UNDERSTANDING THE EVOLUTION OF WORLD BUSINESS CYCLES[ϒ]

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Preliminary and Incomplete

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 and country-specific components in the main macroeconomic aggregates (output, consumption, and investment) of the G-7 countries. We then 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 then use our factor measurements in vector autoregressions to study how different types of shocks may 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.

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1. Introduction

An often repeated view in the 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 rising trade and financial linkages.[1] It is indeed the case that globalization has picked up momentum in recent decades. For example, the cumulative increase in the volume of world trade is almost three times larger than that of world output since 1960. More importantly, there has been a striking increase in the volume of international financial flows during the past two decades as these flows have jumped from less than 5 percent to approximately 20 percent of GDP of industrialized countries (see IMF (2001, 2002)).[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 comovement amongst macroeconomic aggregates across countries. For example, trade linkages generate both demand and supply-side spillovers across countries. Through these types of spillover effects, stronger 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 dominant, then the degree of comovement of cycles might be expected to decrease (see Frankel and Rose (1998)). Financial linkages could result in a higher degree of business cycle comovement 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 (see Kalemli-Ozcan, Sorensen, and Yosha (2003)).

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 of these empirical studies employ cross-country or cross-region panel regressions to understand the role of global linkages on the

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[1] A couple of recent examples on this view are the followings: "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] Lane and Milesi-Ferretti (2001, 2003) provide an extensive documentation of changes in the volume of international financial flows.

comovement properties of business cycles in advanced countries.[3] While Imbs (2003) 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 (2003) document that international trade is the most important transmission channel of business cycles. The results by Kose, Prasad, and Terrones (2003, 2004a) suggest that trade and financial linkages have a positive impact on cross-country output and consumption correlations.

Other empirical studies take a different route and directly examine the evolution of comovement properties of the main macroeconomic aggregates over time.[4] For example, Heathcote and Perri (2004) document that the correlations of output, consumption, and investment between the U.S. and an aggregate of Europe, Canada, and Japan are lower in the period 1986-2000 than in 1972-1985. Helbling and Bayoumi (2003) find that while the correlations of output between the United States and other G-7 countries went down over the period of 1973-2001, most cross-country correlations across the other G-7 economies remained quite stable during this period. Results by Doyle and Faust (2003) indicate that there is no significant change in the correlations between the growth rate of output in the United States and in other G-7 countries over time.[5]

Some other researchers employ recently developed econometric methods for treating factor models to study the degree of business cycle comovement. Kose, Otrok, and Whiteman (2003) employ a Bayesian dynamic factor model and use the annual data of sixty developed and developing countries covering the period 1960-1992. They find that while there is a significant common component driving business cycles in both developed and developing countries, the common component plays a much more important role in explaining business cycles in developed economies than it does in developing countries. Gregory, Head, and Raynauld (1997) use Kalman filtering techniques to estimate a dynamic

[3] Frankel and Rose (1998), Clark and van Wincoop (2001), and Calderon, Chong, and Stein (2002) find that, among industrialized countries, pairs of countries that trade more with each other exhibit a higher degree of business cycle comovement. Canova and Dellas (1993) consider the transmission of business cycles via international trade using time series data. Forbes and Chinn (2003) find that trade linkages are more important than financial linkages in transmitting shocks from large economies to world financial markets. Brooks and Del Negro (2003) documents that international stock market comovement has increased for firms, which are more diversified across countries, over time.

[4] 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 Stock and Watson (2002) and Kose, Prasad, and Terrones (2004b) for a detailed analysis about recent research on this issue.

[5] Backus and Kehoe (1992) and Bergman, Bordo, and Jonung (1998) examine the historical evolution of business cycle characteristics using long annual data series.

factor model and identify the common fluctuations across macroeconomic aggregates in the G-7 countries for the period 1970-1993.[6]

This paper examines the *changes* in the nature of G-7 business cycles over time by employing a Bayesian dynamic latent factor model and estimates common components in the main macroeconomic aggregates (output, consumption, and investment) 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. Our objective is to address the following questions: First, has the common factor become 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? Third, do changes in the degree of comovement of business cycles seem to be associated with specific shocks?

Our study extends the empirical research program on international business cycles along several dimensions. First, we consider the roles of G-7 and country-specific factors which capture the changes in G-7 and national business cycles. Since our dynamic factor model enables us to simultaneously capture the dynamic comovement in output, consumption, and investment series of the G-7 economies, we are able to study the relationship between the G-7 and country-specific factors and fluctuations in different macroeconomic variables. Specifically, we calculate variance decompositions that find the fraction of variance of each macroeconomic aggregate that is attributable to the G-7 factor, the country factor or the idiosyncratic component.

Second, we provide a systematic examination of the evolution of G-7 business cycles over three 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

[6] Monfort, Renne, Ruffer, and Vitale (2003) also employ similar 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 comovement over the past three decades. 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. They find evidence for a world business cycle and for a European business cycle.

demarcation is essential for differentiating the impact of common shocks from that of globalization on the degree of comovement of business cycles.

Increased integration could also affect the dynamics of comovement by changing the nature and frequency of shocks. Considering the important role played by macroeconomic shocks and the dynamic interactions between the global linkages and shocks, our third 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 productivity, 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 and productivity shocks) and our measures of common economic activity.

We describe the methodology used to estimate dynamic factors in section 2. Section 3 presents the results of our analysis for the full sample period. In section 4, we present the results for the sub-periods. Section 5 first briefly explains the estimation of vector autoregressions (VARs) with dynamic factors and then reports the results. 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 that paper. Dynamic factor models are the dynamic counterparts to s*tatic* unobserved factor models that are common in psychology and other social sciences. A static factor model provides a description of the variance-covariance matrix of a set of random variables, while a dynamic factor model provides a description of the spectral density matrix of a set of time series. Thus the dynamic factor(s) describe contemporaneous and temporal covariation among the variables.

To fix these ideas, , suppose x is a vector of Q random variables and Σ is the associated covariance matrix. Then x is said to have factor structure if Σ can be written in the form

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

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,

$$x = af + u$$

where f is a $K \times 1$ vector of factors, a is the $Q \times K$ vector of "factor loadings", and u is the 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 rows. 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 elements of x.

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) $$y_{i,t} = a_i + b_i^{G-7} f_t^{G-7} + b_i^{country} f_{i,t}^{country} + \varepsilon_{i,t} \qquad E\varepsilon_{i,t}\varepsilon_{j,t-s} = 0 \text{ for } i \neq j,$$

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

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 factors; finally, we complete one step of the Markov chain by sampling each country factor conditioning on the other country factors and the G-7 factor. This sequential sampling of the full set of conditional distributions is known as "Gibbs sampling." (See Chib and Greenberg, 1996, Geweke, 1996, 1997.)[7] 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

[7] 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.

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 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 (1960:1-2001:4)

In this section, we present our estimation results for the full sample period 1960:1-2001:4. 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 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.

