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The Synchronization of GDP Growth in the G7 During US Recessions.

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Abstract

Using the dynamic conditional correlation (DCC) model due to Engle (2002), we estimate time varying correlations of quarterly real GDP growth among the G7 countries. In general, we find that rather heterogeneous patterns of international synchronization exist during US recessions. During the 2007-2009 recession, however, international co-movement increased substantially.

Key words: dynamic conditional correlation; business cycle synchronization; recession

JEL codes: E3; E32; F4; F41

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1   Introduction

Conventional wisdom holds that recessions are highly synchronized across industrialized countries. So far, however, the available evidence is mostly anecdotal.[1]

In this note, we estimate time-varying correlations using the dynamic conditional correlation (DCC) model introduced by Engle (2002). To our knowledge, this is the first application of the DCC model to macroeconomic data. Our results indicate a strong increase in output growth correlations among the G7 countries during the 2007-2009 recession in the United States. We also show that this increase was rather unusual in the sense that we find only little evidence suggesting that output growth rates became more synchronized during previous recessions.

Our analysis is closely related to the empirical literature on business cycle synchronization (see, e.g. Otto et al., 2001; Ayhan Kose et al., 2003; Imbs, 2004) and especially to Crucini et al. (2008), Ayhan Kose et al. (2008), Doyle and Faust (2005) and Stock and Watson (2005) who also study the correlation of business cycles in the G7 countries. In contrast to the existing literature, we focus explicitly on the synchronization of GDP growth during recessions. Claessens et al. (2009) show that recession periods typically occur simultaneously across countries. We focus, in contrast, on the cross-country correlation of output growth dynamics during recessions.

2   Data and methodology

Let $y_t = (y_{1,t}, ..., y_{7,t})'$ denote the vector of quarterly growth rates of per capita real GDP in the G7 countries (Canada, France, Germany, Italy, Japan, UK and US). We calculate $y_{i,t}$ as the fourth difference of the log of quarterly real GDP per capita. The sample ranges from the first quarter of 1960 to the third quarter of 2009. Data are obtained from the OECD Main Economic Indicators.

The estimation of the DCC model involves two steps: first, we specify each conditional variance as a univariate Generalized Autoregressive Conditional Heteroskedasticity

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[1]An exception is Imbs (2010), who shows that the correlation of industrial production has increased strongly since the end of 2008.

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(GARCH) process and second, we use the standardized residuals from the first step to construct the conditional correlation matrix. Specifically, the DCC model is defined as

$$y_t = \mu_t + \epsilon_t, \quad \text{where} \quad \epsilon_t | \Omega_{t-1} \sim N(0, H_t), \tag{1}$$

$$\epsilon_t = H_t^{1/2} u_t, \quad \text{where} \quad u_t \sim N(0, I), \tag{2}$$

$$H_t = D_t R_t D_t, \tag{3}$$

where $\mu_t = (\mu_{1,t}, ..., \mu_{7,t})'$ is the conditional mean vector of y_t, which we specify to follow an autoregressive process of order 4. ϵ_t is the vector of residuals based on the information set, Ω, available at time $t-1$. The residuals are normally distributed with zero mean and conditional covariance matrix $H_t = (h_{i,j,t})$. I is a 7×7 identity matrix. $D_t = diag(h_{1,1,t}^{1/2}, ..., h_{7,7,t}^{1/2})'$ is a diagonal matrix of square root conditional variances, where $h_{i,i,t}$ follow univariate GARCH processes, and R_t is the matrix containing the time-varying conditional correlations defined as

$$R_t = diag(q_{1,1,t}^{-1/2}, ..., q_{7,7,t}^{-1/2}) Q_t diag(q_{1,1,t}^{-1/2}, ..., q_{7,7,t}^{-1/2}), \tag{4}$$

where $Q_t = (q_{i,j,t})$ is a symmetric, positive definite matrix:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha u_{t-1} u_{t-1}' + \beta Q_{t-1}, \tag{5}$$

where $u_t = (u_{1,t}, ..., u_{7,t})'$ is the vector of standardized residuals, $\bar{Q}$ is the unconditional covariance matrix of u_t, and α and β, which are the values of the autoregressive and variance coefficients, respectively, are nonnegative scalars satisfying $\alpha + \beta < 1$.

Because normality of the residuals is rejected, we estimate the DCC model using the quasi-maximum likelihood estimator under the multivariate student's t distribution.

