UNDERSTANDING THE EVOLUTION OF WORLD BUSINESS CYCLES[ϒ]

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January 2003

Abstract: This paper studies the changes in world business cycles during the period 1960-2001. We employ a Bayesian dynamic latent factor model to estimate common components in the main macroeconomic aggregates (output, consumption, and investment) of the G7 countries. Using the model, we estimate common and country-specific factors. These factors are used to quantify the relative importance of the common and country components in explaining comovement in each observable aggregate over three distinct time periods: the Bretton Woods (BW) period (1960:1-1972:2), the period of common shocks (1972:3-1986:2), and the globalization period (1986:3-2001:4). We also study how different types of shocks have affected the nature of business cycle comovement over these three periods. We find that the common factor explains a larger fraction of output, consumption and investment volatility in the globalization period than it does in the BW period. The common factor also accounts for a larger fraction of investment variation in the period of globalization than it does in the common shock period. Movements in interest rates seem to be the predominant source of comovement for most countries, with oil prices playing a critical role in Japan and to a lesser extent in the U.K. during the common shock period. The main driver of observed comovement in the globalization period remains unidentified, leaving open the possibility that it involves productivity shocks.

[ϒ] We would like to thank Linda Tesar, Prakash Loungani and Pre-Conference participants for useful suggestions.
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1. Introduction

An often repeated view in popular press in recent years is that the nature of world business cycles has changed over time due to "globalization", which is often associated with developing trade links and more integrated financial markets.[1] It is indeed the case that globalization has picked up momentum in recent decades. The growth rate of world trade has been greater than that of world output in almost all years since 1960 and the cumulative increase in the volume of world trade is almost three times larger than that of world output over this period. A more dramatic element in the process of globalization has been the surge in cross-border capital flows over the last two decades. Since the early 1980s, capital flows have jumped from less than 5 percent to approximately 20 percent of GDP for advanced countries.[2]

Has the nature of world business cycles really been changing over time in response to stronger global linkages? Economic theory does not provide definitive guidance concerning the impact of increased trade and financial linkages on the properties of business cycles. International trade linkages generate both demand and supply-side spillovers across countries. Through these types of spillover effects, stronger international trade linkages can result in more highly correlated business cycles. However, if stronger trade linkages are associated with increased inter-industry specialization across countries, and industry-specific shocks are important in driving business cycles, then international business cycle comovement might be expected to decrease.[3]

Financial linkages could result in a higher degree of business cycle synchronization by generating large wealth effects. However, they could decrease the cross-country output correlations as they stimulate specialization of production through the reallocation of capital in a manner consistent with countries' comparative advantage. Such specialization of production, which could result in more exposure to industry- or country-specific shocks, would typically be expected to be accompanied by the use of

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[1] The followings constitute just a small set of examples on this view: "As economic and financial interdependence continue to increase, developments in one economic area will affect other economies more than in the past. As a result, global business cycles are likely to become self-reinforcing, which could make booms and recessions in developed economies more severe." (*The Economist*, September 26, 2002) "As the world economy has become more integrated, a downturn in one economy spreads faster to another..." (*The Economist*, August 25, 2001). "…Increased interdependence…means that much of the world can move down in tandem…" (*NY Times*, August 20, 2001).

[2] Several papers document the increase in global financial and trade flows during the recent decades. See IMF (2001, 2002), OECD (2002), Heathcoat and Perri (2002a, 2003), Chen and Yi (2002), Hummels, Ishii, and Yi (2001), and Prasad, Wei, and Kose (2003).

[3] See Kose and Yi (2001, 2002) for the link between international trade and business cycle comovement. Using the model developed by Backus, Kehoe and Kydland (1994), they examine whether a standard international business cycle model is able to replicate the positive empirical relation between international trade and business cycle correlation. They find that in a world of fully integrated asset markets, the model predicts that high trade intensity is associated with lower business cycle correlations. Under portfolio autarky, the model delivers increased correlations as trade intensity increases, but the increased correlation is only a fraction of what it is in the data.

international financial markets to diversify consumption risk (see Kalemli-Ozcan, Sorensen and Yosha (2003)). This could lead to less correlated cross-country fluctuations in output and could result in stronger comovement of consumption across countries.

Recent empirical studies are also unable to provide a concrete explanation for the impact of stronger trade and financial linkages on the nature of business cycles. Some empirical studies find that growing global linkages have a positive impact on the synchronization of business cycles in advanced countries.[4] Imbs (2002), Otto, Voss, and Willard (2001) and Kose, Prasad, and Terrones (2003a) examine the role of bilateral trade, financial openness, and sectoral similarity on business cycle correlations across industrialized countries: Imbs (2002) finds that the extent of financial linkages, sectoral similarity, and the volume of intra-industry trade all have a positive impact on business cycle correlations. Otto, Voss, and Willard (2001) find international trade is the most important transmission channel of business cycles. The results by Kose, Prasad, and Terrones (2003a) suggest that trade and financial linkages have a positive impact on output and consumption correlations.[5]

Other empirical studies examine the evolution of business cycle properties of the main macroeconomic aggregates over time, and find evidence of desynchronization. For example, Heathcote and Perri (2002) document that the correlations of output and productivity between the U.S. and an aggregate of Europe, Canada, and Japan are lower in 1986-2000 relative to 1972-1985.[6] Helbling and Bayoumi (2002) document that while the correlations between the United States and other G-7 countries go down over the period of 1973-2001, most cross-country correlations across the other G-7 economies have remained quite stable during this period. Doyle and Faust (2002a, 2002b) study the changes in the correlations between the growth rate of GDP in the United States and in the other G-7 countries over time. They find that there is no significant change in the correlations during this period.[7]

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[4] Running cross country or cross region panel regressions, Frankel and Rose (1998), Clark and van Wincoop (2001), Otto, Voss, and Willard (2001), Calderon, Chong, and Stein (2002) and others have all found that, among industrialized countries, pairs of countries that trade more with each other exhibit a higher degree of business cycle comovement. Some recent empirical research Fidrmuc (2002) and Gruben, Koo and Millis (2002) finds that intra-industry trade is more important than inter-industry trade or total trade in driving the GDP co-movement. For time series work on the transmission of business cycles via international trade, see Canova and Dellas (1993), Schmitt-Grohe (1998), and Prasad (1999).

[5] Several recent studies focus on the dynamics of volatility and find that there has been a steady decrease in the US output volatility. Explanations for this decrease are many ranging from "the new economy" driven changes to the use of effective monetary policy during the recent period. See Blanchard and Simon (2001) and McConell and Quiros (2000). Kose, Prasad, and Terrones (2003b) examine the evolution of volatility in developed and developing countries over time.

[6] Olivei (2001) studies how consumption and output correlations across the G-7 countries change over time. He finds that there has been a marked decline in most of the output and consumption correlations from the period 1973-1987 to the period 1988-1998.

[7] Backus, Kehoe, and Kydland (1992) examine the evolution of business cycle characteristics for a number of developed countries. Bergman, Bordo, and Jonung (1998) study cross country correlations of several macro

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Some other researchers employ recently developed econometric methods for treating factor models to study the changes in the degree of business cycle comovement. Kose, Otrok, and Whiteman (2003) employ dynamic factor models and find that there is a significant common component in driving business cycles in developed and developing countries.[8] Monfort, Renne, Ruffer, and Vitale (2002) employ Kalman filtering techniques to estimate a dynamic factor model using the output series of the G-7 countries for the period 1970-2002. They find that the correlations between the common factor and individual country outputs exhibit a declining trend which they interpret as an indication of declining synchronization over the past three decades.[9]

This paper examines the changes in the nature of G-7 business cycles over time by estimating common dynamic components in main macroeconomic aggregates. In particular, we address the following questions: First, has the common factor been becoming more important in explaining business cycles in the G-7 countries? Second, how do changes in the common factor affect fluctuations in different macroeconomic aggregates (output, consumption, and investment)? Third, what types of shocks explain the changes in the nature of business cycles?

To study these questions, we employ a Bayesian dynamic latent factor model and estimate common components in the main macroeconomic aggregates of the G-7 countries. In particular, we decompose macroeconomic fluctuations in these variables into the following: (i) the G-7 factor (common across all variables/countries); (ii) country factors (common across aggregates in a country); and (iii) factors specific to each variable. A static factor model provides a description of the variance-covariance matrix of a set of random variables; the method of principal components is one implementation of this idea. A dynamic factor model provides a description of the spectral density matrix of a set of time series, and thus the factors describe contemporaneous and temporal covariation among the variables. In particular, our dynamic factor model enables us to simultaneously capture the dynamic comovement in output, consumption, and investment series of the G-7 economies.

Our study extends the empirical research program on international business cycles along several dimensions. First, we provide a systematic examination of the evolution of G-7 business cycles over three

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aggregates of 13 industrialized countries for the period 1873-1995 and find that the degree of business cycle synchronization has been increasing over time across different monetary regimes.

[8] Gregory, Head, and Raynauld (1997) use Kalman filtering and dynamic factor analysis to identify the common fluctuations across macroeconomic aggregates in G7 countries. Clark and Shin (2000) use a VAR factor model to study the importance of common and country-specific shocks in accounting for variation in industrial production in European countries. Lumsdaine and Prasad (2003) develop a weighted aggregation procedure, and examine the correlations between the fluctuations in industrial output in seventeen OECD countries and an estimated common component, and find evidence for a world business cycle and for a European business cycle.

[9] However, they also find that the impact of the North American factor on most European countries has increased over time for most countries implying that business cycle linkages have increased during the globalization period.

different periods. In particular, we argue that it is crucial to think about the period from 1960 to the present as being composed of three distinct sub-periods. The first, 1960:1-72:2, corresponds to the Bretton Woods (BW) fixed exchange rate regime. The second, 1973:1-86:2, witnessed a set of common shocks associated with sharp fluctuations in the price of oil and contractionary monetary policy in major industrial economies. The third period, 1986:3-2001:4, represents the globalization period in which there were dramatic increases in the volume of cross-border asset trade. This demarcation is essential for differentiating the impact of common shocks from that of globalization on the degree of comovement of business cycles.

Second, we consider the roles of G-7 and country specific factors which capture the changes in G-7 and national business cycles. We also study how G-7 and country specific factors affect the fluctuations in different macroeconomic variables. Specifically, we calculate variance decompositions that decompose the fraction of variance of each macroeconomic aggregate that is attributable to the G-7 factor, the country factor or the idiosyncratic component. The results of the variance decompositions are used to address several interesting issues associated with the changes in the nature of G-7 business cycles: For example, arguments that globalization has increased the importance of the G-7 business cycle should be evident in these variance decompositions. Moreover, the degree to which there is a differential change in the variance decompositions across aggregates is useful in interpreting the sources of these changes in a more structural sense. For example, we examine whether there is any evidence supporting the claim that investment dynamics are now more heavily affected by global factors (rather than domestic ones), since financial markets have become more integrated.

Increased integration could also affect the dynamics of comovement by changing the nature and frequency of shocks. First, as trade and financial linkages get stronger, the need for a higher degree of policy coordination might increase, which, in turn, raises the correlations between shocks associated with nation specific fiscal and/or monetary policies. This would naturally have a positive impact on the degree of business cycle synchronization.[10] Second, shocks pertaining to changes in productivity could become more correlated, if increased trade and financial integration leads to an acceleration in knowledge and productivity spillovers across countries (see Coe and Helpman (1995)). Third, increased financial

[10] However, it is not clear, at least in theory, whether increasing trade and financial linkages indeed lead to a growing need for the implementation of coordinated policies. Traditional arguments, based on trade multiplier models, would suggest that increased linkages implies a growing need for international policy coordination (see Oudiz and Sachs (1984)). Recent research by Obstfeld and Rogoff (2002) provides results quite different than those in the previous literature. They argue that integration may in fact diminish the need for policy coordination since international capital markets generate an expanded set of opportunities for cross-country risk sharing.

integration and developments in communication technologies lead to faster dissemination of news shocks through financial markets.[11]

Considering the important role played by macroeconomic shocks and the dynamic interactions between the global linkages and shocks, our final contribution focuses on the evolution of their importance over time. In particular, we attempt to establish an empirical link between the changes in G-7 business cycles and changes in exogenous variables that are thought to be the sources of economic fluctuations. At the center of contemporary models of business cycles are changes in fiscal and monetary policies, changes in the terms-of-trade, and fluctuations in oil prices. To understand the importance of the changes in these sources in different time periods, we combine our dynamic factor model with a vector autoregression, which allows us to study the interrelationship between those variables thought to cause fluctuations (e.g. monetary shocks) and our measures of common economic activity. Our econometric model follows the recent work of Bernanke, Boivin, and Eliasz (2002) who develop the factor-augmented VAR (FAVAR) to study the affects of monetary policy in a closed economy framework.

