Measuring the Sources of Cyclical Fluctuations in the G7 Economies*

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Abstract

We analyze herein the importance of four types of shocks in contributing to the business cycles of the G7 economies. After disentangling the common permanent and transitory shocks in the G7 outputs, we identify the domestic and foreign components of such shocks for each country. This provides us with quite a flexible palette for understanding the degree of openness of the G7 countries, useful information for the analysis of the strengths and weaknesses of each national economy. Our empirical analysis reveals that the cycles of most of the G7 outputs are dominated by their domestic components and that the foreign components are almost entirely due to permanent shocks.

Keywords: International business cycles; Permanent-transitory decomposition; Serial correlation common features; Frequency domain analysis.

JEL: C32, E32

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1 Introduction

For many years, applied econometricians have been developing tools with a view to extracting common components in a set of economic time series. Among these components, the presence of common trends and common cycles (Vahid and Engle, 1993) brings important information both from a statistical and economic point of view. For instance, the existence of such comovements provides support for some types of convergence or the sustainability of an optimal currency area (Beine *et al.*, 2000). This paper shows that the output series of the G7 economies are governed by five common trends and three common cycles, thus providing support for the existence of comovements both in the long and short-run. Given the relative heterogeneity of the G7 economies, we cannot hope to obtain a single source of long-term fluctuations and it is likely there is a multitude of growth factors determining the dynamics of national outputs, a phenomenon documented *inter alia* in Bernard and Durlauf (1996). Using also the G7 output series but over a different sample period, Cheung and Westermann (2002) uncover six common trends. However, they find a single common cycle, thus indicating a stronger short-term integration than in this study, which utilizes data post the first oil shock.

However, to be instructive for policy making, these descriptive statements concerning co-movements should be accompanied by a deeper analysis of the contribution of different shocks to the cyclical fluctuations of output series. In this paper, after having determined the number of common components, we further decompose cyclical output fluctuations into four elements. Using the approach by Centoni *et al.* (2004), we first assess the relative importance of foreign and domestic shocks in contributing to national business cycles. Indeed, it is important for policy makers to know whether cyclical output fluctuations are mainly generated by shocks of domestic or foreign origin. For both foreign and domestic shocks, we then determine whether they have a predominant permanent or transitory effect. To touch on the huge literature on the latter distinction, allow us to recall that this additional information is crucial to understanding whether national business cycles are affected by permanent supply shocks or transitory demand shocks. For instance, if demand shocks are largely responsible for fluctuations, there may be a role for aggregate Keynesian-type policies.

Based on Centoni *et al.* (2004), our strategy differs from the usual strategy consisting of extracting from the outputs of several countries a common dynamic factor summarizing the worldwide component (see *inter alia* Gregory *et al.* (1997) and Kose *et al.* (2004)). Indeed, we obtain a pair of domestic [foreign] permanent-transitory (hereafter, PT) shocks for each of the G7 countries. However, unlike a number of recent papers, Dufourt (2005) and Galí (2004) *inter alia*, we do not want to resort to a particular economic theory, such as a real business cycle model, in order to further identify these shocks as monetary or productivity in nature. This will

be either the weakness or the strength of our paper, depending on the reader's point of view.

This paper is organized as follows. In Section 2, we briefly review the PT decomposition by Centoni and Cubadda (2003), the notion of serial correlation common feature by Engle and Kozicki (1993), and the measures of the importance of domestic and foreign components of the PT shocks in explaining business cycles by Centoni *et al.* (2004). Section 3 presents our empirical analysis of the G7 output series. Similar to most studies (see e.g. King *et al*, 1991), the empirical results indicate that permanent shocks are the main source of business cycles. But in contrast to Canova and Marrinan (1998) and Mellander *et al.* (1992), we find that foreign shocks account for a small portion of the cyclical fluctuations of the non-European G7 countries (about 13% for Japan and 25% for the US). Ahmed *et al.* (1993) and Kwark (1999) reached a similar conclusion for the US economy using a structural VAR approach. This portion is around 53% for the European countries. Moreover, we show that the domestic component is responsible for most of the business cycle effects of transitory shocks for all the G7 countries whereas the foreign component dominates the cyclical variability which is due to permanent shocks in France, Germany and Italy.

