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Business Cycle Synchronization During US Recessions Since the Beginning of the 1870s

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Abstract

This paper examines the synchronization of business cycles across the G7 countries during US recessions since the 1870s. Using a dynamic measure of correlations, results depend on the globalization period under consideration. During the 2007-2009 recession, business cycles co-movements increased to unprecedented levels.

Keywords: Dynamic conditional correlation, Business cycle synchronization, Recession, Globalisation

JEL codes: E3; E32; F4; F41; N10

1. Introduction

How synchronized are business cycles across industrialized countries during US recessions? The empirical literature is limited. The most related existing studies suggests that business cycle co-movements increase during US recessions across industrialized countries (Antonakakis and Scharler, 2012) and across industrialized and developing countries (Imbs, 2010; Yetman, 2011), at least, since the beginning of the 1960s. An unprecedented increase in international correlations during the latest recession of 2007-2009 is also reported in the former two studies.

Yet, little is known on the degree of business cycle synchronization during downturns of US economic activity before the 1960s and in relation with the most recent ones. Artis et al. (2011) examine the effects of globalization on business cycle co-movements since 1880. The goal of this paper is to contribute towards the study of business cycle synchronization dynamics during US recessions from a historical perspective. To achieve that, we obtain a time-varying measure of business cycles correlations based on the dynamic conditional correlation (DCC) model of Engle (2002), and thus extend the work of Antonakakis and Scharler (2012) to a more comprehensive study of 30 recession episodes during the last 142 years. Taking into account both time variation and conditional heterogeneity in business cycle correlations, this measure has several advantages compared to commonly used measures. It is able to distinguish negative correlations due to episodes in single years, synchronous behavior during stable years and asynchronous behavior in turbulent years. Unlike rolling windows, an alternative way to capture time variability, the proposed measure does not suffer from the so-called "ghost features", as the effects of a shock are not reflected in n consecutive periods, with n being the window span. In addition, under the proposed measure

there is neither a need to set a window span, nor loss of observations, nor subsample estimation required.

The results suggest rather heterogeneous patterns of international business cycles synchronization during US recessions. On average, US recessions have significantly positive effects on business cycle co-movements only in the period following the breakdown of the Bretton Woods system of fixed exchange rates, while strongly decoupling effects among the G7 economies are documented during recessions which occurred under the classical Gold Standard. During the 2007-2009 recession, business cycles co-movements increased to unprecedented levels.

This study is closely related to the empirical literature on business cycle synchronization (see, e.g. Artis et al., 2011; Imbs, 2004; Ayhan Kose et al., 2003; Otto et al., 2001) and especially to Crucini et al. (2011), Yetman (2011), Ayhan Kose et al. (2008), Doyle and Faust (2005) and Stock and Watson (2005) who also study business cycles co-movements in the G7 countries. In contrast to these studies, most of which focus on the sources of business cycle correlations, the focus here is explicitly on the synchronization of business cycles during US recessions. According to Claessens et al. (2009), recession periods typically occur simultaneously across countries. The focus here is, on the contrary, on the cross-country correlation of business cycles dynamics during US recessions.

2. Data and methodology

Let us define $y_t = (y_{1,t}, ..., y_{7,t})'$ as the vector of annual growth rates of real GDP per capita in the G7 countries, namely, Canada, France, Germany, Italy, Japan, UK and US. Each $y_{i,t}$ is calculated as the first difference of the log of annual GDP per capita in 1990 US dollars (converted at Geary Khamis PPPs).[1] The data sample ranges from 1870 to 2011 totaling 142 years of observations. The series are obtained from the Total Economy Database of the University of Groningen, which updated the database of Maddison (2003).[2]

To obtain time-varying measure of business cycle correlations, we employ the DCC model of Engle (2002). The estimation of the DCC model involves two steps: first, each conditional variance is specified as a univariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) process and second, the standardized residuals from the first step are used 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 is specified to follow an autoregressive process of order 1. 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

[1] The results presented below are not sensitive to different transformations such as detrended HP-filtered series. These results are available upon request.