We describe the methodology used to estimate dynamic factors in section 2. Section 3 presents the results of our estimations for the full sample period. In section 4, we present the results for the sub-periods. Section 5 first briefly explains the estimation of FAVAR. Then, the results of estimations are reported. Section 6 concludes.

2. Methodology

This section introduces the methodology used in estimating the dynamic factors. In particular, we use a multi-factor extension of the single dynamic unobserved factor model in Otrok and Whiteman (1998). Kose, Otrok, and Whiteman (2003) employ a similar multi-factor model in an exercise involving developed and developing countries. Since they provide a detailed discussion about the multi-factor models, the rest of this section is brief and closely follows the description in their paper. Dynamic factor models are the dynamic counterparts to s*tatic* unobserved factor models that are common in psychology. A static factor model provides a description of the variance-covariance matrix of a set of random variables; the method of principal components is one implementation of this idea. A dynamic factor model provides a description of the spectral density matrix of a set of time series, and thus the factor(s) describe contemporaneous and temporal covariation among the variables.

Specifically, suppose x_i is a vector of Q measurements of person i's academic achievement (e.g., GPA, class rank, scores on the PSAT, SAT, ACT, GRE, GMAT, etc.) and Σ is the associated covariance matrix. Then x is said to have factor structure if Σ can be written in the form

[11] For example, Cochrane (1994) argues that the role of shocks associated with unobserved news could be important in driving business cycle fluctuations.

$$\Sigma = \Gamma\Gamma' + U$$

where Γ is $Q \times K$, $K << Q$, and U is diagonal with positive entries on the diagonal. This structure implies that x_i can be thought of as being explained by a set of K common factors and idiosyncratic noise. That is,

$$x_i = af + u_i$$

where f is an $K \times 1$ vector of factors, a is the $Q \times K$ vector of "factor loadings", and u_i is the person-specific noise. Typically, one employs the identification assumptions that the factors are independent and have variance 1.0, and that the u_i's are uncorrelated across individuals. If there is no other information on the factors f, they are "unobservable" and their characteristics must be learned indirectly via the pattern of correlation in the x_i's. It might be thought that the vector of scores would be determined in large part by a small number of factors ("intelligence", "test-taking ability", etc.), but there is no direct way of identifying what the factors are, only indirect ones via the factor loadings.

In the time series context, suppose y_t is an Q-dimensional vector of covariance stationary time series at date t (e.g., growth rates of output, consumption, and investment in a set of countries), and S_{yy} is its associated spectral density matrix. Then the time series $\{y_t\}$ is said to have *dynamic* factor structure if S_{yy} can be written in the form

$$S_{yy} = LL' + V$$

where L is $Q \times K$, $K << Q$, and V is diagonal with positive entries on the diagonal. This structure means that all of the comovement amongst the variables is controlled by the M-dimensional set of " dynamic factors". In addition, in the time domain, y_t can be represented as

$$y_t = a(L)f_t + u_t$$

where a(L) is a $Q \times K$ matrix of polynomials in the lag operator, $\{f_t\}$ is a K-dimensional stochastic process of the factors, and the errors in u_t may be serially but not cross-sectionally correlated. The factors are in general serially correlated, and may be observed or unobserved.

In our implementation, there are K dynamic, unobserved factors thought to characterize the temporal comovements in the cross-country panel of economic time series. Let N denote the number of countries, M the number of time series per country, and T the length of the time series. Observable variables are denoted $y_{i,t}$, for $i = 1,\ldots,M\times N$, $t=1,\ldots,T$. There are two types of factors: N country-specific factors ($f_i^{country}$, one per country), and the single G-7 factor ($f^{G\text{-}7}$). Thus for observable i:

(1) $$y_{i,t} = a_i + b_i^{world} f_t^{world} + b_i^{country} f_{i,t}^{country} + \varepsilon_{i,t} \qquad E\varepsilon_{i,t}\varepsilon_{j,t-s} = 0 \text{ for } i \neq j,$$

where n denotes the country number. The coefficients b_i^j are called "factor loadings", and reflect the degree to which variation in $y_{i,t}$ can be explained by each factor. We use output, consumption and investment data for each of seven countries, so there are M×N (3*7=21) time series to be "explained" by the N+1 (7+1=8) factors. The "unexplained" idiosyncratic errors $\varepsilon_{i,t}$ are assumed to be normally distributed, but may be serially correlated. They follow p_i-order autoregressions:

(2) $$\varepsilon_{i,t} = \phi_{i,1}\varepsilon_{i,t-1} + \phi_{i,2}\varepsilon_{i,t-2} + \ldots\ldots + \phi_{i,p_i}\varepsilon_{i,t-p_i} + u_{i,t} \qquad Eu_{i,t}u_{j,t-s} = \sigma_i^2 \text{ for } i = j \text{ and } s=0, 0 \text{ otherwise.}$$

The evolution of the factors is likewise governed by an autoregression, of order q_k with normal errors:

(3) $$f_{k,t} = \varepsilon_{f_k,t}$$

(4) $$\varepsilon_{f_k,t} = \phi_{f_k,1}\varepsilon_{f_k,t-1} + \phi_{f_k,2}\varepsilon_{f_k,t-2} + \ldots + \phi_{f_k,q_k}\varepsilon_{f_k,t-q_k} + u_{f_k,t}$$

$$Eu_{f_k,t}u_{f_k,t-s} = \sigma_{f_k}^2 ; Eu_{f_k,t}u_{i,t-s} = 0 \text{ all k, i, and s.}$$

Notice that all the innovations, $u_{i,t}$, i = 0,...,M×N and $u_{f_k,t}$, k = 1,…,K, are assumed to be zero mean, contemporaneously uncorrelated normal random variables. Thus all comovement is mediated by the factors, which in turn all have autoregressive representations (of possibly different orders).

There are two related identification problems in the model (1)-(4): neither the signs nor the scales of the factors and the factor loadings are separately identified. Signs are identified by requiring one of the factor loadings to be positive for each of the factors. In particular, we require that the factor loading for the G-7 factor be positive for U.S. output; country factors are identified by positive factor loadings for output for each country. Scales are identified following Sargent and Sims (1977) and Stock and Watson (1989, 1992, 1993) by assuming that each $\sigma_{f_k}^2$ is equal to a constant.

Because the factors are unobservable, special methods must be employed to estimate the model. Gregory, Head and Reynauld (1997) follow Stock and Watson (1989, 1992, 1993) and treat a related model as an observer system; they use classical statistical techniques employing the Kalman filter for estimation of the model parameters, and the Kalman smoother to extract an estimate of the unobserved factor. Otrok and Whiteman (1998) used an alternative based on a recent development in the Bayesian literature on missing data problems, that of "data augmentation" (Tanner and Wong, 1987).

In our context, data augmentation builds on the following key observation: if the factors were observable, under a conjugate prior the model (1)-(4) would be a simple set of regressions with Gaussian autoregressive errors; that simple structure can in turn be used to determine the conditional (normal) distribution of the factors given the data and the parameters of the model. Then it is straightforward to generate random samples from this conditional distribution, and such samples can be employed as stand-ins for the unobserved factors. Because the full set of conditional distributions is known—parameters given data and factors, factors given data and parameters—it is possible to generate random samples from the joint posterior distribution for the unknown parameters and the unobserved factor using a Markov Chain Monte Carlo procedure. In particular, taking starting values of the parameters and factors as given, we first sample from the posterior distribution of the parameters conditional on the factors; next we sample from the distribution of the G-7 factor conditional on the parameters and the country and regional factors; then we sample each regional factor conditional on the G-7 factor and the country factors in that region; finally, we complete one step of the Markov chain by sampling each country factor conditioning on the G-7 factor and the appropriate regional factor. This sequential sampling of the full set of conditional distributions is known as "Gibbs sampling." (See Chib and Greenberg, 1996, Geweke, 1996, 1997.)[12] Under regularity conditions satisfied here, the Markov chain so produced converges, and yields a sample from the joint posterior distribution of the parameters and the unobserved factors, conditioned on the data. Additional details can be found in Otrok and Whiteman (1998).

The macro time series data are from the OECD Quarterly National Accounts and IFS. We use quarterly output, consumption and investment data of the G-7 countries for the period 1960:1-2001:4. Each series was log first-differenced and demeaned. Thus we used M=3 series per country for N=7 countries, with T = 168 time series observations for each. One concern with procedures that extract measures of the G-7 business cycle is that large countries drive the G-7 component simply because of their size. In the procedure used here we are working in growth rates, so the size of the country can have no direct impact on the results. That is, the econometric procedure that extracts common components does not distinguish between a 2% growth rate in the US and a 2% growth rate in the Italy. Put another way, the procedure is a decomposition of the second moment properties of the data (e.g. the spectral density matrix).

In our implementation, the length of both the idiosyncratic and factor autoregressive polynomials is 3. The prior on all the factor loading coefficients is N(0,1). For the autoregressive polynomials

[12] Technically, our procedure is "Metropolis within Gibbs", as one of the conditional distributions—for the autoregressive parameters given everything else—cannot be sampled from directly. As in Otrok and Whiteman (1998), we follow Chib and Greenberg (1996) in employing a "Metropolis-Hastings" procedure for that block.

parameters the prior was N(0,Σ), where $\Sigma=\begin{bmatrix}1 & 0 & 0\\ 0 & .5 & 0\\ 0 & 0 & .25\end{bmatrix}$. Because the data are growth rates, this prior embodies the notion that growth is not serially correlated; also, the certainty that lags are zero grows with the length of the lag. Experimentation with tighter and looser priors for both the factor loadings and the autoregressive parameters did not produce qualitatively important changes in the results reported below. As in Otrok and Whiteman (1998), the prior on the innovation variances in the observable equations is Inverted Gamma (6, 0.001), which is quite diffuse.

3. Business Cycles in the G-7 Countries (1960:1-2001:1)

In this section we present our estimation results for the full sample period1960:1-2001:4. First, we describe the time pattern of the G-7 factor and its relationship with country factors and macroeconomic aggregates for some select countries. This is followed by a brief discussion of the results of variance decompositions for the full sample.

3.1. Evolution of the G-7 Factor

Figure 1a displays the median of the posterior distribution of the G-7 factor, along with 5 and 95 percent quantile bands. The G-7 factor is estimated quite precisely as it is evident from the narrowness of the bands. More importantly, the G-7 factor is able to capture some of the major economic events of the past 40 years. In particular, the behavior of the G-7 factor is consistent with the steady expansionary period of the 1960s, the boom of the early 70s, the recession of the mid-1970s (associated with the first oil price shock), the recession of the early 1980s (associated with the tight monetary policies of major industrialized nations), the expansionary period of the late 80s, the recession of the early 1990s, and the highly synchronized downturn of early 2000.[13]

How do the G-7 and country specific factors interact with each other and with domestic macroeconomic aggregates? To answer this question, we study Figures 1b, 1c, and 1d which present the G-7 factor along with country specific factor and the growth rates of output in the U.S., Germany, and Japan respectively. In each figure, the solid line refers to the G-7 factor, the dotted lines refer to the country factor, the dashed lines represent the growth rate of output. In Figure 1b, we plot the median of the U.S. country-specific factor along with the G-7 factor, and the growth rate of U.S. output. This figure

[13] Backus and Gali (1997) study the impact of international factors in driving the recessions of the early 1990s. They argue that the recessions in different countries were mostly driven by country specific factors during this period. They also note that continental European countries may have been effected by the transmission of interest rate shocks from Germany since they were members of the ERM.

shows that several of the peaks and troughs of the U.S. country factor coincide with the NBER reference cycle dates[14]: the recessions of 1970, 1975, 1980, and 1982, and the booms of 1973, 1980, and 1981. Similarly, movements in the G-7 factor are consistent with some of the business cycle reference dates: the troughs of 1975, 1980, 1982, and the peaks of 1969, and 1973.