2 Statistical methodology

Let us assume that an n-vector X_t of cointegrated series of order (1,1) is generated by the following Vector Error-Correction Model [VECM]

$$\Gamma(L)\Delta X_t = \alpha\beta' X_{t-1} + \varepsilon_t, \quad t = 1, ..., T \tag{1}$$

for fixed values of $X_{-p+1}, ..., X_0$, where $\Gamma(L) = I_n - \sum_{i=1}^{p-1} \Gamma_i L^i$, α and β are both $(n \times r)$ matrices of full rank r, the matrix $\alpha'_\perp \Gamma(1) \beta_\perp$ has rank equal to $(n-r)$, and ε_t are i.i.d. $N_n(0, \Omega)$ innovations. Series X_t also admit the following Wold representation

$$\Delta X_t = C(L)\varepsilon_t,$$

where $C(L) = I_n + \sum_{i=1}^{\infty} C_i L^i$ is such that $\sum_{j=1}^{\infty} j \, |C_j| < \infty$ (see e.g. Johansen, 1996).

Assuming hereafter that series X_t represent the outputs of n different countries, a possible source of the cyclical comovements across countries is the presence of common shock transmission mechanisms. In order to explore this possibility, we resort to the notion of Serial Correlation Common Feature (hereafter, SCCF) by Engle and Kozicki (1993), according to which series ΔX_t have s SCCF's relationships iff there exists a $n \times s$ matrix δ with full column rank and such that $\delta' C(L) = \delta'$. Hence, the impulse response functions of series ΔX_t are collinear. As shown by Vahid and Engle (1993), the existence of s SCCF relationships is also equivalent to the presence

of $(n-s)$ common cycles in the multivariate decomposition by Beveridge and Nelson (1981). Optimal statistical inference on SCCF is obtained by either canonical correlation analysis or full information maximum likelihood, see Vahid and Engle (1993) for details.

Another popular explanation for the existence of international business cycles is the presence of common shocks across different national economies. As shown by Centoni and Cubadda (2003), series X_t admit a PT decomposition where the common permanent and transitory shocks are respectively given by

$$u_t^P = \alpha_\perp' \varepsilon_t \quad \text{and} \quad u_t^T = \alpha' \Omega^{-1} \varepsilon_t, \tag{2}$$

the permanent and transitory components of series X_t are respectively P_t and T_t, $X_t = P_t + T_t$, $\Delta P_t = P(L)u_t^P$, $\Delta T_t = T(L)u_t^T$, and

$$\begin{aligned} P(L) &= C(L)\Omega\alpha_\perp(\alpha_\perp'\Omega\alpha_\perp)^{-1}, \\ T(L) &= C(L)\alpha(\alpha'\Omega^{-1}\alpha)^{-1}. \end{aligned}$$

It is easy to verify that the shocks u_t^P only have permanent effects on series X_t, and the components P_t and T_t are uncorrelated at all lags and leads.

Centoni *et al.* (2004) further decomposed the PT shocks (2) into their domestic and foreign components. In particular, the permanent [transitory] domestic shock of the jth country $u_{jt}^{P,D}$ $[u_{jt}^{T,D}]$ is defined as the component of the common permanent [transitory] shocks u_t^P $[u_t^T]$ which is explained by the permanent [transitory] shock which has contemporaneous effect on the jth country output. Consequently, the permanent [transitory] foreign shock of the jth country $u_{jt}^{P,F}$ $[u_{jt}^{T,F}]$ is the component of the common permanent [transitory] shocks u_t^P $[u_t^T]$ which is independent from jth country permanent [transitory] domestic shocks.

Building on Centoni and Cubadda (2003), Centoni *et al.* (2004) proposed measuring the business cycle effect of PT foreign shocks by the portion of the spectral mass of the jth country output at the business cycle frequencies which is explained by the jth country permanent [transitory] foreign shocks. Similarly, the business cycle effects of PT domestic shocks is measured by the portion of the spectral mass of the jth country output at the business cycle frequencies, which is explained by the jth country permanent [transitory] domestic shocks. Remarkably, although these measures are conceptually formulated in the frequency domain, they can be easily computed after having estimated the parameters of model (1), see Centoni *et al.* (2004) for details.