[2] Data are obtained from: http://www.conference-board.org/data/economydatabase/ and http://www.worldeconomics.com/Data/MadisonHistoricalGDP/Madison%20Historical%20GDP%20Data.efp.

matrix of square root conditional variances, where $h_{i,i,t}$ follow univariate GARCH processes, and R_t is a symmetric 7×7 matrix containing the time-varying conditional correlations given by

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

or

$$\rho_{i,j,t} = \frac{q_{i,j,t}}{\sqrt{q_{i,i,t} q_{j,j,t}}}, \tag{5}$$

with diagonal elements being equal to one and off-diagonal elements equal to the dynamic conditional correlations, where $q_{i,j,t}$ denotes the elements of an auxiliary, 7×7 symmetric, positive definite matrix Q_t defined as

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha u_{t-1} u_{t-1}^{'} + \beta Q_{t-1}, \tag{6}$$

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 are nonnegative scalars satisfying $\alpha + \beta < 1$.

The DCC model is estimated using the quasi-maximum likelihood estimator under the multivariate Student's t distribution as the normality assumption of the residuals is rejected.

3. Estimation Results

Table 1 presents the estimation results of the DCC model.[3] According to Table 1, 18 out of the 21 dynamic conditional correlations are significant at the 5% level. In addition, the estimated correlations are large and significant for countries in close geographical proximity, such as the US and Canada, and the European countries. For example, the highest and most significant correlations exist between US and Canada, and Italy and France. On the contrary, the estimated correlation between Germany and Japan, Canada and Japan, and Germany and the US are quantitatively small and insignificant.

Notice 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 plots the pairwise dynamic conditional correlations obtained from the DCC model together with US recessions as defined by the National Bureau for Economic Research Business Cycle Dating Committee.[4] According to this figure, the patterns of business cycle synchronization are rather heterogenous during US recessions. For instance, in many country pairs during the 1893-97 and the 1948-49 recessions, business cycle synchronization actually declined, while the highest degree of business cycle synchronization occurred during the "Great Recession" (2007-09) and the Great Depression (1929-33), when correlations reached a peak.

Given these initial inspections of business cycle correlation patterns during US recessions from Figure 1, we now formally test the hypothesis that international business cycles are indeed (a)synchronized during US recessions. To achieve that, we transform the estimated dynamic correlations, $\rho_{i,j,t}$, between countries i and j according to $dc_{i,j,t} = log((1 + \rho_{i,j,t})/(1 - \rho_{i,j,t}))$, so

[3] For the sake of brevity, the GARCH estimation results for the first step are not presented but are available upon request.

[4] Using US recessions to define periods of economic downturns is not restrictive, as Claessens et al. (2009) and Yetman (2011) showed that the occurrence of recessions is quite synchronized across countries.

that to ensure our dependent variable is not confined to the interval $[-1, 1]$, and estimate panel regressions of the form

$$dc_{i,j,t} = \alpha_{i,j} + \beta Trend + \gamma rec_t + \epsilon_{i,j,t}, \tag{7}$$

where $\alpha_{i,j}$ are cross-section fixed effects, $Trend$ is a linear time trend and rec_t denotes a dummy variable that is equal to 1 if the US economy was in a recession in year t, and 0 otherwise.[5]

Table 2 presents the results. From column (1) we observe that US recessions are positively, albeit insignificantly, associated with increased business cycle co-movements. However, column (2) suggests that correlations behave rather heterogeneously during individual recessions that occurred near the end of the 19th century. Specifically, during the 1887-88 recession, business cycle co-movements increased significantly, although to a small extend. On the contrary, the extent of business cycle co-movements declined significantly during the 1893-97 recession.[6] Put differently, the G7 economies "decoupled" from each other during the 1893-97 recession. Other recession episodes under column (2) enter insignificant.

In column (3), we add ten dummy variables for US recessions that occurred till the first half of the 20th century. Among them, the Great Depression of 1929-33 was the only recession that was significantly and positively associated with increased business cycle synchronization. The majority of the remaining recessions were negatively, yet insignificantly, associated with business cycle co-movements, apart from the 1948-49 recession during which correlations declined significantly, albeit marginally. These results remain qualitatively and quantitatively similar even when we introduce two additional dummy variables for US recessions that occurred during the 1950s under Column (4). The only striking difference is that these two dummy variables enter significantly negative, thus further strengthening the decoupling effect across the G7 economies before the 1960s.