3 Estimation Results

Table 1 shows the estimation results.[2] We see from Table 1 that 8 out of the 21 dynamic correlations are significant at 5% level of significance. Moreover, 12 correlations are significant at the 10% level. In addition, the estimated correlations are large and significant for

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[2]For the sake of brevity, the GARCH estimation results for the first step are not presented here. Detailed results are available on request.

countries closely geographically related such as the European countries, and the United States and Canada. For instance, we obtain the highest and most significant correlations between Germany and France, Italy and France, and the United States and Canada. In contrast, the correlations between the United States and Italy, Canada and Italy, and Japan and Germany are quantitatively small and insignificant.

Note that the DCC model is well specified as the multivariate versions of the Portmanteau statistic of Hosking (1980) and Li and McLeod (1981) do not reject the null hypothesis of no serial correlation in the standardized and squared-standardized residuals, respectively, up to 10 lags.

Figure 1 shows the dynamic conditional correlations obtained from the DCC for each pair of countries along with US recessions as defined by the National Bureau for Economic Research Business Cycle Dating Committee.[3] Note that using US recessions to define periods of economic downturns is not restrictive, as Claessens et al. (2009) showed that the occurrence of recessions is quite synchronized across countries. The question remains: how synchronized output dynamics are during these periods of downturns? As shown in Fig. 1, the highest degree of business cycle synchronization occured during the 2007-2009 downturn as correlations reached a peak.

Although Fig. 1 suggests that correlations increased during the 2007-2009 recession, we now formally test the hypothesis that recessions, and in particular the 2007-2009 recession, are indeed associated with a stronger international synchronization of output growth. To do so we estimate panel regressions of the form

$$dc_{i,j,t} = \alpha_{i,j} + \beta rec_t + \epsilon_{i,j,t}, \tag{6}$$

where $dc_{i,j,t} = log((1 + \rho_{i,j,t})/(1 - \rho_{i,j,t}))$ and $\rho_{i,j,t}$ is the estimated dynamic correlation between countries i and j. Note that we transform the dynamic correlations to ensure that our dependent variable is not confined to the interval $[-1, 1]$. Our results are not sensitive to this transformation. $\alpha_{i,j}$ are cross-section specific effects and rec_t denotes a dummy variables that is defined as $rec_t = 1$ if the US economy was in a recession in quarter t and $rec_t = 0$ otherwise.

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[3]For the 2007-2009 recession we set the end date to the third quarter of 2009 which coincides with the end of our sample.

Table 2 shows the results. From Column 1 we see that US recessions are associated with significantly higher international correlations. However, Column 2 shows that the correlations behave rather heterogeneously during individual recessions. Here, we estimate Equation 6 with the dummies $rec_{1980} = 1$ for the period 1980Q1 to 1982Q4 and zero otherwise. rec_{1990}, rec_{2001} and rec_{2007} are defined analogously to capture the 1990, the 2001 and the 2007-2009 recessions, respectively.[4] According to our estimates, the recession during the early 1980s was associated with significant, albeit quantitatively small, increase in international synchronization. During the recessions in 1990 and 2001 we find no significant effect and in the former episode, the point estimate is even negative. However, during the 2007-2009 recession we obtain a highly significant and quantitatively large effect. According to the point estimate, the conditional correlations increased on average by slightly more than 0.2 points, which is not just statistically significant, but also economically substantial.

In Column 3, we add the dummy $rec_{<1980}$. which is equal to 1 during recessions that occurred before 1980 and equal 0 otherwise. We see that although we obtain similar effects for the recessions that occurred after 1980, $rec_{<1980}$ enters with a negative sign and significantly at the 10% level. Thus, it appears that before 1980, US recessions were associated with a de-synchronization of GDP growth rates. To illustrate this point further, we estimate a specification with $rec_{<1980}$ and a dummy that captures recessions after 1980: $rec_{>1980}$. According to Column 4, a high degree of international synchronization during US recessions occurs only since the early 1980s. And together with the results reported in Columns 2 and 3, this last result suggests that the overall higher synchronization during recessions we see in Column 1 is to some extent due to the early 1980s, but mostly to the 2007-2009 recession. This result illustrates further that the strong increase in international output co-movements is a rather unique feature of the latest downturn.

Stock and Watson (2005) find that business cycles have generally become less synchronized since 1985. To allow for such a structural break, we re-estimate Equation 6 and include a dummy, D_t, which is equal to 1 if $t > 1984Q4$ and equal to 0 otherwise.

