G7 countries that are denoted by y_t^i where i is the country index. All data has been seasonally adjusted. The sample period is 1958:1 - 1998:12. Prior to estimation, the logarithm of industrial production has been taken.

Unit Root Tests

Country	t-statistic $\log(y_t^i)$	t-statisticΔ $\log(y_t^i)$
Canada	-2.206	-6.690^*
France	-1.723	-10.254^*
Germany	-2.111	-8.670^*
Italy	-2.808	-8.870^*
Japan	-2.308	-5.589^*
UK	-2.955^*	-8.801^*
US	-2.704	-6.908^*

Table II Augmented Dickey-Fuller test statistic for 6 lags

i) 95 % critical value is -2.87 after Dickey and Fuller (1981)

ii) Rejection of the null (unit root) at 95% is denoted by an asterix

In order to detect potential unit roots in the data series, we estimate an Augmented Dickey-Fuller (ADF) test. Table II reports the test statistics for an ADF test with 6 lags. We included a constant plus time trend. As the t-values in column two show, one can not reject the hypothesis of a unit root in the log of industrial production for all countries but the UK[18]. In contrast, testing the first-difference of log industrial production suggests to

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[18] Interestingly, checking serveral lags 4 through 10, one was always able to reject the hypothesis of a unit root in UK industrial production. Nevertheless, UK industrial production is treated so as if it were

reject the hypothesis of a unit root. We take the evidence to conclude that the log of industrial production is integrated of order one in all countries with the exception of the UK.

In order to detect potential cointegrating relationships, we estimate the Johansen-Juselius test for each output series with respect to the US. Table III reports the likelihood ratio based statistics on the maximal eigenvalues of the stochastic matrix with respect to the US. Attention is restricted to the more specific eigenvalue statistics since the trace statistic more often gives rise to contradictory inferences. A lag length of 7 is selected as it seemed to reliably induce white noise-like residuals. A constant and a time trend has been included.

Cointegration Tests

Country	$\mathrm{LR}_{\max}$ for $r \leq 0$	$\mathrm{LR}_{\max}$ for $r \leq 1$
Canada	12.624*	4.256
France	14.649*	4.427
Germany	10.150*	4.758
Italy	11.079*	7.182
Japan	9.036*	3.760
UK	15.760*[19]	7.645

Table III Johansen-Juselius Test Statistics

i) Critical values for the hypothesis that $r \leq 0$ are 15.001 at the 90% interval and 17.148 at the 95% interval; for $r \leq 1$, critical values are 2.705 and 3.845 respectively; Non-rejection of H_0 at 95% confidence level is denoted by an asterix

ii) $\mathrm{LR}_{\max}$ is the likelihood ratio test based on maximal eigenvalue of stochastic matrix

r is meant to denote the number of cointegrating vectors. As the statistics for $r \leq 0$ in table III reveals, one is unable to reject the null that there is no cointegrating relationship between US and the other G7 country's industrial production at conventional levels. In contrast, one is able to reject the hypothesis that there is one cointegrating vector at conventional confidence levels. We interpret the evidence in that there is no cointegration between US and each of the G7 industrial production variables[20]. Henceforth, it is

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integrated of order one.

[19] The high $\mathrm{LR}_{\max}$ value is an expected outcome since UK industrial production is I(0) whilst US industrial production is I(1) .

[20] To check for robustness, we also estimated the Johansen-Juselius test for various lag lengths. The inference drawn from that exercise confirmed our conclusion. In the majority of all cases, we were never able to reject the hypothesis of no cointegration at the 95 % interval, but we could always reject the hypothesis of cointegration at the same confidence level. The evidence is taken to support the argument

assumed that there are no cointegrating relationships in G7 industrial production data with respect to the US.

4.2 Specification and Estimation

Since all data has been assumed to be $I(1)$, the series are rendered stationary by taking first-differences of the logarithm of each variable. The output differential with respect to US is defined by

$$y_{us}^{i} = \Delta \log y^{us} - \Delta \log y^{i}. \tag{8}$$

The index i stands for Canada, France, Germany, Italy, Japan and the UK. The index of the output differential is to be read as follows. y_{us}^{i} denotes the output differential between the US and country i. It is assumed that $y = [y_{us}^{i},\ \Delta \log y^{i}]'$ is a bivariate covariance stationary vector process for any i. Then the elements of x can be expressed as linear combinations of past and present structural shocks. That is x has a vector moving average representation

$$y_t = A(L) \times \varepsilon_t \tag{9}$$

where $\varepsilon = \left[\varepsilon^{h}, \varepsilon^{g}\right]'$ is a vector of serially uncorrelated structural disturbances with zero mean and unit variance. The structural innovations are assumed to be orthogonal. ε^{h} and ε^{g} are interpreted as country-specific and global supply shocks. $A(L)$ is a 2×2 matrix of polynomial lags with $A(0) = I_2$. The reduced form moving average representation of y is

$$y_t = C(L) \times e_t \tag{10}$$

where $e = [e^{1}, e^{2}]'$ is a non-structural residual vector with zero mean and variance-covariance matrix Σ. $C(L) = A(L) \times S^{-1}$ is a 2×2 matrix of polynomial lags that is subject to estimation. S is a 2×2 matrix to be identified. The elements of e are linear combinations of the structural shocks by

$$e_t = S \times \varepsilon_t. \tag{11}$$

Equation (11) with the normalization $E\varepsilon_t\varepsilon_t' = I$ implies

$$\Sigma = S \times S'. \tag{12}$$

In general, equation (10) is used to get consistent estimates of $C(L)$ and Σ applying OLS techniques. In order to recover the structure in (9), one needs to identify the S matrix.

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that there are no cointegrating realtionships present in the data.

The identity in (12) imposes 3 nonlinear restrictions on the S matrix by the estimates of Σ. Just-identification of S requires an additional restriction that is placed on S. Using the insights from economic theory, the global supply shock is to have no long run impact on the differential of the output level. This assumption translates into the restriction

$$c_{11}(L) \times s_{12} + c_{12}(L) \times s_{22} = 0 \tag{13}$$

that is placed on S.

4.3 Empirical Evidence: Impulse Responses and Variance Decomposition

Prior to estimation, the data has been demeaned. On a first stage of estimation, the reduced form VAR (10) is truncated at different lags to see which lag length induces white noiselike residuals.

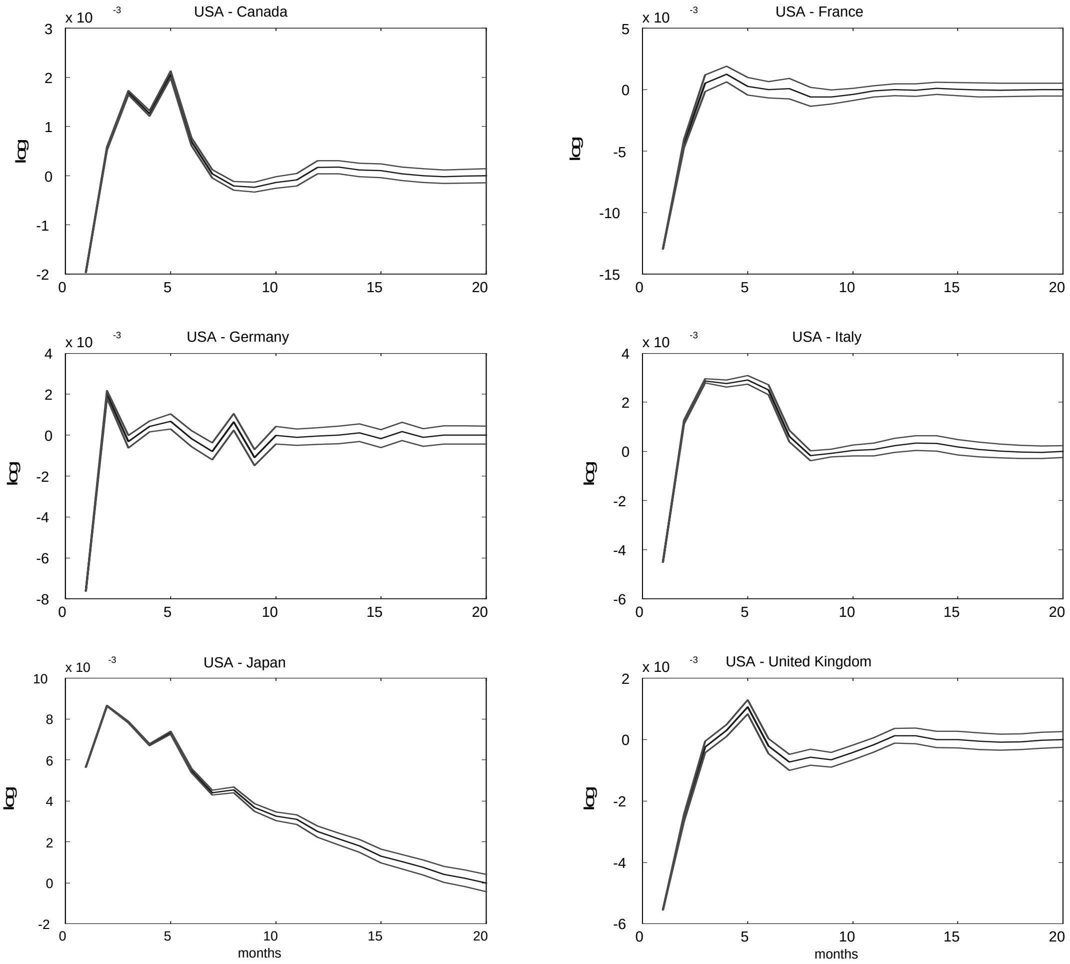

Figure 3: Output Differential: Mean Impulse Response and Two-Standard Error Bands to a Global Supply Shock

The Durbin-Watson statistics suggest that from lag 8 onwards, the residuals in all estimations contain no significant autocorrelations[21]. Another reference is made to the Akaike information criteria. The suggested lag length by this criteria varies greatly over the country pairs in the sample, starting from 4 lags (US-Germany) and reaching 11 lags (US-France). It seems noteworthy that the Akaike statistics only display marginal differences across different lag length. Given this evidence and for the sake of comparison, we decided to truncate equation (10) at 7 lags.

