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Globalization and Monetary Policy Comovement: Evidence from G-7 Countries

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Abstract

This paper empirically characterizes comovement in monetary policy of G-7 countries during 1980-2009. I estimate a Taylor rule for each country and use residual from the Taylor rules to estimate a dynamic latent factor model with common and Europe specific factors. I quantify importance of the G-7 factor in explaining comovement in residual variation of monetary policy and show that the G-7 factor is particularly important during a period of globalization (1988- 2003). I estimate dynamics of importance of the G-7 factor using rolling sub-samples and show that trade-openness increases comovement in monetary policy in Europe. (JEL classification: C11, C38, F42, E52. Keywords: Comovement in monetary policy, Globalization, Dynamic latent factor model, Bayesian estimation.).

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1 Introduction

Globalization is increasing links between the world's economies, particularly through trade flows and capital markets. For example, 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 past two decades as these flows have jumped from less than 5% to approximately 20% of GDP of industrialized countries.[1] Does such a dramatic increase in global interdependence mean that international policy coordination is now a necessity for effective policy making?

This question has given rise to a lively debate among academic economists and policymakers.[2] The popular press joined this debate during global financial crisis in 2008 when all major central banks announced coordinated cuts in interest rates to halt the first global recession since the Great Depression. However, there is little empirical evidence suggesting coordination in monetary policy beyond synchronization of the timing of announcement.[3] This paper is an empirical investigation into the question: is there any evidence of increased global comovement in monetary policy with growing importance of global trade and financial links?

I provide empirical evidence in favor of monetary policy comovement by estimating a Bayesian dynamic latent factor model and identifying a common component in the monetary policy instrument of G-7 countries. I first estimate a country-by-country Taylor rule allowing for current output gap, inflation stabilization and interest rate smoothing. I estimate a dynamic latent factor model on the residual of the Taylor rule using Bayesian posterior simulation.

There is strong empirical evidence suggesting presence of a global factor in output gap and inflation (see, for example, Neely and Rapach (2011)). Monetary policy has the stated objective of output and inflation stabilization. As long as global factors affect output and inflation processes of domestic economies, naturally monetary policy would be influenced by such global factors. As a result, systematic part of monetary policy is also globally coordinated. My two-step empirical

[1] See Kose et al. (2008), Lane et al.(2007) for reference.

[2] See Brooks et al.(2003), Taylor (2008), Bernanke(2007), and Rogoff (2006) for example.

[3] See Dougherty et al. (2008), NY Times, and Buiter (2008), Financial Times.

strategy allows me to analyze the effect of globalization on monetary policy beyond its effects on output gap and inflation.[4]

In the dynamic factor model I allow for a G-7 factor that affects all the countries in my sample, and a Europe factor that affects only the Euro-area countries. The Euro-area countries have the same central bank for almost one- third of my sample period. I incorporate the Europe factor to allow for this effect.

Both the G-7 factor and the Europe factor are very well- identified in the estimation. I consider fraction of variance of the residual of the Taylor rule that is attributable to the G-7 factor as the relevant measure of importance of global comovement in monetary policy. The G-7 factor explains a significant fraction (on average 15% over the entire sample) of residual variation in monetary policy.[5]

Does increase in cross-country trade and financial linkages increase comovement in monetary policy? In order to answer this, I systematically examine evolution of monetary policy coordination over different periods using two different approaches. First, I consider the period from 1980 to 2009 as being composed of three different sub-periods and estimate Taylor rules and factor models separately for each sub-period.[6] I choose the subperiods closely following Kose et al.(2008) and Stock et al. (2005). The first sub-period, 1980-1987, witnessed a set of common shocks associated with sharp fluctuations in oil prices and severely contractionary monetary policy in major industrial economies. The second period, 1988-2003, represents the globalization period that witnessed dramatic increases in the volume of cross-border trade in goods and assets. The third sub-period, 2004-2009, coincides with a brief period of globalization followed by a period of significant asset

[4]See section 3.2.1 for further discussion regarding choice of empirical strategy.

[5]Kose et al. (2008) report similar magnitudes for variation explained by the G- 7 factor for real macroeconomic aggregates.

[6]I choose the sample period 1980 to 2009 as the main sample. Clarida et al.(1998) discuss how major central banks started a concerted effort to reign in inflation in 1979. This suggests a structral break in monetary policy around 1980. Since in the main sample, I estimate the same Taylor rule over the entire period, I chose 1980 to be a reasonable starting point. On the other hand, post-2009, major central banks have kept their policy rate close to the zero lower bound and hence a conventational Taylor rule may not be applicable beyond 2009.

price volatility, global recession and trade-collapse. These demarcations are useful for differentiating the impact of common shocks from that of globalization on the degree of comovement in monetary policy. The globalization period is associated with a higher degree of global comovement compared to the common shocks and crisis period. Second, I evaluate time variation in the degree of coordination by estimating Taylor rules and factor models using rolling sub-periods following Kose et al.(2008). While both approaches lead to broadly similar findings, the second approach provide a more complete characterization of the evolution of global comovement in monetary policy.

Importance of the G-7 factor varies significantly across countries and over time. I analyze the effect of globalization, both trade and financial integration, on the time path of global comovement in monetary policy studying impulse responses in an estimated VAR. Trade integration significantly increases global comovement for the European countries. In the VAR, I also control for asset price volatility and real effective exchange rate volatility.

I also explore alternative interpretations of monetary policy synchronization. Most importantly, countries may synchronize their reactions to inflation and output gap fluctuations. I show evidence of increasing similarity in how central banks of G-7 countries respond to inflation over the sample period. Allowing for a common Taylor rule, I show that the G-7 factor plays an even higher role in explaining residual variation in monetary policy of the G-7 countries.

I discuss the related literature in section 2, and describe the data and the econometric analysis in section 3. Section 4 presents the estimation results. Section 5 concludes.

2 Related Literature

The existing literature on international dimensions of monetary policy is primarily theoretical and *normative* in nature. For example, Ball (1999), Benigno et al.(2006), Corsetti et al.(2004), Duarte and Obstfeld (2008) and Sutherland (2004) build a two country dynamic, stochastic, general equilibrium model and analyze an open economy *optimal* monetary policy problem. In a related branch of literature, Rogoff et al.(2006) and Taylor et al. (2008) advise policymakers on how to conduct monetary policy in a global economy. These papers address normative questions like should central banks pay any attention to exchange rate or asset price volatility in a globalized market or should global excess capacity play a role in optimal monetary policy.

This paper, on the contrary, is a *positive* and empirical analysis of monetary policy in the open economy. The questions that I address are whether global factors affect *observed* monetary policy, specifically whether the effect of global factors extend beyond effects on domestic output gap and inflation, and whether globalization and volatility affect evolution of the global factor in monetary policy.

Mishkin (2009) discusses that globalization "affects the ability of monetary policymakers to stabilize prices and output in two ways: (i) through its effects on the behavior of inflation and output and (ii) through its effects on the ways in which monetary policy influences inflation and output–that is, on the monetary transmission mechanism". Boivin and Giannoni (2008) find no strong evidence of a change in the transmission mechanism of monetary policy due to global forces.

A closely related branch of literature studies the evolution of global inflation, namely whether global factors affect the domestic inflation process, e.g. Bianchi and Civelli (2013), Borio and Filardo (2007), Ihrig et al.(2007). This literature reaches mixed conclusion regarding effects of globalization on domestic inflation. Bianchi and Civelli (2009), and Borio and Filardo (2007) find evidence in favor of the globalization hypothesis, while Ihrig et al.(2007) find no conclusive evidence in favor of this hypothesis. In a very related paper Neely and Rapach (2011) investigate the extent to which international inflation rates move together and what factors influence global and regional comovements, and they find that international components significantly influence national inflation rates. Ciccarelli and Mojon (2010) look for a global component in 22 OECD inflation rates, finding a global factor that is useful for forecasting national inflation rates. Mumtaz and Surico (2011) consider inflation rates from eleven industrialized countries, concluding that inflation rates have become more similar and less predictable since the 1960s but fails to find a common trend in inflation persistence. Monacelli and Sala (2009) investigate factors in disaggregated price data for four OECD countries. Beck et al. (2009) investigate euro area and national factors in disaggregated price data and find that euro area effects account for approximately half of monthly price variation.

This paper is also related to the empirical literature on global business cycle, particularly

Kose et al.(2003, 2008). Kose et al.(2003) employ Bayesian dynamic latent factors and identify global business cycle as a global factor in macroeconomic aggregates of various countries. In a related paper, Kose et al.(2008) analyze the evolution of global business cycle in the G-7 countries by studying the variance explained by the G-7 factor in macroeconomic aggregates using different sub-periods. They conclude that the G-7 factor was most important in the common shocks period, 1973-1986, followed by the globalization period, 1987-2003, and was least important during the Bretton-Woods fixed exchange rate regime, 1960-1972. Stock et al. (2005) employ a factor-structural VAR model to analyze the importance of international factors in explaining business cycles in the G-7 countries and conclude that comovement has fallen in the globalization period of 1986-2002 compared to the common shocks period in 1960-1985. In this paper I find that global coordination in monetary policy was at least as high in the globalization period (1988-2004) as in the common shocks period (1980-1987).