How do the G-7 and country specific factors interact with each other and with domestic macroeconomic aggregates? Figures 1b, 1c, and 1d 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 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 shows that several of the peaks and troughs of the U.S. country factor coincide with the NBER reference cycle dates[8]: 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.

While 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), there are some notable differences between the two factors in almost every decade. For example, 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 captures the prolonged expansionary period, whereas there are at least a couple of downturns in the G-7 factor.

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. 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 were 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. While the country factor is able to capture this period of high growth, the G-7 factor does not show strong comovement with Japanese output during this period. Japan was very much influenced by the OPEC recession in the 1970s due to Japan's strong dependence on imported oil. Japan and the G-7 component move closely in the first half of the 1980s, 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.

These findings indicate that common and country-specific factors play different roles at different points in time in different countries. In some episodes, the country factor is more strongly

[8] 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. For these dates, see NBER web page. All other reference business cycle dates are taken from IMF (2002).

reflective of domestic economic activity, while in others the domestic growth reflects the fluctuations 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.[9] 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:

$$\text{(6)} \qquad \operatorname{var}(y_{i,t}) = (b_i^{G-7})^2 \operatorname{var}(f_t^{G-7}) + (b_i^{country})^2 \operatorname{var}(f_{i,t}^{country}) + \operatorname{var}(\varepsilon_{i,t}) \quad .$$

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

$$\frac{(b_i^{G-7})^2 \operatorname{var}(f_t^{G-7})}{\operatorname{var}(y_{i,t})} \quad .$$

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 three important results: First, the G-7 factor is able to explain a sizeable fraction of volatility of all three aggregates. 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. Second, while most of the variation in output is

[9] For space considerations, we do not report the factor loadings. These results are available from the authors upon request.

due to the country factor, idiosyncratic factors on average seem to be playing a more important role than the other two factors in driving the dynamics of fluctuations in consumption and investment.

Third, the country factor accounts for a larger share of consumption variation than it does for output in all countries except France and Italy. 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.[10]

Another important observation is that the idiosyncratic factor on average explains close to 50 percent of investment variation. 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.[11]

In the previous subsection, we learned that the importance of the G-7 and country factors vary over time in explaining time series pattern of fluctuations in output. This subsection 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. This sub-period is characterized by the steady nature of growth and stable dynamics of business cycles.[12] The second, 1972:3-86:2,

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[10] Backus, Kehoe, and Kydland (1995) refer to apparent inconsistency between the theory and the data as "the quantity anomaly."

[11] Christodoulakis, Dimelis, and Kollintzas (1995) use the data of 12 EU countries and report that roughly 80 percent of cross-country investment correlations are lower than those of output.

[12] Interestingly, there was a discussion about the obsolescence of business cycle in the late 1960s, which was, in some aspects, quite similar to the one in the late 1990s (see Bronfenbrenner (1969)).

witnessed a set of common shocks associated with sharp fluctuations in the price of oil and contractionary monetary policy in major industrial economies. Of course, the first and second periods are different because of the difference in exchange rate regime. 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.[13] 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.

What is the difference between the common shock period (2nd period) and the period of globalization (3rd period)? 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 the 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 (see Heathcoat and Perri (2002)). During this period, there has also been a substantial increase in the volume of international trade. Second, the globalization period coincides with a structural decline in the volatility of U.S. output, as documented by McConnell 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 (2003)).[14] Third, the period of common shocks witnessed a set of common shocks associated with sharp fluctuations in the price of oil and a set of contractionary monetary policies in the major industrial economies that have not characterized the most recent period.

We examine the properties of G-7 and national business cycles in each sub-sample period by estimating factor models for each sub-period. Figure 2 presents the subperiod factor medians together with those estimated using the full sample (i.e., not allowing the three periods to be different.) The two estimates (full sample and sub-period sample) correspond most closely during the common shock

[13] Gerlach (1988) concludes that the exchange rate regime has an impact on the stylized business cycle facts.
[14] Smith and Summer (2002) and Djyk, Osborn, and Sensier (2002) provide more detailed discussions of the decline in business cycle volatility in industrialized countries.

period. This is not too surprising because of the volatility of the period. What the figure reveals is that by not breaking the sample into the sub-periods, the full sample results make the Bretton Woods period look better than it was, and masks the positive nature of the globalization period.

In addition to the factor estimates, 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-3d.

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 in the first period. Not surprisingly, the G-7 factor accounts for a smaller fraction of the 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 some 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 (see Heathcoat and Perri (2002)) and Helbling and Bayoumi (2002)). For investment, though, the G-7 factor becomes more important over time.

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 while there is a marginal increase in the average variance of consumption explained by the G-7 factor in the globalization period relative to the first period, the average 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 except 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 Canada, the U.S., and the U.K. For all countries except Germany and Japan, the G-7 factor is more important in the globalization period than in the first period. For France and Italy, the relative importance of the G-7 factor is even greater in the globalization period.

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 early 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.

To gain insight into the behavior of business cycles in Germany and Japan during the period of globalization, note that the Japanese economy suffered a prolonged recession that was aggravated by a sharp fall in asset prices and a severe banking crisis, while 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 slow 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. To assess the impact of increased financial linkages on the degree of comovement in consumption fluctuations over time, 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. 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.

Figure 3d displays the findings concerning the dynamics of investment. 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.

We also find that the country factor, on average, becomes less important in explaining the variance of output and investment in the globalization period relative to the first period. However, the country factor is more important in explaining the volatility of consumption in the globalization period relative to the earlier periods.

5. Sources of Changes in the G-7 Business Cycles *[very preliminary and incomplete]*

In the 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 suggested how increased financial and trade linkages could play a role in explaining these developments. Of course, other more easily identifiable phenomena may also help explain these developments. To address this issue, 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 developed the factor-augmented VAR (FAVAR) to study the affects of monetary policy in a closed economy framework. Their work is motivated by the curse of dimensionality associated with standard VAR models: the number of parameters grows with the *square* of the dimension of the vector of the VAR. Our motivation is similar; with 7 countries, 3 measures of economic activity and 4 measures of potential sources of economic activity (monetary policy, fiscal policy, technology, 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 price and liquidity puzzles traditionally found in studies using monetary VARs.

Here we are using the FAVAR not to bring additional information into the system to identify the effects of a monetary policy shock as in Bernanke et. al, but to investigate the effects of a monetary shock (or oil shock, etc.) on world economic activity. That is, we are interested in the response of the factors to a shock to policy variables. An issue we face is the choice of policy or source variables to include in the VAR. One approach would be to extract common factors from the source variables in each country and interpret the common factor as common world policy. For example, one could extract a common interest rate factor from overnight interest rates in the G-7 and use this factor in the VAR. Since there is some difficulty in interpreting such a factor as a common policy[15] we choose instead to use policy or source variables in one country in the VAR. In particular, we choose the United States because of the major role it plays in the world economy. Hence, we will study the empirical relationships between the world factor, the U.S. country factor and the U.S. federal funds rate, oil prices in the U.S. (which are essentially common across the world), and the U.S. government spending. The questions we can address in this model are: (1) Do U.S. monetary shocks Granger-cause global volatility and comovement? (2) Are U.S. fiscal shocks important in driving the the global economy? (3) Are oil price shocks important relative to monetary and fiscal shocks? We then ask the same question in each of our three sub-periods. While our identification scheme cannot provide the final answer on the source of global comovement, it adds valuable new evidence on the role of shocks originating in the dominant economy in the world.