The U.S. country factor and the G-7 factor exhibit some common movements (e.g., the troughs of 1975, 1980, and 1982, and the peak of 1973). However, there are some notable differences between the two factors in almost every decade. The G-7 factor is booming in the late 1970s, whereas the U.S. country factor indicates an economic contraction during the same period. In the first half of the 1980s, the G-7 factor shows a relatively long recessionary period, while the U.S. country factor exhibits back-to-back booms in 1981 and 1984. In the 1990s, the U.S. factor displays the prolonged expansionary period, whereas there are at least a couple of downturns in the G-7 factor. The correlation between the median G-7 factor and U.S. output growth is 0.4, suggesting that the U.S. represents an important source of G-7 economic fluctuations though clearly G-7 fluctuations have an important component not related to the US.

Figure 1c presents the median of the German country-specific factor along with the G-7 factor, and the growth rate of German output. The country factor captures the German recessions of 1967, 1975, and 1982, and exhibits the peaks of 1964, 1973, and 1979.[15] The pattern of fluctuations suggests that the boom in 1973 and the recession in 1982 were worldwide events, while the recovery of the mid 1970s, the peaks of 1979, 1983, and 1992, and the trough of 1969 was associated with domestic factors.

Figure 1d displays the medians of the G-7 factor, the country factor of Japan, and the growth rate of Japan's output. The Japanese economy grew rapidly during the 1960s and the country factor is able to pick this period of high growth. However, the G-7 factor does not show strong comovement with Japanese output during this period. The OPEC recession hit harder and faster in Japan than the rest of the world, reflecting Japan's strong dependence on imported oil. While the growth rate of output was positive in 1965 and 1980, the estimated country-specific factor displays downturns in 1965 and 1980 since there were marked declines in Japanese investment during these years, and the estimated country factor captures the common movements in output, consumption as well as investment. For the first half of the 1980s, as Japan went, so went the world. But the downturn of the latter half of the decade, for example the one in 1986, was idiosyncratically Japanese. During the 1990s, there was a clear decrease in the degree of comovement between fluctuations in the G-7 factor and the growth rate of Japanese output. In

[14] The NBER reference business cycle dates: Troughs: Feb. 1961, November 1970, March 1975, July 1980, November 1982, March 1991. Peaks: April 1960, December 1969, November 1973, January 1980, July 1981, July 1990, March 2001.

[15] These peak and trough dates are taken from IMF (2002b).

particular, the (ten-year) correlation between the G-7 factor and the growth rate of output (investment) goes down from 0.52 (0.65) during the 1980s to 0.15 (0.03) during the 1990s.

The results reported in this section suggest that to the extent that there are country-specific and worldwide sources of economic shocks, these play different roles at different points in time and around the globe. In some episodes, the country factor is more strongly reflective of domestic economic activity, while in others the domestic growth reflects the common worldwide pattern embodied in the G-7 factor. We examine how the quantitative importance of different factors change in explaining the variations in output, consumption, and investment growth over time more formally in section 4.

3.2. Variance Decompositions for the Full Sample

To measure the relative contributions of the G-7, country, and idiosyncratic factors to variations in aggregate variables in each country, we estimate the share of the variance of each macroeconomic aggregate due to each factor. In particular, we decompose the variance of each observable into the fraction that is due to each of the two factors and the idiosyncratic component. With orthogonal factors the variance of observable i can be written:

$$(6)\qquad \mathrm{var}(y_{i,t}) = (b_i^{world})^2\ \mathrm{var}(f_t^{world}) + (b_i^{country})^2\ \mathrm{var}(f_{i,t}^{country}) + \mathrm{var}(\varepsilon_{i,t})\quad .$$

The fraction of volatility due to, say, the G-7 factor would be:

$$\frac{(\mathrm{b}_{\mathrm{i}}^{\mathrm{world}})^2\ \mathrm{var}(\mathrm{f}_{\mathrm{t}}^{\mathrm{world}})}{\mathrm{var}(\mathrm{y}_{\mathrm{i,t}})}\ .$$

These measures are calculated at each pass of the Markov chain; dispersion in their posterior distributions reflects uncertainty regarding their magnitudes.

The results of our variance decompositions for the full sample period are presented in table 1. There are five important results: First, the G-7 factor is able to explain a sizeable fraction of volatility of the three aggregates (see figure 2a). In particular, the G-7 factor on average accounts for more than 25 percent of output variation and it explains more than 15 percent of the volatility of consumption and investment. The importance of the G-7 factor differs quite a bit across countries. It accounts for roughly 60 percent of output variation in France while the share of output variance attributable to the G-7 factor is less than 13 percent in the U.S. In France, Germany, Italy, and Japan, more than 20 percent of output and consumption variation is explained by the G-7 factor (see figure 2b). Second, while most of the variation in output is due to the country factor, idiosyncratic factor on average seems to be playing a more important role than the other two factors in driving the dynamics of fluctuations in consumption and investment (figure 2a).

Third, the country factor accounts for a larger share of consumption variation than it does for output in all countries except France and Italy (Figure 2c). On average, the variance of consumption explained by the country specific factor is larger than 35 percent while only 18 percent of the consumption variation is due to the G-7 factor. This, together with the finding that the common factor explains a smaller fraction of consumption volatility than output volatility is consistent with a widely documented observation in the international business cycle literature: cross-country correlations of output growth are larger than those of consumption growth.[16]

Another important observation is that the idiosyncratic factor on average explains close to 50 percent of investment variation (figure 2d). In Canada and the U.K., more than 70 percent of the fluctuations in investment is explained by the idiosyncratic factor and it is able to explain more than 30 percent of the investment volatility in other countries. The idiosyncratic behavior of investment volatility in our model is consistent with observed cross-country investment correlations: these correlations are low and generally lower than the cross-country correlations of output (see Zimmerman 1995, Christodoulakis, Dimelis, and Kollintzas 1995)[17].

In the previous subsection, we learn that the importance of the G-7 and country factors vary over time in explaining time series pattern of fluctuations in output. This section shows that the impact of the G-7 and country factors differ across macroeconomic aggregates. Then, how do their roles in explaining the volatility of these aggregates change over time? The next section addresses this question.

4. Changing Nature of the G-7 Business Cycles

To study the evolution of the roles played by the G-7 and country specific factors in driving business cycles, we divide the full sample into three distinct sub-samples: The first, 1960:1-72:2, corresponds to the Bretton Woods (BW) fixed exchange rate regime. The second, 1972:3-86:2, witnessed a set of common shocks associated with sharp fluctuations in the price of oil and contractionary monetary policy in major industrial economies. The third period, 1986:3-2001:4, represents the globalization period in which there were dramatic increases in the volume of cross-border asset trade. This demarcation is essential for differentiating particularly the impact of common shocks from that of globalization on the degree of business cycle comovement.

[16] Backus, Kehoe, and Kydland (1995) refer to apparent inconsistency between the theory and the data as "the quantity anomaly." (A simple model with risk sharing would suggest that consumption across countries ought to be more correlated than output.)

[17] Christodoulakis, Dimelis, and Kollintzas (1995) use the data of 12 EU countries and report that 48 out of that 66 cross-country investment correlations are lower than those of output.

The first sub-period is characterized by the steady nature of growth and stable dynamics of business cycles. Interestingly, there was a discussion about the obsolescence of business cycle in the late 1960s.[18] The second period, which we call the common shock period, are characterized by the oil price shocks in the 70s and the changes in monetary policy regimes in the early 1980s. Of course, the first and second periods are different because of the exchange rate regime coincides with the Bretton Woods fixed exchange rate regime as well. However, it is still a question whether (and how) the monetary regime affects the properties of business cycles in main macroeconomic aggregates. For example, Baxter and Stockman (1989), Baxter (1991), and Ahmet et. al. (1993) find that different types of exchange rate regimes do not result in significant changes in the behavior of the main macroeconomic aggregates.[19]

What is the difference between the common shock period and the period of globalization? There are at least three major differences: First, there are clear forces associated with stronger global linkages in the period of globalization. As we have already stated there has been a substantial increase in the cross-border asset trade since the mid 1980s. For example, the U.S. holdings of foreign assets (Canada, Japan, and Europe) have grown significantly since the mid 1980s, from 6.7 percent to 12.8 percent of total US capital stock. The U.S. holdings of foreign assets (Rest-of-the World) have also risen from 24.1 percent to 39.3 percent since 1985.[20] During this period, there has also been a substantial increase in the volume of international trade (see World Bank (2000)). Second, 1986 marks the beginning of a structural decline in the volatility of U.S. output, as documented by Connell and Perez-Quiros (2000) and Blanchard and Simon (2001). This decline in the volatility of output is common to at least five of the G-7 economies (see Doyle and Faust (2002).[21] Third, the period of common shocks witnessed a set of common shocks associated with sharp fluctuations in the price of oil and contractionary monetary policy in major industrial economies.

We examine the properties of G-7 and national business cycles under each sub-sample period by estimating factor models for each sub-period. Then, for each sub-period, we calculate variance decompositions that decompose the fraction of variance of each macroeconomic aggregate that is attributable to the G-7 factor, the country factor or the idiosyncratic component. The results of the variance decompositions are reported in table 2 and figures 3a-3e.

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[18] There was a discussion about the end of business cycle in the late 1960s which was quite similar to the discussions we observed during the late 1990s. Minsky (1968) notes that *"... if the policy prescriptions of the New Economics were applied, business cycles as they had been known would be a thing of the past."* For an extensive discussion about this see Bronfenbrenner (1969).

[19] Gerlach (1988) concludes that the exchange rate regime has a significant impact on the stylized business cycle facts.

[20] For evidence on this see Heathcoat and Perri (2002b) and Dalsgaard, Elmeskov and Park (2002).

[21] Smith and Summer (2002) and Djyk, Osborn, and Sensier (2002) provide more detailed discussions of the decline in business cycle volatility in industrialized countries.

Figure 3a presents the average variance of each aggregate explained by the G-7 factor. The importance of the G-7 factor is larger during the common shock period than that in the first period. Not surprisingly, the G-7 factor accounts for a smaller fraction of variance of output and consumption during the period of globalization than it does during the common shock period. These results are consistent with the findings of several recent studies documenting that there has been a decrease in the degree of business cycle synchronization from the common shock period to the globalization period. For investment, though, the G-7 factor becomes more important over time. The results for the common shock period suggest that comovement is especially influenced by common supply shocks.

To isolate the role of globalization in driving the degree of comovement, we compare the period of globalization with the Bretton Woods period. The average variance due to the G-7 factor has increased from roughly 7 percent in the first period to 19 percent in the globalization period. We also find that, on average, the G-7 factor explains a larger fraction of consumption and investment volatility in the globalization period than it does in the first period. While there is a marginal increase in the variance of consumption explained by the G-7 factor in the globalization period relative to the first period, the share of investment variance due to the G-7 factor is roughly tripled during the globalization period. These findings suggest that the degree of comovement of business cycles of major macroeconomic aggregates across the G-7 countries has indeed increased during the globalization period.

Figure 3b presents the variance of output explained by the G-7 factor for each country. For all countries, there is a significant increase in the variance of output explained by the G-7 factor in the common shock period relative to the first period. However, moving from the common shock period to the globalization period, the variance explained by the G-7 factor has declined in all countries but France and Italy. While the decline in the importance of the G-7 factor from the common shock period to the globalization period is quite dramatic for Germany and Japan, it is much more modest for the U.S., Canada and the U.K. For all countries except Germany and Japan, the G-7 factor is more important in the globalization period than that in the first period. For France and Italy, the relative importance of the G-7 factor is even greater in the globalization period. What are the potential explanations of these results?