As in Kose et al.(2008), I also obtain a time path of the importance of the G-7 factor for each country by estimating the Taylor rules and the dynamic factor model using the rolling sub-samples. Then, I systematically explore determinants of importance of the G-7 factor in a manner similar to Imbs (2004) who analyzes importance of trade openness and financial integration on business cycle synchronization. Kose et al. (2003) also examine impact of rising trade and financial integration on international business cycle comovement and find limited support in favor of globalization increasing synchronization of business cycles. Walti (2011) also find evidence favoring trade and financial integration contributing to higher stock market return comovements. In this paper I consider influence of a global factor on the residual of the Taylor rule, i.e. after purging observed monetary policy of direct influence of global factors on output gap and inflation. Thus, evidence of presence of a global factor in monetary policy as presented in this paper provides evidence that global forces influence monetary policy makers beyond direct influence on output and inflation dynamics.

Methodologically, this paper is related to the literature on estimation using Bayesian posterior simulation methods (Geweke (1996, 1997), and Kim et al.(1999)), particularly Bayesian estimation of dynamic factor models (Justiniano (2004), Otrok et al.(1998)), and Kauffmann et al. (2000)). I use Gibbs sampling to estimate the dynamic factor model following Justiniano (2004).

In the estimated model the unobservable factors are independently distributed over time but affect dynamics via non-zero lagged factor loadings.

3 Data and Econometric Analysis

3.1 Data

I use quarterly data from G-7 countries for the period 1980-2009. All quarterly data are seasonally adjusted. I use 3 -month Treasury bill rate as the measure of monetary policy instrument. This short-term nominal interest measure is a standard measure of monetary policy instrument in the literature (see for example, Bianchi and Civelli (2013)).

The real GDP data are first passed through a Hodrick-Prescott filter which defines potential output for any country.[7] Following Hodrick et al.(1997), I set the parameter of the filter to 1600 for quarterly data. I then compute output gap for country c as the percentage deviation of real GDP from the potential,

$$x_{c,\ t} = \frac{\text{real GDP}_{c,\ t}}{\text{potential output}_{c,\ t}} - 1,$$

where $x_{c,\ t}$ stands for output gap of country c at time t. I use quarter to quarter % change in CPI as the measure of inflation. I collect interest rate, real GDP and CPI data from the International Financial Statistics (IFS) database of IMF.

Following Imbs (2004), I use volume of exports and imports to GDP ratio as the measure of trade-openness. Given rising trade with emerging economies (especially China) over my sample period and influence of such trade on price levels in G-7 countries, I consider overall trade integration as my key measure of globalization.[8] For robustness checks, I also construct a within-G-7 measure of trade-openness using NBER bilateral trade data from Feenstra et. al (2005). Bilateral trade flows data are available at a yearly frequency for the period 1960 to 2000. I follow Lane et al. (2007)

[7] Many papers (see, for example, Cecchetti et al. (2007)) argue that H-P filter captures central bank perspectives on the output gap.

[8] See the discussion concerning "China exports deflation" in Rogoff(2006).

in constructing a measure of financial integration of a country as the ratio of external assets and liabilities to GDP. I collect exports and imports data from the IFS database of IMF, and external assets and liabilities data from Lane et al.(2007). External assets and liabilities data and bilateral trade data are available only at an annual frequency, and are converted to quarterly data using quadratic interpolation.

I also use data on real effective exchange rate volatility and stock market volatility. Most advanced economies experienced a stunning decline in output and inflation volatility while continuing to experience high volatility in many asset markets over my sample period. The question of whether central banks should pay attention to asset price volatility has received considerable attention in the literature (see, for example, Rogoff (2006), Lansing (2008), Rigobon and Sack (2003), Chadha and Sarno (2003), Ball (1998)). In this paper I examine whether measures of globalization increases global comovement in monetary policy while controlling for asset price volatility. I collect real effective exchange rate data from the IFS, and stock market index data from the Global Financial Database (GFD). A broad stock index is chosen to reflect economy-wide asset price volatility. For example, I use S & P 500 Total Return Index for the US. For the rest of the countries I use UK FTSE All Share Return Index, Canada S & P TSX 300 Total Return Index, France SBF-250 Total Return Index, Germany CDAX Total Return Index, Italy BCI Global Return Index, and Japan Nikko All-Japan Return Index. Monthly stock index data are converted to quarterly frequency using arithmetic averaging. Following Rogoff (2006), I measure volatility as 3-month rolling standard deviation of month-to-month log change of the corresponding variable.

3.2 Econometric Analysis

3.2.1 Empirical Strategy

For each country I estimate a Taylor rule using standard OLS regressions. I allow for an interest-rate smoothing objective of the central bank in addition to output and inflation stabilization objectives in the Taylor rule (see, for example, Taylor (1993)). The estimating equation is

$$i_{c,\,t} = \alpha_c + \beta_c \pi_{c,\,t} + \gamma_c x_{c,\,t} + \delta_c i_{c,\,t-1} + \epsilon_{c,\,t}, \tag{1}$$

where $i_{c,\ t}$ is monetary policy rate for country c at time t, $\pi_{c,\ t}$ is CPI inflation over the previous four quarters and $x_{c,\ t}$ is output gap.

I estimate a dynamic factor model on the panel of residuals from the Taylor rule. The dynamic factor model is given by

$$\epsilon_{c,\ t} = B_0^c F_t + B_1^c F_{t-1} + .. + B_P^c F_{t-P} + \xi_{c,\ t} = B^c(L) F_t, \tag{2}$$

where F_t is a vector of 2 factors, B_k^c , $k = 1 : P$, is a 1×2 vector of factor loadings for country c at lag k, and $B^c(L)$ is a P-th degree lag polynomial for country c. The factor loadings reflect the degree to which variation in $\epsilon_{c,\ t}$ can be explained by each factor. The first factor (F_t^{G7}) is a G-7 factor affecting all the countries in the sample, the second factor is a Europe (F_t^{EUROPE}) factor affecting only the three Euro-area countries. Thus, the assumption in the factor model is that the deviation of the monetary policy from the standard Taylor rule for the G-7 countries has a common G-7 factor and a Europe factor common to the Euro-area countries, in addition to idiosyncratic disturbances.

The unexplained idiosyncratic errors, $\xi_{c,\ t}$, are assumed to be normally distributed, but possibly serially correlated. They follow Q-order autoregressions,

$$\xi_{c,\ t} = \varphi_0^c \xi_{c,\ t-1} + \varphi_1^c \xi_{c,\ t-2} + .. + \varphi_Q^c \xi_{c,\ t-Q} + \eta_{c,\ t} = \varphi_Q^c(L) \xi_{c,\ t-1}, \tag{3}$$

where φ_j^c , $j = 1 : Q$ are autocorrelation coefficients, and $\varphi_Q^c(L)$ is a lag polynomial of order Q. Notice that all the innovations, $\eta_{c,\ t}$, and the factors are assumed to be zero mean, contemporaneously uncorrelated normal random variables,

$$\begin{aligned} \eta_{c,\ t} &\sim N(0, \sigma_c^2), \\ F_t &\sim N(0, \Sigma). \end{aligned} \tag{4}$$

Thus, Σ is a diagonal matrix with variance of the factors, $\sigma^2_{F_t^{G7}}$ and $\sigma^2_{F_t^{EUROPE}}$, as the diagonal entries. However, the factors affect the relevant variable, $\epsilon_{c,\ t}$, with P lags.[9] Also, the idiosyncratic

[9] An alternative assumption would be that the factors affect $\epsilon_{c,\ t}$ only contemporaneously, but the factors have autoregressive representation. While these two assumptions are equivalent theoretically, the assumption made in

errors are orthogonal to the factors. The time paths of the factors $\{F_t\}$, the factor loadings B_k^c, the autocorrelation coefficients φ_j^c, the error variances σ_c^2, and the factor variances $\sigma^2_{F_t^{G7}}$ and $\sigma^2_{F_t^{EUROPE}}$ are jointly estimated. Importance of the G-7 factor is measured as

$$IMPG7_c = \frac{\sum_{k=1}^{P} B_k^c(1,1)^2 * var(F_t^{G7})}{var(\epsilon_{c,\,t})}, \tag{5}$$

where $var(.)$ is the measured variance of the relevant variable.

It is imperative to understand the economic logic behind fitting the dynamic factor model on residual from the Taylor rule. It is well-documented that global factors affect domestic output and inflation and to the extent that monetary policy aims at output and inflation stabilization, monetary policy is affected by global factors. The question that I address here is whether central banks synchronize their policy reactions beyond the influence of global factors on domestic output and inflation. The optimal monetary policy literature (for example, Benigno et al. (2006) and Corsetti et al. (2004)) unanimously argues that monetary policy should take into account global factors when those factors affect domestic output and inflation. The debate is whether monetary policy should take into account global factors beyond their effects on output and inflation in the face of rapid and dramatic increases in globalization. Importance of the G-7 factor in residual of the Taylor rule, as estimated in this paper, is meant to shed light on this debate.