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[4]Note that the recession during the early 1980s was actually a sequence of two recessions. The first one occurring between 1980Q1 to 1980Q3 and the second one between 1981Q3 to 1982Q4. Because our results remain unchanged, we pool these two intervals and treat them as a single recession period.

Column 5 of Table 2 shows that the dummy enters negatively and significantly, whereas rec_{1980}, rec_{1990} and rec_{2001} become insignificant. However, the dummy for the 2007 to 2009 recession remains highly significant.

As a robustness analysis, we repeated the estimation with the correlation between contemporaneous GDP growth in the United States and lagged GDP growth in the remaining G7 countries. In addition, we augmented Equation 6 with aggregate as well as cross-section specific time trends. Our results remain unchanged.

4   Conclusion

In this paper we show that the 2007-2009 recession in the United States is associated with unusually highly synchronized output growth dynamics in the G7 countries. We estimate that, on average, the conditional correlations of GDP growth rates increased by roughly 0.2 points during this period. A key question that arises is why output dynamics during this downturn were so synchronized across the G7 countries.

According to Mendoza and Quadrini (2009) financial integration and contagion may have been a source of the high synchronization. Buch et al. (2010) found that banks transmit shocks internationally. To the extent that banking sectors suffered from severe adverse shocks during the 2007-2009 downturn, this transmission channel may have contributed substantially and more than usually to the high synchronization of output growth rates. A detailed analysis of these issues remains an interesting direction for further research.

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Figure 1: Estimated Conditional Correlations
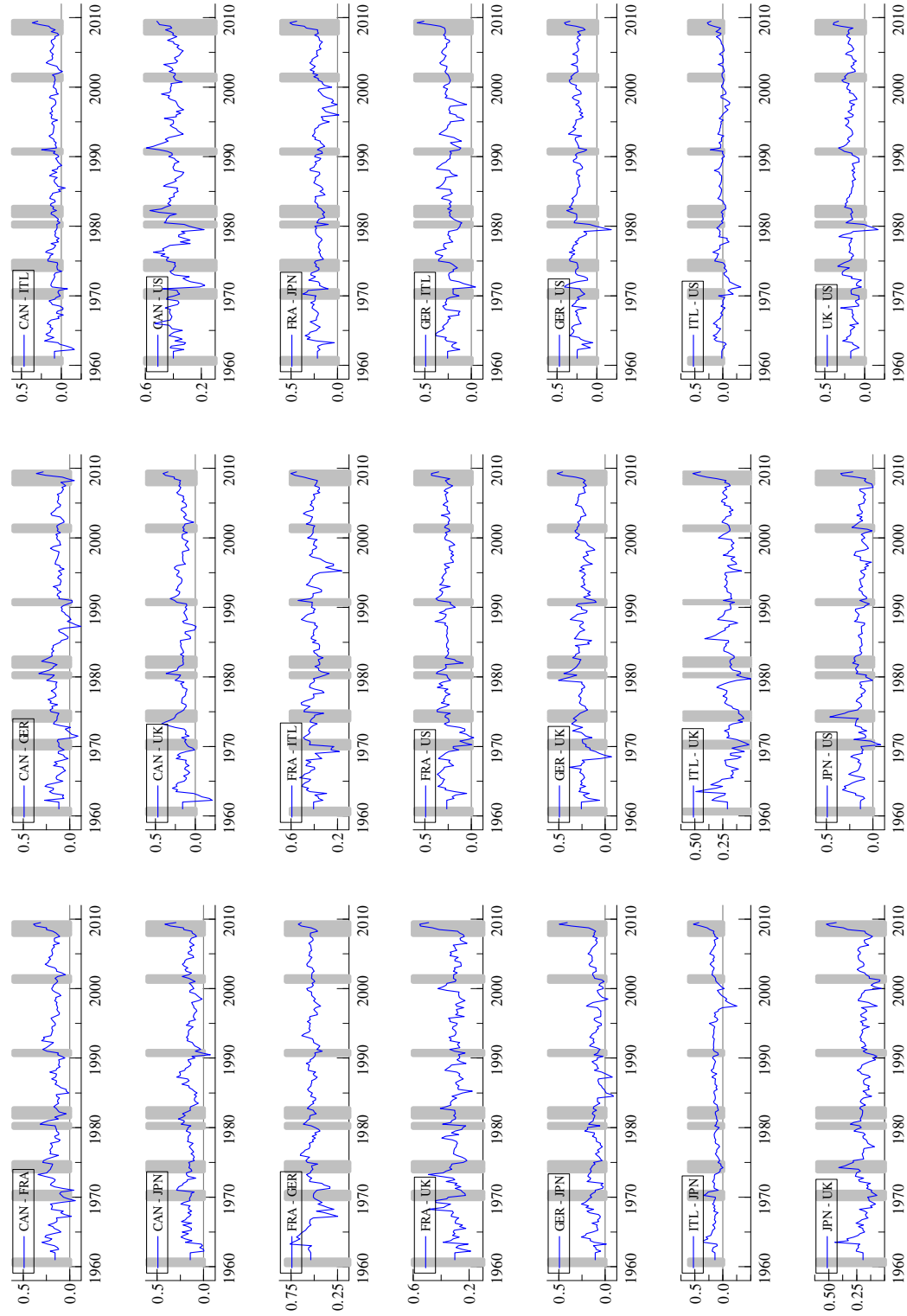
Notes: The figure shows the estimated correlations of real GDP growth rates in the G7 countries. Shaded grey areas denote US recessions as defined by NBER.