A possible explanation for the latter result is that, while other G-7 countries liberalized their capital accounts in the 1970s (Canada, Germany, U.S.) or the 1980s (Japan, U.K.), Italy and France did not remove all of the barriers on capital account transactions until the beginning of the 1990s. In other words, the effect of the financial integration was felt early on during the common shock period in all countries of the G-7 except Italy and France, where the full impact of financial reforms occurred only during the globalization period.

What about the business cycles in Germany and Japan during the period of globalization? The Japanese economy suffered a prolonged recession that was aggravated by a sharp fall in asset prices and a severe banking crisis. The unification process and the Maastricht criteria forced Germany to implement a set of tight fiscal and monetary policies that resulted in a relatively long period of low growth during the 1990s. In other words, business cycles in these countries have been mostly driven by domestic forces during the period of globalization.

Figure 3c reports the variance of consumption explained by the G-7 factor in each country. What is the impact of increased financial linkages on the degree of comovement in consumption fluctuations over time? To answer this question we again focus on the first period and the period of globalization. In all countries except Germany, there has been an increase, albeit a small one in some cases, in the variance of consumption due to the G-7 factor in the globalization period relative to the first period. This result is consistent with the predictions of theory. For example, Cole (1993) presents a model in which increased financial integration reduces the impact of wealth effects associated with a country's own productivity shocks while it increases the wealth effects of productivity shocks abroad. These changes increase the cross-country consumption correlations.[22] Increasing financial linkages could also increase the degree of consumption comovement as they stimulate specialization of production through the reallocation of capital in a manner consistent with countries' comparative advantage in the production of different goods.[23]

Figure 3d displays the findings concerning with the dynamics of investment. As we have already stated, the G-7 factor becomes more important in explaining investment variation over time. In fact, the variance of investment captured by the G-7 factor has increased in all countries but Germany and the U.S. during the period of globalization relative to the first period. In France and Italy, the share of investment variance due to the G-7 factor has risen in the globalization period relative to the first period. This finding is consistent with our earlier explanation that the full impact of financial reforms in Italy and France took place only during the globalization period.

Figures 3e shows that the country factor becomes less important in explaining the variance of output and investment in the globalization period relative to the first period. However, the role played by country factor in explaining the volatility of consumption increases in the globalization period relative to the earlier periods.

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[22] While these findings are consistent with one-good stochastic dynamic models like the ones in Baxter and Crucini (1995) and Kollmann 1996), they are not consistent with the predictions of two-good business cycle models. Heathcote and Perri (2002a) find that eliminating the trade of financial assets increases the degree of comovement in standard business cycle models.

[23] For example, Kalemli-Ozcan, Sorensen and Yosha (2003) find that there is a significant positive correlation between the degree of financial integration (risk sharing) and specialization of production. Kose, Prasad, Terrones (2003a, 2003b) find that increased financial linkages help reduce the volatility of consumption and increase the degree of consumption comovement in industrialized countries.

5. What are the sources of changes in the G-7 Business Cycles?

In previous section, we documented how the degree of comovement across countries has changed over time and that the importance of the G-7 factor was greatest during the period 1972-1986. We have already explained how increased financial and trade linkages could play a role in explaining these developments. Of critical importance is to understand how the roles of different types of shocks in explaining these developments change over time. To answer this question we combine our dynamic factor model with a vector autoregression to study the interrelationship between those variables thought to cause fluctuations (e.g. monetary shocks) and our measures of common economic activity. Our econometric model follows the work of Bernanke, Bovin, and Eliasz (2002) who develop the factor-augmented VAR (FAVAR) to the study the affects of monetary policy in a closed economy framework. The motivation for their model is to address the criticism that standard VAR models are limited in the number of variables that can be included due to the rapidly increasing dimension of VAR models as variables are added. Out motivation is similar, with 7 countries, 3 measures of economic activity and 4 measures of potential sources of economic activity (monetary policy, fiscal policy, terms of trade, and oil prices) we have a system of 49 variables. With the small samples we are interested in we would quickly exhaust degrees of freedom in a standard VAR. The FAVAR achieves parameter reduction while still incorporating essential information in the estimation procedure. In the closed economy framework Bernanke, Bovin, and Eliasz (2002) find that this additional information alleviates puzzles traditionally found in VAR studies.

5.1. The Model

Let F_t be a vector containing the G-7 and country factors, and S_t be a vector with measures of money, productivity and oil prices for each country. The model is now changed to:

(7) $$\begin{bmatrix} F_t \\ S_t \end{bmatrix} = \begin{bmatrix} \Phi(L) & A(L) \\ C(L) & D(L) \end{bmatrix} \begin{bmatrix} F_{t-1} \\ S_{t-1} \end{bmatrix} + E_t$$

(8) $$Y_t = B^F(L)F_t + B^S(L)S_t + V_t$$

$\Phi(L)$ is a matrix polynomial with zeros restrictions such that the lags of the factors only enter in their own equations, not of other factors. A(L) has zero restrictions so that a country factor depends only on the source variables in it own country. The G-7 factor depends on all source variables. C(L) has similar zero restrictions as A(L). D(L) has zeros restrictions so that each variable depends on own lags, not lags of other variables. B^F has zero restrictions consistent with Section 3 of the paper, and B^S has zero restrictions so that each variable only depends on country specific sources. We can view the factor analysis in section 3 as a restricted version of (7)-(8).

For our study we are interested in two sets of results from the estimation of the econometric model given by (7)-(8). The first is the affect of including source variables (S_t) on the variance decompositions reported in section 3. Equation (8) shows that in the new model Y_t depends not only on the G-7 and country factors, but also on monetary, fiscal, terms of trade and oil variables. Of interest is whether or not, and if so how, the inclusion of these additional variables affects the importance of the G-7 (country) cycle. For example, when oil prices are included if the importance of the G-7 (country) factor decreases then we would conclude that the comovement in country i that can be attributed to oil prices represents the decrease in importance in the G-7 (country) factor. Since we are including a vector of potential sources we can address which variable is most important for explain fluctuations in each time period. Conversely, if we find that the inclusion of these additional variables has no explanatory power, that leaves us to conclude that productivity (or some other unnamed variable) is the most likely cause of fluctuations.

The second set of results in which we are interested involves the more traditional impulse response functions often used in VAR analysis. The additional twist here is that we can measure the response of the G-7 (country) factor to shocks that originate in any particular country. For example, how does the G-7 factor respond to a shock to monetary policy in the United States? Such an analysis requires assumptions traditionally used in the VAR literature about causal orderings of variables (or some other identification scheme).

5.2. Variance Decompositions

The potential source variables that we investigate are oil prices, terms of trade, government spending (fiscal policy) and interest rates (monetary policy), for each of our seven countries.[24] Government spending, oil prices and terms of trade are all entered as log first differences, and interest rates enter in levels. In order to calculate variance decompositions analogous to those presented in section 3 we need our regressors to be orthogonal. The factors are orthogonal to the source variables by construction but the source variables are not orthogonal to each other. We orthogonalize the source

[24] Government spending series are Real Government Expenditure from the OECD Quarterly Accounts. Oil prices (in $ terms) are taken from the IFS. They are first converted into domestic currency and then deflated by CPI of each country. Terms of trade is the ratio of export prices to import prices both of which are from the IFS. Different types of short-terms interest rate series are used for different countries depending on the availability of the data. These series are taken from the IFS. For France and Italy, we use Government Bond Yield Rate Series. For Japan and Germany, Call Money Rate Series; for Canada, Official Discount Rate Series; for the U.K, T-Bill Rate Series; and for the U.S., Fed Funds Rate Series are used.

variables in the usual way by regressing the 1st variables on the second and using the residual as the orthogonal measure of the 2nd variable. We construct orthogonalized versions of all our source variables in this fashion. The first ordering we use places oil first, terms of trade second, government spending third and interest rates last. In a later section we will check the robustness of our results to these orderings.

The results for each sub-period are presented in Tables 3a-3c. We interpret these tables by comparing them to the analogous table from Section 4. From Table 3a we see that in the first period the importance of the idiosyncratic component falls significantly across all variables. Apparently the variables we add as source variables are most useful in explaining the variation that is idiosyncratic to many of the time series. For example, in Germany, fluctuations in oil price and terms of trade explain 11 and 7 percent of output volatility but very little of consumption or investment volatility. It also appears that movements in interest rates (a proxy for monetary policy) explain a significant portion of volatility in some aggregates.

In the second period, we see that the importance of the G-7 factor falls relative to the model in section 4. Table 3b indicates that much of the comovement captured by the G-7 factor in section 3 can now be captured by fluctuations in interest rates, which explain up to 20 of variability for some aggregates. Surprisingly, the importance of oil price fluctuations between periods 1 and 2 does not increase significantly for most countries. One striking exception is Japan where oil price fluctuations explain 25, 36 and 19 percent of output, consumption and investment variability. Comparing with the table2b for the common shocks in section 4 we see that the importance of the G-7 and country factors fall for Japan when oil is added as a possible explanatory variable. Apparently much of Japan's link to the G-7 over this time period is through oil prices while other countries are more linked to G-7 activity through interest rates.

In the globalization period, fluctuations in oil prices and terms of trade seem to account for little comovement while interest rates are still important, albeit not as important as in the common shock period (Table 3c). For the globalization period, the most striking result is the importance of fiscal policy in driving business cycles in Germany. Given events in Germany during this period, this is perhaps not surprising. In terms of our model, we see that instead of crediting comovement in Germany in this period to a 'country' factor as in section 4, we now credit it to fiscal policy (note that the importance of the country factor is much lower in the variance decomposition that includes fiscal policy relative to those in section 4 for Germany).

Looking across the tables 3a-3c, we see that while the source variables we have investigated help explain comovement in some sub-periods, a significant portion is still not explained. So what then, is the source of fluctuations in these time periods? One obvious candidate is productivity. If G-7 productivity does explain the comovement that is observed in all sub-periods (the importance of the G-7 factors after accounting for the influence of our potential source variables) we would conclude that in the final period that productivity has been the largest source of G-7 fluctuations. A caveat to this is that we are attributing all comovement not explained to productivity, while there may be other sources we have not considered.

In sum, we find that in the first period comovement across macro aggregates is generally low in section 4, and little of the comovement we do find can be explained by fluctuations in oil prices, terms of trade, government spending, interest rates or productivity (viewing productivity as the residual explanatory variable for comovement), except for a few idiosyncratic cases as discussed in section 4. In the common shock period, we find that comovement is much higher and that interest rates are the predominant source of comovement for most countries, with oil prices playing a critical role in Japan and to a lesser extent the UK (section 4). In the globalization period, we conclude that productivity may play the predominant role of explaining observed comovement. [Impulse Response Functions: To be added]

6. Conclusion and Summary

We study the changes in the nature of G-7 business cycles over time by estimating common dynamic components in main macroeconomic aggregates (output, consumption, and investment). In particular, we employ a Bayesian dynamic latent factor model and decompose macroeconomic fluctuations in these variables into the following: (i) the G-7 factor (common across all variables/countries); (ii) country factors (common across aggregates in a country); and (iii) factors specific to each variable.

We first show that to the extent that there are country-specific and worldwide sources of economic shocks, these play different roles at different points in time and around the globe. In some episodes, the country factor is more strongly reflective of domestic economic activity, while in others the domestic growth reflects the common pattern embodied in the G-7 factor. We document that the G-7 factor is able to explain a sizeable fraction of volatility of the three aggregates for the period 1960:1-2001:4. In particular, the G-7 factor on average accounts for more than 25 percent of output variation and it explains more than 15 percent of the volatility of consumption and investment. We also find that the importance of the G-7 factor differs quite a bit across countries.

We then examine the evolution of the roles played by the G-7 and country specific factors in driving business cycles in three distinct sub-periods. Our results suggest that the G-7 factor accounts for a smaller fraction of variance of output and consumption during the period of globalization than it does during the common shock period. More importantly, there is a marked increase in the variance of output due to the G-7 factor from the first period to the globalization period. The G-7 factor, on average, explains a larger fraction of consumption and investment volatility in the globalization period than it does in the first period. These findings indicate that the degree of comovement of business cycles of major macroeconomic aggregates across the G-7 countries has indeed increased during the globalization period.