The picture is, nevertheless, reversed under column (5) of Table 2, when we introduce dummy variables for the remaining US recession episodes that occurred in the 20th century along with the 2001 and the latest 2007-09 recession. According to column (5), a high degree of international synchronization during US recessions occurs only since the early 1960s. Despite the 1990-91 recession, during the 1969-70, 1973-75, 2001 and the 2007-09 recessions, international business cycles synchronization increased significantly, and especially during the latest global recession of 2007-09. In particular, we find that, on average, conditional correlations of business cycles increased by roughly 0.10 points during the latest recession of 2007-09. Put differently, international business cycle synchronization increased to unprecedented levels during the "Great Recession" than any other individual recession period since the beginning of the 1870s.

The fact that correlations are higher during US recessions which occurred since the 1960s, is further illustrated under column (7) where we include only two dummy variables for recessions occurred before and after the 1960s. Only the latter variable enters significantly positive, while the former is insignificantly negative.

Artis et al. (2011) found evidence that international business cycle synchronization increased since the 1950s. Here we find evidence, under column (6) that international business cycle synchronization significantly increase also during US recessions that took place since the 1950s, while no significant relation exists before the 1950s.

[5] The results are not sensitive to this transformation though.

[6] Note that the recession during the 1893-97 was actually a sequence of two recessions. The first one occurring between 1893 to 1894 and the second one between 1895 to 1897. Because results remain unchanged, these two intervals are pooled and treated as a single recession period. A similar approach has been adopted for the pooled 1910-14, 1918-21 and the 1980-82 recessions dummie variables below.

Finally, in column (8) we consider the degree of business cycles synchronization for US recessions during four fundamental globalization periods of the world economy: 1880-1913 (classical Gold Standard; with relatively free trade and capital mobility), 1920-1939 (Great Depression; trade and capital controls), 1950-1973 (Bretton Woods era of fixed but adjustable exchange rates; limited capital mobility) and the 1973-2011 (floating exchange rates; increased trade and capital integration) periods. Results suggest that business cycle co-movements significantly increase only for US recessions after the breakdown of the Bretton Woods system of fixed exchange rates. In contrast, during the classical Gold Standard period, US recessions are even negatively associated with business cycle co-movements at the 10% level, indicating decoupling effects among the G7 economies during that period. For US recessions that occurred during the 1920-1939 period and the Bretton Woods period of 1950-1973, no significant effects could be identified.[7]

4. Conclusion

In this paper we found that the 2007-2009 recession, compared to any of the 30 recession episodes which occurred since the 1870s in the United States, increased business cycle synchronization across the G7 countries to unprecedented levels. US recessions had, on average, significantly positive effects on business cycle co-movements only in the period following the breakdown of the Bretton Woods system of fixed exchange rates, while strongly decoupling effects among the G7 economies were documented during recessions which occurred under the classical Gold Standard.

A key question that arises is why business cycle correlation dynamics are so heterogenous during recession episodes across the G7 countries. Mendoza and Quadrini (2010) shows that financial integration and contagion may have been a source of the high synchronization during the latest recession. Yet, while the current economic crisis has been triggered, among others, by a burst of asset price bubbles and originated in the financial sector, the implied slump in output and rise in unemployment in many countries feeds back to the financial sector, e.g., by increasing financial stress experienced in the banking industry due to an increased number of defaults. Thus, simultaneous feedback effects between economies' real and financial sectors may be an important feature of contagion and magnification effects of destabilizing shocks during periods of financial and economic crises. A detailed analysis of these issues remains an interesting avenue for future research.

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[7] 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 estimated Eq. (7) with individual recessions dummies added in a stepwise fashion. Our results remain unchanged.