5.1. The Model

Do to the short time series length of our subsamples we focus the VAR analysis on a sequence of bi-variate VARs. Let F_t be a vector containing either the G-7 or country factor, and S_t be a vector with either the U.S. federal funds rate, government spending, oil prices, and technology. Each bi-variate VAR is then :

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

5.2. Granger Causality Tests

Granger-causality tests allow us to begin to examine the interrelationships between our estimated factors and the underlying source variables. Specifically, these tests enable us to determine which source variables help predict the factors, and whether the factors help predict the "source" variables, in which case the latter are perhaps not so much source as consequence. Table 3a contains the results for the full sample period. The tests reveal that the US does in fact appear to be a driving force in the world economy. The US country factor Granger causes the world factor, and US policy

[15] An additional issue is the fact that some countries differ in their choice of policy instrument.

variables (the Fed Funds rate and government spending) also Granger cause the world factor.[16] In none of these cases do we find reverse causality. It also appears that US technology as measured by the Solow residual Granger causes the world factor. Of course, this technology could be common to the world. Not surprisingly, oil prices also have significant predictive power for the world factor. These results are consistent with the notion that the U.S., either through policy or technology, is a significant force in the global economy. We now turn to analyze how these relationships may have evolved over time.

In Table 3b we repeat the Granger tests for the 1960:2-1972:2 subsample. Unlike in the full sample the US no longer appears to drive the world economy. The US factor does not Granger cause the world factor nor do the US monetary and fiscal policy variables do so. There is weak evidence that the US Solow residual Granger causes the world economy. We conclude that in this period the causal (i.e., predictive) relationship from the US to the world is relatively weak.

Next we turn to the common shock period, 1972:3-1986:2. In Table 3c we see that the Granger causal relationships are much stronger. While there is no causal relationship between U.S. economic activity (as measured by the U.S. country factor) and the world factor, there are strong relationships between the U.S. policy variables and the world factor. Both U.S monetary and fiscal variables Granger cause the world factor. Additionally, there is a strong casual relationship between both oil prices and the U.S. Solow residual and the world factor. In the case of oil prices, feedback goes both ways because the world factor helps predict oil prices as well. We conclude that the strong comovement in this period is due to common shocks, both those that have originated in the U.S. (fed funds and government spending) and the global oil shocks.

In the globalization period (Table 3d), some link between U.S policy variables and the world economy remains—the Fed Funds rate still Granger causes the world factor—as along with a link between World economic activity and the US factor (the World factor Granger causes the US factor. Yet the feedback between the funds rate and the world factor is now two-way. Moreover, the predictive power in technology flows from the world to the US: the world factor seems to help predict the U.S. Solow residual, but not *vice versa*. We interpret these results as indicating that while the U.S.

[16] When we refer to with regressions using the world or country factor we are using the median of the estimated factors. Since the quantiles of the factor estimate are tight and the correlation between the median quantile and say the 5% or 95% quantiles are very close to 1, uncertainty in the factor estimates should have minimal impact on the results.

can still 'export' its policy shocks to the rest of the world, there are few additional linkages that 'export' U.S. economic activity to the rest of the world. In fact, there are additional signs that world events help predict economic activity in the U.S. The nature of this linkage is likely increased trade integration.

6. Summary and Conclusion

We study the changes in the nature of G-7 business cycles over time by estimating common dynamic components in the 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 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 estimated dynamic factors with variables thought to have a causal or predictive relationship with the factors in a series of bi-variate vector autoregressions. This 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 findings indicate that the period labeled the 'common shock' period is indeed driven by common shocks. These shocks are both policy-based shocks that originate in the U.S. and the global oil shocks. In the globalization period, the world seems to evolved to a stage where the U.S. follows the lead of the world economy rather than *vice versa*. We interpret this result as suggesting the value of further work investigating the nature of trade linkages.

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Table 1: Variance Decompositions: Factors (Full Sample, in percent)

	Full Sample	G-7			Country			Idiosyncratic		
	1960:1-2001:4	5%	Median	95%	5%	Median	95%	5%	Median	95%
Canada	Output	12.01	13.80	15.60	38.97	42.87	46.84	38.31	42.67	46.76
	Consumption	4.89	6.12	6.91	37.26	40.60	43.74	49.52	53.71	57.02
	Investment	4.98	5.87	6.53	18.49	20.27	22.31	71.44	73.78	75.78
France	Output	53.51	58.33	62.61	26.38	29.77	33.34	10.61	12.24	14.16
	Consumption	31.84	36.33	39.66	9.48	12.77	17.44	49.16	50.36	51.57
	Investment	34.36	36.73	39.07	29.06	32.18	35.16	29.76	31.92	33.76
Germany	Output	22.01	23.44	24.86	58.56	61.53	63.94	13.31	15.58	17.72
	Consumption	8.79	10.68	11.83	36.06	38.07	40.34	49.95	51.30	52.84
	Investment	7.78	9.19	10.43	56.72	59.20	62.38	29.56	31.47	33.48
Italy	Output	27.34	29.83	31.66	43.98	46.47	49.10	21.99	24.20	26.61
	Consumption	25.69	27.50	29.70	16.06	17.63	20.36	53.28	54.73	56.31
	Investment	12.66	13.87	15.25	44.18	46.73	49.14	37.44	39.58	41.64
Japan	Output	30.68	32.77	34.70	61.84	64.20	66.43	2.29	3.33	4.48
	Consumption	11.49	13.60	15.36	52.72	55.00	57.68	30.46	31.48	32.71
	Investment	26.64	29.33	32.64	31.11	34.20	36.42	35.29	36.30	37.23
U.K.	Output	13.04	14.25	15.41	62.99	65.60	68.26	16.46	20.02	23.03
	Consumption	2.87	3.47	4.14	48.89	51.35	53.74	42.44	45.44	47.35
	Investment	5.53	6.22	7.04	15.24	16.75	18.14	74.88	76.53	77.94
U.S.	Output	11.19	12.80	14.66	67.09	70.07	73.34	13.70	16.33	19.01
	Consumption	8.84	9.93	11.23	38.78	41.27	43.14	46.95	48.67	50.51
	Investment	11.49	12.62	14.06	47.63	49.48	51.48	35.91	37.48	39.03
AVERAGE	Output	24.25	26.46	28.50	51.40	54.36	57.32	16.67	19.20	21.68
	Consumption	13.49	15.38	16.97	34.18	36.67	39.49	45.97	47.96	49.76
	Investment	14.78	16.26	17.86	34.63	36.97	39.29	44.90	46.72	48.41

Notes: In each cell, the share of the variable's variance explained by a particular factor is reported. Median refers to median of posterior quantile, 5% and 95% refer to corresponding quintiles of variance shares.

