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Cross country co-movements of GDP growth rates: are they systematic?

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Abstract

Using factor analysis this paper examines discernable patterns of real GDP growth comovementsacross 97 countries, using consistent time series data for the period 1961-2008.Of these countries only 21 are found to form three statistically significant groupings, wheremembership count exceeds more than two. Ten major OECD European countries plus Japanand Hong Kong form the first well-defined common bloc of countries (G12). The second bloc,consisting of six major Asian countries (G6), have GDP growth rates that exhibit a very highdegree of correlation, based on their robust factor loadings. The last group of countiescollectively witnessed a very substantial degree of cross-country growth co-movementsconstituted four (G4) Anglo-Saxon countries. We conclude that, inter alia, geographicalproximity, cultural ties and the level of socio-economic and financial ties among countriesdetermine the global systematic co-movements of growth rates. This paper also identifies theextent to which the GDP growth rates in the remaining 76 countries are intertwined with thatof the above three groups of countries. We conclude that the recent US recession is expectedto initially engulf other Anglo-Saxon countries as well as G12 and G6 countries, beforeexerting its adverse knock-on effects to the rest of the world.

Keywords

Cross, country, movements, GDP, growth, rates, are, they, systematic

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CROSS-COUNTRY CO-MOVEMENTS OF GDP GROWTH RATES: ARE THEY SYSTEMATIC?

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Using factor analysis this paper examines discernable patterns of real GDP growth co-movements across 97 countries, using consistent time series data for the period 1961-2008. Of these countries only 21 are found to form three statistically significant groupings, where membership count exceeds more than two. Ten major OECD European countries plus Japan and Hong Kong form the first well-defined common bloc of countries (G12). The second bloc, consisting of six major Asian countries (G6), have GDP growth rates that exhibit a very high degree of correlation, based on their robust factor loadings. The last group of counties collectively witnessed a very substantial degree of cross-country growth co-movements constituted four (G4) Anglo-Saxon countries. We conclude that, inter alia, geographical proximity, cultural ties and the level of socio-economic and financial ties among countries determine the global systematic co-movements of growth rates. This paper also identifies the extent to which the GDP growth rates in the remaining 76 countries are intertwined with that of the above three groups of countries. We conclude that the recent US recession is expected to initially engulf other Anglo-Saxon countries as well as G12 and G6 countries, before exerting its adverse knock-on effects to the rest of the world.

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Keywords: Recession, Economic linkages, Factor analysis, Cross-country GDP growth

1. Introduction

There has been considerable interest in the literature on the impact of globalization and regional economic integration on business cycle synchronization. The conventional view argues that both these developments have contributed to increased trade and financial linkages resulting in closer cross-border economic interdependence and a convergence of business cycle synchronization. Increased trade and financial interdependence increases the sensitivity of economies to external shocks and increases business cycle co-movements due to widening the channels by which shocks can spill-over to other economies (Kose, Otrok and Prasad, 2008). On the other hand the impressive growth performance of emerging market economies, such as China and India, have occurred despite sluggish economic growth and recessionary conditions in industrialized economies such as the United States, Europe and Japan. This has resulted in some observers questioning the potency of international channels of business cycle transmission, and that the business cycles of emerging market economies have become de-coupled from that of the industrial economies. Studies have also suggested that there is evidence of a common world business cycle, supplemented by, less important, region specific factors (Kose, Otrok and Whiteman, 2003)[1].

In the context of this debate, the paper conducts a factor analysis, using both the principal components (PC) and maximum likelihood (ML) methods, to examine discernable patterns of real GDP growth rate co-movements across 97 countries at various stages of economic development and geographical locations. The analysis is conducted using consistent time series data for the period 1961-2008. A primary objective is to identify whether there are statistically significant country groupings based on real GDP growth co-movements, which would suggest that regional and/or other factors contribute to business cycle synchronization and may be more important than world (global) factors. In this sense our results can be interpreted as indicating the degree and importance of global synchronization relative to de-coupling factors such as that arising from regional integration and synchronisation.

Our results suggest that of the 97 countries considered only 21 are found to form *three statistically significant groupings*, where membership count exceeds more than two. Ten

[1] Hence there may be both de-coupling and increased synchronisation taking place at the same time.

major OECD European countries plus Japan and Hong Kong form the first well-defined common bloc of countries (G12) with highly correlated or synchronized GDP growth rates. The second bloc, consisting of six major Asian countries (G6), have GDP growth rates that exhibit a very high degree of correlation, based on their robust factor loadings. The last group of countries collectively witnessed a very substantial degree of cross-country growth co-movements and constituted four (G4) Anglo-Saxon countries (Australia, Canada, the UK and the US). The paper also considers the existence and significance of interactions between these three groups.

Overall, our results appear consistent with the findings of Kose, Otrok and Prasad (2008). They find that business cycle synchronization within industrial and emerging market economies has become more important, while business cycle synchronization has become less important between them over the period 1985-2005. Group specific factors have, therefore, become more important in explaining business cycle synchronization. Hence there may be de-coupling of the business cycles between industrial and emerging market economies (China and India), rather than convergence of business cycles between these groups.

This paper also identifies the extent to which the GDP growth rates in the remaining 76 countries are intertwined with that of the above three groups of countries. Of these, 43 countries showed little evidence of interaction. The extent of influence of the major three blocs of countries on the economic growth of the remaining 33 countries is also determined, providing important policy implications particularly in the context of the recent global financial crisis. According to our results, there is a bi-directional Granger causality pairwise across all of the G12, G6 and G4 countries in terms of their GDP growth movements. This means that the recent US recession could be expected to initially engulf other Anglo-Saxon countries as well as G12 and G6 countries, before exerting its adverse knock-on effects to the rest of the world.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on business cycle synchronization, highlighting key explanatory factors contributing to co-movements of GDP growth. Section 3 presents the empirical methodology utilized in the paper. Section 4 describes the summary statistics and the sources and definition of the annual time series data employed for the period 1961-2008. Section 5 discusses the empirical results. Section 6 provides a brief discussion of the possible reasons for the country groups identified and the extent of their influence on other nations outside these groups and policy implications. Section 7 provides some concluding remarks.

2. Business Cycle Sychronisation - Literature Review

While there is considerable empirical literature indicating a high degree of synchronisation between the business cycles[2] of industrialised economies (Gerlach, 1988; Backus and Kehoe, 1992; Baxter, 1995; Canova and Marrinan, 1998; Otto, Voss and Willard, 2001; and Imbs, 2003), little unanimity exists over the theoretical explanation for this. Common explanations include: (1) economic interdependencies arising from trade and financial flows (Backus, Kehoe and Kydland, 1992; Imbs, 2003)[3],; (2) the occurrence of common external shocks (Gregory, Head and Raynauld, 1995; Kose, Otrok and Whiteman, 2003); (3) common economic structures (Imbs, 2000; Otto, Voss and Willard, 2001; Kalemi-Ozcan, Sorensen and Yosha, 2001; Imbs, 2001; and Clark and Wincoop, 2001); (4) monetary and fiscal policy coordination[4]; (5) common language and cultural factors (Artis, 2000); (6) the strength of economic transmission channels (Imbs, 2003); and (7) technical change and new technology adoption (Tang, Goenewold and Leung, 2008; Koren and Tenreyo, 2007).

[2] Or cross country co-movements of GDP as emphasised in this paper.

[3] Economic theory, however, is ambiguous about the impact of increased trade and financial linkages on business cycle properties (see Kose, Otrok and Whiteman, 2003). Papageorgiou (2002) shows that trade intensity may not be critical in the determination of economic growth, and possible business cycle correlation, for high and low income countries, but is pivotal in grouping the growth, and possible business cycle correlation, of high and low growth middle income countries.

[4] Such as for those countries in the Eurozone.

Trade in goods and services is the most commonly advanced transmission mechanism contributing to fluctuations in economic activity across countries (Otto, Voss and Willard, 2001)[5] through both demand and supply side spill-overs (Kose, Otrok and Whiteman, 2003). The importance of these for business cycle correlation depends upon the extent of bilateral trade between two countries, and the importance of such trade to aggregate demand and supply of both countries (Otto, Voss and Willard, 2001). Both types of spill-over suggest a positive relationship between bilateral trade and business cycle co-movements[6], as found in a number of studies[7]. However, should trade linkages encourage inter-industry specialisation across countries, and industry specific shocks become important in driving business cycles, then the co-movement of international business cycles is likely to diminish as countries are impacted by idiosyncratic shocks (Frankel and Rose, 1998; Kose, Otrok and Whiteman, 2003; Kose and Yi, 2001, 2002).