3.2.2 Estimation Strategy

Estimation of the dynamic factor model requires further identification and normalization assumptions. Identification denotes exclusion restrictions with the aim of interpreting the factors as representing shocks of different nature. Here, the identification assumption is that the Europe factor, F_t^{EUROPE}, does not affect the non- Euro-area countries. The Europe factor reflects that the

this paper, lags in factor loadings and no autoregression in factors, allows for simpler estimation technique following Justiniano (2004). Kose et al. (2003, 2008) employ the alternative assumption. It would be tempting to combine dynamics in the factor loadings with autoregressions in the factors themselves, resulting in generalized factor models. This approach, however, can result in difficulties in the estimation due the problem of common roots in ARMA models. See, for example, Quah et al. (1993).

three Euro-area countries in the sample, France, Germany and Italy, have a common central bank throughout most of the sample period.[10] Hence,

$$B_k^c(1,2) = 0,$$

for c= USA, Canada, UK, and Japan, and for all k. Following Justiniano (2004) and Kose et al.(2007), I normalize the contemporaneous factor loading of the US for the G-7 factor and the contemporaneous factor loading of France for the Europe factor to unity,

$$B_0^{US}(1,1) = 1,\ B_0^{FRANCE}(1,2) = 1.$$

This assumption helps us identify scales and signs of the factors separately.[11]

Because the factors are unobservable, special methods must be employed to estimate the model. I employ Bayesian posterior simulation techniques to estimate the dynamic latent factor model. The estimation procedure builds on the following key observation: if the factors were observable, under a conjugate prior the models (2)- (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 factors using a Markov Chain Monte Carlo procedure.[12] The process

[10] An alternative way to capture the common central bank for the Euro-area countries is discussed in section 4.

[11] In any particular ordering of the countries, one can normalize contemporaneous factor loading for the first country to fix the scale of the G- 7 factor, and can normalize contemporaneous factor loading for the first Euro-area country to fix the scale of the Europe factor. See Justiniano (2004) for further discussion on normalization assumptions.

[12] In particular, given arbitrary starting values of $(\{F_t\}_0, \Sigma_0, \{B_k^c\}_0, \{\varphi_j^c\}_0, \{\sigma_c^2\}_0)$, in iteration 1 I draw the factors $\{F_t\}_1$, conditional on $(\Sigma_0, \{B_k^c\}_0, \{\varphi_j^c\}_0, \{\sigma_c^2\}_0)$; then draw the factor variance Σ_1, conditional on $(\{F_t\}_1, \{B_k^c\}_0, \{\varphi_j^c\}_0, \{\sigma_c^2\}_0)$; then draw the factor loadings $\{B_k^c\}_1$, conditional on $(\{F_t\}_1, \Sigma_1, \{\varphi_j^c\}_0, \{\sigma_c^2\}_0)$; then draw the AR coefficients $\{\varphi_j^c\}_1$, conditional on $(\{F_t\}_1, \Sigma_1, \{B_k^c\}_1, \{\sigma_c^2\}_0)$; and finally, draw the error variances $\{\sigma_c^2\}_1$, conditional on $(\{F_t\}_1, \Sigma_1, \{B_k^c\}_1, \{\varphi_j^c\}_1)$.

is iterated a large number of times. This sequential sampling of the full set of conditional distributions is known as Gibbs sampling.[13] 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.

In my implementation, the lag in factor loadings (P) and the length of idiosyncratic autoregressive polynomial (Q) are both 1. I follow Kose et al. (2008) to specify the prior distributions. The prior on all the factor loading coefficients and the autoregressive parameters is N(0, 1). The prior assumption on the factor loadings reflect the expectation that on average the factors do not affect the residuals from the monetary policy rule. The prior on the error variances and the factor variances is Inverted Gamma (6, 0.001), which is very diffuse. A diffuse prior allows for considerable uncertainty regarding the parameter of interest.[14]

4 Estimation Results from the Dynamic Factor Model

Results from Full Sample First, I present estimation results for the full sample period 1981:1-2009:4. All the figures and tables are reported in the appendix. Figure 1 displays median of the posterior distribution of the G-7 factor, along with 5% and 95% error 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 general trend of monetary policy in G-7 countries. In Figure 2, I plot the G-7 factor (the solid line) along with the average Treasury bill rate of the G-7 countries (the dash-dot line) and the US Treasury bill rate (the dashed line). All the series are normalized to unity at the beginning of the period in 1981:1. The G-7 factor tracks development of the Treasury bill rates quite well.[15] For example, contractionary monetary policy of

[13] See Kim et al.,1999 and Geweke (1996, 1997) for reference.

[14] Regardless of such a loose prior, the variance parameters are well-identified in the data (see Table 2 in the appendix).

[15] Correlation between average G-7 interest rate and the G-7 factor is .25, and correlation between US Treasury bill rate and the G-7 factor is .34. The correlations are quite high considering that the G-7 factor is estimated using residuals from the standard Taylor rule.

the early 1980's, expansionary monetary policy after the dot- com bubble in 2001 for a prolonged period and the world-wide cut in interest rates during the recent crisis in 2007-2009 period are well captured by the G-7 factor.

In Figure 3, I present the estimated Europe factor along with relevant error bands, and in Figure 4, I compare the estimated G-7 factor (the solid line) and the estimated Europe factor (the dashed line). While the Europe factor and the G-7 factor display some comovements, there is significant variation in the time paths of the two factors in every decade. This justifies incorporating two different factors to explain regional and G-7 wide comovements in monetary policy. Estimated factor loadings, AR parameters, factor and error variances are described in Tables 1-3.

I estimate variance decomposition as described in (5) to measure contribution of the G-7 factor in explaining residual from Taylor rules. Figure 5 displays the variation explained by the G-7 factor over the entire sample. The estimated contribution is approximately 30% for the US, around 20% for Canada and around 10-15% for UK, Germany, France and Italy. Higher importance of the G-7 factor in North America probably reflects the fact that the G-7 factor essentially captures influence of the Federal Reserve on international monetary policy.

However, Japan appears to be an outlier with very little contribution from the G-7 factor. While contribution of the G-7 factor varies significantly across time for the rest of the countries, Japan is little affected by the G-7 factor in any sub-sample. This may reflect that events specific to Japan, a period of strong growth in the 1980's followed by the collapse of Japanese asset price bubble and a prolonged recession, have influenced Japanese monetary policy significantly more than the global shocks. Japan also stands out from the rest of the G-7 countries in terms of global business cycle.[16]

Results from Different Subsamples Do we observe an increased importance of the G-7 factor with increase in globalization? To analyze this key question, I distinguish periods in which countries experience common shocks from periods in which countries become more integrated through global

[16] See for example, Kose et al. (2008) and Doyle et al. (2005) for evidence that the global factors affected little of real economic activity in Japan over this sample period.

trade and financial linkages. I divide the sample period into three sub-samples: the oil-price shock and contractionary monetary policy period (1980-1987), the globalization period (1988-2003), and the housing bubble and crisis period (2004-2009), and estimate country-specific Taylor rules and the dynamic factor model ((2)- (4)) separately for each sub-sample. Kose et al. (2008) also consider the 1980-1987 period as a period in which the industrialized countries experienced common shocks in oil prices, and followed overtly contractionary monetary policy. They also estimate their dynamic factor model using real variables separately for this period to distinguish this period as a time of global shocks. Roubini et al.(2010) elaborate that the US housing bubble started building in 2004, reached it's peak in 2005-2006, and collapsed in 2007 ushering in global stock market turmoil and recession. On the other hand, the period 1988-2003 is associated with unprecedented increases in global linkages in goods and asset markets. Over this period, average trade openness of G-7 countries increase by 25% , while the average financial integration measure increase by 160% (as depicted in Figures 6 and 7, respectively). Thus, my breakdown of the sample period into the three sub-samples essentially allows me to separately analyze a common shock period, followed by a period of rapid globalization, and another common shock period. The subsamples roughly correspond to Bai-Perron (2003) structural break dates in average trade integration and financial integration measures, as reported in Tables 4 and 5.

From estimated parameters and factors from each sub-sample I compute country- specific contribution of the G-7 factor in different sub-samples. In Figure 8, I display contribution of the G-7 factor in different sub-samples on average for the G-7 countries and for the US. On average, the G-7 factor explains approximately 14% both in the early common shock period and in the globalization period, and less (9%) in the recent crisis period. For the US, the G-7 factor explains a significantly higher % of variation in the globalization period, compared to either the common shock period or the crisis period. This result is different from the global business cycle literature. Both Kose et al. (2008) and Stock et al.(2005) analyze the global business cycle for the G-7 countries. They find that the contribution of the G-7 factor was higher in the common shocks period of the early 1980's. Thus, comovement in monetary policy in the globalization period is even more pronounced than real comovement in macroeconomic aggregates.

Results from Rolling Subsamples and VAR To explore this result further I estimate the Taylor rules and factor models using 7-year rolling sub-periods incremented by a quarter. In other words, I roll the start and end dates forward by a quarter for each sub-period after each estimation. Figure 9 reports variation explained by the G-7 factor on average across G-7 countries. The estimation results obtained from rolling sub- samples reveal a finer nature of time variation in the importance of the G-7 factor. In the first half of the 1990's, included in my globalization sub-sample (1988-2003), the G-7 factor is less important than the common shocks period in the early 1980's. However, the degree of global comovement increases rapidly beginning the late 1990's. The recent crisis period actually shows a trend of slight decline in the variation explained by the G-7 factor. This broad pattern is similar across the G-7 countries throughout the sample.

Estimation using rolling sub- samples allows me to explore systematically determinants of importance of the G-7 factor over time and across countries. The main question of this paper is to assess effects of globalization, namely trade and financial integration, on importance of the G-7 factor. Also, whether asset price and exchange rate volatility affect comovement in monetary policy is a pertinent question in the literature.[17] On the other hand, globalization itself may also be the result of coordinated policies across countries. Similarly, it is possible that central banks coordinate to reduce exchange rate volatility and hence correlation observed in the regression actually implies a reverse causation. Or, central banks make correlated mistakes (since the relevant variable in the factor model is the residual from the Taylor rule) which exacerbates asset price volatility.