The figures 4.1 and 4.2 show the cumulative impulse response functions to a positive

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[21] The Durbin-Watson statistics differed substantially over the country pairs and lag length. E.g. the DW statistic for Germany-US showed at lag length 6 values that were close to 2, at lag length 8, DW statistics approached 1.80, and from 9 lags onward, values for the DW statistic were again close to 2.

global supply shock for the output differential and the output levels respectively. The figures also display the associated two standard error bounds[22]. Several features of the dynamic responses deserve attention. A positive global supply shock raises output in all countries permanently. The increases are small but significant in all countries, thus confirming with our theory that global shocks raise output permanently across countries. Further, we recognize a European pattern in the output responses to a global shock. After an increase on impact, output falls sharply across all European countries.

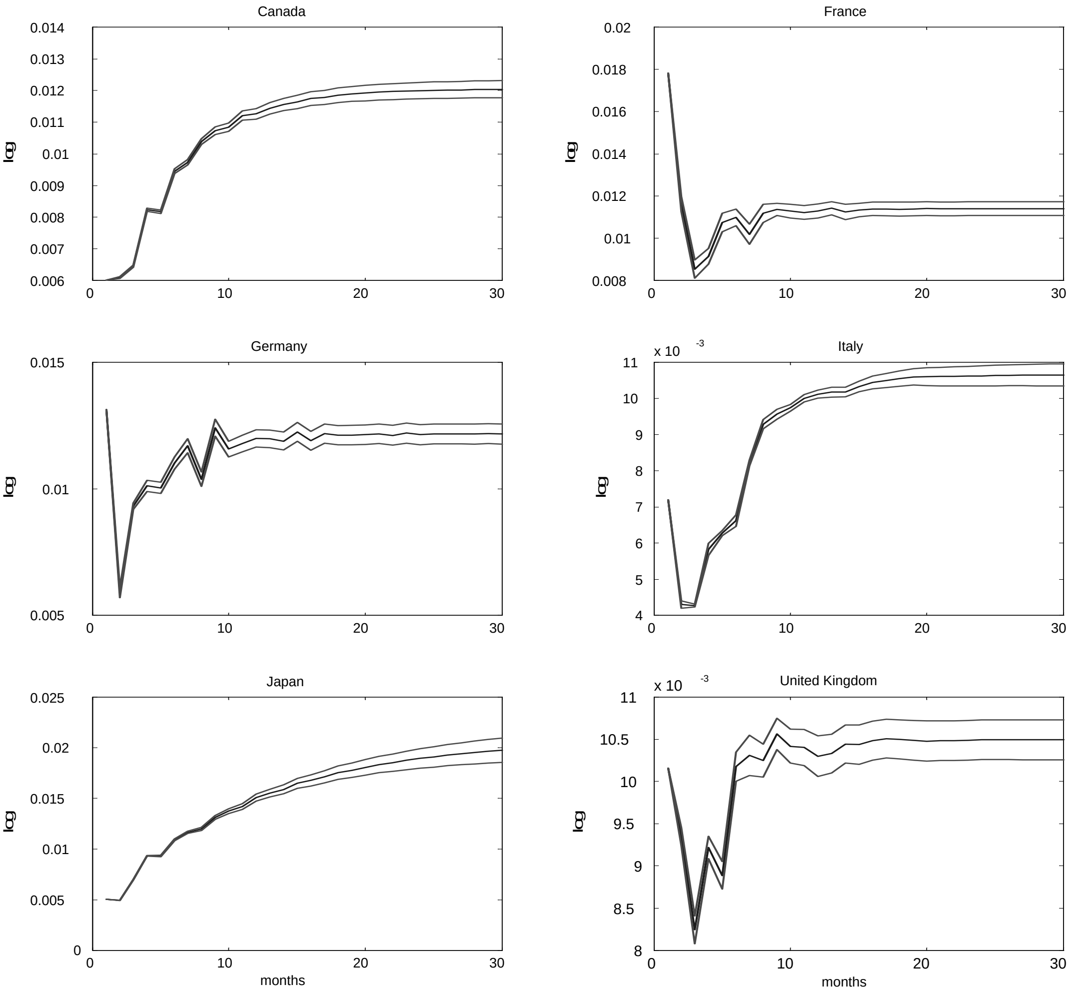

Figure 4: Domestic Output: Mean Impulse Responses and Two-Standard Error Bands to a Global Supply Shock

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[22] Standard errors are obtained by Monte-Carlo integration based on 100 draws from a normal distribution of the reduced form VAR model. Draws are conditioned on the initial S matrix which explains the lack of uncertainty in the contemporaneous responses.

Then, output restarts growing until reaching its new steady state after 10 - 12 month. The output differentials converge to zero or are insignificantly different from zero at a horizon of 20 months, thus confirming the model's prediction. Further, the pattern of the dynamic responses varies over the G7 countries. On impact, a global shock generates a positive output differential for Japan implying that US industrial production rises more than Japanese output. For the other countries, this pattern is reversed. This evidence is taken in support of our approach to focus on long run properties of time series thus avoiding implausibly restrictive short run restrictions. Another feature refers to the persistence of global shocks. It appears that after 12 - 15 months, the economies have completed the adjustment and reached their new equilibrium. The dynamic responses to domestic supply shocks are summarized in the appendix B. A domestic supply shock to either of the 6 countries raises domestic output permanently. The increases are significant for all G7 countries. As one would expect, a domestic supply shock implies a permanent and significant worsening of the output differential. Again, these observations are in line with the predictions of our stylized model.

The impulse response function analysis allows to draw inferences on the way a global supply shock most likely affects output across countries. Yet, we do not know how important global shocks are in comparison to country-specific shocks. It might well be that a global shock raises output and thus provokes co-movements in macroeconomic variables across countries. But if global shocks only account for a minor fraction of output variability, this insight is of little help. In order to assess the relative importance of country-specific and global shocks, the contribution of each structural shock to the variance of a k-step ahead forecast error in each variable is calculated.

The upper section of table IV reports the forecast error shares in the output variables of G7 countries - without the US[23] - that can be attributed to country-specific supply shocks. The forecast error shares are shown for selected horizons at 1, 10, 20 and 30 months ahead. The lower section of the same table reports the contribution of global shocks to the forecast error variance in the output variables. The elementary wise addition of the upper and lower section should always yield a value of 100 percent which simply confirms the identity that country-specific and global shocks account for the complete forecast error variance in industrial production.

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[23] Recall that the US has been assumed as the reference for world output.

Forecast-Error Variance Decomposition

Horizon	Canada	France	Germany	Italy	Japan	UK
Country Specific Shocks						
1 month	34.66	42.60	46.63	65.83	93.69	35.97
10 month	16.99	28.60	30.14	51.41	81.03	18.29
20 month	13.86	22.44	23.05	42.15	80.39	13.28
30 month	12.92	19.95	20.54	38.78	80.24	11.44
Global Shocks						
1 month	65.34	57.40	53.37	34.17	6.31	64.03
10 month	83.01	71.40	69.86	48.59	18.97	81.71
20 month	86.14	77.56	76.95	57.85	19.61	86.72
30 month	87.08	80.05	79.46	61.22	19.76	88.56

Table IV Variance Decomposition for Industrial Production - Values in Percent

There are four characteristics to be noted. First, global shocks seem to account for a significant fraction of the forecast error variance in all countries. With the exception of Japan, global shocks account always for more than one-third of the forecast error. Second, the shares vary substantially across countries. For example, global shocks explain between 7 percent (Japan) and 65 percent (Canada) of the one-period-ahead forecast error. Third, for any country in the sample, the share of the forecast error variance that is accounted for by global shocks increases with the forecast horizon. Hence, the relative importance of country-specific shocks diminishes with the forecast horizon. Fourth, at a forecast horizon of 1 to 10 month, country-specific and global shocks appear to be equal candidates for explaining the forecast errors. The third and fourth observation lead one to argue that country-specific shocks appear to be an important explanatory factor for short run forecast errors whilst global shocks contribute largely to forecast errors at longer horizons.

Altogether, global supply shocks appear to be an important determinant to account for output fluctuations across major industrialized economies. Given the evidence, it seems plausible to argue that co-movements in macroeconomic variables are to a substantial extent the result of common exogenous shocks.