Consequently, in theory, the role of bilateral trade in explaining cross country business cycle co-movements is ambiguous. Despite this, there is no evidence to support the viewpoint that greater trade through specialisation leads to less synchronised economies, particularly where such specialisation takes place in the context of intra-industry trade (Otto, Voss and Willard (2001). For example, Frankel and Rose (1998) find a strong and robust direct positive relationship between trade and business cycle synchronisation, arguing that trade-induced specialisation has a small effect on business cycles and is dominated by the positive direct link. Harrigan (2001) and Harrigan and Zakrajsec (2000), on the other hand, show that

[5] These authors find that international trade is the most important transmission channel of business cycles.

[6] For a more detailed explanation of the link between international trade and business cycle co-movement see Otto, Voss and Willard (2001) and Kose and Yi (2001, 2002).

[7] Frankel and Rose (1998), Clark and Wincoop (2001), Otto, Voss nd Willard (2001), Calderon, Chong and Stein (2002), using cross country or cross region panel regressions, find that among industrialised countries, pairs of countries that trade most with each other have a robust positive and high degree of business cycle co-movement. Studies by Fidrmuc (2002) and Gruben, Koo and Millis (2002) find that intra-industry trade is more important than inter-industry trade or total trade in determining GDP co-movements. Canova and Dellas (1993), Schmitt-Grohe (1998) and Prasad (1999) provide a time series analysis on the transmission of business cycles through international trade.

indirect trade induced specialisation patterns are significant and consistent with theory. Imbs (2003) also finds a strong overall effect of trade on business cycle co-movements, with a sizeable portion of this working through intra-industry trade.

Financial market linkages is another important mechanism for the international transmission of business cycle shocks (Meyer, 2001; Otto, Voss and Willard, 2001; Imbs, 2003; Kose, Otrok and Whiteman, 2003)[8]. While financial linkages can be anticipated to have both direct and indirect impacts on output co-movements, theory is again ambiguous over the direction and degree of such synchronisation. Financial linkages could encourage specialisation in production by channelling capital finance towards sectors in which countries have a comparative advantage. This could reduce business cycle co-movements as industry, or country, specific shocks become more important. This could be accompanied by the use of international financial markets to diversify consumption risk (Kalemli-Ozcan, Sorensen and Yosha, 2003) resulting in stronger co-movements of consumption across countries.

The empirical evidence on this issue is also ambiguous. For example, Heathcote and Perri (2003) argue that the US business cycle has become increasingly idiosyncratic due to the increasing share of international assets held in the US. Other empirical studies suggest, however, that capital flows are correlated internationally, and that financial integration tends to synchronise business cycles (see for instance Claessens, Dornbusch and Park, 2001; Calvo and Reishart, 1996; or Cashin, Kumar and McDermott, 1995). Thus the link between finance and cycle correlations is ambiguous for two reasons: first, the sign of the direct link is unclear in general, second, the indirect specialisation effect could either mitigate or reinforce the direct link.

Economies with similar economic structures, and subject to sector specific shocks, are also likely to have substantial business cycle synchronisation, although relatively little empirical analysis has been conducted on this issue (Imbs, 2000). Studies by Otto, Voss and

[8] For more discussion on the possible transmission of shocks emanating from FDI, trade in equities and long term bonds for the international transmission of business cycle shocks, see Otto, Voss and Willard (2001).

Willard (2001), Kalemi-Ozcan, Sorensen and Yosha (2001), Imbs (2001) and Clark and Wincoop (2001) find a significant positive role for an index of similarity in production structures on business cycle synchronization. Although these studies suggest a sizeable direct impact of specialisation on business cycles, none consider the possibility that specialisation could be an indirect manifestation of trade or financial integration.

Monetary policy coordination is another potential explanation for common business cycles[9] [10]. Frankel and Rose (1998), for example, viewed the high correlation of output among members of the European Exchange Rate Mechanism as being partly due to their common monetary policy. Otto, Voss and Willard (2001), however, argue that common monetary policies between countries reflects one of three factors: (1) similar responses to common shocks; (2) similar responses to shocks that are transmitted from another country; or (3) explicit of implicit monetary policy coordination. In the first case common monetary policies can arise from the existence of common economic structures and common underlying shocks between countries, under a flexible bilateral exchange rate. But the common monetary policies and business cycle behaviour are indicative of common economic structures and underlying shocks. In the second case, again for a flexible exchange rate regime, if two countries are closely integrated through trade and financial markets, then an idiosyncratic shock to one can be transferred to the other through these linkages. If the two countries share similar monetary policy objectives, then common business cycle and monetary policy behaviour can be observed, although in this case the underlying explanation is the presence of other transmission channels. With a fixed bilateral exchange rate the monetary policies of two countries are explicitly and automatically coordinated. In this case, monetary policy serves as

[9] Theory is not clear as to whether the implementation of coordinated policies is needed from increasing trade and financial linkages. Oudiz and Sachs (1984) argue that there is while Obstfeld and Rogoff (2002) suggest otherwise.

[10] Monetary policy coordination is likely to lead to closer business cycle coordination where there is similarity in cross country 'liquidity effects' (see Lastrapes and McMillin, 2004). That is the negative response of interest rates to monetary shocks. The existence and divergence of liquidity effects across countries will likely depend upon divergences in the institutional aspects of financial markets (e.g. transaction costs, size, efficiency and importance of financial intermediaries) (see Lastrapes amd McMillin, 2004, p.891).

a transmission channel for idiosyncratic shocks and also ensures a common response to common shocks. In both instances the coordinated monetary policy is likely to contribute to stronger correlation of growth cycles such as for the Eurozone economies.

La Porta et al. (1998) argue that common legal systems and accounting standards can contribute to synchronised business cycles. A country's legal structure provides the basis for trade in goods and financial assets and enforcement of property rights. Hence, countries with a similar legal system covering: the protection of: economic agents, corporate governance, investor protection, and labour market organisation, are likely to have more integrated financial markets and institutions and more synchronised business cycles arising from common shocks. Relatedly, accounting standards are an important aspect of corporate governance relating to investor protection. The higher the quality of accounting standards the less costly it is for firms to engage in trade and investment overseas. Countries with similar accounting standards are, therefore, more likely to engage in international trade and finance flows with each other, contributing to greater business cycle synchronisation.

Proximity of countries and common language may also be important in business cycle synchronisation. A common language may promote economic integration by influencing both the level and depth of communication and flow of ideas between countries, while proximity may pick up common historical ties between particular countries, reduce transportation costs and stimulate trade linkages (Krugman, 1991; Otto, Voss and Willard, 2001).

Daly (1993) argues that deregulation across countries can result in convergence of the degree of flexibility of economies, so that the effects of shocks are likely to be similar. Hence countries that have pursued reforms are anticipated to be more likely to respond similarly to common shocks. If structural reforms have made countries more flexible, then they are also likely to respond more quickly to external shocks. Bernard and Durlauf (1995) suggest and test the new definitions of convergence and common trends for per capita output for 15

OECD economies. While they reject any significant convergence, they find substantial evidence of common trends.

The development, use and speed of adoption of new technology presents another potential source of business cycle synchronisation[11]. From a supply side perspective, new technologies can contribute to better means of production, generating an expansion in investment, employment and output. New technologies may also be an important source of cyclical behaviour through their effects on financial markets, such as the technology driven stock market bubble of the late 1990s. Tang, Goenewold and Leung (2008) present results to suggest that countries with little technological capacity are likely to experience higher growth volatility, and more synchronised business cycles, because they tend to be heavily dependent on a single sector or single commodity[12]. An external shock for such countries, such as a deterioration of the terms of trade, will produce a severe downturn and greater likelihood of business cycle synchronisation (see also Koren and Tenreyro, 2007). Such countries are also likely to be heavily dependent on foreign investment and technology in their drive for industrialisation. Industries that are more dependent on external finance are hit harder during recession, especially when they operate under a poor financial system (Braun and Larrain, 2005) and are, therefore, likely to have more synchronised business cycles.

In the following section a factor analysis is conducted to investigate the relationship among the GDP growth rates of 99 countries, aimed at identifying the existence, or otherwise, of systematic covariation among them.

3. Econometric Methodology

Traditional factor analysis assumes that time series data have no unit roots. Thus, the empirical results indicate that real GDP (Y_t) are mainly I(1) and GDP growth rates $ln(Y_t/Y_{t-1})$

[11] See Schlei (1986) for an explanation of the role of technology in driving economic cycles.