To allow for these possibilities of reverse causation, I estimate a reduced form VAR model on $(trade\_int_{c,\,t}, fin\_int_{c,\,t}, REER\_vol_{c,\,t}, stock\_vol_{c,\,t}, IMPG7_{c,\,t})$ where $IMPG7_{c,\,t}$ is importance of the G-7 factor for country c in a sub-sample of 7 years ending at time t, $trade\_int_{c,\,t}$ is a measure of trade integration for country c in a sub-sample of 7 years ending at time t, $fin\_int_{c,\,t}$ is a measure of financial integration for country c in a sub-sample of 7 years ending at time t, $REER\_vol_{c,\,t}$ is a measure of real effective exchange rate volatility for country c in a sub-sample

[17] For example, Taylor (2008) argues that central banks should not attempt to stabilize asset prices or exchange rates while Corsetti et al., (2004) argue that reducing exchange rate volatility should be a part of optimal monetary policy rule in the open economy.

of 7 years ending at time t, and $stock\_vol_{c,\,t}$ is a measure of stock market volatility for country c in a sub-sample of 7 years ending at time t. Any particular ordering of the variables in a VAR reflect the assumption that a variable contemporaneously affects the variables below it in the ordering, and affects all the variables with a lag. For example, in this particular ordering monetary policy comovement, as measured by $IMPG7_{c,\,t}$, affects both globalization variables and volatility variables only with a lag.

In Figure 10a-10g, I report the impulse responses of the comovement measure, $IMPG7$, from the VAR estimated with two lags for each variable. The dotted lines correspond to two standard deviation error bands, and the solid line represents the average response for each country. In US (Figure 10a) and Canada (Figure 10b), the integration measures do not significantly impact importance of the G-7 factor. A similar result is observed for Japan (Figure 10g). On the other hand, for the four European countries (Figures 10c for Germany, Figure 10d for Italy, Figure 10e for France, Figure 10f for UK) trade integration is found to significantly increase importance of the G-7 factor over the medium run– accumulated impulse response of importance of G-7 factor to one s.d. shock to trade integration is significantly positive after 10 quarters. No such significance is observed for financial integration measures.[18]

I have checked robustness of the results by estimating the VAR with different lags and by changing the order of the variables; by including within G-7 trade integration as the relevant measure; excluding data after 2006 to limit impact of the global financial crisis period as an extreme event driving the results . While magnitudes of the responses vary, nature of the responses remain unchanged. Thus, it is safe to interpret these results as evidence for increasing comovement in monetary policies of the European countries in the face of rising trade integration. Mishkin (2006) discusses possible impact of globalization on monetary policy via its effect on output gap and inflation , and via its effect on monetary transmission mechanism. Here I consider residual of the Taylor rule to measure importance of the G-7 factor. Also, European countries have a common

[18]Using average data across G-7 countries, I find a significant positive impact of financial integration on importance of G-7 factor. However, the effect is very short run and the accumulated effect is not significantly different from zero. Moreover, the average response masks important heterogeniety across countries and hence not reported here. All results are available upon request.

central bank formulating a common optimal monetary policy over most of the sample period. Thus, this evidence of a positive impact of trade integration on importance of G-7 factor in Europe possibly points towards impact of trade integration on international transmission of US monetary policy.

An Alternative Interpretation of Monetary Policy Coordination So far, I have considered a particular empirical interpretation of monetary policy coordination, i.e. via comovement in the residual of Taylor rule. It is important to acknowledge that there can be different ways of capturing the broader concept of monetary policy coordination. For example, central banks may choose to synchronize their systematic reaction to output gap and inflation fluctuations. This can be captured by Taylor rules that become increasingly similar over time with increases in globalization. I estimate a separate Taylor rule (1) for each of the G-7 countries using my rolling sub-samples. For any coefficient in the Taylor rule, I construct variance across the G-7 countries over that corresponding sub-sample. In Figure 11, I plot time path of variance of inflation and output gap coefficients of Taylor rules. The solid line corresponds to variance of the inflation coefficient (denoted by β in equation (1)), and the dashed line corresponds to variance of the output gap coefficient (denoted by γ in equation (1)). Evidently, the G-7 countries are increasing responding in a similar manner to inflation, as represented by a steady decline in variance of the inflation coefficient across G-7 countries. Variance of the output gap coefficient also shows a declining trend towards the end of the sample period, even though not quite as evident as the inflation coefficient. This evidence points towards increasing similarity in systematic responses to inflation and output gap of the central banks of the G-7 countries.

What is the implication for importance of the G-7 factor, if I allow for monetary policy synchronization in Taylor rules themselves? I estimate a common Taylor rule for all the countries, and use the residual from this common rule to estimate the dynamic factor model consisting of equations (2) to (4). In Figure 12, I show variance explained by the G-7 factor using residuals from a common Taylor rule. Comparing with Figure 5 which reports variance explained by the G-7 factor using residuals from country specific Taylor rules, importance of the G-7 factor has increased substantially for all the countries except Japan. On average, the G-7 factor explains 23% of the residual variation in monetary policy instruments when common Taylor rules are used to calculate the residual, as opposed to 15% when country specific Taylor rules are used. Interestingly, allowing for a common Taylor rule, G-7 factor is roughly equally important for Germany and Canada.

I checked robustness of this result in various ways. First, I allow only a common inflation coefficient across countries instead of a Taylor rule with all common coefficients. Second, I allow a Taylor rule that is common among the European countries, and allow rest of the countries to have their country-specific Taylor rules. For a significant part of my sample the Euro area countries have a common central bank. Moreover, even before emergence of a common European Central Bank, there is strong evidence that monetary policies of UK, France and Italy were significantly influenced by Bundesbank monetary policy (see, for example, Clarida, Gali and Gertler (1998)). It is imperative to check the extent to which nature of impulse responses in the estimated VAR (most importantly, conclusion regarding impact of trade integration of importance of the G-7 factor in the European countries) are affected by this common central bank in Europe. To this end, I estimate a common Taylor rule for a) the three Euro- area countries and b) for the Euro area countries and UK. In my rolling sub-sample estimations, I also use country-specific Taylor rules for all countries except for the European countries starting 1999, the year in which the common central bank across Europe was established.

I use the residuals from these different first-stage regression to fit a dynamic factor model as before. The nature of the impulse responses, specifically a positive and significant influence of trade integration on importance of the G-7 factor in the European countries, remain unchanged. All results are available upon request.

5 Summary and Conclusion

The analysis of implications of international economic interdependence for the gains from cross-country cooperation between monetary authorities has a long history (see, for example, Conen et al. 2007). However, the existing literature is primarily normative in nature focusing on optimal monetary policy in the open economy. This paper, on the contrary, is an empirical analysis of monetary policy in the open economy. The questions that I address are whether global factors affect monetary policy, specifically whether the effect of global factors extend beyond effects on domestic output gap and inflation, and whether measures of globalization affect evolution of the global factor in monetary policy.

I study changes in the nature of coordination in monetary policy among the G-7 countries over time by estimating common dynamic components in monetary policy. In particular, I employ a Bayesian dynamic latent factor model and decompose the residual from the Taylor rule into a G-7 factor, a Europe factor, and idiosyncratic components.

I first show that the G-7 factor is very well-identified and tracks the evolution of monetary policy in the G-7 countries. I document that the G-7 factor is able to explain a sizable variation in monetary policy that was left unexplained by the Taylor rule. The G-7 factor, in particular, assumes an important role during the period of rapid globalization beginning in late 1990's. I also estimate the dynamic factor model using rolling sub-samples and analyze the effect of trade integration and financial integration on global comovement in monetary policy. Trade integration is shown to increase comovement in monetary policy in the European countries.

It is worth noting that the European countries (as well as for Canada) are relatively more open economies compared to US and Japan. Does this evidence from G-7 European countries regarding positive influence of trade integration on monetary policy comovement generalize to a larger sample including other highly open economies (e.g. emerging economies in Latin America and Asia), or is it a result restricted to European economies? What are the emprical channels via which goods market integration influences monetary policy coordination beyond its direct influence on domestic output gap and inflation? These are some important questions for further research.

References

[1] Ball L. 1998. Policy Rules for Open Economies. NBER working paper No. 6760. http://www.nber.org/papers/w6760

[2] Benigno G, Benigno P. 2006. Designing Targeting Rules for International Monetary Policy Cooperation. *Journal of Monetary Economics* **53**: 473- 506. http://dx.doi.org/10.1016/j.jmoneco.2005.03.009

[3] Beck, G. W., Hubrich K., Marcellino, M.M. 2009. Regional Inflation Dynamics Within and Across Euro Area Countries and A Comparison with the United States. *Economic Policy*. 24 (57), pp 141-184.

[4] Bernanke B. 2007. Globalization and Monetary Policy. Remarks by the Chairman of the Board of Governors of the US Federal Reserve System, at the Fourth Economic Summit, Stanford Institute for Economic Policy Research, Stanford, California, March 2, 2007.

[5] Bianchi F, Civelli A. 2013. Globalization and Inflation: Structural Evidence from a Time Varying VAR Approach. *Duke University mimieo.*

[6] Borio C, Filardo A. 2007. Globalization and Inflation: New Cross Country Evidence of the Global Determinants of Domestic Inflation. *Bank of International Settlements working paper* No. 227.

[7] Boivin, Jean, and Marc Giannoni. Global forces and monetary policy effectiveness. No. w13736. National Bureau of Economic Research, 2008.

[8] Brooks R, Forbes K, Imbs J, Mody A. Dancing in Unison? *Finance and Development*: **40(2)**: 46- 49.