5 Global Shocks and Oilprice Shocks

If the proposed identification scheme is to have a sensible economic interpretation, it is expected to identify the negative global supply shocks in 1974 and 1979 that are associated with the first and second oilprice shocks as a minimal requirement. Although industrial production in G7 countries do not display an apparent co-movement in response to the second oilprice shock, this benchmark date is included because the OECD business cycle chronology reports a common peak and trough in 1979 and the month thereafter for all G7 countries[24]. For this purpose, we re-estimate equation (10) truncating the VAR model this time at 10 lags[25]. By means of equation (11), the structural shocks from the regression residuals are recovered. Figure 5.1 displays the idiosyncratic and global shock components in the output variables of the G7 countries. The vertical intercepts are meaningless since the curves have been shifted for illustrative purposes. For illustrative purposes, the figure only reports the components for the sample period 1965:1 - 1984:12. The dotted vertical lines in figure 5.1 denote the periods 1974:9 and 1980:2 associated with troughs of both oilprice crisis in the 1970's and the global recovery from the first oilprice shock with the peak in 1978:1. These dates are considered as prominent benchmarks. First, global components in industrial production across G7 countries are substantially alike - neglecting difference in levels. Second, the upper panel in figure 5.1 suggests that the global components seem to account for the major output declines in 1974 and 1979 across all G7 countries. Third, country-specific components - as shown in the lower panel of figure 5.1 - appear to be largely uncorrelated across countries.

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[24] A reference for OECD business cycle dates is Artis, Bladen-Hovell and Zhang (1995).

[25] The alteration in the lag length was chosen to accomplish a sharper distinction amongst country-specific and global shocks. It does not have any qualititative impact on the impulse response functions nor variance decompositions.

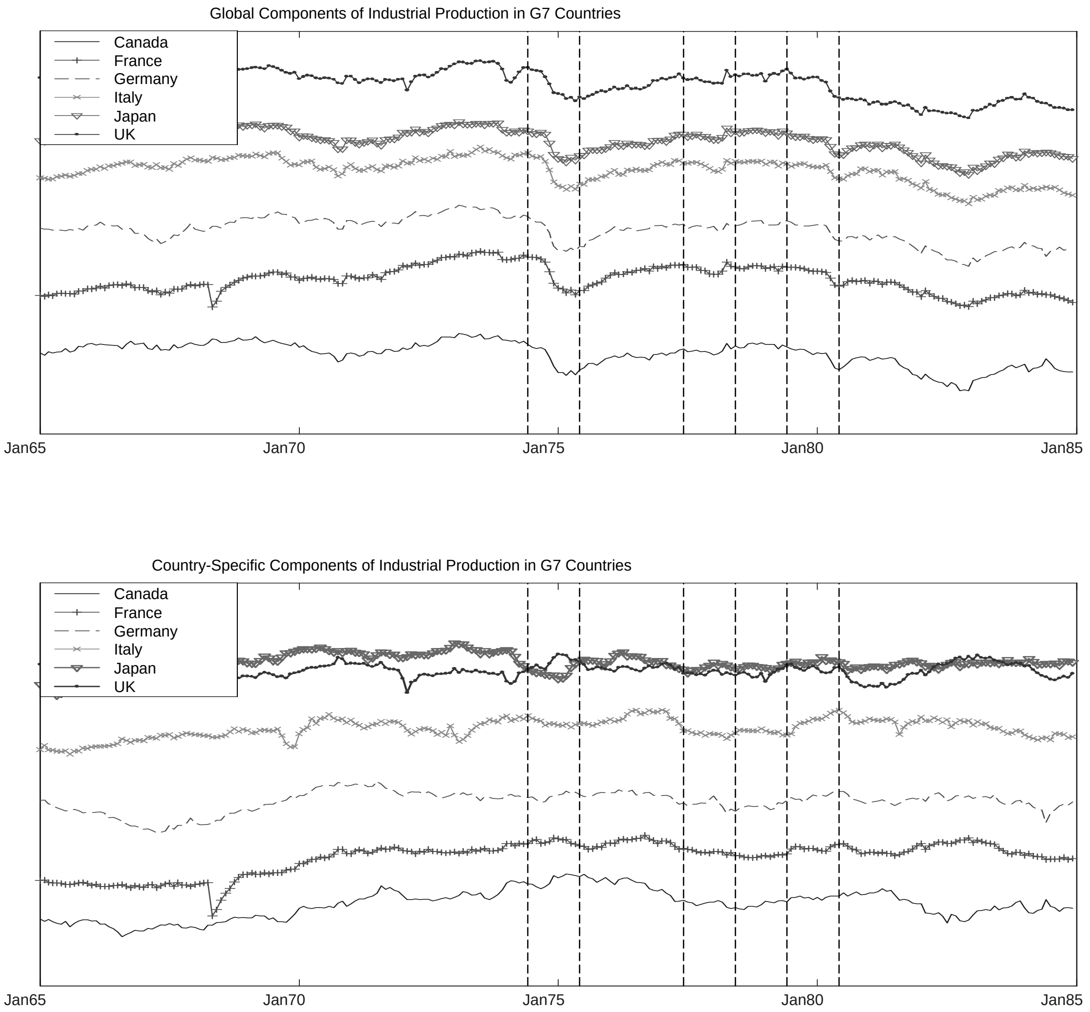

Figure 5: Country-Specific and Global Components of Output

The figures 10.3 - 10.8 in appendix B display the movements in the level of output associated with country-specific and global shocks for each country separately. In these figures, vertical lines refers to country-specific business cycle dates as reported in Artis, Balden-Hovell and Zhang (1995). Solid vertical lines denote a business cycle peak; related troughs are highlighted by a dashed line. In general, these figures attribute both, country-specific and global, output components an important role in explaining the business cycles. For many business cycle dates, it seems hard to tell if there was a global or country-specific shock. Only for some prominent examples, we are able to identify the source. For example, the recessions in 1974/75 and 1979/80 are clearly due to the oilprice shocks in all G7 countries. The identification scheme also detects prominent country-specific shocks. For example, the recession in France in 1968 is triggered by a large negative country-specific shock that is associated with a severe union strike. Also large country-specific shocks are identified for Germany in 1984 and 1990 where the former results from a union strike and the latter from German-reunification. These events are undoubtedly country-specific in nature.

To reinforce the identifications' ability to distinguish between country-specific and global output shocks, we estimate the cross-sectional covariance matrix of the structural disturbances. That is, we estimate $\xi^h_{i,j} = cov\left(\varepsilon^h_{ti}, \varepsilon^h_{tj}\right)$ and $\xi^g_{i,j} = cov\left(\varepsilon^g_{ti}, \varepsilon^g_{tj}\right)$ for $i, j = 1, ..., 6$ where $\xi_{i,j}$ denote the cross-sectional covariances of structural disturbances between country i and j. The subscripts h and g refer to country-specific and global shocks. Table V reports estimates for the variance-covariance matrices. First, recall that variances of structural shocks have been normalized to one, that is $\xi^h_{i,j} = \xi^g_{i,j} = 1$ for $i = j$. Then, the covariances are identical to the correlation coefficients - apart from approximation errors.

Global and Country-Specific Shocks

	Canada	France	Germany	Italy	Japan	UK
Canada		0.30	0.21	0.15	0.06	0.21
France	0.65		0.41	0.30	0.03	0.37
Germany	0.66	0.67		0.23	0.08	0.42
Italy	0.77	0.72	0.73		−0.02	0.29
Japan	0.85	0.76	0.79	0.89		0.03
UK	0.69	0.62	0.69	0.75	0.78	

Table V Cross-Sectional Covariances of Identified Shocks

The lower triangular matrix in table V reports the covariance structure $\xi^g_{i,j}$ amongst global shocks. Intuitively and by the very definition, global shocks are expected to be highly correlated across countries whilst we suspect country-specific shocks to be largely uncorrelated. The evidence clearly supports this notion. Note, that the covariances are all positive and significant. The implied correlation coefficients range between 0.65 for the sample pair France - Canada at the lower end, and 0.89 for Italy - Japan at the top. Interestingly, the implied cross-sectional averages of covariances of the global shocks are much closer to unity than those reported in Hoffmann (2000). The average cross-sectional correlation between global shocks is 0.73. In contrast, looking at country-specific shocks, the average cross-sectional correlation drops to 0.21. The cross-sectional covariances $\xi^h_{i,j}$ of the country-specific shocks are shown in the upper triangular matrix of table V[26]. Gen-

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[26] The corresponding figure to table V for the country-specific shock is reported in the appendix B.

erally, the covariances amongst country-specific shocks are positive and to some extent not significantly different form zero. For the country-pair Italy - Japan, country-specific shocks display even negative covariances. The contemporaneous correlation coefficients range between -0.02 for the pair Italy - Japan and 0.42 for Germany and the UK. To summarize the evidence, global shocks, identified with respect to the US, tend to occur symmetrically across G7 countries. However, country-specific shocks also appear to co-vary although the average correlation is much lower. We consider the significant correlations between country-specific shocks as minor drawback that results from the bilateral analysis of structural shocks