Table 2a: Variance Decompositions: Factors (Period 1, in percent)

	Period 1	G-7			Country			Idiosyncratic		
	1960:1-1972:2	**5%**	**Median**	**95%**	**5%**	**Median**	**95%**	**5%**	**Median**	**95%**
Canada	**Output**	3.60	5.47	8.13	36.41	44.10	53.38	39.94	48.70	56.22
	Consumption	9.38	14.04	18.29	14.22	19.73	25.58	57.61	62.87	68.46
	Investment	6.40	8.91	11.94	16.84	22.30	28.48	61.59	67.58	72.44
France	**Output**	0.69	1.51	2.94	70.57	74.76	78.11	18.87	22.30	25.77
	Consumption	1.82	3.73	6.29	48.07	51.67	55.59	39.01	42.69	46.30
	Investment	1.86	3.63	6.26	56.44	61.13	65.68	29.56	33.78	37.66
Germany	**Output**	13.24	20.55	27.61	55.81	64.47	72.44	12.12	15.33	18.41
	Consumption	13.04	22.23	29.06	19.92	26.78	34.31	47.85	50.69	53.52
	Investment	8.54	14.33	19.71	53.56	60.16	65.44	22.88	26.04	29.13
Italy	**Output**	1.64	3.76	6.41	79.96	83.73	87.15	8.34	10.94	13.58
	Consumption	7.07	16.07	23.89	26.31	31.92	36.81	48.49	52.00	54.90
	Investment	9.14	14.00	19.04	61.04	66.47	70.83	17.30	20.02	22.51
Japan	**Output**	0.86	1.86	3.75	88.56	91.10	94.22	3.32	4.95	7.33
	Consumption	0.33	0.71	1.51	48.38	49.97	52.16	46.48	48.51	50.23
	Investment	1.12	2.66	4.68	51.25	53.91	55.90	40.87	42.50	44.01
U.K.	**Output**	4.15	6.85	10.17	80.21	83.98	87.25	3.63	6.74	10.69
	Consumption	0.45	1.21	2.44	36.38	38.72	40.97	57.74	59.65	60.99
	Investment	2.98	5.16	9.10	44.21	47.57	50.86	43.81	46.16	47.86
U.S.	**Output**	2.59	4.63	6.95	69.06	75.58	81.86	12.65	18.50	23.92
	Consumption	3.14	6.78	11.55	44.21	48.19	53.19	38.32	42.85	46.70
	Investment	6.76	10.04	14.41	26.24	29.47	32.96	56.41	59.67	62.37
AVERAGE	**Output**	3.82	6.38	9.42	68.65	73.96	79.20	14.13	18.21	22.27
	Consumption	5.03	9.25	13.29	33.93	38.14	42.66	47.93	51.32	54.44
	Investment	5.26	8.39	12.16	44.23	48.71	52.88	38.92	42.25	45.14

Notes: In each cell, the share of the variable's variance explained by a particular factor is reported. Median refers to median of posterior quantile, 5% and 95% refer to corresponding quintiles of variance shares.

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

	Period 2	G-7			Country			Idiosyncratic		
	1972:3-1986:2	5%	Median	95%	5%	Median	95%	5%	Median	95%
Canada	Output	24.89	26.90	29.01	22.80	28.00	34.16	38.67	45.07	50.84
	Consumption	13.17	14.50	16.03	27.87	34.67	42.09	43.50	50.98	57.63
	Investment	2.98	3.69	4.59	23.54	28.40	34.31	61.94	67.48	72.38
France	Output	47.77	50.80	53.94	25.17	31.53	36.24	13.22	17.67	22.40
	Consumption	21.39	23.63	26.13	3.73	6.38	9.30	66.43	68.53	70.58
	Investment	34.02	36.67	39.76	21.79	25.97	31.16	32.61	37.42	40.83
Germany	Output	75.99	79.89	83.72	4.48	6.46	8.93	9.99	12.38	14.89
	Consumption	29.85	33.02	36.62	11.61	16.73	22.19	46.54	49.91	53.46
	Investment	32.68	35.69	39.34	21.42	28.25	35.79	30.94	36.22	41.20
Italy	Output	17.25	19.00	21.14	40.11	46.58	52.18	29.37	34.77	39.91
	Consumption	20.48	22.56	25.09	9.39	11.95	15.56	60.83	63.80	67.08
	Investment	8.91	10.43	11.71	37.98	45.13	51.36	37.98	44.80	51.38
Japan	Output	17.68	20.09	22.34	74.09	76.66	79.15	2.03	2.87	3.93
	Consumption	3.00	3.95	4.99	59.96	61.68	63.52	33.04	34.30	35.60
	Investment	14.67	16.53	18.15	48.81	51.09	52.94	31.67	32.62	33.43
U.K.	Output	26.37	28.60	30.93	37.54	42.64	48.26	23.38	28.53	33.13
	Consumption	12.06	13.77	15.82	49.99	56.53	62.98	22.34	29.60	36.33
	Investment	1.32	1.85	2.49	4.57	6.16	7.73	90.20	91.89	93.11
U.S.	Output	30.30	32.76	35.24	50.03	54.11	58.13	9.48	12.52	15.43
	Consumption	24.41	26.91	29.14	26.50	28.97	31.54	42.42	44.57	46.13
	Investment	28.68	30.61	32.71	44.31	47.63	50.47	19.55	21.84	23.85
AVERAGE	Output	34.32	36.86	39.48	36.32	40.85	45.29	18.02	21.97	25.79
	Consumption	17.77	19.76	21.97	27.01	30.99	35.31	45.01	48.81	52.40
	Investment	17.61	19.35	21.25	28.92	33.23	37.68	43.55	47.47	50.88

Notes: In each cell, the share of the variable's variance explained by a particular factor is reported. Median refers to median of posterior quantile, 5% and 95% refer to corresponding quintiles of variance shares.