[9] Buiter W. 2007. The Coordinated Central Bank Action That Wasn't. *Financial Times*. (Date of Access: December 13, 2007)

[10] Ciccarelli M., Mojon B. 2010. Global Inflation. Review of Economics and Statistics 92 (3), 524-535.

[11] Cecchetti S, Hooper P, Kasman B, Schoenholtz K, and Watson M. 2007. Understanding the Evolving Inflation Process. *U.S. Monetary Policy Forum vol 8.*

[12] Coenen G., Giovanni L., F. Smets, R. Straub. 2010. International Transmission and Monetary Policy Cooperation. Chapter (pp 157-192) in *International Dimensions of Monetary Policy.* Editoed by Gali J., M. Gertler), University of Chicago Press.

[13] Corsetti G, Pesenti P. 2005. International Dimensions of Optimal Monetary Policy. *Journal of Monetary Economics*, **52**: 281- 305. http://dx.doi.org/10.1016/j.jmoneco.2004.06.002

[14] Chadha J. S., L. Sarno. 2003. Monetary Policy Rules, Asset Prices and Exchange Rates. CEPR Discussion Paper No. 4114.

[15] Dougherty C, Andrews E. 2008. Central Banks Coordinate Global Cut in Interest Rates, *New York Times.* http://www.nytimes.com/2008/10/09/business/09fed.html?pagewanted=all&_r=0

[16] Doyle B, Faust J. 2005. Breaks in the Variability and Comovement of G- 7 Economic Growth. *Review of Economics and Statistics.* **87**: 721- 740. doi:10.1162/003465305775098134

[17] Duarte M., M. Obstfeld. 2008. Monetary Policy in the Open Economy Revisited: The Case for Exchange-rate Flexibility Restored. *Journal of International Money and Finance* **27**: 949-957.

[18] Feenstra R, Lipsey R, Deng H, Ma A, Mo H. 2005. World Trade Flows: 1962-2000. *NBER working paper* No. 11040.

[19] Geweke J.1996. Monte Carlo Simulation and Numerical Integration, in Amman, H., Kendrick, D., Rust, J., (eds.), *Handbook of Computational Economics*, North Holland, 731- 800.

[20] Geweke J. 1997. Posterior Simulators in Econometrics, in Kreps, D., Wallis, K.F., (eds.), *Advances in Economic and Econometrics: Theory and Applications*, vol III, Cambridge University Press, 128- 165.

[21] Hodrick R, Prescott E.1997. Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit, and Banking.* **29**: 1-16.

[22] Ihrig J, Kamin S, Lindner D, Marquez J. 2007. Some Simple Tests of the Globalization and Inflation Hypothesis. *International Finance Discussion Paper.* Board of Governors of the Federal Reserve System, No. 891. DOI: 10.1111/j.1468-2362.2010.01268.x

[23] Imbs J. 2004. Trade, Finance, Specialization, and Synchronization *Review of Economics and Statistics* **86**: 723- 734. doi:10.1162/0034653041811707

[24] Justiniano A. 2004. Estimation and Model Selection in Dynamic Factor Analysis, *Princeton University mimieo.*

[25] Kauffmann S. 2000. Measuring Business Cycles with a Dynamic Markov-Switching Factor Model: An Assessment using Bayesian Simulation Methods. *Econometric Journal* **3**: 39- 65. DOI: 10.1111/1368-423X.00038

[26] Kim C, Nelson C. 1999. *State Space Models with Regime Switching*, MIT press.

[27] Kose M. A., E. E. Prasad, M.E. Terrones. 2003. How Does Globalization Affect the Synchronization of Business Cycles?. IZA Discussion Paper No. 702.

[28] Kose M. A., Otrok C, Whiteman C.H. 2008. Understanding the Evolution of World Business Cycles. *Journal of International Economics* **75**:110-130. http://dx.doi.org/10.1016/j.jinteco.2007.10.002

[29] Kose M. A., Otrok C, Whiteman C.H. 2003. International Business Cycles: World, Region, and Country Specific Factors. *American Economic Review* **93**: 1216-1239.

[30] Lane P, Miles- Ferretti G.M. 2007. The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970- 2004. *Journal of International Economics* **73**: 223- 250. http://dx.doi.org/10.1016/j.jinteco.2007.02.003

[31] Lansing K. J. 2008. Monetary Policy and Asset Prices. 2008. FRBSF Economic Letter. Number 2008-34.

[32] Monacelli T., Sala L. 2009. The International Dimension of In‡ation: Evidence from Disaagregated Consumer Price Data. Journal of Money, Credit and Banking 41 (st), 101-120.

[33] Mishkin F.S. 2009. Globalization, Macroeconomic Performance, and Monetary Policy. *Journal of Money, Credit and Banking*, Supplement to Vol. 41, No. 1.

[34] Mumtaz H., Surico P. 2012. Evolving International Inflation Dynamics: World and Country-specific Factors. *Journal of the European Economic Association.* Volume 10, Issue 4. pp 716-734. DOI: 10.1111/j.1542-4774.2012.01068.x

[35] Neely C. J., and D. E. Rapach. 2011. *Journal of International Money and Finance.* Vol 30, pp 1471-1490. doi: 10.1016/j.jimonfin.2011.07.009

[36] Otrok C, Whiteman C.H. 1998. Bayesian Leading Indicators: Measuring and Predicting Economic Conditions in Iowa. *International Economic Review* **39**: 997- 1014.

[37] Quah D, Sargent T. 1993. A Dynamic Index Model for Large Cross Sections, in Stock, J.H., Watson, M.W. (eds.), *New Research on Business Cycles, Indicators, and Forecasting*, University of Chicago press.

[38] Rigobon R, and Sack B. 2003. Measuring the Reaction of Monetary Policy to the Stock Market. *Quarterly Journal of Economics.* Vol. 118, No. 2, pp. 639-669.

[39] Rogoff K.S. 2006. Impact of Globalization on Monetary Policy, *Federal Reserve Bank of Kansas City, Jackson Hole symposium.*

[40] Roubini N, Mihm S. 2010. *Crisis Economics: A Crash Course in the Future of Finance*, Penguin press.

[41] Stock J, Watson M.W. 2005. Understanding Changes in International Business Cycles. *Journal of European Economic Association* **3**: 968- 1006. DOI: 10.1162/1542476054729446

[42] Sutherland A. 2004. International Monetary Policy Coordination and Financial Market Integration *CEPR Discussion Paper* No. 4251.

[43] Taylor J. B. 2008. The Impacts of Globalization on Monetary Policy. *Banque de France, International symposium.*

[44] Taylor J. B. 1993. Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214.

[45] Walti S. 2011. Stock market synchronization and monetary integration. *Journal of International Money and Finance* **30**: 96-110.

6 Graphs and Tables

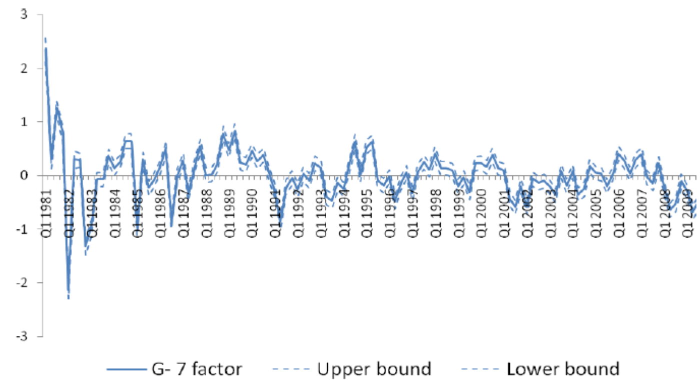

Figure 1: Estimated G-7 factor.

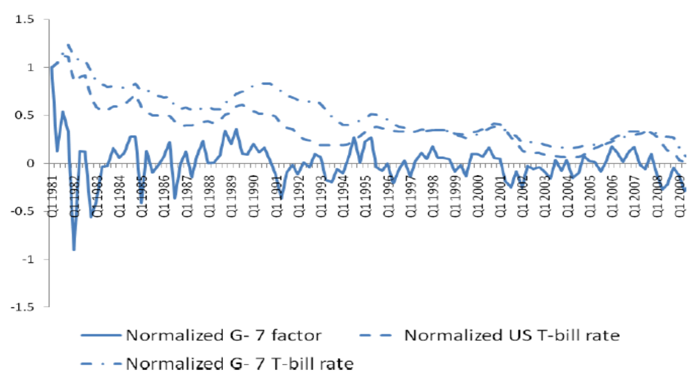

Figure 2: The G-7 factor and Treasury bill rates of the US and the G-7 countries.

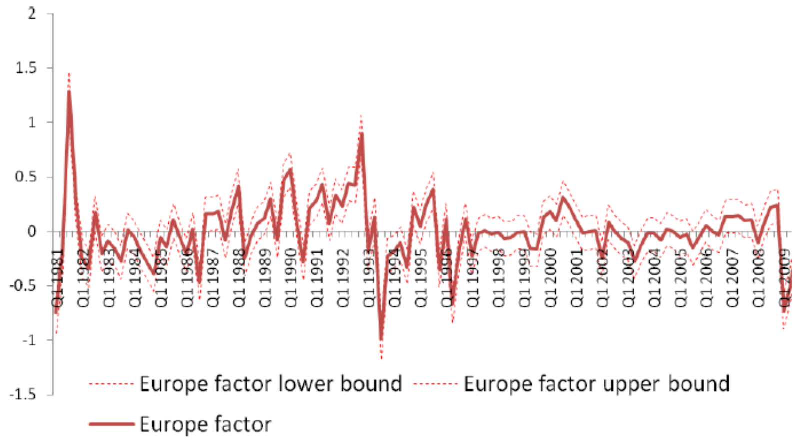

Figure 3: Estimated Europe factor.