[12] Koren and Tenreyo (2007) provide a theory of technological diversification to explain why GDP is more volatile in low income countries.

are I(0). The results have not been reported in this paper but they are available from the authors upon request. Factor analysis is one of the most well-known methods of classical multivariate analysis (Hair *et al.*, 1998; Tabachnick and Fidell, 2001; Tsay, 2002). Factor analysis obtains a reduced set of uncorrelated latent variables using a set of linear combinations of the original variables, so as to maximize the variance of these components. Specifically, for a given multivariate set of k variables, the model can be described as follows:

$$\begin{cases} r_1 - \mu_1 = \ell_{11} f_1 + \ell_{12} f_2 + \ldots + \ell_{1m} f_m + \varepsilon_1 \\ r_2 - \mu_2 = \ell_{21} f_1 + \ell_{22} f_2 + \ldots + \ell_{2m} f_m + \varepsilon_2 \\ \quad \vdots \;=\; \vdots \\ r_k - \mu_k = \ell_{k1} f_1 + \ell_{k2} f_2 + \ldots + \ell_{km} f_m + \varepsilon_k \end{cases} \tag{1}$$

or in matrix notation we can write:

$$\boldsymbol{r} - \boldsymbol{\mu} = \boldsymbol{LF} + \boldsymbol{\varepsilon} \tag{2}$$

with $m < k$ and where $\boldsymbol{r} = (r_1, r_2, \ldots, r_k)$ denotes the multivariate vector of GDP growth rates, $\boldsymbol{\mu} = (\mu_1, \mu_2, \ldots, \mu_k)$ is the corresponding mean vector, $\boldsymbol{F} = (f_1, f_2, \ldots, f_k)$ is the resulting common factor vector, $\boldsymbol{L} = [\ell_{ij}]_{k\times m}$ is the matrix of factor loadings, ℓ_{ij} denotes the loading of the i^{th} variable on the j^{th} factor and $\boldsymbol{\varepsilon} = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_k)$ is the specific error of r_i.

2.1 Factor estimation methods

There are two most widely used methods to estimate an orthogonal factor model. The first method is principle component (PC) analysis which does not require the normality assumption of the data and the prior specification of the number of common factors. Depending on the measurement scale of the variables included, this method can be used based on both the covariance and correlation matrixes. The maximum likelihood (ML) method on the other hand is the second most widely used estimation method, and is based on the normal density function and requires a pre-specification of the number of common factors. We first briefly discuss the PC method below.

Let us assume that $(\hat{\lambda}_1, \hat{\boldsymbol{e}}_1), (\hat{\lambda}_2, \hat{\boldsymbol{e}}_2), \ldots, (\hat{\lambda}_k, \hat{\boldsymbol{e}}_k)$ are pairs of the eigenvalues and eigenvectors of the sample covariance matrix $\hat{\Sigma}_r$, where $\hat{\lambda}_1 \geq \hat{\lambda}_2 \geq \ldots \geq \hat{\lambda}_k$ and $m < k$ meaning that the number of latent common factors should be less than the number of original variables. We can then define the matrix of factor loading as follows:

$$\hat{\boldsymbol{L}} \equiv [\hat{\ell}_{ij}] = \left[\sqrt{\hat{\lambda}_1} \hat{\boldsymbol{e}}_1 \mid \sqrt{\hat{\lambda}_2} \hat{\boldsymbol{e}}_2 \mid \ldots \mid \sqrt{\hat{\lambda}_m} \hat{\boldsymbol{e}}_m \right] \quad (3)$$

The diagonal elements of the matrix $\hat{\Sigma}_r - \hat{\boldsymbol{L}}\hat{\boldsymbol{L}}'$ consist of the estimated specific variances. This means that $\hat{\boldsymbol{\Psi}} = \text{diag}\{\hat{\Psi}_1, \hat{\Psi}_2, \ldots, \hat{\Psi}_k\}$, where $\hat{\Psi}_i = \hat{\sigma}_{ii,r} - \sum_{j=1}^{m} \hat{\ell}_{ij}^2$, and $\hat{\sigma}_{ii,r}$ is the $(i, i)^{\text{th}}$ element of $\hat{\Sigma}_r$. We can estimate the communalities by $\hat{c}_i^2 = \hat{\ell}_{i1}^2 + \hat{\ell}_{i2}^2 + \ldots + \hat{\ell}_{im}^2$. Using this method the error matrix associated with our approximation is equal to $\hat{\Sigma}_r - (\hat{\boldsymbol{L}}\hat{\boldsymbol{L}}' + \hat{\boldsymbol{\Psi}})$, which should ideally be a null matrix. The sum of squared elements of $\hat{\Sigma}_r - (\hat{\boldsymbol{L}}\hat{\boldsymbol{L}}' + \hat{\boldsymbol{\Psi}})$ is always less than or equal to $\hat{\lambda}_{m+1}^2 + \hat{\lambda}_{m+2}^2 + \ldots + \hat{\lambda}_k^2$. Hence the resulting approximation error is determined by the sum of squares of the excluded eigenvalues. According to the solution in equation (3), as the number of common factors or m increases the computed factor loadings remain unchanged

In the ML method, on the other hand, it is assumed that the common factors (or $\boldsymbol{F}$) and the specific factors (or $\boldsymbol{\varepsilon}$) are jointly normal. We can then conclude that $\boldsymbol{r}$ is multivariate normal with mean $\boldsymbol{\mu}$ and covariance matrix $\Sigma_r = \boldsymbol{L}\boldsymbol{L}' + \boldsymbol{\Psi}$. Therefore, one can use the ML method to estimate $\boldsymbol{L}$ and $\boldsymbol{\Psi}$ subject to $\boldsymbol{L}'\boldsymbol{\Psi}^{-1}\boldsymbol{L} = \Delta$, which is a diagonal matrix. The sample mean can be considered as a proxy for $\boldsymbol{\mu}$. For a detailed account of this method, see Johnson and Wichern (2002). In this method the number of common factors should be known *a priori*.

2.2 Factor rotation

If $\boldsymbol{Y}$ is a $m \times m$ orthogonal matrix, the following relations can be written: $\boldsymbol{LL}' + \boldsymbol{\Psi} = \boldsymbol{LYY'L}' + \boldsymbol{\Psi} = \boldsymbol{L}^*(\boldsymbol{L}^*)' + \boldsymbol{\Psi}$ and $\boldsymbol{r} - \boldsymbol{\mu} = \boldsymbol{LF} + \boldsymbol{\varepsilon} = \boldsymbol{L}^*\boldsymbol{F}^* + \boldsymbol{\varepsilon}$ in which $\boldsymbol{L}^* = \boldsymbol{LY}$ and $\boldsymbol{F}^* = \boldsymbol{Y'F}$. Under an orthogonal transformation the communalities and the specific variances do not change. Thus, it is possible to find $\boldsymbol{Y}$ (an orthogonal matrix) to transform the factor model in such a way that the loadings on the common factors are easier to interpret. This transformation involves rotating the common factors in the *m*-dimensional space. In practice there are many ways for rotating the common factors. The varimax method (Kaiser, 1958) is a rotation method which is widely used in the literature and works well in many applications. Let the rotated matrix of factor loadings be $\boldsymbol{L}^* = [\ell_{ij}^*]$ and the i^{th} communalities are shown by c_i^2. We can then define $\tilde{\ell}_{ij}^* = \ell_{ij}^* / c_i$ as the rotated coefficients scaled by the (positive) square root of communalities. In the varimax method the orthogonal matrix **Y** is chosen in such a manner that it maximizes the quantity of:

$$V = \frac{1}{k}\sum_{j=1}^{m}\left[\sum_{i=1}^{k}(\tilde{\ell}_{ij}^*)^4 - \frac{1}{k}\left(\sum_{i=1}^{k}\tilde{\ell}_{ij}^{*2}\right)^2\right] \tag{4}$$

The interpretation of this relation is straightforward. When *V* is maximized it means that the squares of the loadings on each factor are spread out as much as possible. The aim is to facilitate the interpretations of common factors by finding groups of very large and very small coefficients in any column of the rotated matrix of factor loadings.