Table 2c: Variance Decompositions: Factors (Period 3, in percent)

	Period 3	G-7			Country			Idiosyncratic		
	1986:3-2001:4	5%	Median	95%	5%	Median	95%	5%	Median	95%
Canada	Output	13.52	16.20	18.93	27.67	33.64	40.79	42.96	49.40	54.26
	Consumption	14.51	17.20	19.90	37.08	44.73	50.89	31.61	38.40	44.91
	Investment	15.91	18.27	20.59	7.64	11.00	14.64	65.78	69.60	72.50
France	Output	51.49	56.58	62.12	23.58	27.67	32.89	12.90	14.77	17.06
	Consumption	3.31	5.30	8.24	69.36	76.45	81.91	12.39	17.16	22.84
	Investment	58.26	62.47	65.88	6.78	9.22	12.38	25.24	27.60	29.79
Germany	Output	4.16	5.62	7.12	77.02	79.80	82.97	11.01	13.51	16.88
	Consumption	0.73	1.28	2.10	54.59	57.17	59.46	38.44	41.21	43.73
	Investment	4.31	5.70	7.31	62.07	65.02	67.88	26.41	29.05	31.51
Italy	Output	20.76	24.40	27.49	28.91	36.87	43.24	34.94	40.70	46.09
	Consumption	18.32	20.53	22.85	8.24	11.27	14.39	64.76	68.00	70.51
	Investment	33.99	36.91	39.67	19.22	24.20	29.22	34.97	39.35	43.28
Japan	Output	0.38	0.75	1.35	94.23	95.88	97.14	1.99	2.81	4.25
	Consumption	0.42	0.85	1.46	67.13	68.27	69.50	29.13	30.31	31.49
	Investment	7.92	9.41	11.08	32.92	35.21	36.64	53.68	55.50	57.31
U.K.	Output	13.82	16.40	18.99	32.74	40.15	47.24	36.44	43.20	50.04
	Consumption	13.33	15.47	17.79	23.21	28.40	33.88	51.34	55.93	60.59
	Investment	23.71	25.93	27.96	19.99	25.27	29.71	44.81	49.64	53.62
U.S.	Output	13.44	15.87	18.36	44.67	50.17	55.11	29.36	33.98	38.56
	Consumption	10.99	12.96	15.43	29.84	33.43	37.41	49.27	53.04	56.79
	Investment	4.53	6.00	7.52	48.86	53.57	58.52	35.49	39.97	43.76
AVERAGE	Output	16.80	19.40	22.05	46.98	52.02	57.06	24.23	28.34	32.45
	Consumption	8.80	10.51	12.54	41.35	45.67	49.63	39.56	43.44	47.27
	Investment	21.23	23.53	25.72	28.21	31.93	35.57	40.91	44.39	47.40

Notes: In each cell, the share of the variable's variance explained by a particular factor is reported. Median refers to median of posterior quantile, 5% and 95% refer to corresponding quintiles of variance shares.

Table 3a: Granger Causality 1960:2-2001:4

Does	Granger Cause	?	F-Statistic	Significance
Solow	US Factor	No	1.027	0.395
US Factor	Solow	No	1.227	0.302
US Factor	World Factor	Yes	2.021	0.094
World Factor	US Factor	Maybe	1.741	0.144
Fed Funds	World Factor	Yes	2.519	0.044
World Factor	Fed Funds	No	1.082	0.367
Solow	World Factor	Yes	5.486	0.000
World Factor	Solow	No	0.971	0.425
Oil	World Factor	Yes	2.809	0.028
World Factor	Oil	Yes	1.956	0.104
Government	World Factor	Yes	2.219	0.069
World Factor	Government	No	0.404	0.806

Table 3b: Granger Causality 1960:2-1972:2

Does	Granger Cause	?	F-Statistic	Significance
Solow	US Factor	No	1.067	0.387
US Factor	Solow	No	0.639	0.638
US Factor	World Factor	No	1.514	0.219
World Factor	US Factor	No	0.244	0.912
Fed Funds	World Factor	No	1.235	0.313
World Factor	Fed Funds	No	0.189	0.943
Solow	World Factor	Maybe	1.911	0.130
World Factor	Solow	No	0.150	0.962
Oil	World Factor	No	0.390	0.814
World Factor	Oil	No	1.799	0.150
Government	World Factor	No	0.169	0.953
World Factor	Government	No	0.125	0.973

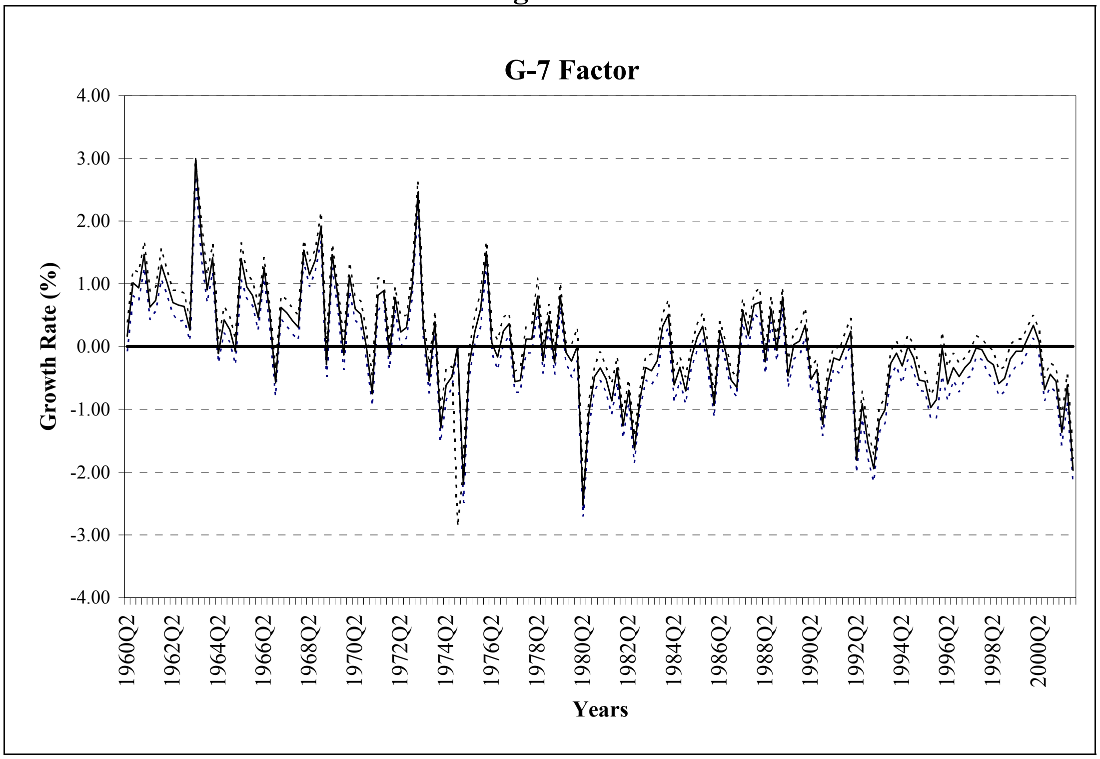
Table 3c: Granger Causality 1972:3-1986:2

Does	Granger Cause	?	F-Statistic	Significance
Solow	US Factor	No	0.471	0.757
US Factor	Solow	No	1.040	0.397
US Factor	World Factor	No	1.313	0.279
World Factor	US Factor	No	1.273	0.294
Fed Funds	World Factor	Yes	4.923	0.002
World Factor	Fed Funds	No	0.459	0.765
Solow	World Factor	Yes	2.883	0.032
World Factor	Solow	No	1.524	0.211
Oil	World Factor	Yes	2.869	0.033
World Factor	Oil	Yes	4.175	0.006
Government	World Factor	Yes	2.351	0.068
World Factor	Government	No	0.344	0.847