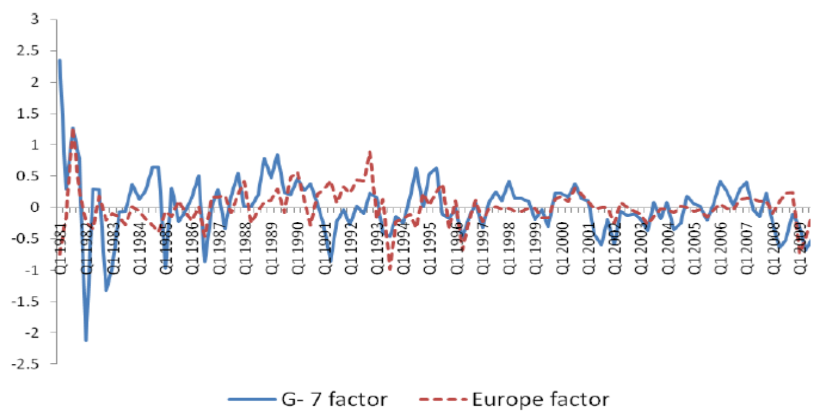

Figure 4: G-7 factor and Europe factor.

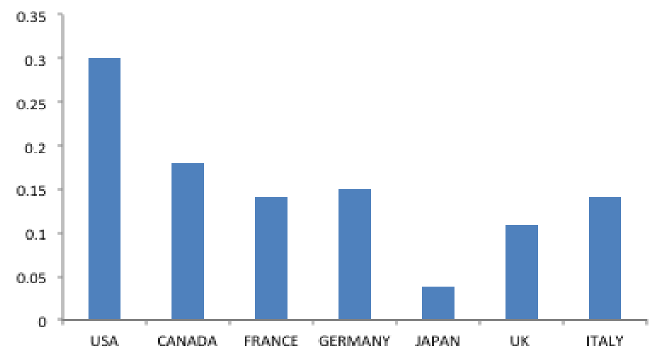

Figure 5: Variation explained by the G-7 Factor, 1981-2009.

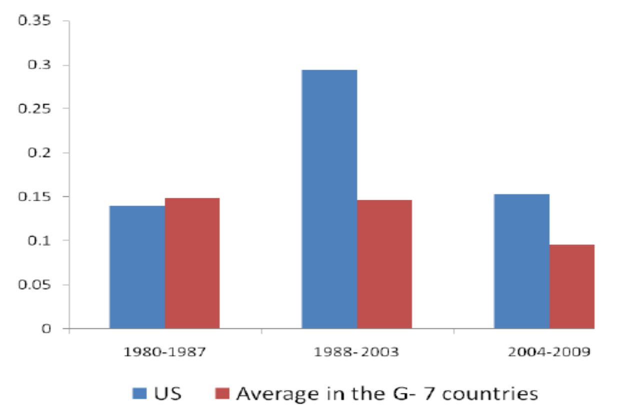

Figure 6: Variation explained by the G-7 factor, different sub-samples.

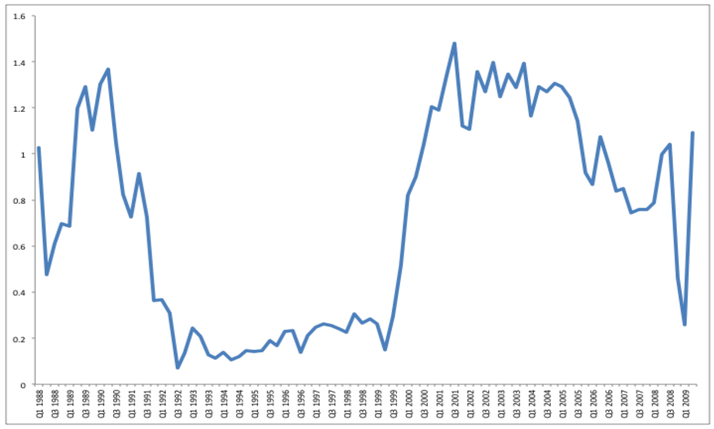

Figure 7: Variation explained by the G-7 factor, using rolling subsamples.

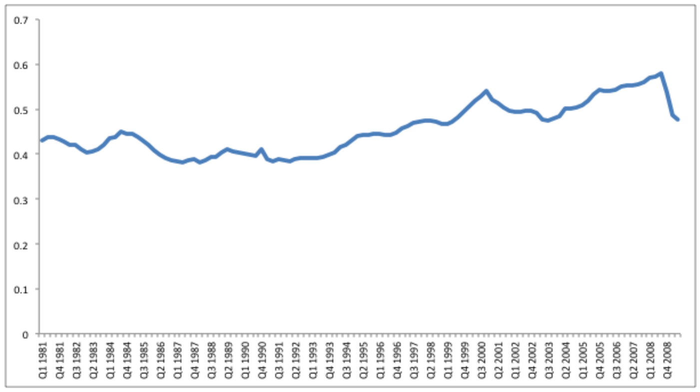

Figure 8: Average Trade Integration among G-7 Countries.

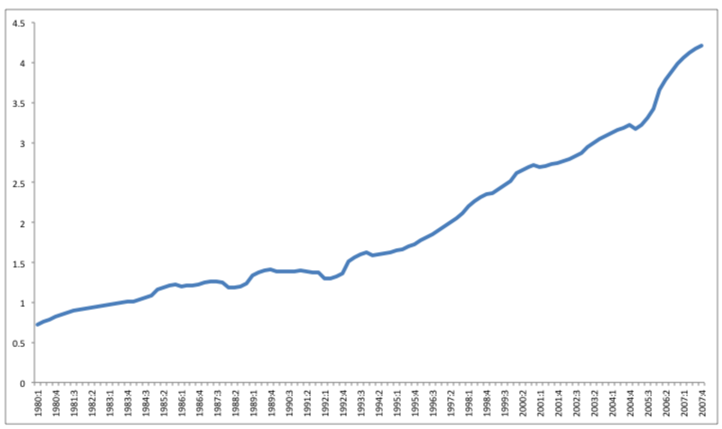

Figure 9: Average Financial Integration among G-7 Countries.

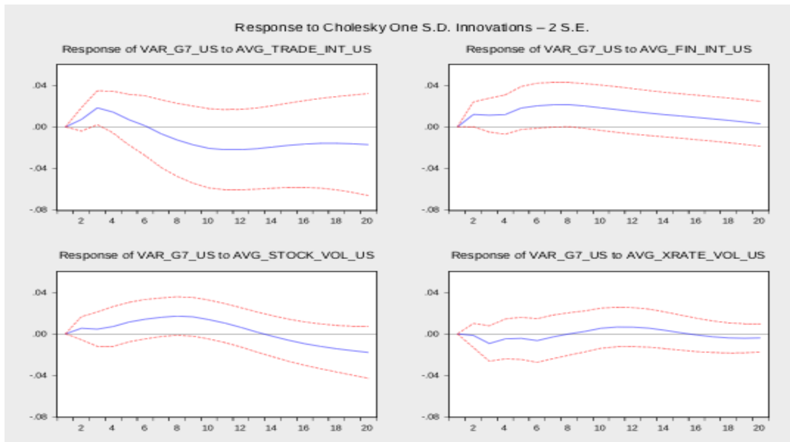

Figure 10a: Impulse Response of Importance of G-7 Factor, US.

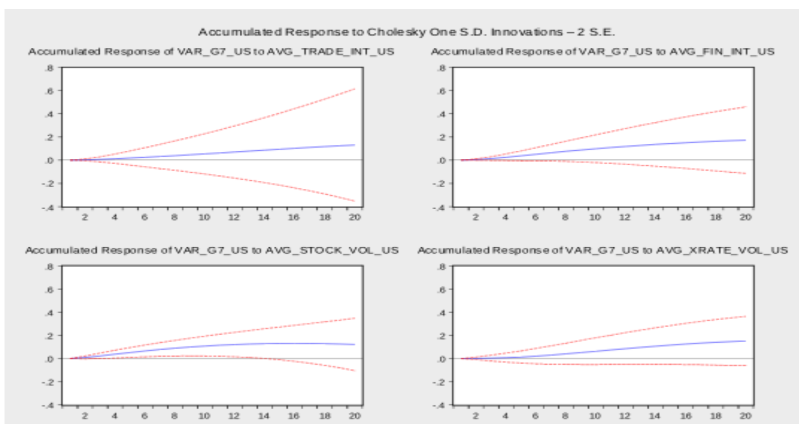

Figure 10a$'$: Accumulated Impulse Response of Importance of G-7 Factor, US.

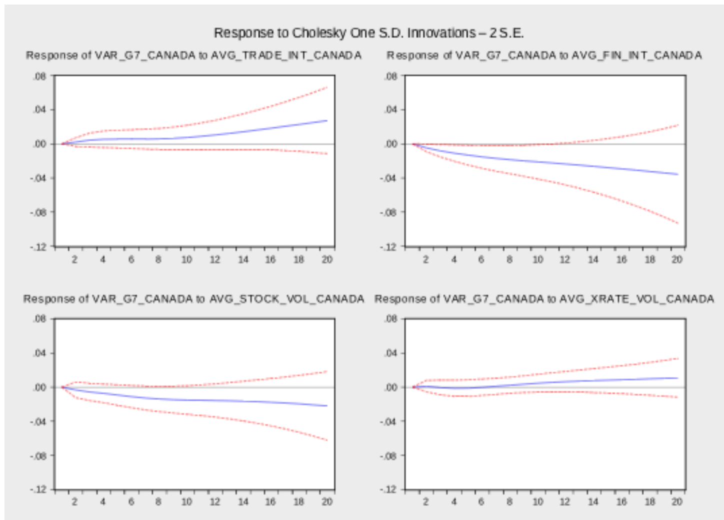

Figure 10b: Impulse Response of Importance of G-7 Factor, Canada.