In the context of figure 5.1, it has been mentioned that oilprice shocks play a prominent role amongst the identified global shocks. Given their comparatively high amplitude and low frequency, it seems reasonable to argue that they should be treated as outliers and excluded from the regression. It is therefore natural to ask if the results are robust when one accounts explicitly for oilprice changes. In particular, we inquire if i) global shocks still account for a significant share in the forecast error of output and ii) if the cross-sectional correlations remain as sharp as seen above. To accomplish this task, we extent our model by an oilprice variable. Let x_t^{oil} be a covariance-stationary vector process with $x^{oil} = [y_{us}^i, \Delta \log y^i, \Delta \log p^{oil}]$, where y_{us}^i and $\Delta \log y^i$ are defined as above. $\Delta \log p^{oil}$ is the log-difference of the barrel spot-price in US dollars[27]. Then x^{oil} has a vector moving average representation

$$x_t^{oil} = A(L) \times \varepsilon_t \tag{14}$$

where $\varepsilon = \left[\varepsilon^h, \varepsilon^g, \varepsilon^o\right]'$ is a vector of serially uncorrelated structural disturbances with zero mean and unit variance. $A(L)$ is a matrix of polynomial lags with $A(0) = I_3$. The innovations are assumed to be orthogonal. ε^h and ε^g are interpreted as country-specific and global supply shocks. ε^o will be referred to as oilprice shock. The reduced form representations (10) - (12) apply with the exception that $C(L)$, S and Σ are now square matrices of dimension 3. Recovering the structural innovations from the residuals necessitates 3 additional restrictions. We identify global shocks by assuming that they have no long run impact on the level of the output differential as before. This translates into a restriction analogous to (13). In order to disentangle the oilprice shock from the supply shocks, we follow Shapiro and Watson (1988) in that the oilprice is solely driven by oilprice shocks. This assumption restricts the two elements of S, $S_{31}$and S_{32}, to zero.

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[27] Taking the spot price index does not change our results. Data is taken from the International Financial Statistics, June 2000.

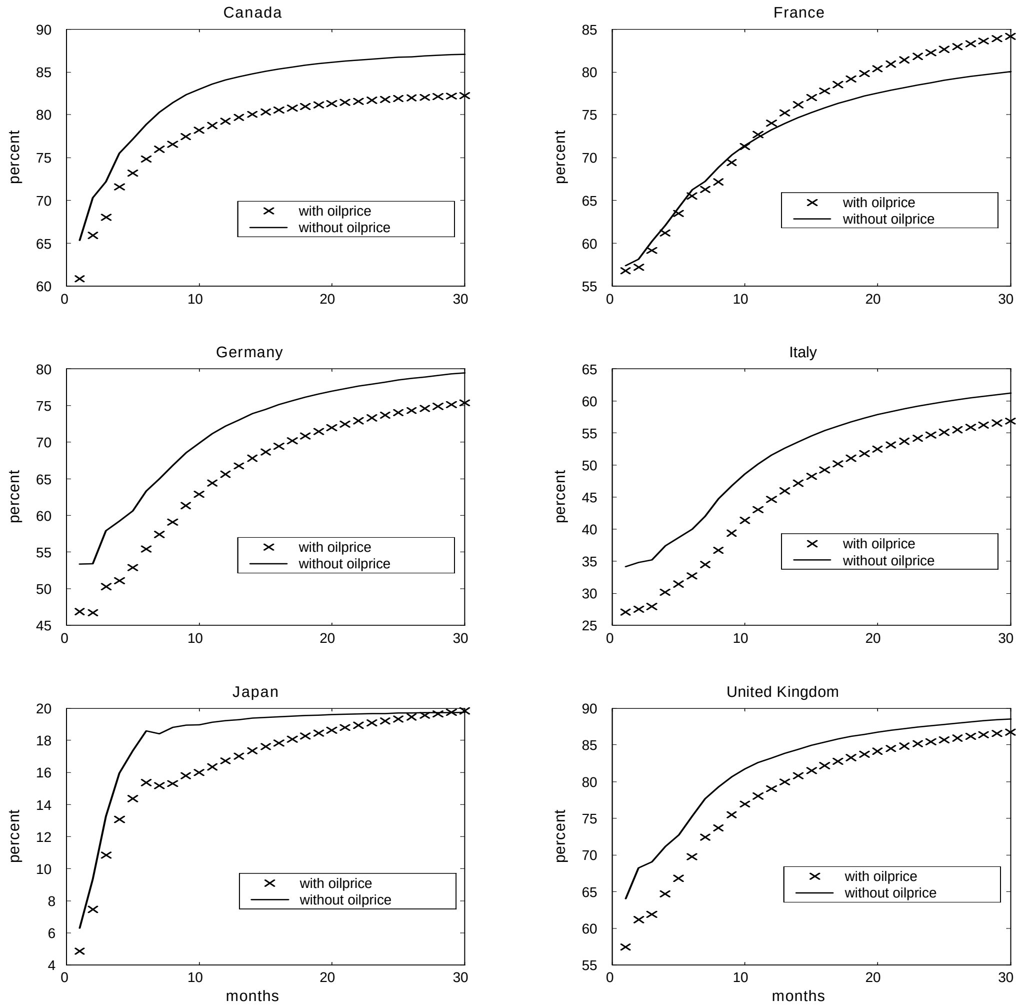

Figure 6: Share of Forecast Error Variance in Output due to Global Shocks

With reference to the Akaike criteria, the VAR model has been truncated at lag 8[28]. First, we look at differences in the composition of the forecast error variance of industrial production. Figure 5.2 illustrates the variance decomposition for both exercises, with and without the inclusion of oilprices[29]. Lines marked by a cross refer to forecast error shares that are computed including an oilprice variable in the VAR model. We do not explicitly consider forecast errors due to oilprice shocks because they typically account for less than 4 percent of the total forecast error in industrial production across all countries.

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[28] In comparison, the bivariate VAR has been truncated at lag 7. So, we think that comparability is preserved.

[29] As a point of reference, we use the forecast error variance shares reported in table IV.

This comes at no surprise since dramatic changes in oilprices are relatively seldom given the time span considered. It is therefore not astonishing that a further discrimination between global and oilprice shocks does not significantly alter the forecast error variance composition of industrial production. Still, country-specific shocks appear to be more important for the short run forecast error; the importance of global shocks increases with the forecast horizon. After controlling for oilprices, the share of global shocks slightly drops for all G7 countries as can be recognized in figure 5.2. For France, the share of the forecast error due to global shocks even increases at longer horizons which is puzzling. Still, global shocks explain between 20 and 82 percent of the forecast error variance in industrial production at a 30 months horizon. The shares decline to 6 -60 percent, if we focus on the one-month-ahead forecast error. After all, global shocks - excluding oilprice shocks - remain an important explanatory factor for economic fluctuations in the short and medium run.

Global and Country-Specific Shocks after controlling for Oilprice Shocks

	Canada	France	Germany	Italy	Japan	UK
Canada		0.37	0.27	0.18	0.07	0.38
France	0.55		0.50	0.34	0.07	0.47
Germany	0.60	0.58		0.26	0.12	0.48
Italy	0.75	0.64	0.69		0.00	0.31
Japan	0.82	0.68	0.76	0.88		0.08
UK	0.64	0.53	0.64	0.71	0.74	

Table VII Cross-Sectional Covariances of Identified Shocks

Looking at cross-sectional relationships, we find that oilprice shocks are almost perfectly correlated across countries ranging between 0.98 and 0.99. This confirms with our intuition since the spot oilprice is a global price common to each country. Table VII summarizes the covariance patterns for global and country-specific shocks. Like in table V, the lower triangular matrix reports the correlations between global shocks; correlations between country-specific shocks are displayed in the upper triangular matrix. The variances have been normalized to one. After controlling for oilprice shocks, global shocks still display a positive and significant correlation with 0.53 at the lower end (France-UK) and 0.88 at the top (Italy-Japan), thus confirming our notion of common exogenous shocks. The comparison with table V reveals no significant decline in the cross-sectional correlations. On average, the correlation amongst global shocks drops from 0.73 to 0.66 if oilprice shocks are explicitly accounted for. This results is perfectly understandable realizing that an important common component has been filtered out from all global shock series. In general, the distinction between country-specific and global shocks in terms of contemporaneous correlations appears less sharply than in table V. Nevertheless, there remains enough substance to identify shocks that are common to all G7 countries.

6 Sensitivity Analysis

In order to check the robustness of our results with respect to data frequency, we reestimate equation (10) using quarterly data of industrial production. It can be shown that the log of quarterly industrial production is stationary in first-differences for all G7 countries. We find no cointegration relationship for the European countries France, Germany, Italy and the UK with respect to US industrial production. However, we are alarmed that the results may be misleading for Canada and Japan. For these countries, the Johansen-test gives no decisive indication if the data contains cointegrational relationships or not. The VAR-model has been truncated at two lags.
The variance decomposition suggests that the relative importance of global shocks still increases with the forecast horizon. The share of global shocks in the forecast error variance of output moderately increase for all countries but Canada where the increase is substantial[30]. The shift in the relative importance of structural disturbances must be expected because we essentially dismiss the high-frequency movements in output time series by applying the model to quarterly data. Since the short run output volatility is largely accounted for by country-specific shocks, their relative influence has to diminish. For the same reason, the cross-sectional correlation between country-specific shocks increases. Global shocks remain to be significantly positive correlated in the cross-section. Here, the average correlation is nearly unchanged with 0.72. Altogether, we interpret the evidence as largely confirming our results.