Table 3d: Granger Causality 1986:2-2001:4

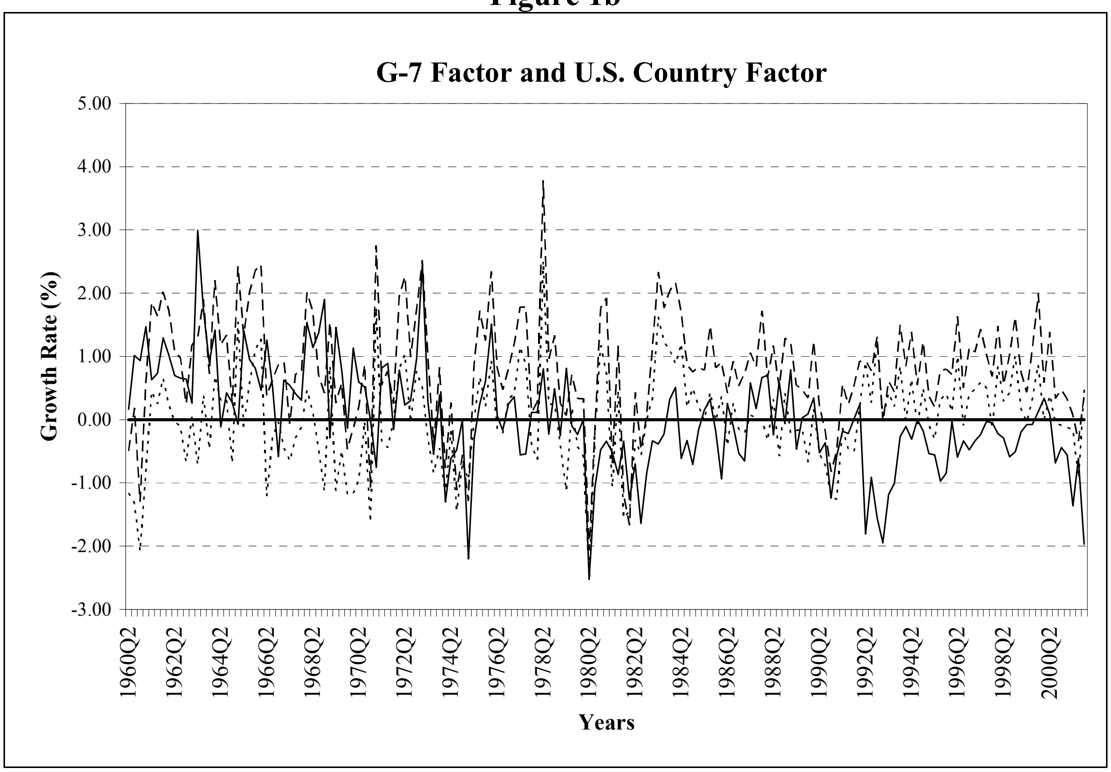
Does	Granger Cause	?	F-Statistic	Significance
Solow	US Factor	No	1.099	0.366
US Factor	Solow	No	1.320	0.275
US Factor	World Factor	No	0.022	1.000
World Factor	US Factor	Yes	2.293	0.071
Fed Funds	World Factor	Yes	2.204	0.081
World Factor	Fed Funds	Yes	2.694	0.041
Solow	World Factor	No	0.488	0.745
World Factor	Solow	Yes	2.318	0.069
Oil	World Factor	No	0.612	0.656
World Factor	Oil	No	1.061	0.385
Government	World Factor	No	0.284	0.887
World Factor	Government	No	1.324	0.273

Figure 1a



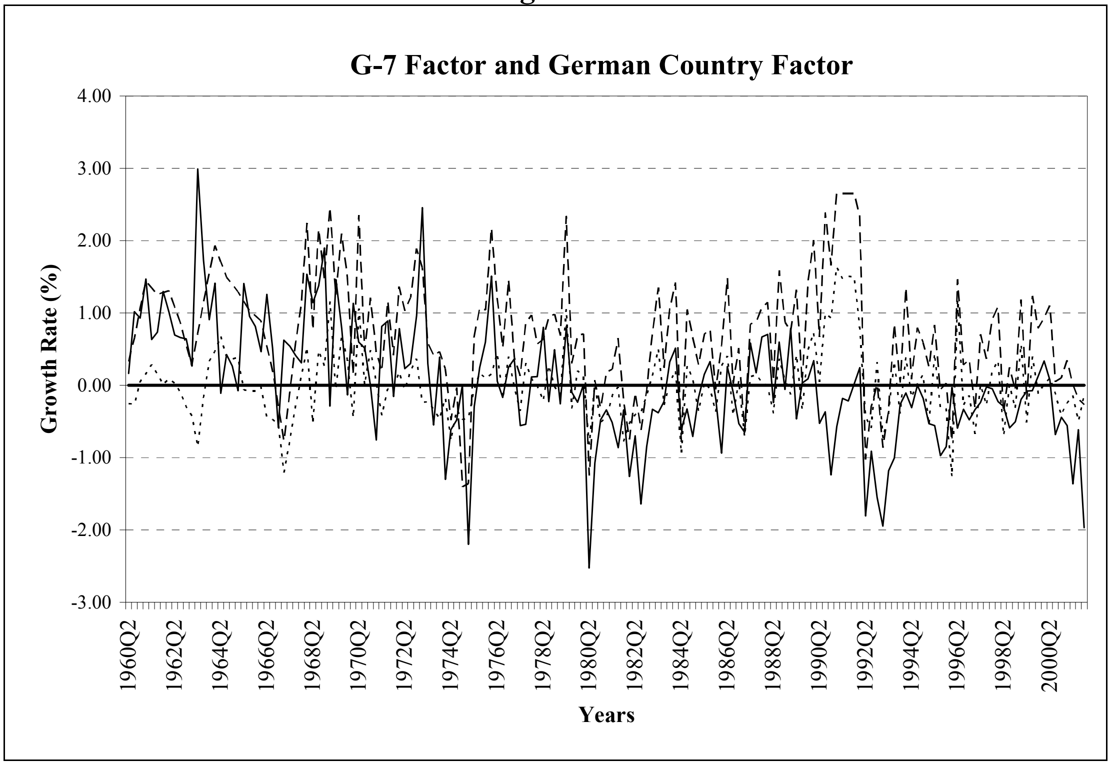
Notes: Solid line=G-7 factor; dotted line= 5 and 95 % quantile bands.