Table 1: Estimation Results of AR(4)-DCC models, Period: 1960q1 - 2009q3

ρ	CAN	FRA	GER	ITL	JPN	UK
FRA	0.1590					
	(1.966)					
GER	0.1158	0.5370				
	(1.332)	(8.743)**				
ITL	0.0875	0.4049	0.2554			
	(1.079)	(5.291)**	(2.830)**			
JPN	0.1439	0.2164	0.1072	0.1399		
	(1.807)	(2.522)*	(1.265)	(1.703)		
UK	0.1589	0.3020	0.2552	0.2086	0.1939	
	(1.884)	(3.825)**	(2.764)**	(2.484)*	(2.489)*	
US	0.3992	0.2645	0.2485	0.0171	0.1356	0.1734
	(5.532)**	(3.158)**	(2.944)**	(0.200)	(1.613)	(2.171)*

α	0.0534 (3.22)**
β	0.6580 (9.10)**
df	9.5963 (4.24)**
Log-Lik	4460.44
AIC	-44.9276
SBC	-43.5848
HQC	-44.3839
$H(10)$	358.399 [0.13]
$H^2(10)$	374.152 [0.09]
$Li - McL(10)$	349.188 [0.15]
$Li - McL^2(10)$	372.186 [0.10]

Notes: $H(10)$, $H^2(10)$ and $Li - McL(10)$, $Li - McL^2(10)$ are the multivariate Portmanteau statistics of Hosking (1980) and Li and McLeod (1981), respectively, up to 10 lags. t-Values in parenthesis and p-values in brackets. The functions of the Akaike (AIC), Schwarz Bayesian (SBC) and the Hannan Quinn (HQC) criteria are:

$AIC = (-2LogLik + k\ln(T))T^{-1},$

$SBC = (-2LogLik + k\ln(\ln(T)))T^{-1},$

$HQC = (-2LogLik + k)T^{-1},$

where k denotes the number of parameters, T denotes the number of observations and $LogLik$ denotes the log-likelihood function.

** and * Denote $p < 0.05$ and $p < 0.01$, respectively.

	(1)	(2)	(3)	(4)	(5)
	Table 2: International Correlations and U.S. Recessions				
rec	0.0408***				
	(0.00795)				
rec_{1980}		0.0211**	0.0197**		0.0148
		(0.00963)	(0.00964)		(0.0101)
rec_{1990}		-0.0332	-0.0345		-0.0270
		(0.0215)	(0.0216)		(0.0216)
rec_{2001}		0.00414	0.00282		0.0104
		(0.0111)	(0.0111)		(0.0112)
rec_{07}		0.212***	0.211***		0.219***
		(0.0201)	(0.0201)		(0.0201)
$rec_{t<1980}$			-0.0203*	-0.0203*	
			(0.0111)	(0.0111)	
$rec_{t>1980}$				0.0679***	
				(0.00905)	
D_{1985}					-0.0125***
					(0.00473)
Obs	4095	4095	4095	4095	4095
R^2	0.740	0.757	0.758	0.744	0.758

Notes: In each specification, the dependent variable is the transformed conditional correlation $dc_{i,j,t} = log((1 + \rho_{i,j,t})/(1 - \rho_{i,j,t}))$, where $\rho_{i,j,t}$ is the estimated dynamic correlation between countries i and j. All specifications include cross-section specific effects. Robust SEs in parentheses.

***, ** and * Denote $p < 0.05$, $p < 0.01$ and $p < 0.1$, respectively.