3 Empirical Analysis

We applied the methods presented in the previous section to the gross domestic product (hereafter, GDP) in volume of G7 countries, i.e. Canada, US, UK, Germany[1], Italy, France and Japan. Quarterly, seasonally adjusted indexes (1995=100) were taken from OECD databases. Canova and Dellas (1993), *inter alia*, documented that after 1973 (i.e. the first oil shock) the presence of common disturbances plays a role in accounting for international output comovements. We then used the sample that spans 1974:Q1 to 2002:Q3, namely $T = 115$ observations.

There exists a positive trend in the log-levels of all series, so we first tested for the presence of common permanent and transitory shocks by a cointegration analysis. A VAR(3) seems to appropriately characterize the covariance structure of the data according to the Akaike Information Criterion (AIC). Indeed, we do not reject the null of no autocorrelation in all the individual equations of the VAR.[2] We used Johansen's trace test for cointegration with a deterministic trend included in the error correction term (Johansen, 1996) in order to capture the differences among the average growth rates of the various national outputs. Table 1 gives the values of the so-called trace test statistics ($Trace$) as well as the associated $p-$values. We do not reject the presence of two cointegrating vectors. This implies that the G7 outputs are driven by five common permanent shocks and two common transitory shocks.

INSERT TABLES 1 & 2 ABOUT HERE

The output growth rates exhibit a cyclical pattern the similarity of which is tested through a SCCF analysis. Having fixed $r = 2$, Table 2 gives the results of the likelihood ratio test for SCCF, and the degrees of freedom (df) as well as the $p-$values associated with both the asymptotic test statistic and a small-sample corrected test statistic ($p-\text{values}^{ss}$) considered by Hecq (2005). It emerges that we cannot exclude the presence of four SCCF vectors. Information criteria also indicate $s = 4$. We conclude that there are three common cycles across the G7 economies.[3]

In order to asses the relative importance of common PT domestic and foreign shocks in contributing to national business cycles, we applied the measures proposed by Centoni *et al.*

[1] The data for Germany for the period 1974:Q1-1990:Q4 were reconstructed by using the GDP of West Germany.

[2] The $p-$values associated to the Lagrange multiplier test statistics for fourth-order residual autocorrelation are 0.61, 0.81, 0.87, 0.29, 0.11, 0.07, 0.51 for respectively $\ln Can_t, \ln US_t, \ln Jap_t, \ln Fr_t, \ln Ger_t, \ln It_t$ and $\ln UK_t$.

[3] In order to check whether the estimated common feature relationships really correspond to international linkages, we tested in a FIML framework (see Vahid and Engle, 1993, for details) for the existence of a SCCF vector with a single element equal to unity and the others equal to zero. The presence of such trivial SCCF vectors is rejected with $p-$values less than 0.001 for each country. We also rejected at the conventional significance levels the null hypothesis that one variable can simultaneously be excluded from the four common feature vectors.

(2004). We estimated the VECM model (1) fixing $r = 2$ and $s = 4$ and derived from the estimated parameters the spectra of each output and its components at the frequencies corresponding to 8-32 quarter periods. In particular, these spectra are computed for frequencies $\omega_k = \frac{\pi}{16}(\frac{199-k}{199}) + \frac{\pi}{4}(\frac{k}{199})$ and $k = 0, 1, ..., 199$. Table 3 gives the estimated measures along with the 95% bootstrapped confidence bounds in brackets.

INSERT TABLES 3

First, the results clearly indicate the dominant role of permanent shocks in explaining business cycles. From Table 3 we see that permanent shocks account for about 85% of cyclical variations in GDP for European countries and Japan and up to 94% for the US and Canada.

Second, we turned to evaluating the importance of the domestic and foreign shocks on the different economies at the business cycle frequencies. Indeed, it emerges that for Japan, Canada, and the US the foreign component of the business cycle is small, ranging from 11% to 30%. Due to their higher degree of openness, European countries are more sensitive to foreign shocks with proportions around 35% for UK and reaching 50% for France and Italy.

Third, for all the G7 economies, the foreign component of the business cycle is almost entirely generated by permanent shocks. This result is consistent with the view that international technology diffusion is an important propagation mechanism of permanent shocks across countries. An important force generating technology spillovers among countries is the international trade of input goods, see e.g. Coe and Helpman (1995), and Eaton and Kortum (2001).[4] Frankel and Rose (1997), *inter alia*, argued that closer international trade links result in more coherent national business cycles.