Figure 1b



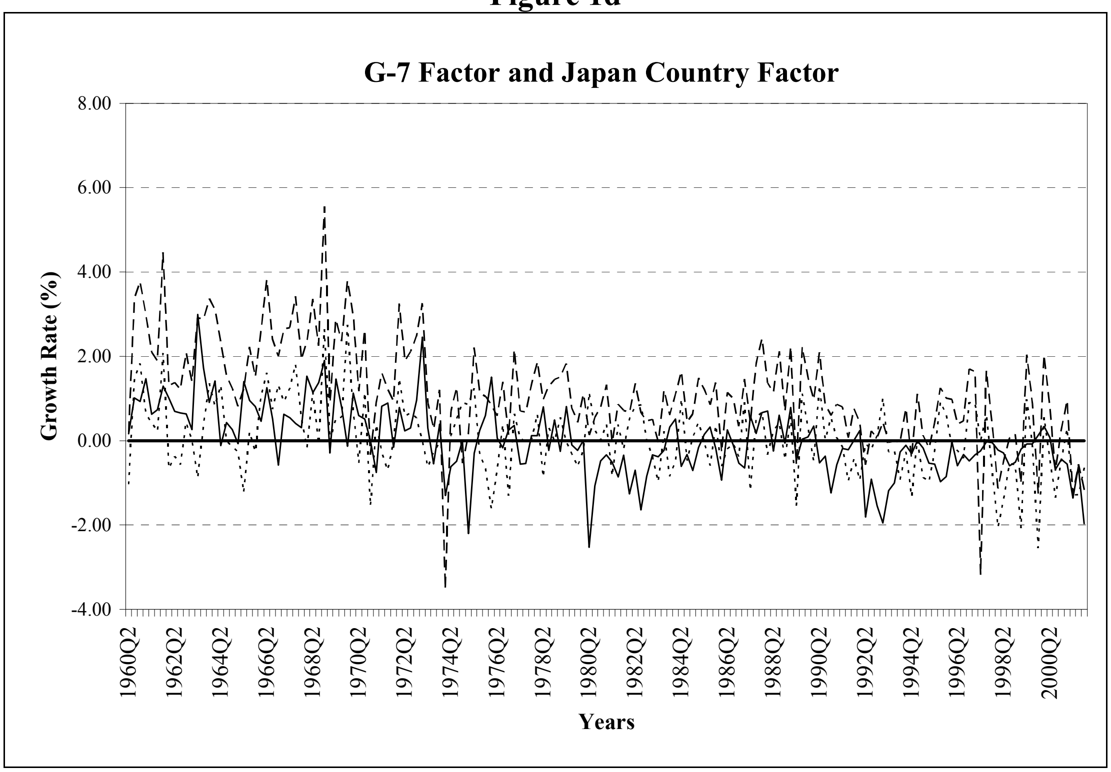
Notes: Solid line=G-7 factor; dotted line=country factor; dashed line= output

Figure 1c



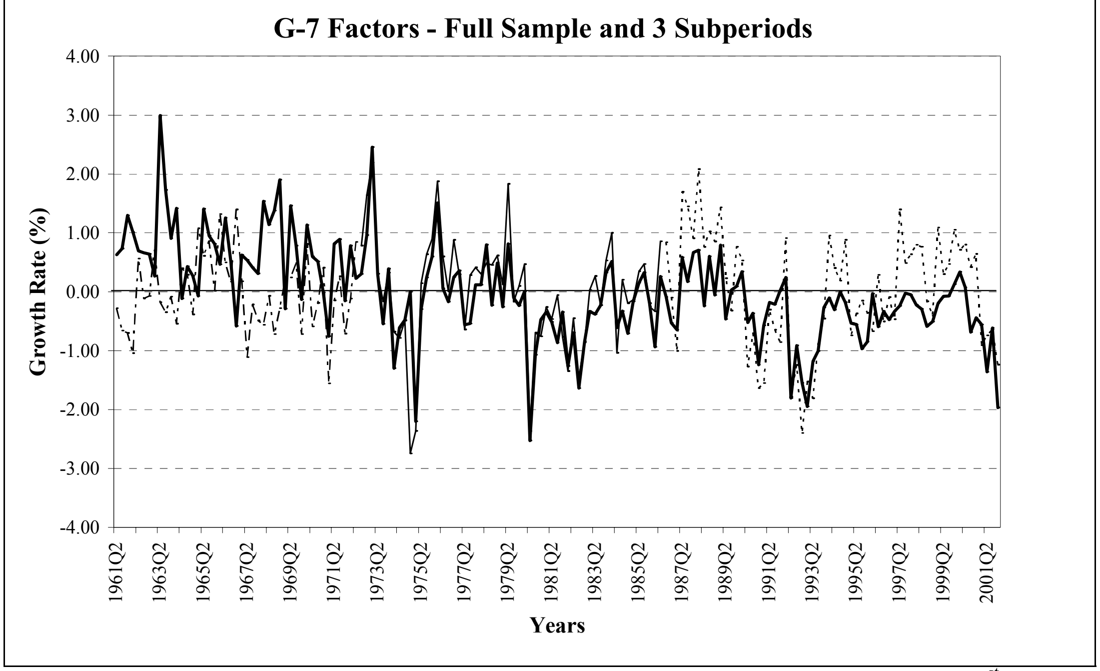
Notes: Solid line=G-7 factor; dotted line=country factor; dashed line= output

Figure 1d



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

Figure 2



Notes: Dark solid line=G-7 factor median (Full Sample); dashed line= G-7 factor median (1st Period); light solid line= G-7 factor median (2nd Period); dotted line= G-7 factor median (3rd Period).