7 Current Account and Investment Responses to Country-Specific and Global Shocks

Under the assumption of a balanced current account, theory predicts that country-specific shocks raise domestic investment and cause a deterioration in the current account of a country. Importantly, if shocks are perceived to be permanent, the response of the cur-

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[30] For example, 57 percent of the one-quarter ahead forecast error is explained by global shocks in comparison to 25 percent share of the one-month ahead forecast error.

rent account overshoots the investment reaction since the consumption level immediately adjusts to its new steady state, thus adding to a worsening of the current account. In contrast, global shocks are not predicted to have an impact on the current account. These implications of intertemporal open economy models have been explored empirically by Glick and Rogoff (1995) and Hoffmann (2000). Both studies estimate equations of the form:

$$\Delta I_t = a_0 + a_1 \varepsilon_t^{cs} + a_2 \varepsilon_t^{g} + a_3 I_{t-1} + a_4\ time + e_t \tag{15}$$

and

$$\Delta CA_t = b_0 + b_1 \varepsilon_t^{cs} + b_2 \varepsilon_t^{g} + b_3 CA_{t-1} + b_4 I_{t-1} + b_5\ time + e_t \tag{16}$$

where I and CA denote investment and the current account, ε^{cs} and ε^{g} refer to country-specific and global shocks. A time trend is included in both regressions. Both studies present empirical evidence that largely supports the theory. To sum up the evidence, country-specific shocks are found to have a positive impact on domestic investment and a negative impact on the current account at conventional confidence levels[31]. Global shocks are shown to have no significant influence on the change in the net foreign asset position of a country. Only Hoffmann (2000) is able to demonstrate an overshooting effect in the current account. He presents point estimates of b_1 that are higher than a_1 in absolute value.

In order to explore the economics of our identified shocks, we estimate equations (15) and (16) using quarterly data[32] on investment and on the current account[33]. For the sake of comparison, the dependent variables are normalized by their standard deviations. Series for country-specific and global disturbances are obtained by applying the identification scheme to quarterly observations of industrial production as outlined above. The data

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[31] There are minor exceptions as far as Glick and Rogoff (1995) are concerned. E.g., the coefficient b_1 is insignificant for Germany and France whilst a_3 counter-theoretically turns out to be significant.

[32] For most of the G7 countries, quarterly data on the current account is not available before 1970 on a regular basis. Also, data on the current account is not available at monthly frequency.

[33] The data is taken from the International Financial Statistics

.

covers the period from 1970:4 until 1997:4. Standard errors are reported in parentheses.

Current Account and Investment

	a_1	a_2	b_1	b_2
Canada	$0.19(0.09)^*$	$0.15(0.09)$	$-0.21(0.09)^*$	$0.04(0.09)$
France	$0.43(0.10)^*$	$0.30(0.11)^*$	$-0.06(0.12)$	$-0.02(0.12)$
Germany	$0.23(0.09)^*$	$0.29(0.09)^*$	$0.04(0.09)$	$-0.005(0.10)$
Italy	$0.51(0.10)^*$	$0.24(0.08)^*$	$-0.13(0.09)$	$-0.04(0.09)$
Japan	$0.28(0.12)^*$	$0.01(0.14)$	$-0.19(0.10)$	$-0.03(0.09)$
UK	$0.12(0.08)$	$0.35(0.09)^*$	$0.05(0.09)$	$0.03(0.10)$

Table VI Individual Country Time Series Regression - 95 % significance level is denoted by *.

Table VI presents the point estimates only for a_1, a_2, b_1 and b_2. The regression results confirm with the theory in several respects. For investment, the coefficients for a_1 are all of the correct sign and are significant at the 95 percent confidence level except for the United Kingdom. The impact of global shocks on domestic investment is positive and significant for France, Germany, Italy and the UK only. Global shocks have not significant impact on the current account in all countries. The fact that the point estimates of b_2 are non-zero may result from the bilateral identification of global shocks which is only a proxy for world output[34]. However, the model is at odds with the empirical evidence in three respects. The identified global shocks appear to have no significant impact on investment in Canada and Japan. This result appears to be interesting since Canada and Japan are important trading partner of the US in the pacific area. Further we cannot identify any overshooting effect of the current account in response to country-specific shocks except for Canada. Most importantly, the point estimates of b_1 are of the correct sign in more than 90 percent of all cases, but they are insignificant across all countries with the exception of Canada. The absence of any measurable statistical relation between country-specific shocks and the current account for most of the G7 countries presents indeed a puzzle that is hard to rationalize.

Two possible explanations are put forth that might account for a non-significant b_1 coefficient estimates. First, we identified country-specific shocks with respect to the US. These shocks might not be that "country-specific"[35] with respect to other important trading partners, a fact that implies less pronounced responses of the current account. The fact

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[34] Glick and Rogoff (1995) use a similar argument to explain the non-zero point estimates of b_2.

[35] The estimated cross-sectional correlations support this notion. Country-specific shocks still display significant correlations as table V suggests. These correlations tend to increase if we use quarterly data as in section 7.

that economic theory is in line with the empirical evidence for Canada enhances this argument because the US is by far the most important trading partner of Canada. Second, if agents need time to "realize" their economic situation, the intertemporal re-allocation of resources may not take place within quarters. Therefore, a statistical relation between country-specific shocks and the current account may only be detectable at longer horizons, e.g., in annual data as used by Glick and Rogoff (1995) and Hoffmann (2000).

8 Conclusion

This paper has attempted to assess the extend to which co-movements in important macroeconomic variables across countries are the result of common exogenous shocks. In the spirit of a highly stylized standard open-economy model of the business cycle, we have assumed that output in all G7 countries is entirely driven by two types of exogenous disturbances: country-specific and global shocks. Subsequently, we estimate a simple VAR model that allows us to identify the structural disturbances outlined above. Several conclusions arise from this study:

1.) The theoretical predictions of an open-economy model with common exogenous shocks are largely consistent with the stylized facts of the international business cycle. In particular, the predicted cross-country correlations of output, consumption, investment and employment match markedly better the empirically observed correlations than standard models without global shocks.

2.) Empirically, country-specific and global shocks appear to be equal candidates for explaining output fluctuations at business cycle frequencies across major industrialized countries.

3.) After controlling for oilprice shocks, global shocks still remain an important explanatory factor.

4.) The identified shocks are consistent with the theoretical predictions in that global shocks appear to have no impact on the current account and country-specific shocks are an important determinant for domestic investment.

5.) Further research is needed to explore the absence of any statistical relation between country-specific shocks and the current account across most of the G7 countries. In particular, one might have to look for country-specific and common shocks amongst

major trade partners to analyze the dynamics of investment and the current account.

References

Artis, M.J., R.C. Bladen-Hovell and W. Zhang (1995), *Turning points in the international business cycle: An analysis of the OECD leading indicators for the G7 countries,* OECD Economic Studies 24, 125 - 165

Backus, P. Kehoe and F. Kydland (1992), *International real business cycles*, Journal of Political Economy 101, 745 - 775

Backus, P. Kehoe and F. Kydland (1994), *Dynamics of the trade balance and the terms of trade: The J-curve,* American Economic Review 84, 84 - 103

Baxter, M. and M.J. Crucini (1993), *Explaining saving-investment correlations*, American Economic Review 83, 416 - 436

Baxter, M. (1995), *International trade and the business cycle,* in: G. Grossman and K. Rogoff, eds., Handbook of international economics, vol. 3 (North-Holland, Amsterdam)

Blanchard, O. and C. Kahn (1982), *A solution algorithm of rational expectation equation systems,* Econometrica , 1305 - 1311

Blanchard, O. and D. Quah (1989), *The dynamic effects of aggregate demand and supply disturbances,* American Economic Review 79, 655 - 673

Cochrane, J. (1997), *Time series analysis for macroeconomics and finance,* unpublished manuscript

Canova, F. and J. Marrinan (1998), *Sources and propagation of international output cycles: common shocks or transmission ?,* Journal of International Economics 46, 133 - 166

Canova, F. and G. di Nicoló (2000), *On the sources of business cycles in the G7,* mimeo

Cantor, R. and N. Mark (1988), *The international transmission of real business cycles,* International Economic Review 29, 493 - 507

Cooley, T. F. (1995), *Frontiers in business cycle research,* Princeton University Press 1995

Galí, J. (1992), *How well does the IS-LM model fit postwar US data ?,* Quarterly Journals of Economics 57, 709- 738

Glick, R. and K. Rogoff (1995), *Global versus country-specific shocks and the current account,* Journal of Monetary Economics 35, 150 - 192

Gregory, A. W. and A.C. Head (1999), *Common and country-specific fluctuations in productivity, investment and the current account,* Journal of Monetary Economics 44, 423 -

451

Hoffmann, M. (2000), *The relative dynamics of investment and the current account in G7 economies,* forthcoming in The Economic Journal