Chamberlain and Rothschild (1983) and Fornie et al. (2000) and Stock and Watson (2002)

4. Data

The data in this paper include annual real GDP growth rates of 97 countries for the last 48 years (1961-2008) obtained from the World Bank (2004), OECD (2009) and International

Monetary Fund (2009).[13] Table 1 presents the descriptive statistics of the data, containing sample means, standard deviations, and the Jarque-Bera statistics and its *p*-value. During the period 1961-2008 the five least volatile countries in terms of the magnitude of standard deviation of real GDP growth rates were Norway, the UK, Austria, Australia and Sri Lanka and the four most volatile ones were Liberia, St. Vincent & the Grenadines, Oman, Rwanda and Gabon. The calculated Jarque-Bera statistics and corresponding *p*-values are used to test for the normality assumption. Based on this test the normality assumption is rejected at least at the 10 per cent level of significance for 54 per cent of the sample countries (52 out of 97). Based on the average annual GDP growth rates over this period, the five slowest growing economies were Democratic Republic of Congo (0.75 per cent), Haiti (0.78 per cent), Central African Republic (1.43 per cent), Liberia (1.61 per cent), Guyana (1.79 per cent). On the other hand the five fastest growing countries were Oman (9.62 per cent), Botswana (9.23 per cent), China (8.09 per cent), Singapore (7.93 per cent) and Korea (7.12 per cent). GDP growth rates are stationary for all 97 countries. Due to space limitations the KPSS (Kwiatkowski, Phillips, Schmidt, and Shin, 1992) unit test results have not been reported in this paper but they are available from the authors upon request.

[Table 1 about here]

5. Empirical Results

4.1 Factor analysis results

We first compute the correlation coefficient matrix and the anti-image correlation coefficient matrix including all 97 sample countries for which consistent time series data on real GDP growth could have been obtained for the period 1961-2008. We then reduced the number of countries from 97 to 21 based on the following two criteria. First, a country is kept in the sample only if the magnitude of the resulting measure of sampling adequacy (MSA) has exceeded 0.50. Second, if there were only one or two countries with statistically significant

[13] It should be noted that the authors could obtain consistently defined real GDP data from the IMF (2009) and the World Bank (2008) only for the period 1961-2008 for 97 countries.

factor loadings appearing on each vector, those countries have also been excluded regardless of their MSAs. It should be noted that the elements located on the main diagonal of the anti-image correlation coefficient matrix are referred to as the measure of sampling adequacy or MSA for the corresponding individual variables in factor analysis. MSA is computed by using the following relationship:

$$\mathrm{MSA_i} = \sum_{i \neq j} \rho_{ij}^2 \div \left(\sum_{i \neq j} \rho_{ij}^2 + \sum_{i \neq j} a_{ij}^2 \right) \qquad (5)$$

where ρ_{ij} is the simple correlation coefficient between variables *i* and *j* and a_{ij} is the partial correlation coefficient between variables *i* and *j*.

Table 2 shows the extent to which real GDP growth rates are correlated pairwise for all of the 21 countries short-listed based on the previous two criteria. Out of 210 cells below the main diagonal of the correlation matrix, there are 109 coefficients, or 52 per cent of the total number of cells (shown in italics), which are above the 5 per cent critical value of 0.30, and thus statistically significant and different from zero. The five highest correlation coefficients belong to Belgium-France (0.84); Italy-France (0.80); Canada-US (0.78); Austria-France (0.73). It is interesting that pairwise the highest correlation coefficients are between countries in the same continent. The anti-image correlation coefficient matrix has also been reported at the bottom of Table 2, containing the negatives of the partial correlation coefficients. Factor analysis is statistically acceptable if most of the off-diagonal elements, which are an indication of correlations not attributable to the resulting common factors, are very small, and at the same time the MSA for each variable on the diagonal of the anti-image correlation matrix is relatively high.

As can be seen from Table 2 all of the elements on the main diagonal of the anti image matrix are larger than the acceptable level of 0.50, varying from a minimum of 0.61 (the UK) to a maximum of 0.94 (Italy and Hong Kong). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.810. We also conducted the Bartlett sphericity test, and, according to the test results $\left[\chi^2 = 724,\ \text{p-value=0.00}\right]$, the null hypothesis that the correlation matrix was an identity matrix was rejected.

[Tables 2 and 3 about here]

In order to obtain a clearer picture of groupings of these 21 countries based on the co-movement of their GDP growth rates during the last 48 years, a factor analysis of the correlation matrix has been conducted. The resulting eigenvalues for only the first three common factors were greater than unity. We reached the same conclusion using the Scree plot (not reported but available from the authors upon request) as a criterion to determine the number of common factors.

After extracting the factor loadings by the principal component method, the resulting loadings have been rotated by the varimax method to facilitate the interpretation of our results which are presented in Table 3. The proportion of variance explained by each factor is also shown in Table 3, indicating that the extracted three factors altogether account for 66.4 per cent of the total variance arising from our 21 country series. Of total variance explained the contribution of the resulting three common factors are 41.2 per cent (representing 12 countries), 16.1 per cent (representing 6 countries) and 9.1 per cent (with four countries). As the number of countries in each vector increases so does the proportion of variance explained.

According to Table 3 the first common factor has relatively larger loadings (>0.40) for the following 12 counties, but relatively lower coefficients for the other nine countries: France (0.887), Belgium (0.860), Austria (0.816) Spain (0.812), Italy (0.781), Switzerland (0.779), Japan (0.759), Portugal (0.747), Germany (0.741), Greece (0.622), Sweden (0.607) and Hong Kong (0.414). We henceforth refer to this first common factor as the G12 (Group of 12).

While the second common factor possesses the highest loadings for the following 6 counties, which we refer to as the G6 group hereafter: Malaysia (0.855), Thailand (0.838), Indonesia (0.817), Korea (0.741), Singapore (0.640) and Hong Kong (0.503). Thus it can be argued that this vector represents mainly the co-movements of the GDP growth rates in neighbouring Asian countries. It should be noted that out of 21 countries only Hong Kong appears on more than one common factor, and the loadings for the remaining 20 countries are not so called ‘complex’. The last group (G4) consists of the following four Anglo-Saxon countries with statistically significant loadings appearing in the third common vector for: US (0.864), Canada (0.822), Australia (0.736) and UK (0.717). As can be seen from the magnitudes of the rotated factor loadings in Table 3, the results are robust and consistent using both the principal components (PC) and maximum likelihood (ML) methods. Therefore, one can conclude that GDP growth rates within each of these three groups are highly interrelated. For example, according to these results, a downturn in the US economy would most immediately have affected the economies of Australia, Canada and the UK.

4.2 GDP growth interaction across group and individual countries

In this section, using the same sample period 1961-2008, our aim is two fold. First, we identify the extent to which GDP growth rates across our three major blocs of countries (G12, G6 and G4) are intertwined and how they interact through time. Second, we examine the overall influence of each of the three blocs on economic growth of the remaining 76 (=97-21) countries, to shed light on their vulnerability or responsiveness to global booms or busts. Before we achieve the above stated two goals, we need to calculate the resulting normalized factor scores for these three blocs using the following relations:

$$G12_t = 0.887*\frac{(r_{5t}-\overline{r}_{5t})}{\sigma_{r_5}} + 0.860*\frac{(r_{3t}-\overline{r}_{3t})}{\sigma_{r_3}} + \frac{(r_{2t}-\overline{r}_{2t})}{\sigma_{r_2}} + 0.812*\frac{(r_{16t}-\overline{r}_{16t})}{\sigma_{r_{16}}} + 0.781*\frac{(r_{10t}-\overline{r}_{10t})}{\sigma_{r_{10}}} + 0.779*\frac{(r_{18t}-\overline{r}_{18t})}{\sigma_{r_{18}}} + 0.759*\frac{(r_{11t}-\overline{r}_{11t})}{\sigma_{r_{11}}} + 0.747*\frac{(r_{14t}-\overline{r}_{14t})}{\sigma_{r_{14}}} + 0.741*\frac{(r_{6t}-\overline{r}_{6t})}{\sigma_{r_6}} + 0.622*\frac{(r_{7t}-\overline{r}_{7t})}{\sigma_{r_7}} + 0.607*\frac{(r_{17t}-\overline{r}_{17t})}{\sigma_{r_{17}}} + 0.414*\frac{(r_{8t}-\overline{r}_{8t})}{\sigma_{r_8}} \quad (6)$$

$$G6_t = 0.855*\frac{(r_{13t}-\overline{r}_{13})}{\sigma_{r_{13}}} + 0.838*\frac{(r_{19t}-\overline{r}_{19})}{\sigma_{r_{19}}} + 0.817*\frac{(r_{9t}-\overline{r}_{9})}{\sigma_{r_9}} + 0.741*\frac{(r_{12t}-\overline{r}_{12})}{\sigma_{r_{12}}} + 0.640*\frac{(r_{15t}-\overline{r}_{15})}{\sigma_{r_{15}}} + 0.503*\frac{(r_{8t}-\overline{r}_{8})}{\sigma_{r_8}} \quad (7)$$

$$G4_t = 0.864*\frac{(r_{21t} - \overline{r}_{21})}{\sigma_{r_{21}}} + 0.822*\frac{(r_{4t} - \overline{r}_4)}{\sigma_{r_4}} + 0.736*\frac{(r_{1t} - \overline{r}_1)}{\sigma_{r_1}} + 0.717*\frac{(r_{20t} - \overline{r}_{20})}{\sigma_{r_{20}}} \quad (8)$$