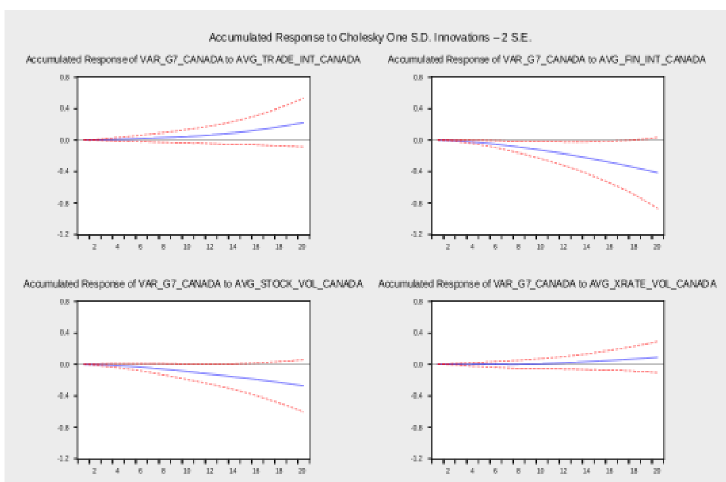

Figure 10b$'$: Accumulated Impulse Response of Importance of G-7 Factor, Canada.

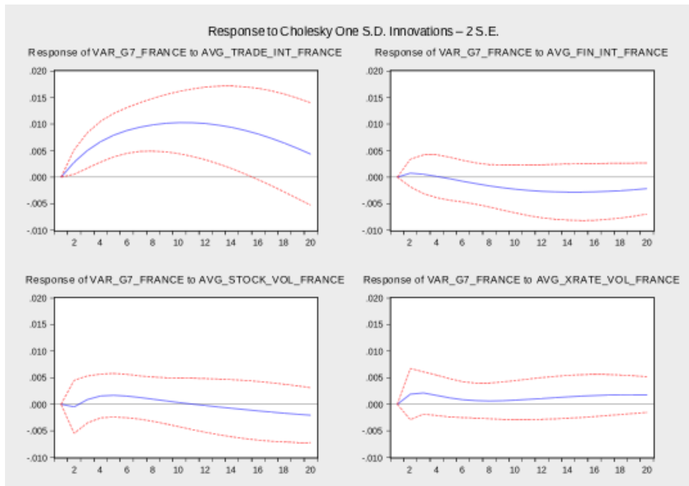

Figure 10c: Impulse Response of Importance of G-7 Factor, France.

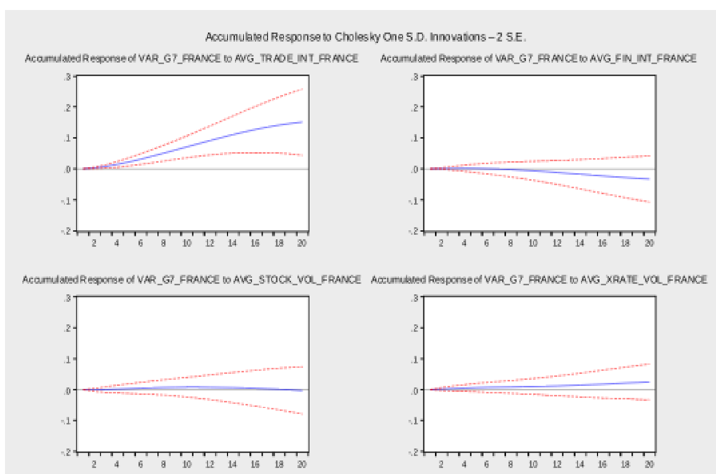

Figure 10c$'$: Accumulated Impulse Response of Importance of G-7 Factor, France.

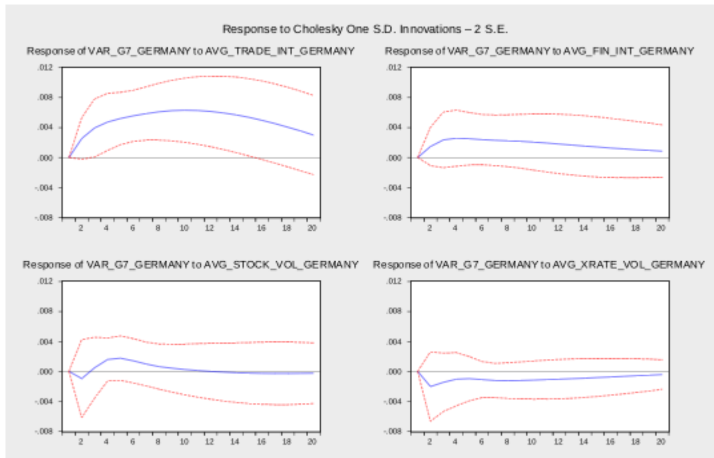

Figure 10d: Impulse Response of Importance of G-7 Factor, Germany.

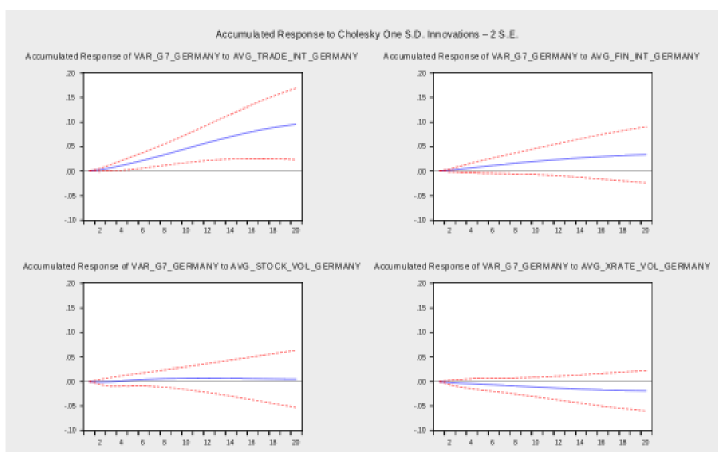

Figure 10d$'$: Accumulated Impulse Response of Importance of G-7 Factor, Germany.

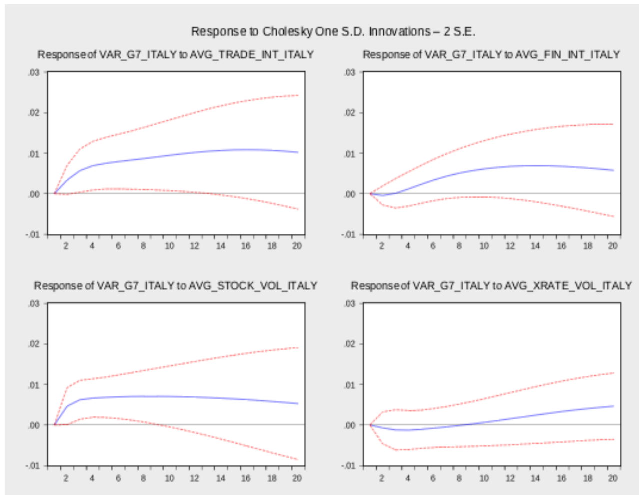

Figure 10e: Impulse Response of Importance of G-7 Factor, Italy.

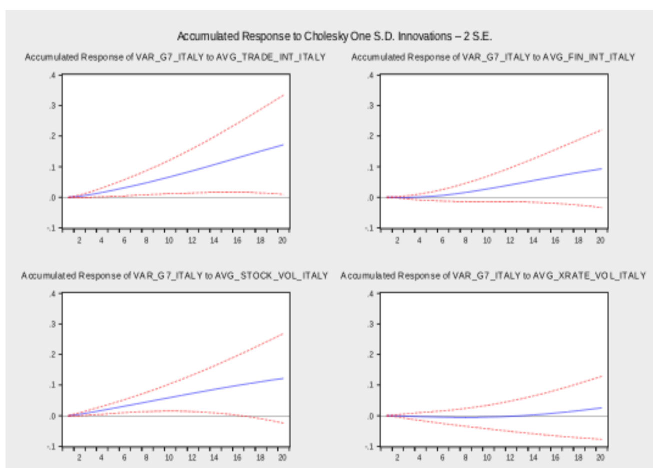

Figure 10e$'$: Accumulated Impulse Response of Importance of G-7 Factor, Italy.

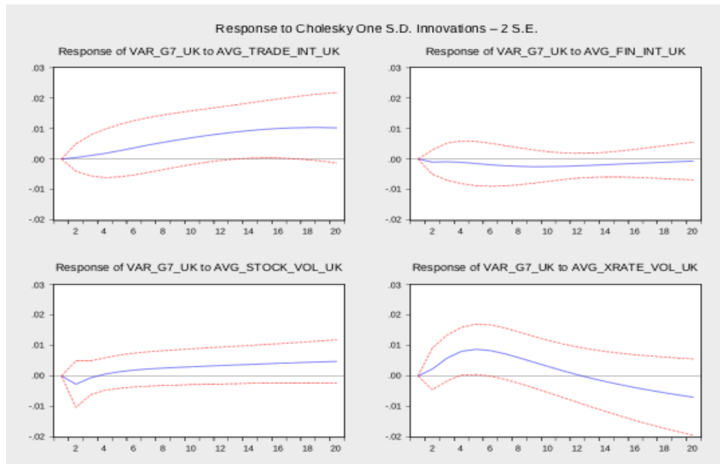

Figure 10f: Impulse Response of Importance of G-7 Factor, UK.