Increased global linkages also affect the dynamics of comovement by changing the nature and frequency of shocks. We study the evolution of the roles played by different types of shocks in explaining the synchronization of business cycles over time. We combine our dynamic factor model with a vector autoregression and study the interrelationship between those variables thought to cause fluctuations (e.g. monetary shocks) and our measures of common economic activity. Our findings indicate that fluctuations in interest rates are the major source of comovement for most countries, with movements in oil prices playing a critical role in Japan and to a lesser extent in the UK. We also find that productivity may play the predominant role of explaining observed comovement in the globalization period.

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Table 1: Variance Decompositions: Factors (Full Sample, 1960:1-2001:4, in percent)

Country	Variable	World	Country	Idiosyncratic
Canada	**Output**	13.80	42.87	42.67
	Consumption	6.12	40.60	53.71
	Investment	5.87	20.27	73.78
France	**Output**	58.33	29.77	12.24
	Consumption	36.33	12.77	50.36
	Investment	36.73	32.18	31.92
Germany	**Output**	23.44	61.53	15.58
	Consumption	10.68	38.07	51.30
	Investment	9.19	59.20	31.47
Italy	**Output**	29.83	46.47	24.20
	Consumption	27.50	17.63	54.73
	Investment	13.87	46.73	39.58
Japan	**Output**	32.77	64.20	3.33
	Consumption	13.60	55.00	31.48
	Investment	29.33	34.20	36.30
U.K.	**Output**	14.25	65.60	20.02
	Consumption	3.47	51.35	45.44
	Investment	6.22	16.75	76.53
U.S.	**Output**	12.80	70.07	16.33
	Consumption	9.93	41.27	48.67
	Investment	12.62	49.48	37.48
Average	**Output**	26.46	54.36	19.20
	Consumption	15.38	36.67	47.96
	Investment	16.26	36.97	46.72

Notes: In each cell, the share of the variable's variance explained by a particular factor is reported.

Table 2: Variance Decompositions: Factors (Sub-periods, in percent)

		Period 1: 1960:1-1972:2			Period 2: 1972:3-1986:2			Period 3: 1986:3-2001:4		
Country	Variable	World	Country	Idiosyncratic	World	Country	Idiosyncratic	World	Country	Idiosyncratic
Canada	Output	5.47	44.10	48.70	26.90	28.00	45.07	17.11	29.22	53.40
	Consumption	14.04	19.73	62.87	14.50	34.67	50.98	19.37	46.37	33.44
	Investment	8.91	22.30	67.58	3.69	28.40	67.48	18.49	8.37	72.51
France	Output	1.51	74.76	22.30	50.80	31.53	17.67	54.31	31.40	14.20
	Consumption	3.73	51.67	42.69	23.63	6.38	68.53	4.13	76.63	18.13
	Investment	3.63	61.13	33.78	36.67	25.97	37.42	59.42	11.62	28.22
Germany	Output	20.55	64.47	15.33	79.89	6.46	12.38	4.72	79.47	14.87
	Consumption	22.23	26.78	50.69	33.02	16.73	49.91	2.05	57.22	39.60
	Investment	14.33	60.16	26.04	35.69	28.25	36.22	5.65	65.36	28.40
Italy	Output	3.76	83.73	10.94	19.00	46.58	34.77	20.62	39.73	39.80
	Consumption	16.07	31.92	52.00	22.56	11.95	63.80	17.93	14.43	66.53
	Investment	14.00	66.47	20.02	10.43	45.13	44.80	34.63	25.43	39.30
Japan	Output	1.86	91.10	4.95	20.09	76.66	2.87	0.78	95.21	3.80
	Consumption	0.71	49.97	48.51	3.95	61.68	34.30	0.75	68.37	30.43
	Investment	2.66	53.91	42.50	16.53	51.09	32.62	8.89	35.01	56.17
U.K.	Output	6.85	83.98	6.74	28.60	42.64	28.53	16.91	35.33	47.42
	Consumption	1.21	38.72	59.65	13.77	56.53	29.60	16.07	25.07	58.00
	Investment	5.16	47.57	46.16	1.85	6.16	91.89	27.76	24.47	47.65
U.S.	Output	4.63	75.58	18.50	32.76	54.11	12.52	16.55	49.10	33.40
	Consumption	6.78	48.19	42.85	26.91	28.97	44.57	15.05	32.07	52.57
	Investment	10.04	29.47	59.67	30.61	47.63	21.84	6.58	53.42	39.36
Average	Output	6.38	73.96	18.21	36.86	40.85	21.97	18.71	51.35	29.56
	Consumption	9.25	38.14	51.32	19.76	30.99	48.81	10.77	45.74	42.67
	Investment	8.39	48.71	42.25	19.35	33.23	47.47	23.06	31.95	44.51

Notes: In each cell, the share of the variable's variance explained by a particular factor is reported.

Table 3a: Variance Decompositions: Factors and Sources (Period 1, in percent)

		Period 1: 1960:1-1972:2						
Country	**Variable**	**World**	**Country**	**Oil**	**Tot**	**Gov. Exp.**	**Int. Rate**	**Idiosnycratic**
Canada	**Output**	2.50	65.40	1.61	1.09	0.72	1.17	22.38
	Consumption	1.33	31.57	0.32	1.31	3.80	3.80	53.58
	Investment	2.58	26.80	0.32	0.32	1.33	0.75	64.60
France	**Output**	1.56	83.87	0.97	0.80	0.84	4.49	3.60
	Consumption	3.37	42.73	2.47	4.56	4.84	0.98	36.33
	Investment	1.30	54.55	0.59	0.64	3.60	6.02	29.47
Germany	**Output**	5.57	88.10	11.11	7.50	0.89	8.55	0.00
	Consumption	7.16	48.73	1.20	0.61	2.77	0.55	32.48
	Investment	2.75	80.49	2.83	2.17	0.63	0.81	2.13
Italy	**Output**	1.71	75.33	0.70	13.30	0.98	7.60	0.00
	Consumption	1.30	45.27	1.07	0.85	3.42	8.82	36.62
	Investment	2.93	73.24	0.77	5.87	0.79	7.20	1.53
Japan	**Output**	2.59	97.13	0.70	3.33	1.41	1.05	0.00
	Consumption	25.80	46.00	0.55	7.71	0.57	2.50	17.77
	Investment	4.73	67.87	1.46	1.52	1.35	1.46	12.47
U.K.	**Output**	1.80	89.27	1.55	6.69	1.11	2.37	0.00
	Consumption	1.92	33.41	7.78	0.43	0.81	4.70	47.07
	Investment	1.58	56.73	0.84	1.56	0.88	1.53	33.00
U.S.	**Output**	14.13	67.78	1.32	0.86	8.53	8.71	0.00
	Consumption	13.04	43.80	0.48	1.65	5.47	2.33	30.73
	Investment	2.27	32.67	3.06	0.53	1.15	19.75	32.03

Notes: In each cell, the share of the variable’s variance explained by a particular factor/source is reported.

Table 3b: Variance Decompositions: Factors and Sources (Period 2, in percent)

		Period 2: 1972:3-1986:2						
Country	Variable	World	Country	Oil	Tot	Gov. Exp.	Int. Rate	Idiosnycratic
Canada	Output	9.87	21.05	0.54	0.33	0.38	10.73	53.53
	Consumption	2.93	39.67	2.88	2.96	0.35	22.20	26.00
	Investment	0.94	25.27	1.93	0.54	0.56	2.67	65.96
France	Output	55.47	8.60	0.29	2.62	5.10	4.85	21.73
	Consumption	19.25	14.10	5.47	0.31	6.92	4.93	45.27
	Investment	44.40	7.87	2.42	0.46	1.44	3.73	34.23
Germany	Output	44.29	11.18	0.66	0.56	1.27	14.82	24.90
	Consumption	12.44	15.30	3.10	0.68	3.52	20.03	43.53
	Investment	15.38	23.40	2.16	0.38	1.87	23.31	30.73
Italy	Output	18.89	33.93	0.51	2.42	1.34	5.33	34.53
	Consumption	19.03	3.87	0.35	1.42	4.05	8.16	61.03
	Investment	15.30	34.53	0.53	0.29	2.86	2.29	41.98
Japan	Output	11.24	55.86	25.07	1.01	5.07	3.79	0.00
	Consumption	6.77	23.03	36.43	0.35	9.11	2.09	21.20
	Investment	2.52	40.70	19.57	8.58	0.91	5.87	19.29
U.K.	Output	29.50	32.62	11.67	0.52	6.73	7.28	8.67
	Consumption	14.11	37.70	6.77	2.33	9.24	7.62	20.07
	Investment	0.56	4.32	2.54	0.10	6.95	6.13	78.47
U.S.	Output	10.14	62.56	2.73	0.69	1.99	12.20	6.12
	Consumption	8.33	26.69	7.50	3.41	1.92	20.47	30.33
	Investment	14.46	54.56	1.90	1.44	3.08	8.62	12.70

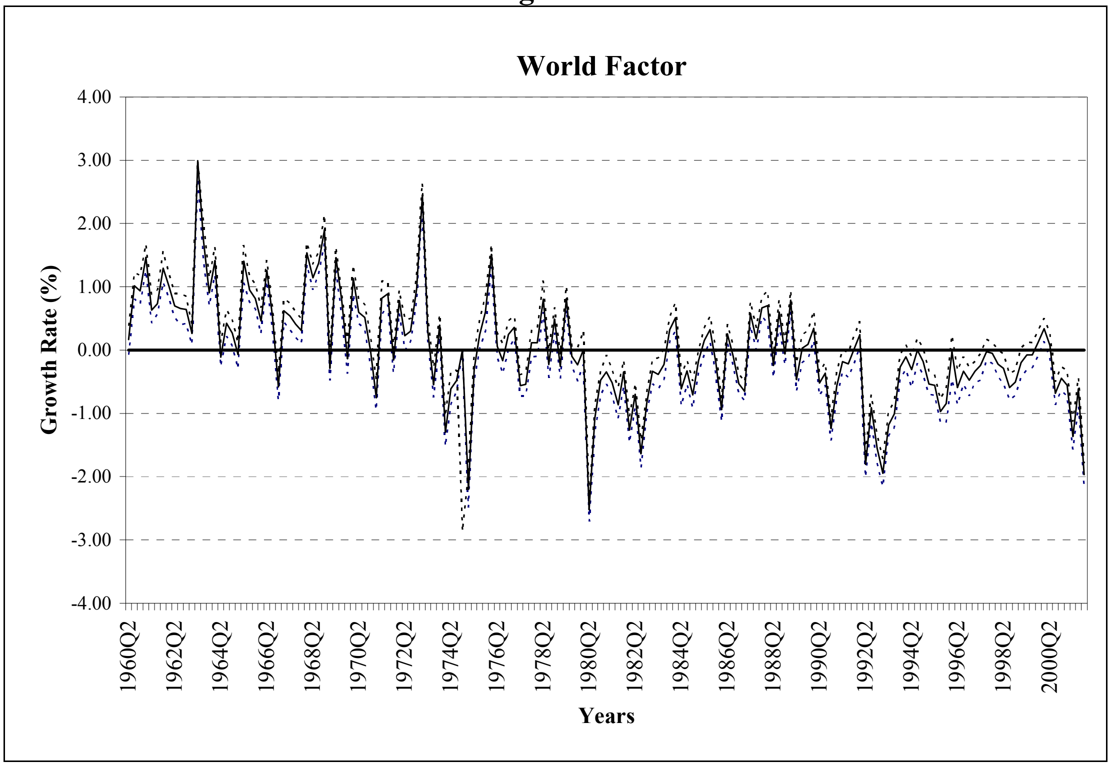
Notes: In each cell, the share of the variable’s variance explained by a particular factor/source is reported.