Where r_{jt} denotes the real GDP growth rate in country *j* (1,2,…,21) and time *t* (1961, 1962,…, 2008), σ_{r_j} and $\overline{r}_j$ are the standard deviation and the mean values for r_{jt}, respectively. Since the resulting three factor scores are stationary (the results are available upon request), we estimate the following unrestricted VAR model to analyse Granger causality across these three groups of countries:

$$\begin{cases} G12_t = \lambda_0 + \sum_{i=0}^{k} \lambda_{1i} G6_{t-i} + \sum_{i=0}^{k} \lambda_{2i} G4_{t-i} + \sum_{i=1}^{k} \lambda_{3i} G12_{t-i} + \mathrm{v}_{1t} \\ G6_t = \eta_0 + \sum_{i=0}^{k} \eta_{1i} G12_{t-i} + \sum_{i=0}^{k} \eta_{2i} G4_{t-i} + \sum_{i=1}^{k} \eta_{3i} G6_{t-i} + \mathrm{v}_{2t} \\ G4_t = \theta_0 + \sum_{i=0}^{k} \theta_{1i} G12_{t-i} + \sum_{i=0}^{k} \theta_{2i} G6_{t-i} + \sum_{i=1}^{k} \theta_{3i} G4_{t-i} + \mathrm{v}_{1t} \end{cases} \quad (9)$$

Using the data for the period 1961-2008, all of the following five lag selection criteria consistently point to an optimal lag length of one (*k*=1): the sequential modified likelihood ratio test statistic, the final prediction error, the Akaike information criterion, the Schwarz information criterion and the Hannan-Quinn information criterion. Based on the Ganger causality test results summarized in Table 4, there is very strong evidence of bi-directional causality pairwise across all these three major blocs of countries.

[Figure 1 and Table 4 about here]

In order to examine the overall influence of each of the three blocs on economic growth of the remaining 76 (=97-21) countries, one can run the following regression:

$$\frac{(\tilde{r}_{jt} - \overline{\tilde{r}}_{jt})}{\sigma_{\tilde{r}_j}} = \phi_0 + \phi_1 G12_t + \phi_2 G6_t + \phi_3 G4_t + \varepsilon_{jt} \quad (10)$$

Where $\tilde{r}_{jt}$ denotes the real GDP growth rate in country j (1,2,…,76) and time t (1961, 1962,…, 2008), $\sigma_{\tilde{r}_j}$ and $\bar{\tilde{r}}$ are the standard deviation and the mean values for $\tilde{r}_{jt}$, respectively. Based on the resulting R^2 and t-ratios, we can identify how individual countries' growth rate has been influenced by global booms or busts using the past data. Equation 10 has been estimated for all remaining 76 countries. However, there were 39 countries for which none of the explanatory variables were significant individually, pairwise or three of them altogether. These countries (G39), which can be described as the least affected by overall GDP growth rates of the G12, G6 and G4 countries, are as follows: Argentina, Bangladesh, Belize, Benin, Bolivia, Burkina Faso, Burundi, Cameroon, Central African, Chad, Congo Democratic, Congo Republic, Dominic Republic, Egypt, Fiji, Gabon, Guyana, Haiti, Madagascar, Malawi, Morocco, Myanmar, Nepal, Nicaragua, Niger, Oman, Pakistan, Panama, Peru, Rwanda, Senegal, Sierra Leon, Sri Lanka, St. Vincent and the Grenadines, Sudan, Syrian, Trinidad, Uruguay and Zambia. Using separate scatter diagrams we have also plotted normalized GDP growth data for each and every one of these 39 countries vs time series data on G12, G6 and G4 but we did not notice any emerging systematic pattern. Due to the lack of space, Figure 1 shows the scatter plots of real GDP growth data for only four of the South America countries included in G39.

On the other hand, Table 5 shows the estimation results of equation 10 for all 37 countries, where at least one of the three explanatory variables was statistically significant. These 37 countries (G37) have been sorted in terms of the magnitude of their coefficient of determination, which can be roughly referred to as a measure of the extent to which the GDP growth rate in an individual country is influenced by those of G12, G6 and G4. For example, compared to the other 36 countries in Table 5, the GDP growth rates in the Netherlands (R^2=0.525) and Denmark (R^2= 0.391) are more heavily influenced by the economic performance of other major industrial nations (i.e. G12 and G4). Conversely, the countries appearing at the bottom of Table 5, such as Papua New Guinea (R^2=0.069) and Jamaica (R^2=0.063), are less influenced by global common movements in real output. Given that the financial and economic ties between Jamaica and G4 on the one hand and Papua New Guinea and the major G6 Asian countries on the other are likely to be stronger, these results do not appear to be counter intuitive for an impartial observer.

[Table 5 about here]

6. Interpretation and Policy Implications

Table 6 summarises the key linkages contributing to GDP growth correlation identified in the introductory section of the paper, and the prospective significance of each of these in the context of the three country groupings highlighted in Section 4. It is likely to be the case that the growth correlation within the three groupings is strongly related to trade and financial flows as well as similar economic structures. For linkages arising

[Table 6 about here]

through macroeconomic policy coordination this is most likely to be relevant in the context of EU member countries in the group, and more specifically those countries that are members of the Eurozone. Such policy coordination is likely to be limited at best amongst the G6 countries while little deliberate policy coordination, out-with the recent fiscal stimulus packages relating to the global financial crisis, is likely to exist between the G4 countries. Common legal and accounting structures are likely to be more prevalent amongst the G4 countries, with some commonality between EU member states primarily of the G12 grouping, with limited commonality between the G6 countries. The influence of geographical proximity is most prevalent among the European countries in the G12 grouping and the G6 grouping but only between two countries in the G4 grouping (US and Canada). Common language and culture is likely to be most prevalent for the English speaking Anglo-Saxon economies of the G4 grouping, of limited prevalence among the G12 grouping and unlikely to be significant for the G6 grouping. The depth and speed of economic reform measures and liberalization within each group is likely to have played an important role in contributing to GDP growth correlation within each of the three country groupings. Finally, commonality in the development and, in particular, speed of adoption of technology and technical change is likely to have played a role in contributing to GDP growth correlation within the G12 and G4 countries in particular. There is considerable variation in the degree of technical change and technology adoption among the G6 countries, so this is unlikely to have played a substantive role in the GDP correlation for this group of countries.

The results presented in the previous section also suggest some potentially interesting policy implications, particularly in the wake of the global financial crisis from September 2008. Based on our findings it can be suggested that the downturn in the financial sector in the US, and subsequent GDP growth slowdown in the US, impacted initially most strongly upon the growth rates of Australia, Canada and the UK, thereby requiring a more urgent and stronger response by the authorities in these countries. This duly arrived in the form of fiscal stimulus packages in early 2009. Our results also suggest that the subsequent GDP growth slowdown in the G4 countries would inevitably adversely impact the GDP growth rates of the G12 and G6 countries. Given that the major reason for such a linkage in the transmission of this occurred through the financial sector, it could be anticipated that this impact on the G12 countries, in particular, would have occurred quite rapidly.

7. Conclusions

The paper has used data for the period 1961-2008 to examine the extent to which real GDP growth rates in 97 countries are interrelated. The results derived from a factor analysis, using both the principal components (PC) and maximum likelihood (ML) methods, indicate that GDP growth rates are highly integrated among: twelve advanced (mainly European) countries (G12= France, Belgium, Austria, Spain, Italy, Switzerland, Japan, Portugal, Germany, Greece, Sweden and to a lesser extent Hong Kong); six Asian countries (G6= Malaysia, Thailand, Indonesia, Korea, Singapore and Hong Kong); and four major Anglo-Saxon countries (G4=Australia, Canada, UK, US). Overall, we conclude that the strength of cross country growth co-movements within each group can be explained, *inter alia*, on factors such as the extent of: trade and financial linkages, commonalities in economic structure, policy coordination, similarities in legal and accounting systems, geographical proximity, common language and cultural affinity, commonalities in economic reform and liberalization, and technology adoption and capacity. The extent of these and their individual importance within the three groups identified in this study have not been discussed in this study and requires further empirical analysis. Certainly, the results for the four Anglo-Saxon countries is of particular interest. Cultural, legal, language, reform, liberalization, technological, trade and finance affinities more than offset geographical distance barriers (with the exception of Canada and the US), structural differences and limited policy coordination.