Johansen, S. (1996), *Likelihood-based inference in cointegrated vector autoregressive models,* Oxford University Press

Kollmann, R. (2001), *Explaining international co-movements of output and asset returns: The role of money and nominal rigidities",* Journal of Economic Dynamics and Control, 25(10), 1547-1583

Kwark, N.S. (1999), *Sources of international business fluctuations: country-specific shocks or worldwide shocks ?,* Journal of International Economics 48, 367 - 385

LeSage, J.P. (1999), *Applied Econometrics using Matlab,* unpublished manuscript, University of Toledo

Lumsdaine, R.L. and E.S. Prasad (1999), *Identifying the common component in international economic fluctuations: a new approach,* IMF Working Paper WP/99/154

Obstfeld, M. (1986), *Capital mobility in the world economy: theory and measurement,* Carnegie-Rochester Conference Series on Public Policy 24, 55 - 104

Obstfeld, M. and K. Rogoff (1995), *The intertemporal approach to the current account,* in: G. Grossman and K. Rogoff, eds., Handbook of international economics, vol. 3 (North-Holland, Amsterdam)

Obstfeld, M. and K. Rogoff (1996), *Foundations of international macroeconomics,* The MIT Press

Phillips, K.L. (1991), *A two-country model of stochastic output with changes in regime,* Journal of International Economics 31, 121 - 142

Reynolds, P. (1993), *International co-movements in aggregate productivity: an empirical analysis,* unpublished manuscript, University of Southern California

Rotemberg, J.J. and M. Woodford (1996), *Imperfect competition and the effect of energy price increases on economic activity,* NBER Working Paper 5634

Sachs, J. (1981), *The current account and macroeconomic adjustment in the 1970s,* Brooking Papers on Economic Activity 1, 201 - 268

Shapiro, M.D. and M. Watson (1988), *Sources of business cycle fluctuations,* NBER Working Paper 2589

Zimmermann, C. (1995), *International trade over the business cycle: stylized facts and remaining puzzles,* unpublished manuscript

9 Appendix A: Limitations

It has been noted in the introduction to section 4 that in the presence of cointegration, the proposed identification does not apply. In order to demonstrate this limitation rigorously, more elaborate arguments are used. Let $\left\{y_t^h\right\}_{t\geq 0}$ and $\left\{y_t^f\right\}_{t\geq 0}$ be sequences of observations for domestic and foreign output and assume that both series are integrated of order one. Define the vector $x_t = \left[y_t^h \;, \; y_t^f\right]'$. Then x_t has a moving average representation analogous to (9)

$$(1-L)\,x_t = A\left(L\right) \times \varepsilon_t. \tag{17}$$

L denotes the one-period lag operator, $A\left(L\right)$ is a 2×2 matrix of lag polynomials and ε_t is a 2×1 vector of structural shocks with *zero* mean and covariance matrix $\Omega = I$. To illustrate the argument, assume for the moment that there are only two structural innovation in this two-country world. There are only country-specific shocks to domestic and foreign output, ε^h and ε^f. This defines the white noise vector $\varepsilon = \left[\varepsilon^h, \varepsilon^f\right]'$. The elements of $A\left(1\right)$ are the limiting impulse-responses of the levels of x_t to structural innovations in ε. E.g., $A_{12}\left(1\right)$ is the limiting impulse-response of the output differential to a global shock.

Definition 1 *The elements of x_t are said to be cointegrated if there exists a 2×1 cointegrating vector α such that $\alpha' x_t$ is stationary.*

The condition that $\alpha' x_t$ be stationary presents an extra restriction that ties the shape of the limiting impulse-responses of x_t.

Corollary 1 *If the elements of x_t are cointegrated with cointegration vector α , then it must be that*

$$\alpha' A\left(1\right) = 0 \tag{18}$$

and that the rank of $A\left(1\right)$ is equal to the number of cointegration relationships in x_t. In the presence of cointegrating relationships, $A\left(1\right)$ is of reduced rank.

The proof[36] exploits the multivariate generalization of Beveridge-Nelson's (1981) decomposition. x_t can be represented by the sum of a random walk (z_t) and a temporary component (c_t)

$$x_t = z_t + c_t \tag{19}$$

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[36] This proof follows the arguments from an unpublished manuscript "Time Series for Macroeconomics and Finance", by J. Cochrane (1997).

where $(1-L)\,z_t = A(1)\,\varepsilon_t$ and $c_t = A^*(L)\,\varepsilon_t$ where $A_j^*(L) = -\sum_{k=j+1}^{\infty} A_k$. Premultiplying (19) by α' gives

$$\alpha' x_t = \alpha' z_t + \alpha' c_t. \tag{20}$$

Noting that $\alpha' c_t$ is a linear combination of stationary variables and that $\alpha' x_t$ is stationary by definition, $\alpha' z_t$ must also be stationary. Since z_t is a random walk, it is either constant or nonstationary. To meet the identity in equation (20), it has to be constant. By the identity

$$(1-L)\,\alpha' z_t = \alpha' A(1)\,\varepsilon_t$$

, it must be that $\alpha' A(1) = 0$.

The condition (18) bears important implication for the limiting impulse-responses of x_t. For illustrative purposes, assume $\alpha' = [1\ ,-1]$[37]. Then by equation (18), we have

$$\begin{array}{c} A_{11}(1) = A_{21}(1) \\ A_{12}(1) = A_{22}(1) \end{array}. \tag{21}$$

The interpretation of (3.21) is straightforward: each variable's long run response to a structural shock must be the same. Hence, a country-specific shock to foreign output induces responses in either countries output with the characteristic that the limiting response on either country's output level is identical. Thus, a zero differential of the limiting output responses is a must outcome in the presence of cointegration. Even if there existed a third structural shock - say a global supply shock -, it may not be identified by restricting the limiting output differential to zero since this is a reserved characteristic of country-specific shocks.

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[37] This assumption is made for illustrative reasons. It is without a loss in generality. The argument applies for other cointegrating vectors with slight modifications.

10 Appendix B: Figures

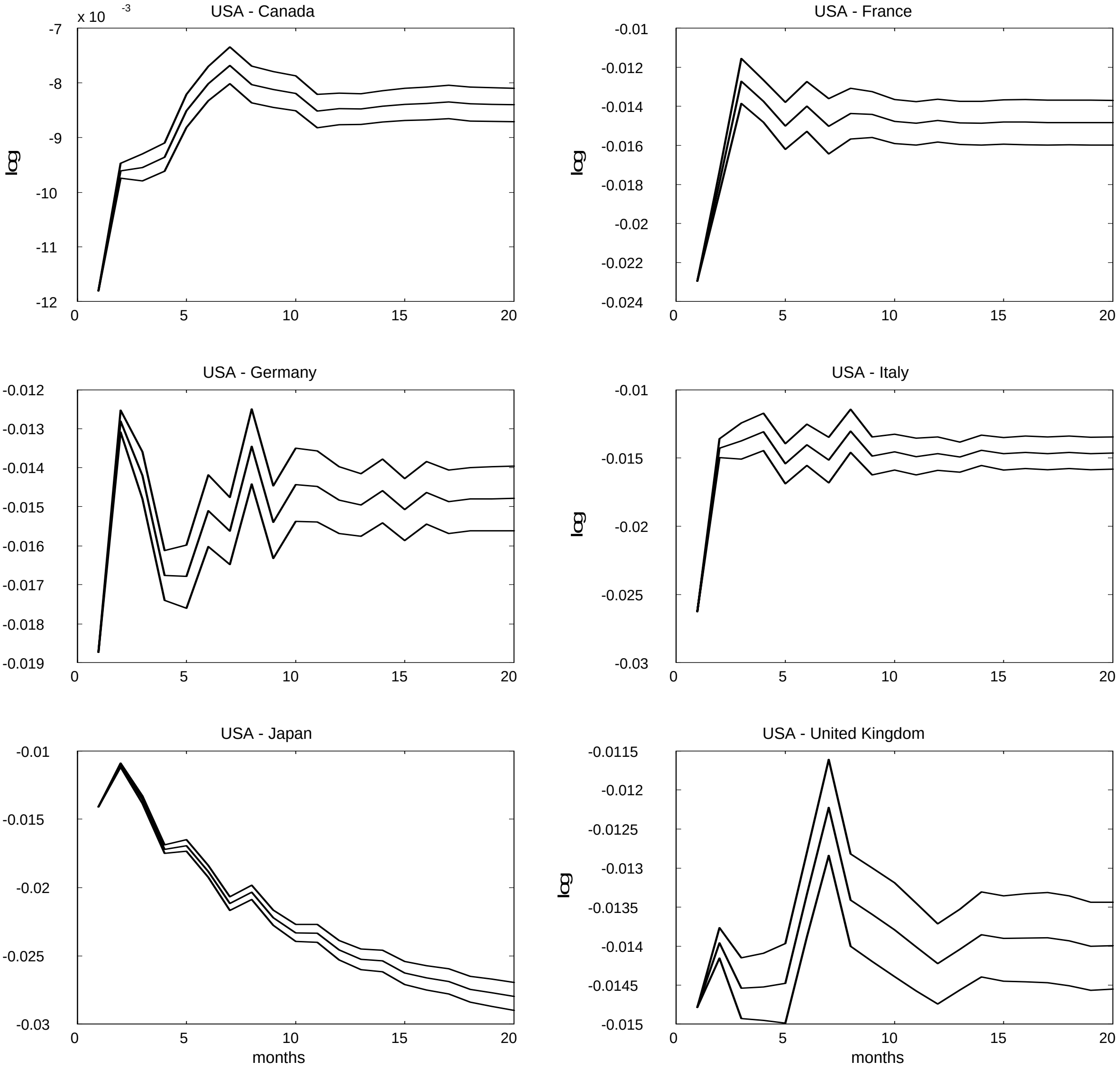

Figure 7: Output Differentials: Mean Impulse Responses and Two-Standard Error Bands to a Domestic Supply Shock