Fourth, the domestic component clearly dominates the cyclical effects of transitory shocks, especially for European countries. This finding is in line with the interpretation that transitory shocks are mainly connected to country-specific monetary and fiscal policies.

Remarkably, previous analyses based on dynamic factor models by Gregory *et al.* (1997) and Kose *et al.* (2003) attributed a more limited role to country-specific shocks in contributing to national business cycles.[5] A possible explanation of these differences is that our identification of the domestic and foreign shocks was not obtained by imposing a factor structure to the data.

[4] See e.g. Keller (2004) for a detailed survey of the importance of various channels of international technology diffusion.

[5] However, our ranking for the degree of each country's openness is very similar to that of Gregory et al. (1997), according to which the countries with the highest share of output variance accounted for by country factors are respectively Japan, Canada, UK, US, Germany, Italy and France.

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	$Trace$	$p-$values
$r = 0$	183.54	0.00
$r \leq 1$	134.17	0.00
$r \leq 2$	88.02	0.06
$r \leq 3$	60.23	0.10
$r \leq 4$	35.96	0.21
$r \leq 5$	18.54	0.32
$r \leq 6$	6.58	0.40

Table 1: Johansen's Trace Test for Cointegration

	LR	df	$p-$values	$p-$values^{ss}
$s \geq 1$	6.43	10	0.77	0.85
$s \geq 2$	21.37	22	0.49	0.68
$s \geq 3$	38.25	36	0.36	0.61
$s \geq 4$	65.99	52	0.09	0.30
$s \geq 5$	117.07	70	<0.001	0.01

Table 2: LR Test for SCCF

		Permanent	Transitory	Total
Canada	Domestic	0.826 [0.545-0.892]	0.046 [0.017-0.073]	0.872 [0.587-0.927]
	Foreign	0.112 [0.059-0.397]	0.014 [0.004-0.033]	0.127 [0.072-0.412]
	Total	0.939 [0.907-0.972]	0.061 [0.028-0.092]	
		Permanent	Transitory	Total
US	Domestic	0.614 [0.330-0.781]	0.067 [0.028-0.096]	0.682 [0.385-0.831]
	Foreign	0.312 [0.163-0.605]	0.005 [0.001-0.016]	0.317 [0.168-0.613]
	Total	0.926 [0.896-0.965]	0.073 [0.034-0.103]	
		Permanent	Transitory	Total
Japan	Domestic	0.650 [0.421-0.822]	0.161 [0.062-0.202]	0.811 [0.556-0.918]
	Foreign	0.184 [0.078-0.437]	0.004 [0.001-0.011]	0.184 [0.081-0.442]
	Total	0.834 [0.792-0.936]	0.166 [0.063-0.207]	
		Permanent	Transitory	Total
France	Domestic	0.372 [0.147-0.642]	0.130 [0.044-0.156]	0.502 [0.237-0.722]
	Foreign	0.497 [0.275-0.762]	0.000 [0.000-0.001]	0.497 [0.276-0.762]
	Total	0.869 [0.843-0.954]	0.130 [0.045-0.157]	
		Permanent	Transitory	Total
Germany	Domestic	0.414 [0.227-0.660]	0.135 [0.053-0.154]	0.549 [0.327-0.752]
	Foreign	0.445 [0.245-0.669]	0.004 [0.000-0.007]	0.450 [0.247-0.672]
	Total	0.860 [0.840-0.945]	0.139 [0.054-0.159]	
		Permanent	Transitory	Total
Italy	Domestic	0.408 [0.234-0.661]	0.101 [0.033-0.126]	0.509 [0.307-0.724]
	Foreign	0.488 [0.272-0.691]	0.002 [0.001-0.004]	0.490 [0.275-0.692]
	Total	0.897 [0.871-0.964]	0.103 [0.035-0.128]	
		Permanent	Transitory	Total
UK	Domestic	0.506 [0.254-0.720]	0.124 [0.055-0.153]	0.631 [0.360-0.801]
	Foreign	0.343 [0.182-0.611]	0.026 [0.009-0.036]	0.368 [0.198-0.638]
	Total	0.849 [0.820-0.932]	0.150 [0.068-0.179]	

Table 3: Measures of the BC effects of Domestic-Foreign PT shocks (s=4)