Figure 3a

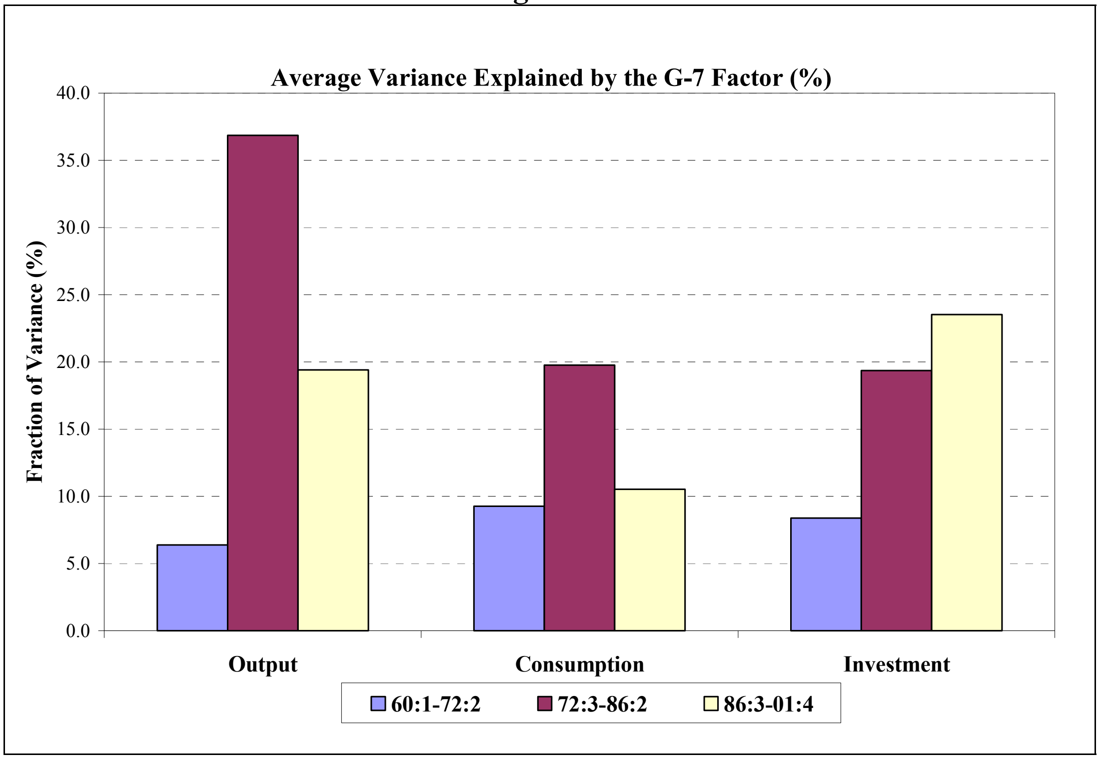


Figure 3b

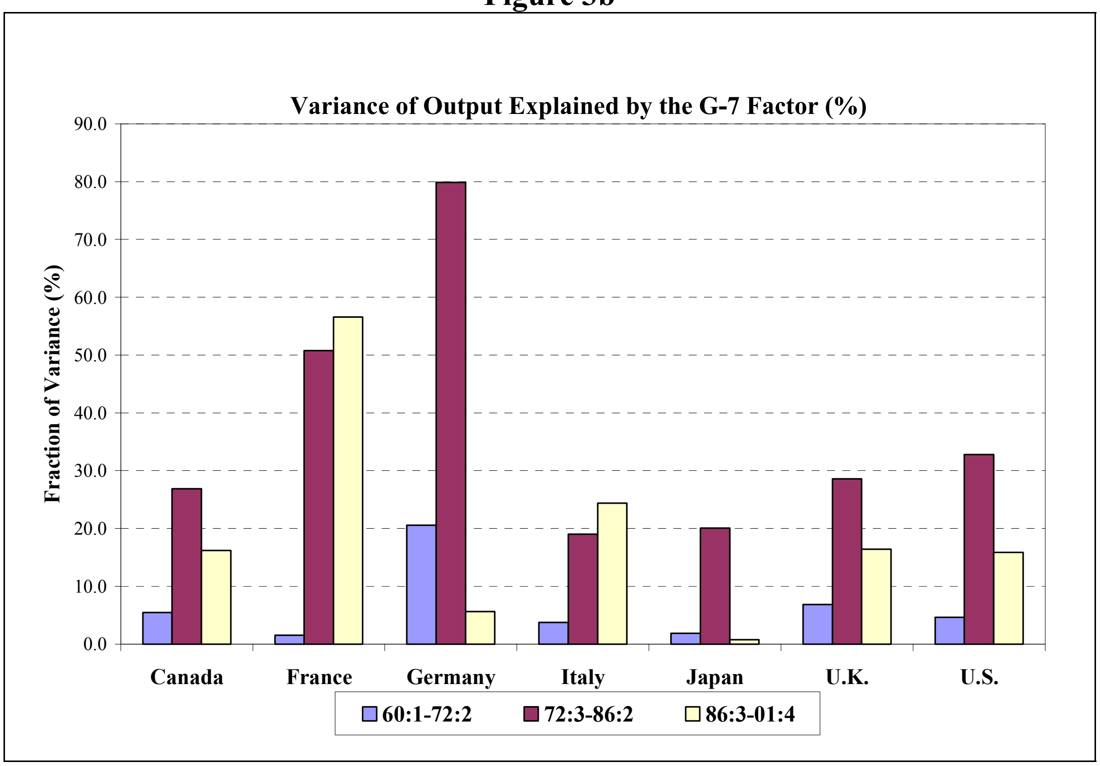


Figure 3c

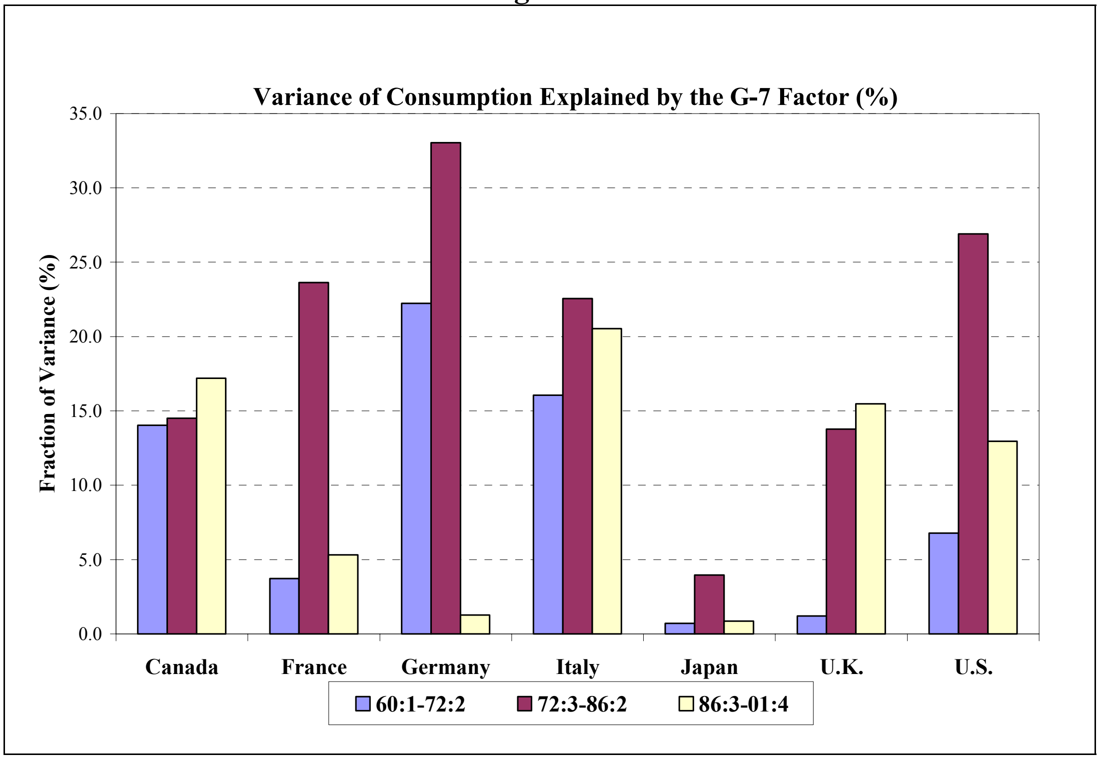


Figure 3d