The results presented also have potentially important implications from a policy perspective. First, they suggest that, for example, the sub prime market crisis in the US and related growth downturn in 2008 would have most likely initially impacted upon GDP growth rates in Australia, Canada and the UK. Second, to avoid a severe decline in GDP growth for the G4 countries from this crisis required a rapid coordinated policy response from within this group. Third, the crisis would then subsequently impact the GDP growth rates of the G12 and G6 countries. Fourth, a coordinated policy response by members within each of the G12 and G6 would then have been most effective. Consequently, the differential impact, required sequencing and breadth of coordinated policy activity can be derived from this study, with this being dependent upon from where the initial shock originated (G4, G6 or G12).

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TABLE 1

DESCRIPTIONS OF THE DATA EMPLOYED, DECEMBER 1987-APRIL 2007

No.	Country	Mean	Standard deviation	Jarque-Bera	No.	Country	Mean	Standard deviation	Jarque-Bera
1	Algeria	3.97	8.08	60.6*	50	Japan	4.45	3.86	4.5
2	Argentina	2.89	5.88	2.5	51	Kenya	4.63	4.88	30.4*
3	Australia	3.65	1.88	7.5*	52	Korea	7.12	3.62	35.5*
4	Austria	3.1	1.83	0.7	53	Lesotho	5.61	6.79	27.5*
5	Bangladesh	3.98	4.07	124.9*	54	Liberia	1.61	21.46	262.6*
6	Barbados	2.95	4.26	0.7	55	Luxembourg	4.05	3.22	2.8
7	Belgium	2.89	1.93	0.3	56	Madagascar	2.01	4.43	20.6*
8	Belize	5.43	3.78	4.2	57	Malawi	4.22	5.31	1.6
9	Benin	3.46	3.09	9.1*	58	Malaysia	6.62	3.38	75.7*
10	Bolivia	2.87	3.6	70.3*	59	Mauritania	4.12	5.86	54.1*
11	Botswana	9.23	5.49	26.2*	60	Mexico	4.34	3.57	5.6
12	Brazil	4.54	4.14	0.1	61	Morocco	4.34	4.52	1.2
13	Burkina Faso	3.79	3.18	2.3	62	Myanmar	5.21	5.7	3.2
14	Burundi	2.61	6	5.4	63	Nepal	3.61	2.86	0.7
15	Cameroon	3.52	5.9	5.9*	64	Netherlands	3.18	1.99	0.3
16	Canada	3.43	2.04	8.1*	65	New Zealand	2.67	3.06	0
17	Cen. Afri.Rep.	1.43	3.96	1.9	66	Nicaragua	2.61	6.37	158.8*
18	Chad	3.08	8.7	21.1*	67	Niger	2.17	6.07	18.9*
19	Chile	4.43	4.72	33.5*	68	Nigeria	4.48	7.69	5.1
20	China	8.09	7.43	211.4*	69	Norway	3.55	1.63	1.6
21	Colombia	4.32	2.26	20.9*	70	Oman	9.62	15.53	331.2*
22	Congo, Dem. Rep.	0.75	6.27	3.4	71	Pakistan	5.55	2.41	0.0
23	Congo, Rep.	4.36	5.93	9.2*	72	Panama	4.95	4.4	62.7*
24	Costa Rica	4.91	3.35	20.6*	73	Papua New Guinea	3.74	4.77	2.3
25	Cote D'ivoire	3.73	5.57	0.4	74	Paraguay	4.32	3.74	1.2
26	Denmark	2.72	2.27	1.6	75	Peru	3.59	5.08	21.9*
27	Dominican Rep.	5.35	5.32	9.0*	76	Philippines	4.1	3.09	102.5*
28	Ecuador	3.95	3.52	14.4*	77	Portugal	3.8	3.2	0.2*
29	Egypt	5.41	2.95	7.7*	78	Rwanda	3.9	11	300.5*
30	El Salvador	3.07	4.21	54.1*	79	Senegal	2.86	4.15	0.9
31	Fiji	3.33	4.77	0.3	80	Seychelles	4.15	6.3	1.4
32	Finland	3.35	2.78	15.0*	81	Sierra Leone	2.57	7.31	26.2*
33	France	3.17	2	1.0	82	Singapore	7.93	4.12	5.3
34	Gabon	4.64	10.11	40.1*	83	Spain	4.03	2.72	5.2
35	Germany	2.69	1.97	0.9	84	Srilan	4.69	1.92	13.7*
36	Greece	4.08	4.04	0.1	85	St. Vincent & the Grenadines	6.53	20.75	2861*
37	Guatemala	3.99	2.51	7.8*	86	Sudan	4.2	5.6	0.3
38	Guyana	1.79	5.29	4.1	87	Sweden	2.7	1.96	1.3
39	Haiti	0.78	4.21	6.7*	88	Switzerland	2.25	2.44	33.5*
40	Honduras	4.18	3	0.1	89	Syrian	5.6	8.05	2.3
41	Hong Kong	7.07	4.62	0.3	90	Thailand	6.58	3.74	144.8*
42	Hungary	3.39	4.23	51.5*	91	Togo	3.53	6.01	1.4
43	Iceland	4.06	3.82	0.3	92	Trinidad And Tobago	4.51	4.94	0.3
44	India	5.13	3.14	13.0*	93	Uk	2.5	1.79	5.5
45	Iran	5.11	6.76	9.8*	94	Uruguay	2.17	4.76	7.6*
46	Ireland	4.91	2.83	0	95	Us	3.23	1.94	2.4
47	Israel	5.52	3.83	3.6	96	Venezuela	3.12	5.39	0.6
48	Italy	3.01	2.35	1.6	97	Zambia	2.38	4.71	1.8
49	Jamaica	1.82	4.17	16.9*					

Note: * indicates that the normality assumption is rejected at the 5 per cent level.