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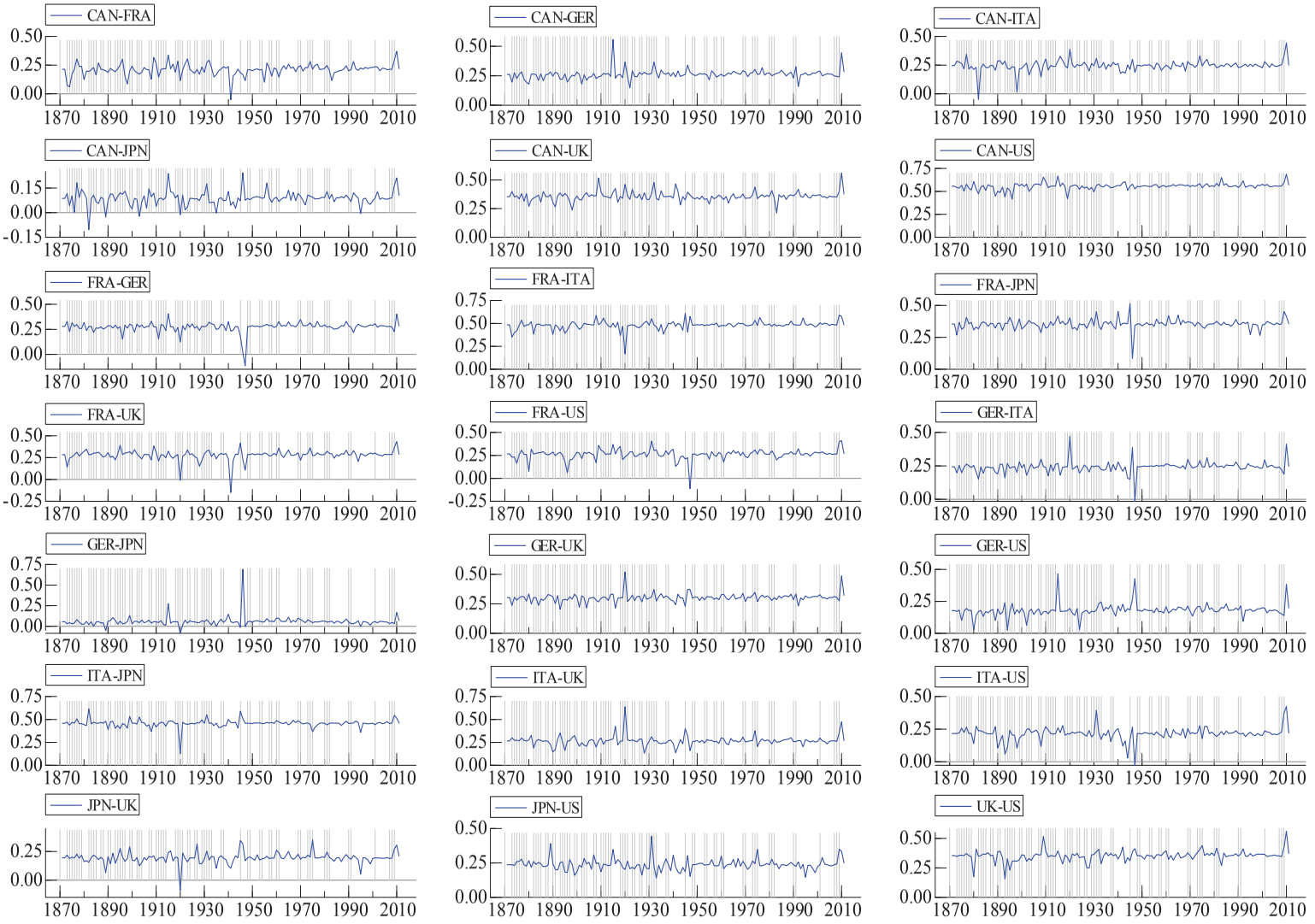
Figure 1: Estimated Conditional Correlations



Note: 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(1)-DCC models, Period: 1870 - 2011

ρ	CAN	FRA	GER	ITA	JPN	UK
FRA	0.2137**					
	(0.0838)					
GER	0.2618***	0.2792***				
	(0.0864)	(0.0857)				
ITA	0.2465***	0.4842***	0.2433***			
	(0.0753)	(0.0785)	(0.0853)			
JPN	0.0867	0.3545***	0.0542	0.4592***		
	(0.0772)	(0.0699)	(0.1050)	(0.0640)		
UK	0.3545***	0.2849***	0.3022***	0.2664***	0.1950**	
	(0.0766)	(0.0961)	(0.0946)	(0.0920)	(0.0935)	
US	0.5567***	0.2657***	0.1784	0.2170**	0.2374***	0.3542***
	(0.0588)	(0.0839)	(0.1151)	(0.0866)	(0.0868)	(0.0880)
α	0.0539 (0.0246)**					
β	0.7145 (0.0542)***					
df	4.5291 (0.5202)**					
Log-Lik	1916.06					
AIC	-26.3413					
SBC	-25.1074					
HQC	-25.8399					
$H(10)$	352.608 [0.12]					
$H^2(10)$	330.750 [0.11]					
$Li - McL(10)$	350.845 [0.13]					
$Li - McL^2(10)$	328.874 [0.12]					

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. Standard Errors in parenthesis and p-values in square 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 $p < 0.01$, $p < 0.05$ and $p < 0.10$, respectively.