Table 3c: Variance Decompositions: Factors and Sources (Period 3, in percent)

		Period 3: 1986:3-2001:4						
Country	**Variable**	**World**	**Country**	**Oil**	**Tot**	**Gov. Exp.**	**Int. Rate**	**Idiosnycratic**
Canada	**Output**	18.42	20.40	1.23	0.30	3.04	20.02	34.60
	Consumption	19.47	28.93	2.73	0.17	0.52	12.23	29.67
	Investment	30.18	5.20	0.26	1.48	18.38	10.31	32.93
France	**Output**	64.88	23.07	0.61	0.56	0.40	0.63	7.93
	Consumption	9.68	68.97	0.49	0.62	0.62	1.54	15.50
	Investment	65.60	5.77	0.65	0.25	6.44	0.42	19.05
Germany	**Output**	22.82	30.02	1.93	3.99	37.80	11.36	0.00
	Consumption	2.98	31.00	3.61	0.83	36.50	7.59	15.33
	Investment	16.88	13.60	0.38	2.71	41.73	4.35	19.00
Italy	**Output**	24.33	37.00	1.16	0.34	0.35	0.47	32.60
	Consumption	17.87	11.23	2.68	1.90	2.12	0.72	60.80
	Investment	33.02	22.93	0.87	0.22	0.21	2.03	39.02
Japan	**Output**	3.92	77.56	5.00	0.63	2.82	5.84	0.73
	Consumption	0.40	70.67	2.58	0.60	1.21	1.63	20.00
	Investment	18.01	21.24	3.75	1.98	0.61	6.11	46.62
U.K.	**Output**	18.67	25.37	4.40	0.23	0.99	15.82	32.53
	Consumption	18.69	14.00	4.20	0.53	6.00	14.47	41.02
	Investment	26.73	17.60	1.25	2.40	2.32	3.90	43.83
U.S.	**Output**	19.13	42.47	0.41	0.46	0.99	5.45	27.57
	Consumption	33.11	22.20	1.60	0.55	0.35	20.70	19.80
	Investment	10.90	52.78	0.87	0.37	3.87	8.38	19.00

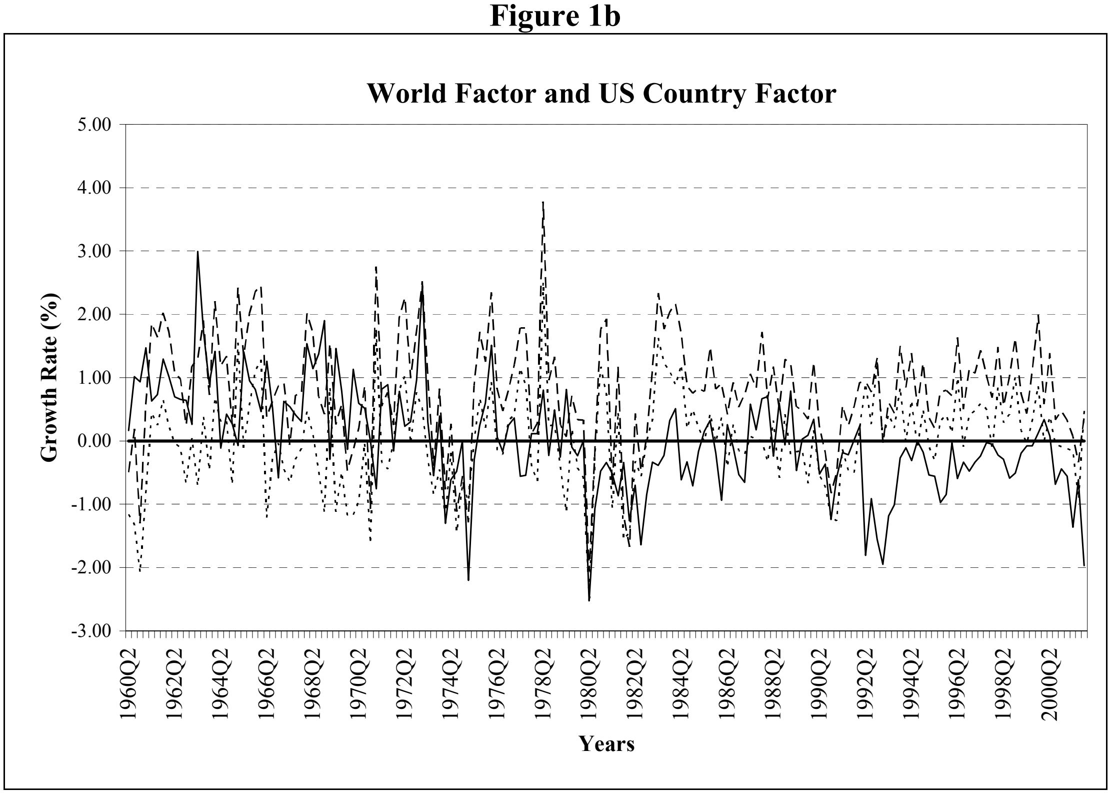
Notes: In each cell, the share of the variable’s variance explained by a particular factor/source is reported.

Figure 1a



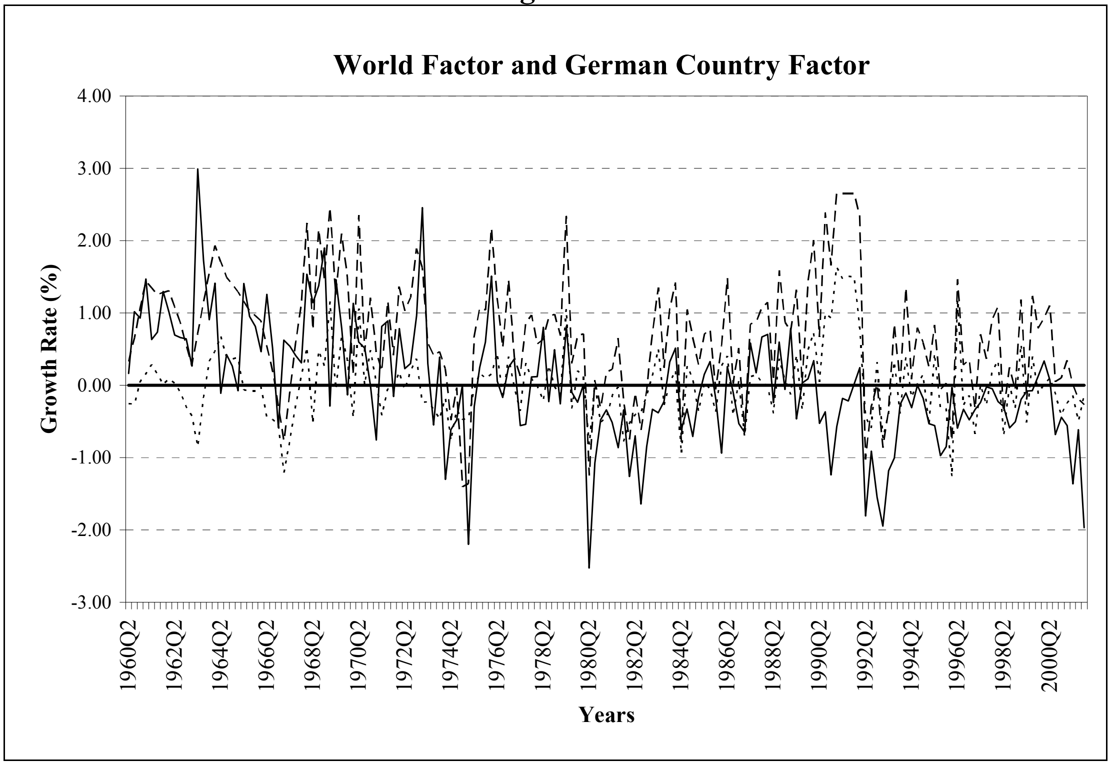
Notes: Solid line=G-7 factor; dotted line= 5 and 95 percent quantile bands.

Figure 1b



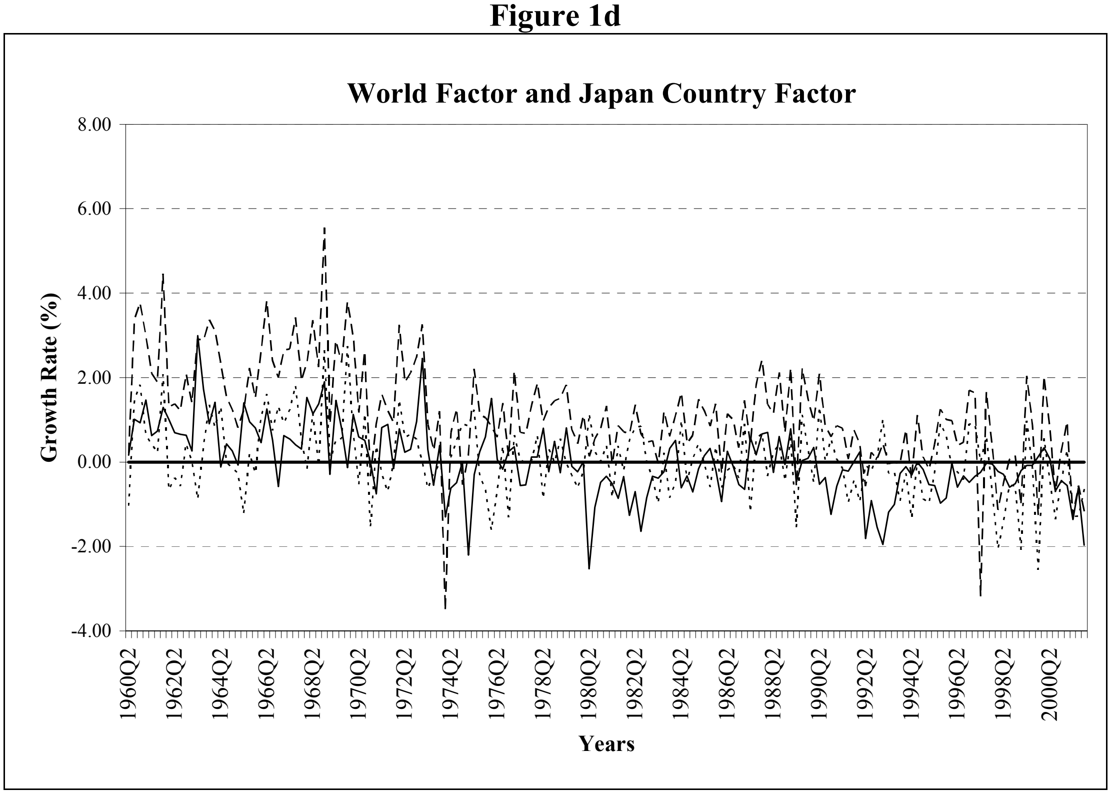
Notes: Solid line=G-7 factor; dotted line=country factor; dashed line= output