TABLE 2
CORRELATION AND ANTI-IMAGE CORRELATION COEFFICIENTS FOR 21 MAJOR COUNTRIES

Annual growth rate		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}	r_{13}	r_{14}	r_{15}	r_{16}	r_{17}	r_{18}	r_{19}	r_{20}	r_{21}
											Correlation Coefficients											
r_1	Australia	1.00																				
r_2	Austria	0.07	1.00																			
r_3	Belgium	*0.32*	*0.70*	1.00																		
r_4	Canada	*0.64*	0.29	*0.50*	1.00																	
r_5	France	*0.33*	*0.73*	*0.84*	*0.56*	1.00																
r_6	Germany	0.18	*0.72*	*0.72*	*0.39*	0.70	1.00															
r_7	Greece	0.30	*0.49*	*0.51*	*0.35*	0.56	*0.54*	1.00														
r_8	HongK	0.12	*0.33*	*0.47*	*0.39*	0.46	*0.51*	*0.33*	1.00													
r_9	Indonesia	-0.17	0.03	0.06	-0.11	-0.14	0.18	-0.11	0.27	1.00												
r_{10}	Italy	0.30	*0.59*	*0.75*	*0.49*	0.80	*0.59*	*0.41*	*0.51*	0.06	1.00											
r_{11}	Japan	*0.35*	*0.60*	*0.64*	*0.36*	0.73	*0.65*	*0.65*	*0.46*	0.15	*0.71*	1.00										
r_{12}	Korea	0.09	0.28	0.21	0.20	0.26	*0.34*	0.12	*0.33*	*0.50*	0.31	*0.39*	1.00									
r_{13}	Malaysia	-0.15	0.20	0.27	0.07	0.13	0.27	0.01	*0.48*	*0.64*	0.27	0.18	*0.47*	1.00								
r_{14}	Portugal	0.14	*0.63*	*0.67*	*0.37*	0.75	*0.61*	*0.42*	*0.39*	-0.03	*0.69*	*0.60*	0.18	0.22	1.00							
r_{15}	Singapore	0.01	*0.36*	0.31	0.15	0.27	0.25	0.30	*0.37*	*0.44*	*0.36*	*0.43*	*0.40*	*0.61*	0.31	1.00						
r_{16}	Spain	0.31	*0.57*	*0.70*	*0.47*	0.79	*0.55*	*0.56*	*0.37*	-0.19	*0.69*	*0.63*	0.13	0.06	*0.57*	0.22	1.00					
r_{17}	Sweden	0.39	*0.37*	*0.62*	*0.48*	0.57	*0.37*	*0.45*	0.20	-0.25	*0.48*	*0.44*	0.03	-0.14	0.31	0.08	*0.57*	1.00				
r_{18}	Switzerland	0.27	*0.59*	*0.67*	*0.36*	0.66	*0.57*	*0.37*	*0.36*	-0.04	*0.58*	*0.56*	-0.03	0.06	0.54	0.29	*0.63*	*0.50*	1.00			
r_{19}	Thailand	-0.01	0.14	0.22	0.04	0.22	0.28	0.09	*0.39*	*0.59*	0.30	*0.44*	*0.67*	*0.65*	0.25	*0.45*	0.07	-0.07	0.06	1.00		
r_{20}	UK	*0.36*	0.24	0.31	*0.51*	0.36	0.26	*0.37*	0.18	-0.17	0.26	0.25	0.29	0.00	*0.40*	0.07	0.32	*0.44*	0.24	0.06	1.00	
r_{21}	US	*0.52*	0.18	0.28	*0.78*	0.37	*0.38*	0.31	*0.39*	-0.09	0.31	0.27	0.21	0.16	0.31	0.09	0.29	0.20	0.25	0.09	*0.61*	1.00
											Anti-image Correlation Coefficients											
r_1	Australia	**0.80**																				
r_2	Austria	0.21	**0.89**																			
r_3	Belgium	-0.26	-0.17	**0.89**																		
r_4	Canada	-0.34	-0.04	-0.04	**0.76**																	
r_5	France	0.13	-0.15	-0.40	-0.25	**0.90**																
r_6	Germany	0.08	-0.32	-0.16	0.15	-0.03	**0.86**															
r_7	Greece	-0.01	-0.05	-0.09	0.04	-0.03	-0.26	**0.81**														
r_8	HongK	0.17	0.17	-0.01	-0.09	-0.05	-0.10	-0.10	**0.94**													
r_9	Indonesia	0.12	0.15	-0.26	-0.26	0.43	-0.23	0.07	0.00	**0.64**												
r_{10}	Italy	-0.01	0.04	-0.11	-0.08	-0.16	0.13	0.18	-0.11	-0.01	**0.94**											
r_{11}	Japan	-0.28	-0.13	0.13	0.28	-0.13	-0.01	-0.40	-0.08	-0.24	-0.27	**0.84**										
r_{12}	Korea	-0.10	-0.25	0.18	-0.03	-0.22	-0.24	0.28	-0.03	-0.30	-0.12	-0.05	**0.62**									
r_{13}	Malaysia	0.09	-0.11	-0.29	0.22	0.08	0.01	0.09	-0.23	-0.28	-0.11	0.37	0.11	**0.65**								
r_{14}	Portugal	0.13	-0.05	-0.11	-0.08	-0.23	-0.24	0.19	0.04	0.08	-0.24	-0.17	0.36	-0.01	**0.83**							
r_{15}	Singapore	0.02	-0.14	0.15	-0.16	0.06	0.31	-0.31	0.04	-0.05	0.01	-0.18	-0.21	-0.50	-0.14	**0.73**						
r_{16}	Spain	0.07	0.11	-0.02	-0.10	-0.22	0.03	-0.20	0.04	0.17	-0.13	-0.14	-0.12	-0.20	0.04	0.12	**0.93**					
r_{17}	Sweden	0.08	0.15	-0.36	-0.33	0.07	-0.14	0.01	0.00	0.24	-0.09	-0.18	0.07	0.04	0.38	-0.05	-0.03	**0.76**				
r_{18}	Switzerland	-0.12	-0.20	-0.06	0.19	-0.14	-0.18	0.35	-0.11	-0.22	-0.02	-0.04	0.46	0.25	0.09	-0.32	-0.25	-0.12	**0.82**			
r_{19}	Thailand	0.02	0.30	0.06	0.03	-0.16	0.06	0.01	0.02	-0.06	0.13	-0.37	-0.41	-0.47	-0.12	0.16	0.20	0.01	-0.12	**0.74**		
r_{20}	UK	-0.01	-0.04	-0.01	0.20	0.10	0.32	-0.27	0.06	-0.01	0.14	0.22	-0.46	0.08	-0.51	0.10	-0.01	-0.47	-0.13	0.04	**0.61**	
r_{21}	US	-0.09	0.12	0.16	-0.68	0.05	-0.35	0.00	-0.10	0.27	-0.01	-0.19	0.10	-0.33	0.17	0.12	0.11	0.40	-0.14	0.06	-0.53	**0.64**

Notes: (a) Italic figures in the correlation coefficient matrix are significant at 1 per cent level or better. (b) The boldfaced elements on the main diagonal of the anti-image matrix are referred to as the measures of sampling adequacy (MSA) and its minimum acceptable value is usually above 0.50. (c) r_j denotes annual GDP growth rate in country j where j=1,2,…,21.

TABLE 3
ESTIMATED ROTATED FACTOR LOADINGS USING THE VARIMAX METHOD

Country	Principal component	Maximum Likelihood	Country	Principal component	Maximum Likelihood	Country	Principal component	Maximum Likelihood
	Factor 1	Factor 1		Factor 2	Factor 2		Factor 3	Factor 3
France	**0.887**	**0.906**	Malaysia	**0.855**	**0.828**	US	**0.864**	**0.903**
Belgium	**0.860**	**0.851**	Thailand	**0.838**	**0.786**	Canada	**0.822**	**0.807**
Austria	**0.816**	**0.765**	Indonesia	**0.817**	**0.794**	Australia	**0.736**	**0.597**
Spain	**0.812**	**0.799**	Korea	**0.741**	**0.657**	UK	**0.717**	**0.601**
Italy	**0.781**	**0.780**	Singapore	**0.640**	**0.600**	Sweden	0.355	0.252
Switzerland	**0.779**	**0.711**	Hong Kong	**0.503**	**0.477**	France	0.275	0.272
Japan	**0.759**	**0.733**	Japan	0.312	0.310	Greece	0.270	0.244
Portugal	**0.747**	**0.723**	Germany	0.291	0.312	Hong Kong	0.247	0.283
Germany	**0.741**	**0.683**	Italy	0.252	0.258	Korea	0.238	0.144
Greece	**0.622**	**0.571**	Portugal	0.176	0.188	Spain	0.230	0.222
Sweden	**0.607**	**0.607**	Belgium	0.162	0.194	Italy	0.215	0.212
Hong Kong	**0.414**	0.381	Austria	0.158	0.175	Belgium	0.197	0.190
Canada	0.345	0.361	US	0.145	0.138	Japan	0.180	0.149
Singapore	0.315	0.267	France	0.085	0.090	Germany	0.165	0.223
UK	0.219	0.236	Canada	0.051	0.045	Portugal	0.150	0.181
Australia	0.178	0.220	Greece	0.018	0.035	Switzerland	0.100	0.151
US	0.141	0.123	UK	0.017	0.005	Thailand	0.019	-0.021
Thailand	0.111	0.134	Switzerland	-0.027	0.022	Austria	-0.018	0.040
Korea	0.091	0.142	Spain	-0.048	-0.029	Singapore	-0.033	-0.005
Malaysia	0.083	0.059	Australia	-0.111	-0.107	Malaysia	-0.042	0.015
Indonesia	-0.108	-0.133	Sweden	-0.233	-0.197	Indonesia	-0.194	-0.180
% of variance	41.2			16.1			9.1	
Cumulative %	41.2			57.3			66.4	