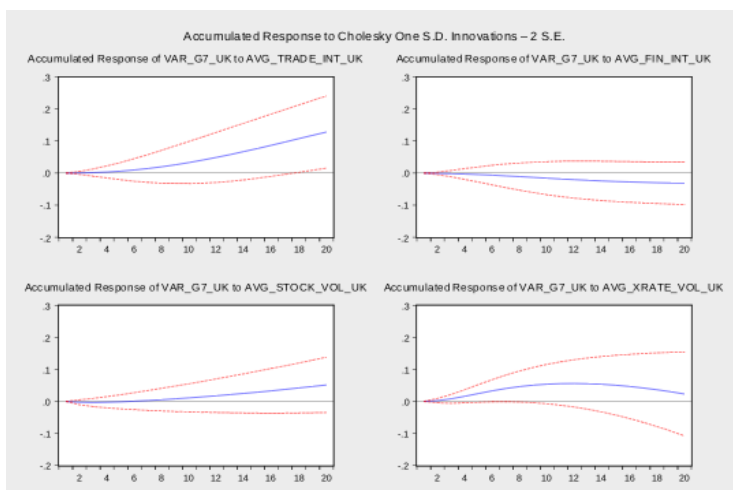

Figure 10f′: Accumulated Impulse Response of Importance of G-7 Factor, UK.

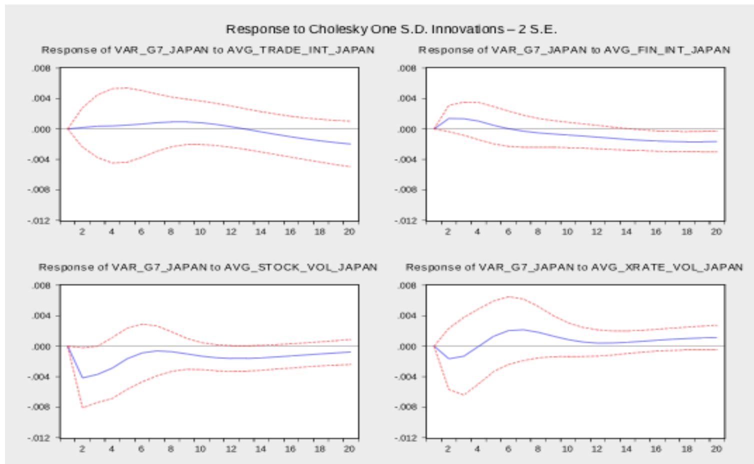

Figure 10g: Impulse Response of Importance of G-7 Factor, Japan.

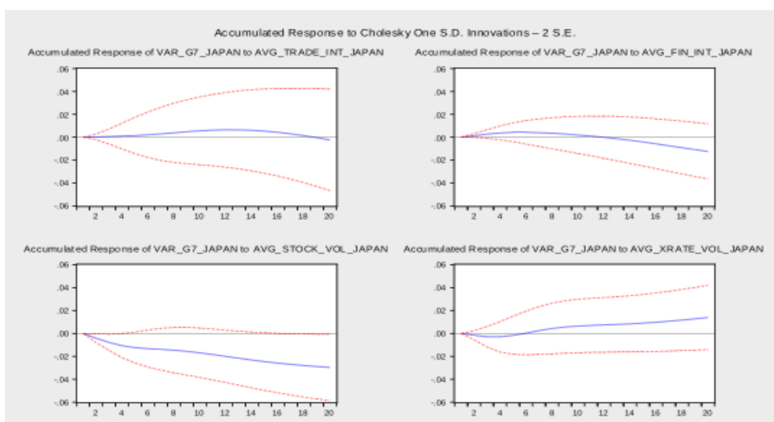

Figure 10g$'$: Accumulated Impulse Response of Importance of G-7 Factor, Japan.

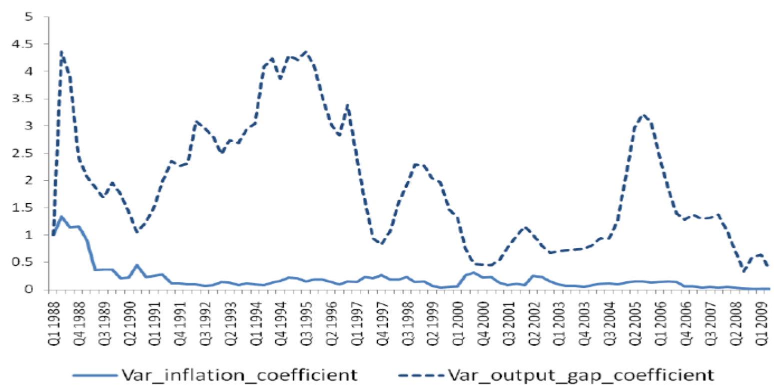

Figure 11: Time path of the variance of the inflation and the output gap coefficients, using rolling sub-samples.

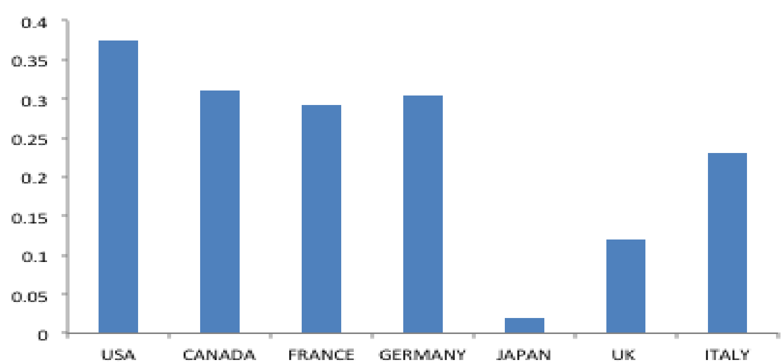

Figure 12: Variance explained by the G-7 factor using a common Taylor rule, 1981-2009.

In Tables 1-3 I report estimated mean parameters with 5% and 95% error bands in parenthesis. In Table 6 I describe sample mean (standard deviation) for the variables used in VAR. Tables 4 and 5 show results for structural break tests for average trade and financial integration series.

Country	G-7	Europe	G-7,1st Lag	Europe, 1st Lag
US	1	0	.014(−.04, .07)	0
Canada	1.03(.96, 1.09)	0	.29(−.23, .35)	0
France	.45(.38, .5)	1	.16(.11, .21)	.12(.05, .19)
Germany	.33(.29, .37)	.25(.19, .31)	.12(.08, .16)	.2(.14, .25)
Japan	.13(.09, .16)	0	.03(0, .06)	0
UK	.33(.26, .39)	0	.15(.09, .2)	0
Italy	.17(.11, .22)	.59(.49, .68)	.19(.14, .24)	.22(.15, .29)

Table 1: Factor loadings.

Country	AR parameter	Error variance
US	.18(.12, .23)	.33(.3, .35)
Canada	.02(−.03, .07)	.43(.4, .46)
France	.03(−.02, .08)	.35(.33, .38)
Germany	.27(.21, .32)	.24(.23, .25)
Japan	.02(−.03, .06)	.23(.22, .25)
UK	.03(0, .08)	.65(.61, .69)
Italy	.19(.14, .23)	.44(.41, .47)

Table 2: AR parameters and error variances.

Factor	Factor variance
G-7	.49(.45, .53)
Europe	.26(.23, .28)

Table 3: Factor variances.

Break test	F- statistic	Critical value (Bai-Perron (2003))	Break dates
0 vs. 1	349.8	8.6	$1997Q2, 1986Q1$
1 vs. 2	54.9	10.1	$2005Q2, 1993Q1$
2 vs. 3	15.3	11.1	$1986Q1, 1997Q2$
3 vs. 4	34.15	11.83	$1993Q1, 2005Q2$
4 vs. 5	0	12.25	–

Table 4: Multiple breakpoint tests(Trade integration).

Break test	F- statistic	Critical value (Bai-Perron (2003))	Break dates
0 vs. 1	433.68	8.6	$1998Q4, 1986Q1$
1 vs. 2	56.65	10.1	$2004Q1, 1994Q1$
2 vs. 3	93.65	11.1	$1994Q1, 1999Q1$
3 vs. 4	48.3	11.83	$1986Q1, 2004Q1$
4 vs. 5	5.6	12.25	–

Table 5: Multiple breakpoint tests(Financial integration).

Country	G-7 importance	Trade Integration	Fin Integration	Stock volatility	Exchange rate volatility
US	.28(.02)	.2(.0006)	1.03(.12)	62.63(1834.9)	2.25(.55)
Canada	.1(.006)	.66(.01)	1.57(.13)	15.732(144)	1.52(.33)
France	.06(.003)	.58(.006)	1.64(.58)	16.04(189.4)	.76(.01)
Germany	.05(.002)	.47(.001)	2.08(1.05)	23(113.78)	.55(.04)
Japan	.04(.004)	.2(.0007)	.98(.04)	55(1307)	8.2(7.8)
UK	.08(.005)	.53(.0005)	4.45(1.54)	111(1058.85)	2.63(.95)
Italy	.06(.004)	.45(.002)	1.21(.33)	77(288)	1.48(1.72)

Table 6: Summary Statistics for VAR.