Figure 1c



Notes: Solid line=G-7 factor; dotted line=country factor; dashed line= output

Figure 1d



Notes: Solid line=G-7 factor; dotted line=country factor; dashed line= output

Figure 2a

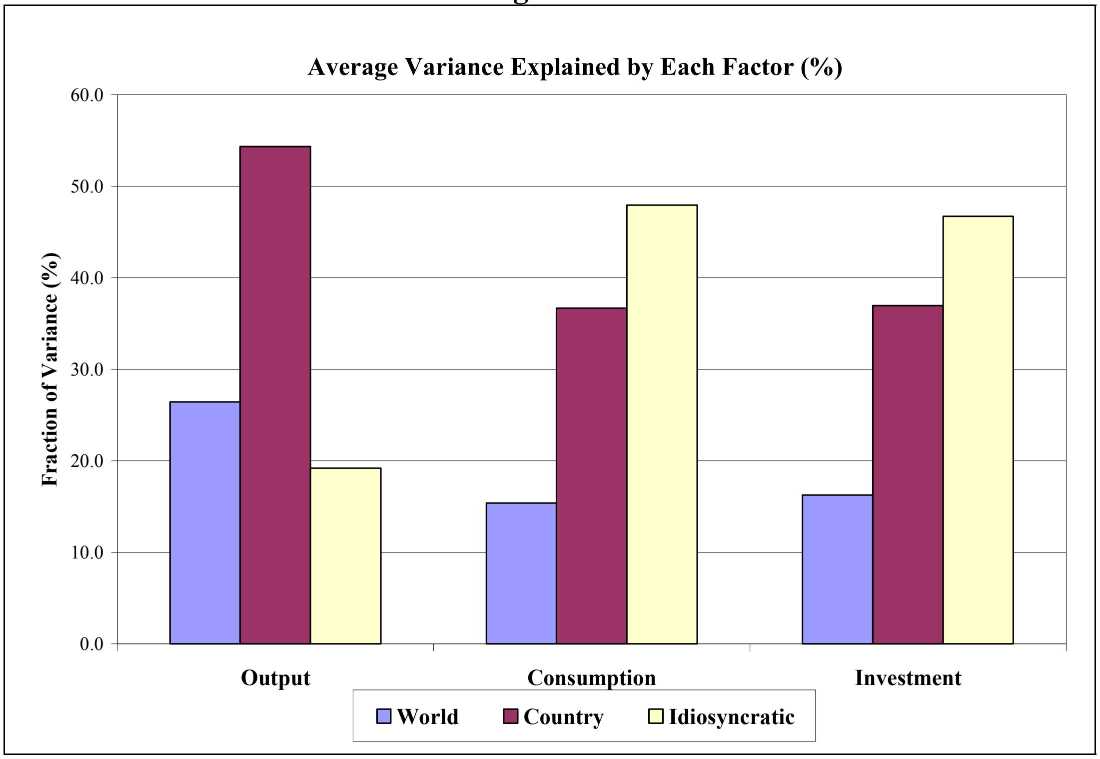


Figure 2b

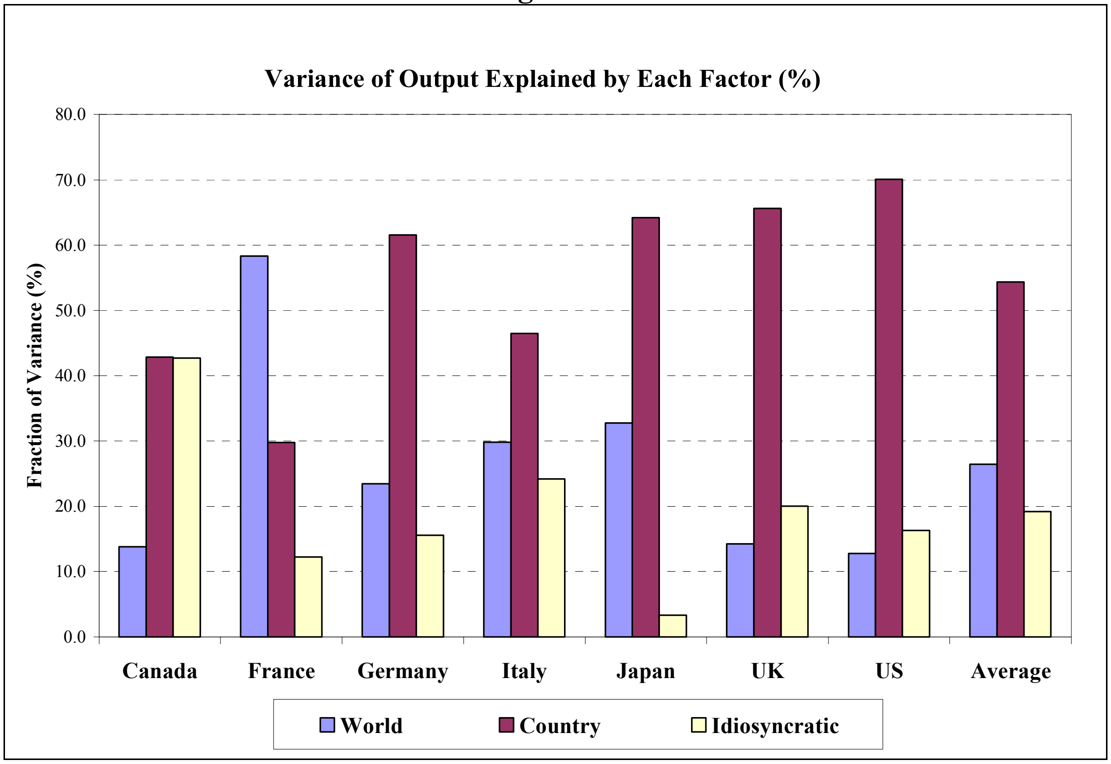


Figure 2c

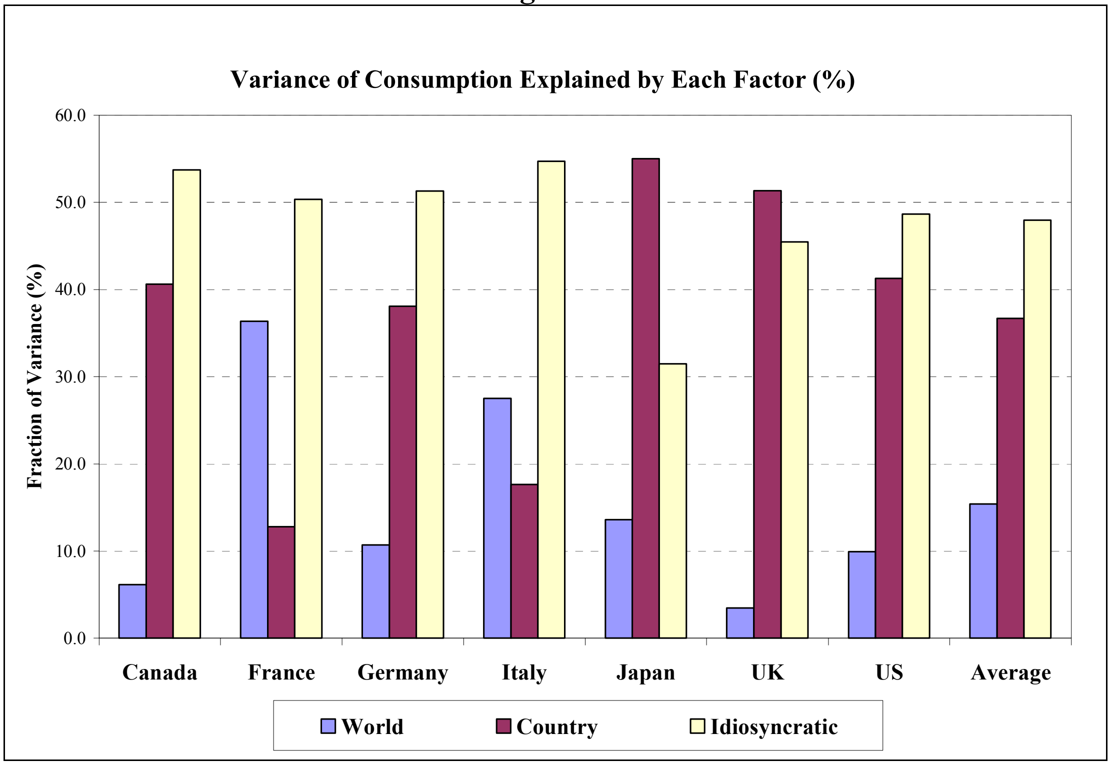


Figure 2d

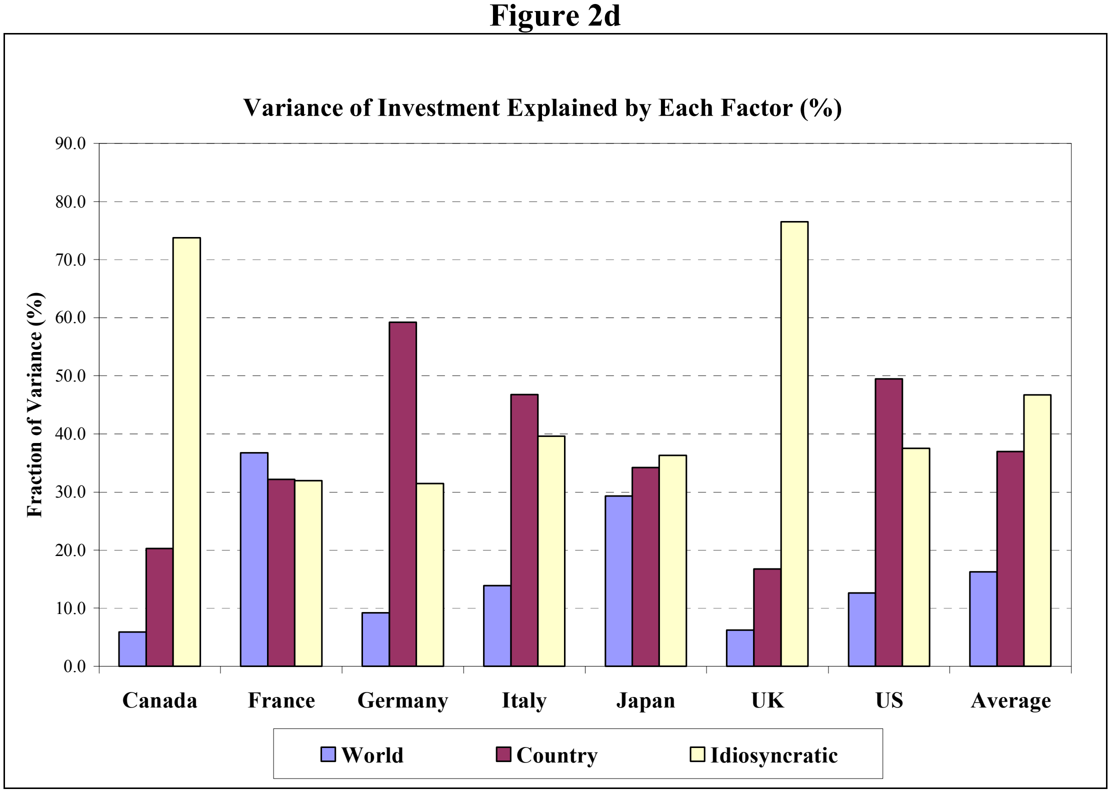


Figure 3a