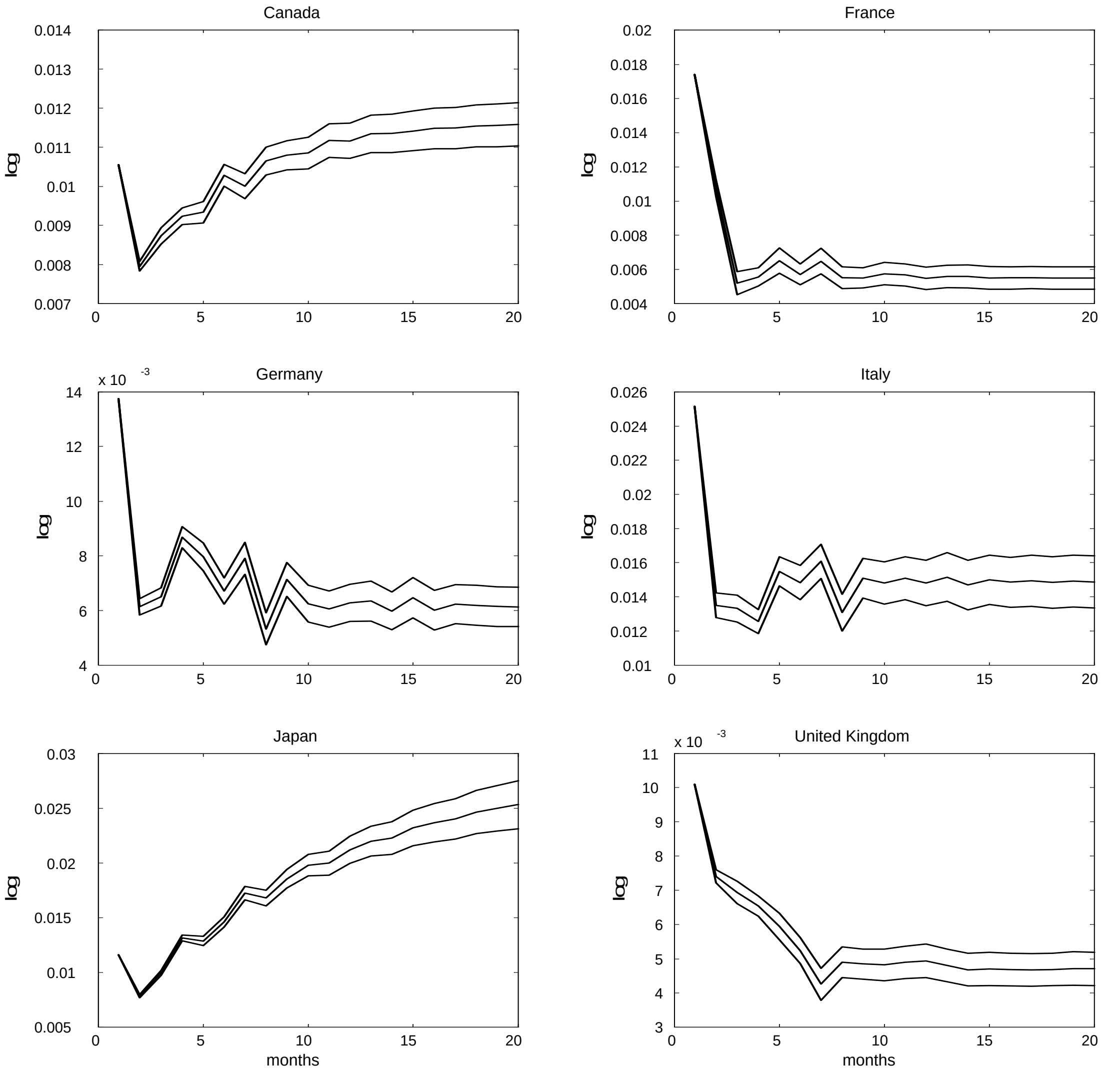

Figure 8: Domestic Output: Mean Impulse Responses and Two-Standard Error Bands to a Domestic Supply Shock