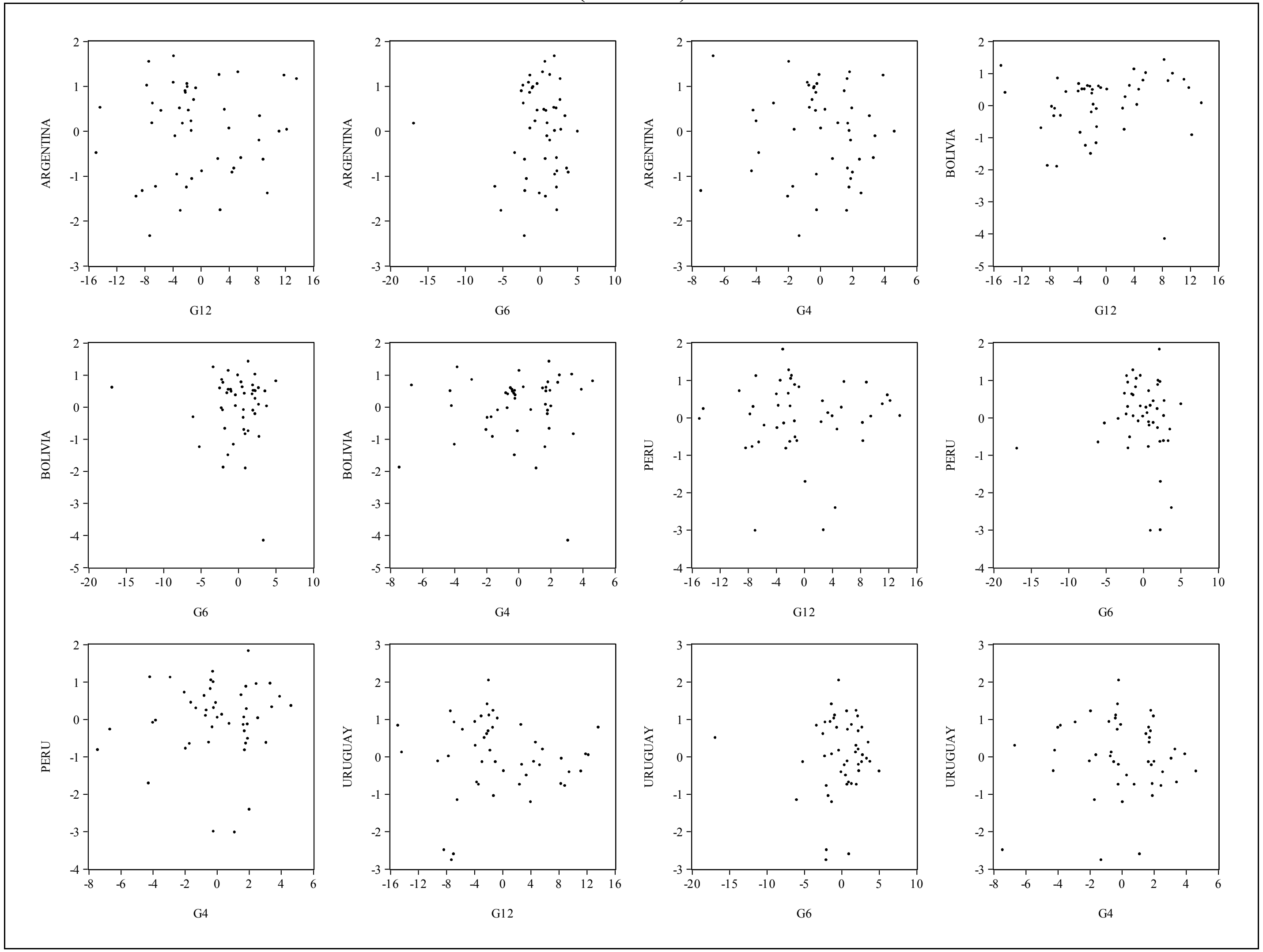
Note: The cut-off for factor loadings is assumed to be 0.40 as shown in boldface numbers.

TABLE 4
GRANGER CAUSALITY TEST RESULTS USING NORMALIZED FACTOR SCORES OF THE THREE MAJOR BLOCS OF COUNTRIES, 1961-2008

Granger Causality direction $\rightarrow$	*G12*	*G6*	*G4*
G12	-	$G12 \rightarrow G6$ F=3.66 [p-value=0.035]	$G12 \rightarrow G4$ F=16.62 [p-value=0.000]
G6	$G6 \rightarrow G12$ F=3.16 [p-value=0.053]	-	$G6 \rightarrow G4$ F=3.17 [p-value=0.052]
G4	$G4 \rightarrow G12$ F=11.75 [p-value=0.00]	$G4 \rightarrow G6$ F=6.46 [p-value=0.004]	-

FIGURE. 1

SCATTER PLOTS REAL GDP GROWTH DATA FOR FOUR SAMPLE SOUTH AMERICA COUNTRIES VS THREE MAJOR GROUPS OF COUNTRIES (1961-08)



Source: World Bank (2004), OECD (2009) and International Monetary Fund (2009).

TABLE 5

RELATIONSHIP BETWEEN GDP GROWTH RATE IN INDIVIDUAL COUNTRIES AND COLLECTIVE ECONOMIC GROWTH RATES IN G12, G6 AND G4 COUNTRIES

$$\frac{(\tilde{r}_{jt}-\bar{\tilde{r}}_{jt})}{\sigma_{\tilde{r}_j}} = \phi_0 + \phi_1 G12_t + \phi_2 G6_t + \phi_3 G4_t + \varepsilon_{jt}$$

Rank	Dependent Variable: $\frac{(\tilde{r}_{jt}-\bar{\tilde{r}}_{jt})}{\sigma_{\tilde{r}_j}}$	Independent variables: $G12_t$ ϕ_1	t-ratio	$G6_t$ ϕ_2	t-ratio	$G4_t$ ϕ_3	t-ratio	R^2
1	Netherlands	0.079	4.7	-	-	0.103	2.3	0.525
2	Denmark	0.067	3.5	-	-	0.095	1.9	0.391
3	Mexico	0.042	2.7	-	-	0.063	1.7	0.363
4	Finland	0.08	4.6	-	-			0.315
5	Costa Rica	-	-	-	-	0.21	4.4	0.299
6	Israel	0.074	4.1	-	-			0.265
7	Colombia	-	-	0.103	6.2	0.082	2.2	0.265
8	Norway	-	-	0.056	2.3	0.152	3	0.241
9	Hungary	0.07	3.8	-	-			0.238
10	Barbados	0.044	2.1	-	-	0.099	1.7	0.238
11	Togo	0.069	3.5	-	-			0.236
12	India	0.026	1.8*	0.023	1.8*	0.103	1.9*	0.233
13	Côte d'Ivoire	0.069	3.7	-	-			0.230
14	China	-	-	0.2	1.9	0.059	2.4	0.224
15	Botswana	0.047	2.4	0.073	1.8			0.220
16	Guatemala	-	-	0.069	2	0.128	2.7	0.212
17	Lesotho	-	-	0.107	2.7	0.095	1.8	0.210
18	New Zealand	-	-	0.062	2.2	0.126	2.3	0.180
19	Honduras	-	-	-	-	0.159	3.1	0.170
20	El Salvador	-	-	-	-	0.158	3.1	0.169
21	Iceland	0.054	2.9	-	-	-	-	0.161
22	Paraguay	0.027	2.2	0.053	2.9	-	-	0.156
23	Brazil	-	-	0.07	1.9	0.085	1.7*	0.148
24	Philippines	-	-	0.11	2.7	-	-	0.138
25	Luxembourg	0.052	2.6	-	-	-	-	0.130
26	Algeria	0.044	2.4	-	-	-	-	0.116
27	Seychelles			-	-	0.131	2.4	0.115
28	Iran	0.036	2.2	-	-			0.104
29	Kenya			-	-	0.122	2.3	0.100
30	Ecuador	0.042	2.1	-	-	-	-	0.085
31	Nigeria	0.041	2	-	-	-	-	0.083
32	Mauritania	0.041	2	-	-	-	-	0.082
33	Liberia	0.028	1.96	-	-	-	-	0.079
34	Venezuela	0.039	1.96	-	-	-	-	0.075
35	Chile	-	-	-	-	0.102	2	0.071
36	Papua New Guinea	-	-	0.078	1.9	-	-	0.069
37	Jamaica	-	-	-	-	0.096	1.82*	0.063

TABLE 6

KEY GDP GROWTH CORRELATION LINKAGES WITHIN THE THREE IDENTIFIED COUNTRY GROUPINGS

Linkage	G12	G6	G4
Trade	√	√	√
Finance	√	√	√
Economic structure	√	√	√
Policy coordination	√	Limited	X*
Legal/accounting system	Some commonality between EU member states only	X	√
Geographical proximity	Proximity between EU member states only	√	Only between the USA and Canada
Common language/culture	Some commonality between EU member states only	X	√
Economic reform/liberalisation	√	√	√
Technology adoption	√	Some commonality	√

Note: * Some coordination in terms of fiscal stimulus package arising from the global financial crisis is an exception here.
Source: Authors