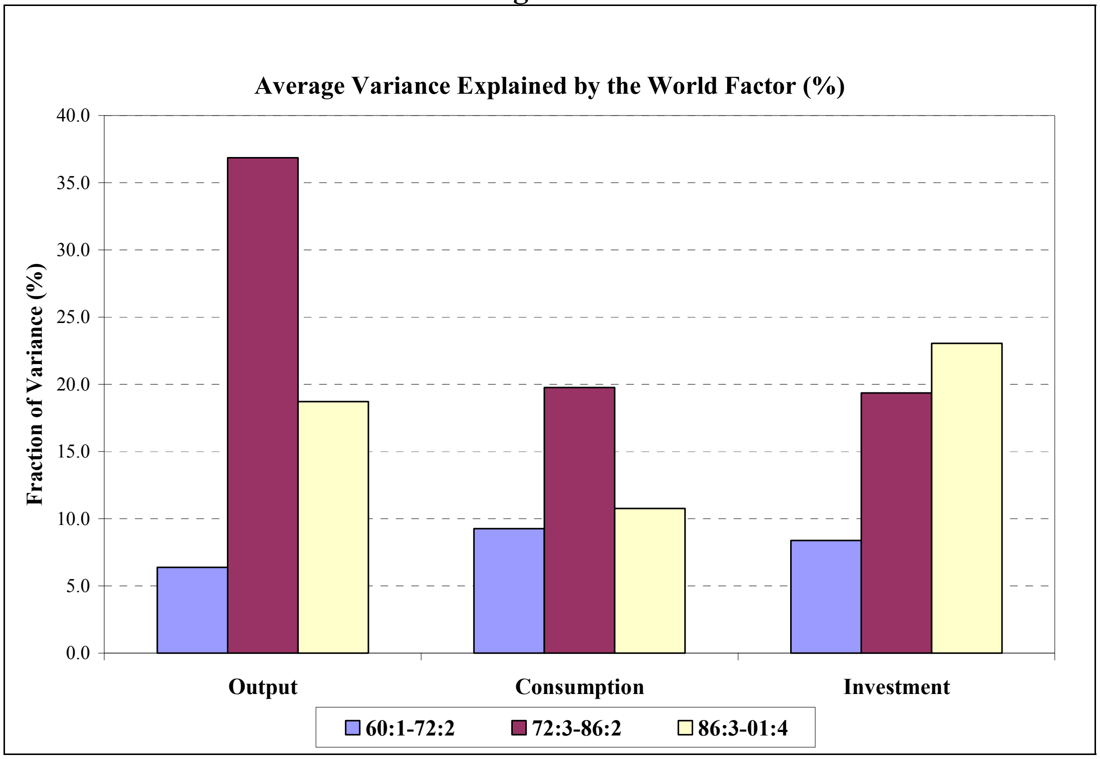


Figure 3b

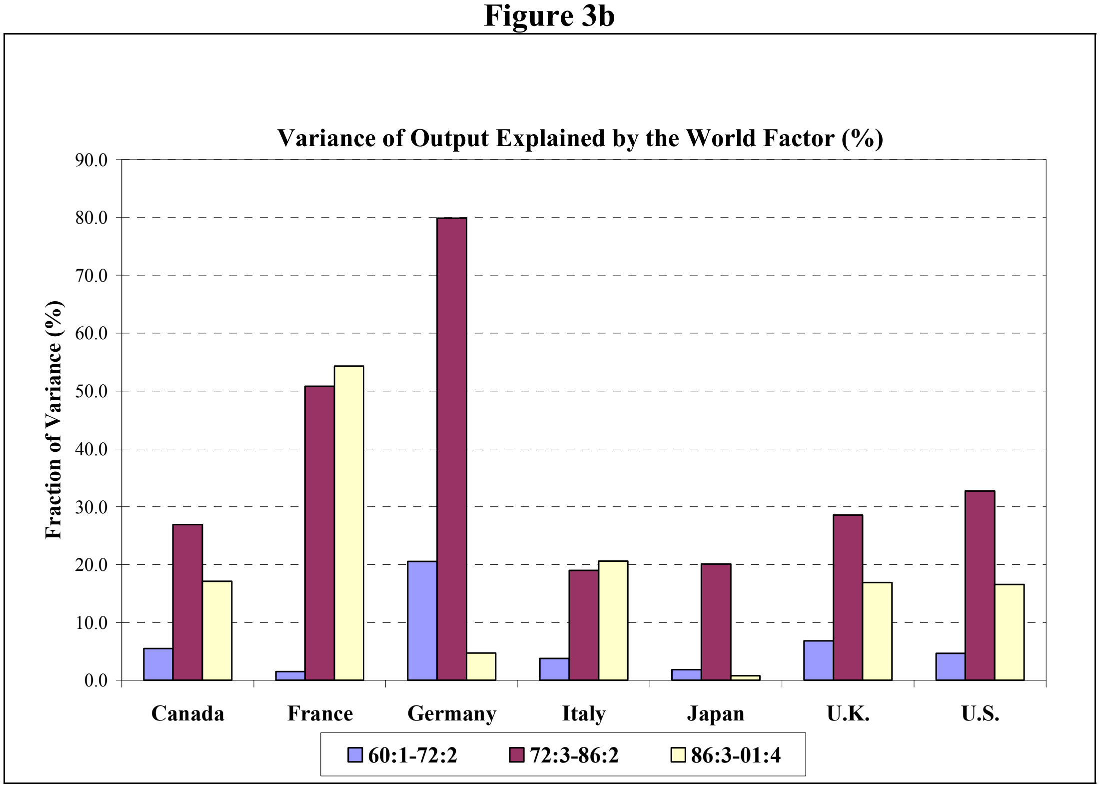


Figure 3c

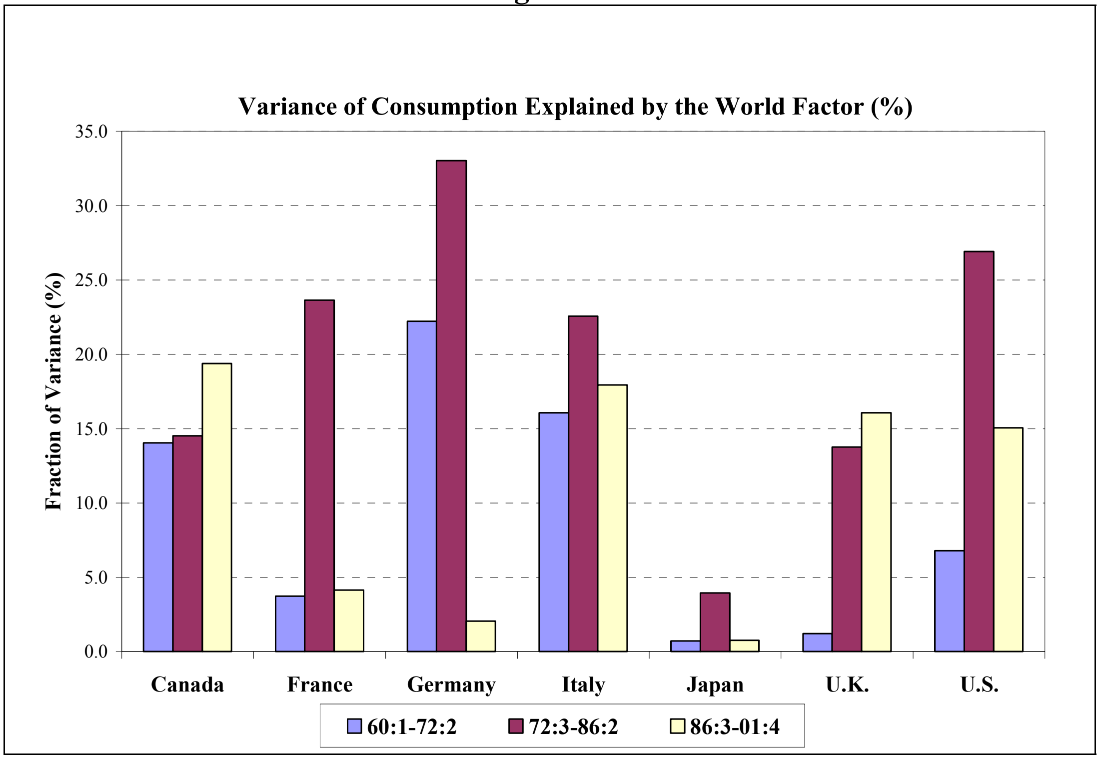


Figure 3d

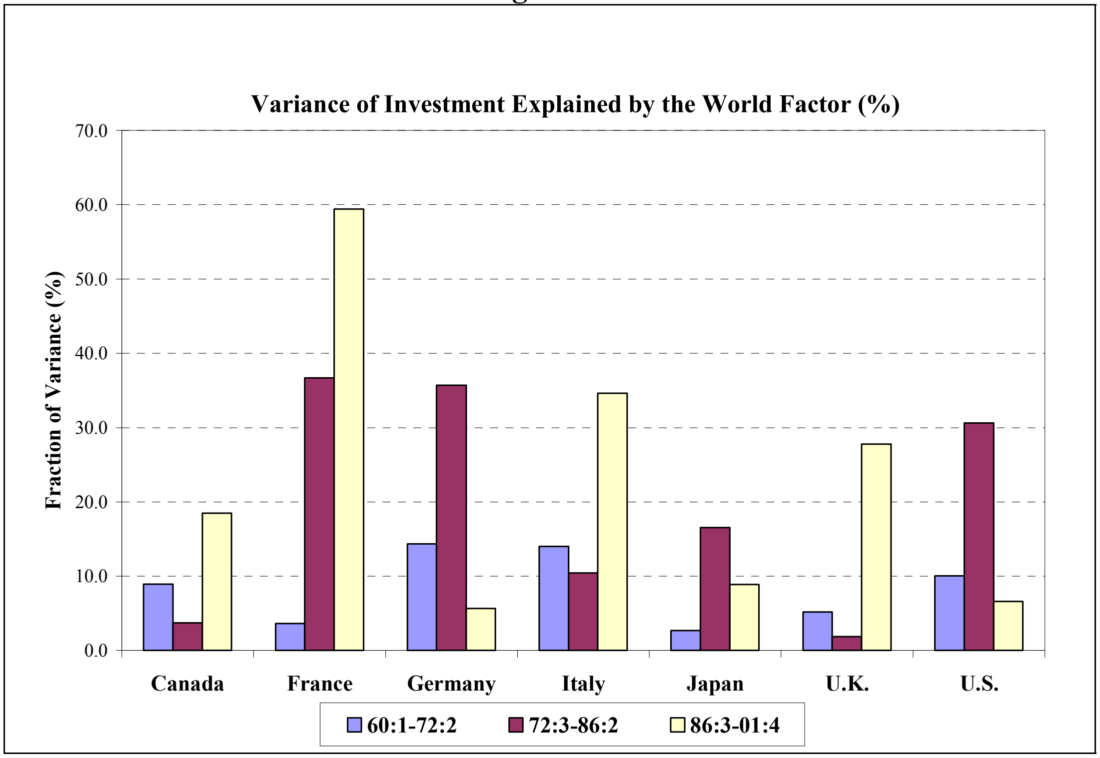
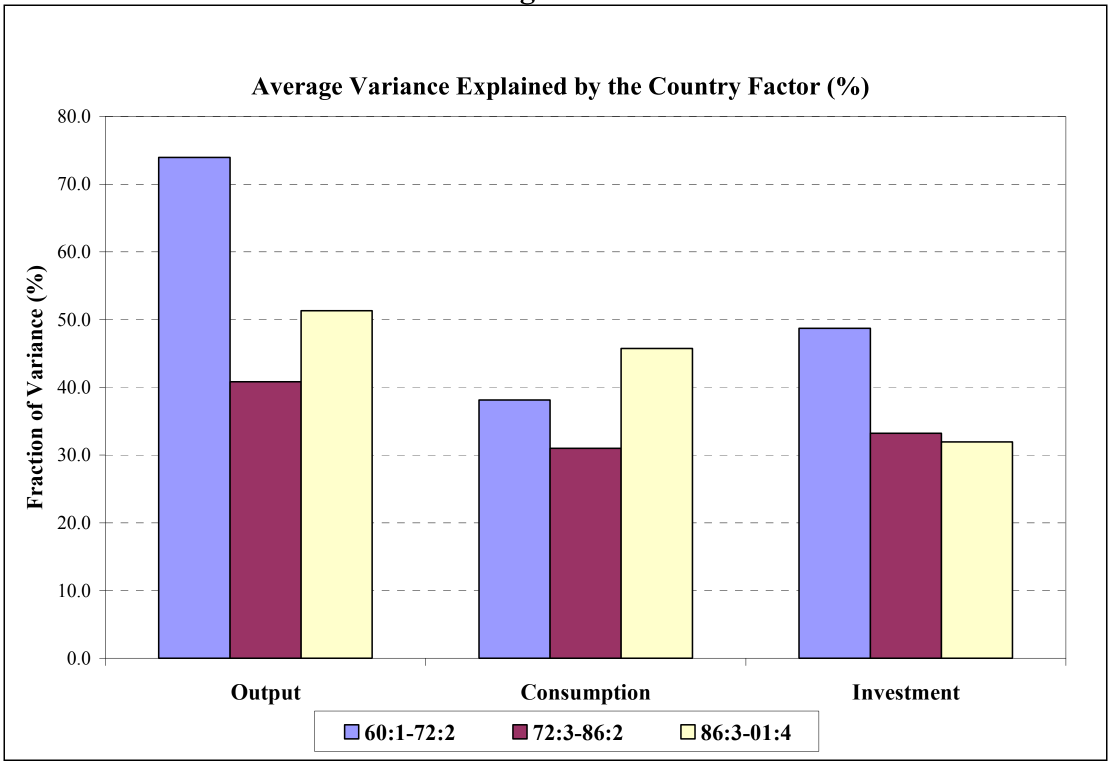


Figure 3e


Average Variance Explained by the Country Factor (%)
Fraction of Variance (%)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Output
Consumption
Investment
60:1-72:2
72:3-86:2
86:3-01:4