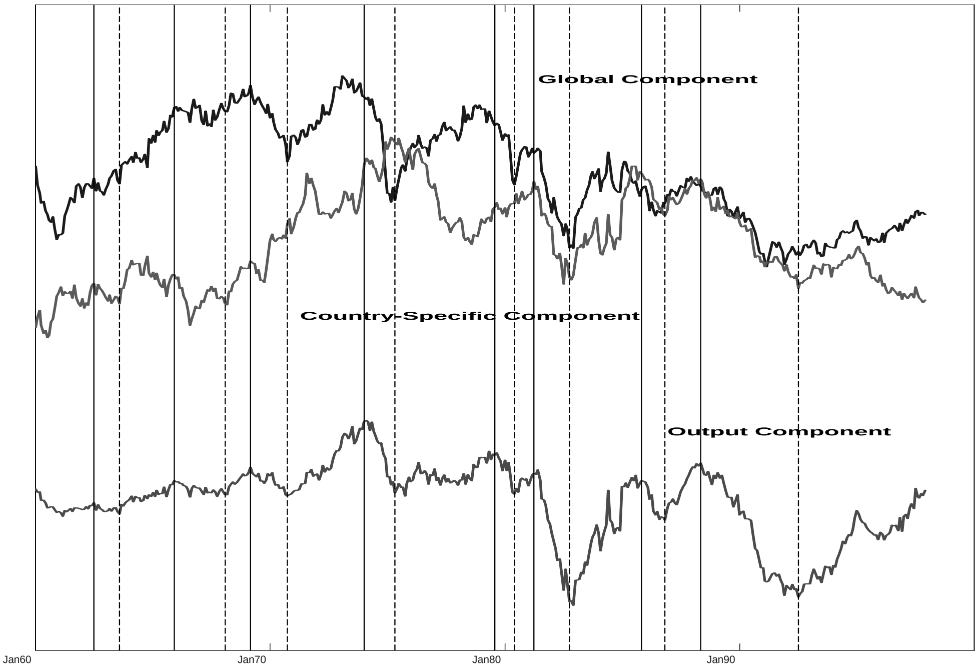

Figure 9: Canada - Decomposition of Industrial Production

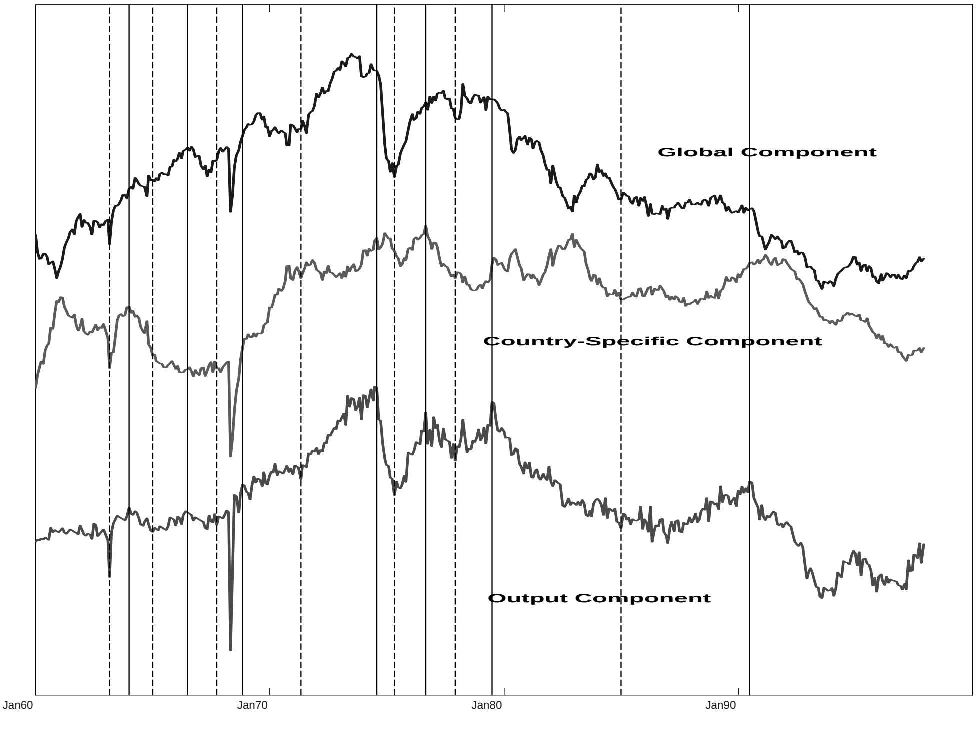

Figure 10: France - Decomposition of Industrial Production

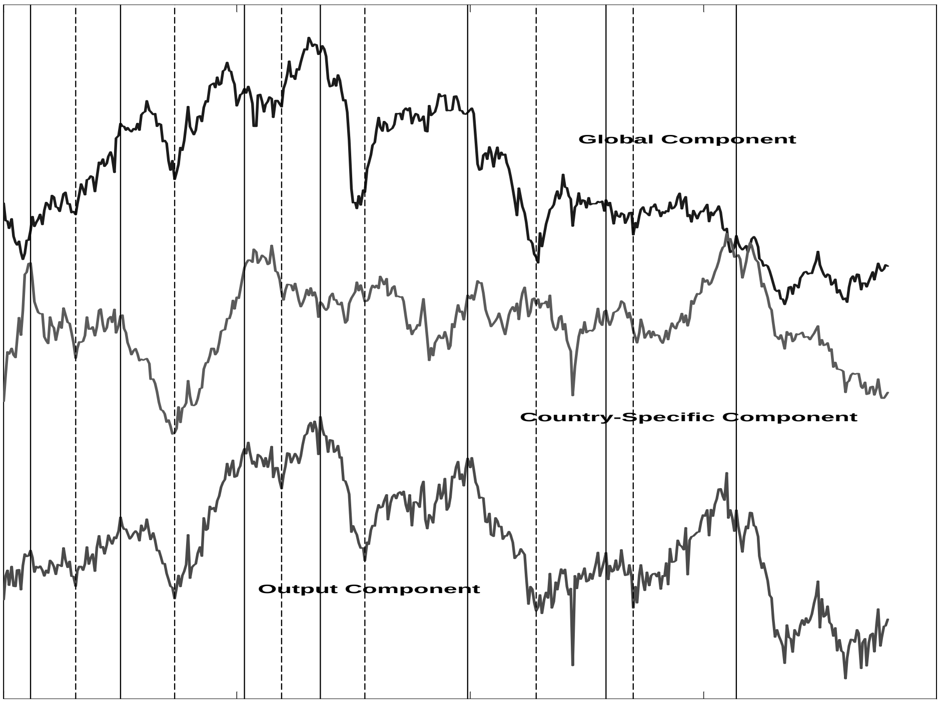

Figure 11: Germany - Decomposition of Industrial Production

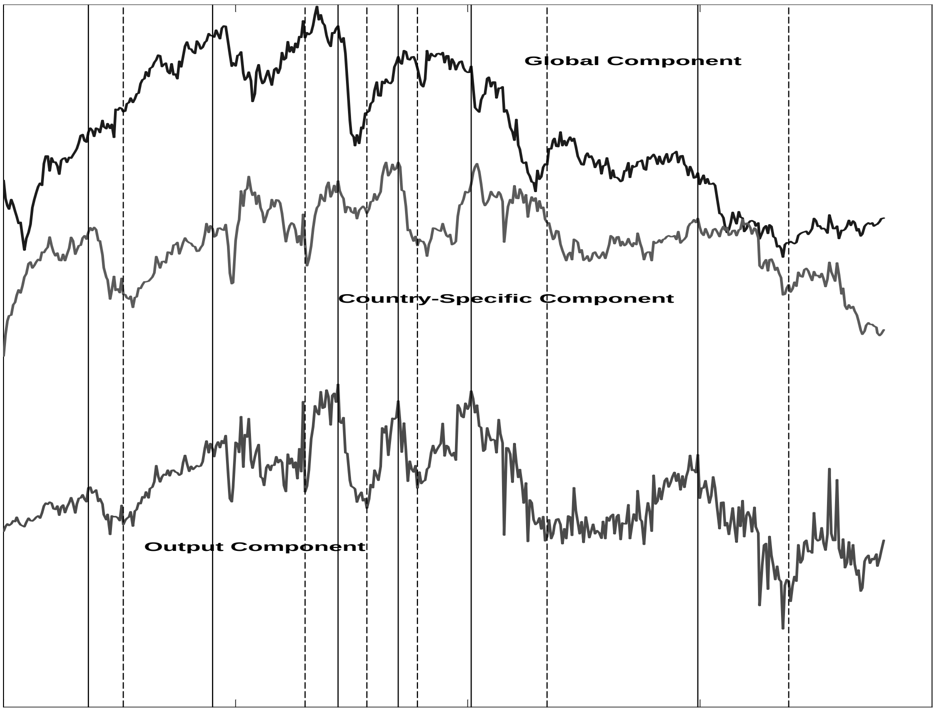

Figure 12: Italy - Decomposition of Industrial Production

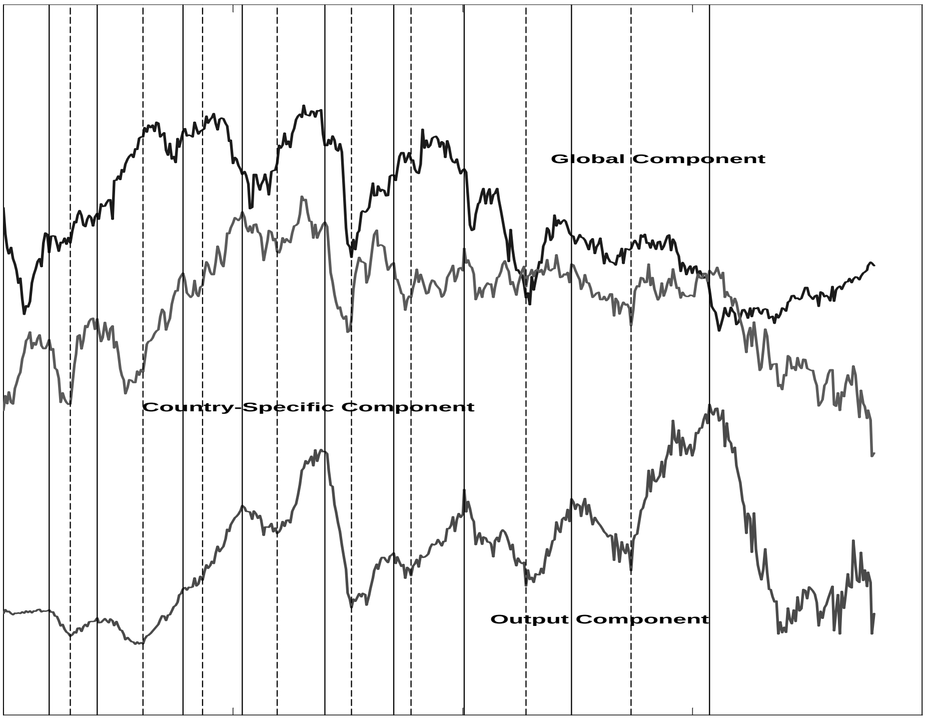

Figure 13: Japan - Decomposition of Industrial Production

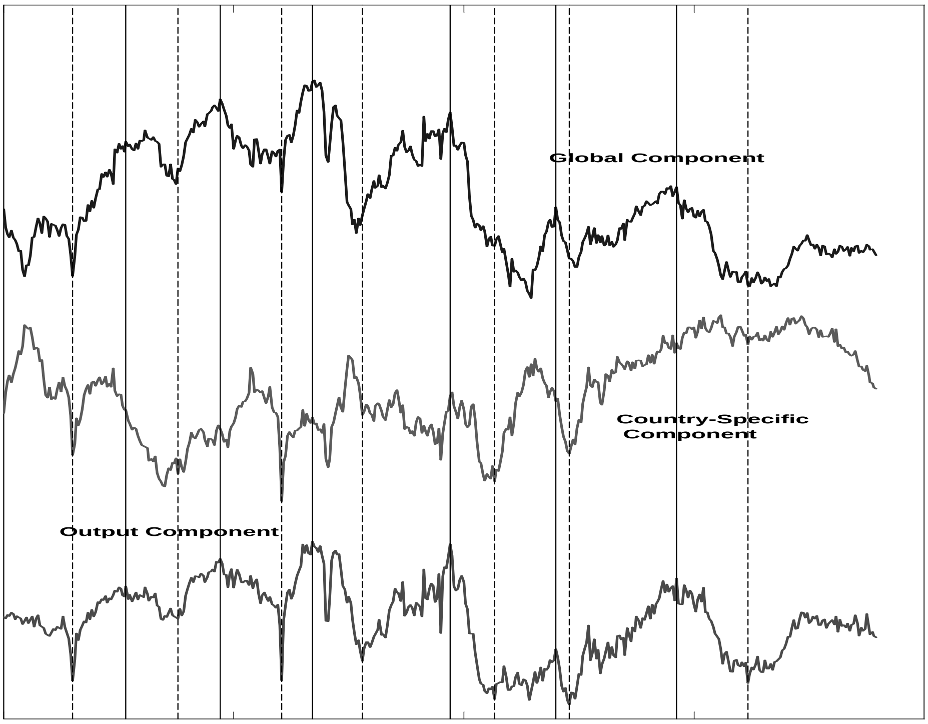

Figure 14: United Kingdom - Decomposition of Industrial Production

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