Table 2: Business Cycle Synchronization during US Recessions

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
rec	0.0061							
	(0.0042)							
$rec_{1873-79}$		0.0090	0.0085	0.0078	0.0066			
		(0.0089)	(0.0099)	(0.0099)	(0.0100)			
$rec_{1882-85}$		-0.0067	-0.0072	-0.0079	-0.0087			
		(0.0129)	(0.0135)	(0.0135)	(0.0136)			
$rec_{1887-88}$		0.0134**	0.0130*	0.0122*	0.0117*			
		(0.0055)	(0.0067)	(0.0068)	(0.0068)			
$rec_{1890-91}$		-0.0252	-0.0255	-0.0263	-0.0267			
		(0.0160)	(0.0164)	(0.0165)	(0.0165)			
$rec_{1893-97}$		-0.0319**	-0.0322**	-0.0329**	-0.0331**			
		(0.0127)	(0.0132)	(0.0132)	(0.0133)			
$rec_{1899-00}$		0.0184	0.0182	0.0175	0.0175			
		(0.0132)	(0.0136)	(0.0136)	(0.0137)			
$rec_{1902-04}$			-0.0183	-0.0190	-0.0188			
			(0.0116)	(0.0116)	(0.0117)			
$rec_{1907-08}$			-0.0048	-0.0055	-0.0051			
			(0.0165)	(0.0165)	(0.0166)			
$rec_{1910-14}$			0.0027	0.0020	0.0027			
			(0.0076)	(0.0077)	(0.0077)			
$rec_{1918-21}$			-0.0172	-0.0179	-0.0168			
			(0.0245)	(0.0245)	(0.0246)			
$rec_{1923-24}$			-0.0012	-0.0019	-0.0006			
			(0.0128)	(0.0128)	(0.0129)			
$rec_{1926-27}$			-0.0105	-0.0112	-0.0097			
			(0.0111)	90.0112)	(0.0112)			
$rec_{1929-33}$			0.0322***	0.0315***	0.0332***			
			(0.0111)	(0.0111)	(0.0112)			
$rec_{1937-38}$			0.0030	0.0024	0.0044			
			(0.0084)	(0.0084)	(0.0085)			
rec_{1945}			0.0314	0.0308	0.0332			
			(0.0447)	(0.0447)	(0.0448)			
$rec_{1948-49}$			-0.0060*	-0.0066*	-0.0040			
			(0.0034)	(0.0035)	(0.0037)			
$rec_{1953-54}$				-0.0104**	-0.0076*			
				(0.0041)	(0.0042)			
$rec_{1957-58}$				-0.0173***	-0.0143**			
				(0.0058)	(0.0059)			
$rec_{1960-61}$					0.0168			
					(0.0117)			
$rec_{1969-70}$					0.0262***			
					(0.0087)			
$rec_{1973-75}$					0.0356***			
					(0.0117)			
$rec_{1980-82}$					0.0018			
					(0.0063)			
$rec_{1990-91}$					-0.0136**			
					(0.0066)			
rec_{2001}					0.0189**			
					(0.0086)			
$rec_{2007-09}$					0.1020***			
					(0.0193)			
$rec_{t<1950}$						0.0012		
						(0.0059)		
$rec_{t>1950}$						0.0108**		
						(0.0045)		
$rec_{t<1960}$							-0.0011	
							(0.0054)	
$rec_{t>1960}$							0.0175***	
							(0.0051)	
$rec_{1880<t<1913}$								-0.0103*
								(0.0059)
$rec_{1920<t<1939}$								0.0087
								(0.0091)
$rec_{1950<t<1973}$								0.0049
								(0.0048)
$rec_{1973<t<2011}$								0.0165***
								(0.0060)
trend	0.0004***	0.0003***	0.0003***	0.0003***	0.0003***	0.0003***	0.0003***	0.0003***
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
N	2961	2961	2961	2961	2961	2961	2961	2961
R^2	0.8601	0.8607	0.8614	0.8615	0.8623	0.8601	0.8603	0.8604

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