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## Abstract

In this study we provide novel results on the extent of international trade synchronization during periods of trade collapses and US recessions. Based on monthly data for the G7 economies over the period 1961-2011, our results suggest rather idiosyncratic patterns of international trade synchronization during trade collapses and US recessions. During the great recession of 2007-2009, however, international trade experienced the most sudden, severe and globally synchronized collapse.

**Keywords:** International Trade Collapse; Synchronization; Recession; Dynamic Conditional Correlation

**JEL codes:** E32; F15; F41; F43

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# 1 Introduction

Conventional wisdom suggests the international trade collapse during the latest economic crisis of 2007-2009 was the most synchronized over the past three decades. The study by Araújo and Oliveira Martins (2011) represents an initial attempt to address this issue. The authors observe that by the end of 2008, more than 90% of the OECD countries exhibited a simultaneous decline in trade, and which was by far the largest one. Yet, empirically, little is known on the extent of international trade synchronization during downturns of economic activity.

Several studies have attempted to explain the causes and/or the size of the latest trade collapse, e.g. through credit constraints, global productions chains effects and generalized loss of confidence (see, for instance, Cheung and Guichard, 2009; Levchenko et al., 2010; Spehar, 2010; Bems et al., 2011; Ahn et al., 2011; Altomonte et al., 2012, among others). Given that the latest crisis led to the deepest and most synchronized recession over the past three decades (Imbs, 2010), accounting for trade synchronization dynamics in addition to individual country effects seems to be highly relevant for identifying the magnitude of the international trade collapse and its repercussions.

The goal of this short note is to contribute towards the study of international trade synchronization dynamics during collapses of international trade and US recessions. To achieve that, we construct a time-varying measure of international trade correlations based on the dynamic conditional correlation (DCC) model of Engle (2002). The DCC model has several advantages compared to other commonly used measures of international trade correlations; in particular, it incorporates time variation and conditional heterogeneity, and it is able to make a clear distinction between stable periods and even short episodes that are best characterized as ‘turbulent times’. 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 need to set a window span, nor loss of observations, nor subsample estimation required.

Our results based on monthly observations over the period 1961-2011 suggest heterogenous patterns of international trade synchronization during collapses of international trade and US recessions prior to 2007, with few regularities to focus on; in contrast, international trade comovements increased to unprecedented levels during the 2007-09 recession and trade collapse. These results highlight the relevance of international trade integration when examining abrupt

changes in international trade.

The remainder of the paper is organized as follows. Section 2 discusses the methodology and describes the data used. Section 3 presents the empirical findings, and Section 4 summarizes and concludes the paper.

## 2 Data and methodology

Let us define  $y_t = (y_{1,t}, \dots, y_{7,t})'$  as the vector of year-on-year monthly growth rates of trade in the G7 countries, namely, Canada, France, Germany, Italy, Japan, UK and US. Specifically, each  $y_{i,t}$  is calculated as the twelfth difference of the log of the sum of monthly exports and imports in current US dollars.<sup>1</sup> The data sample ranges from 1961M1 to 2011M9 totalling 609 monthly observations. The trade series were obtained from OECD's Monthly Statistics of International Trade (MSIT) database. Figure 1 shows the evolution of the year-on-year growth rate of trade in the G7 countries along with periods of negative trade growth and US recessions. According to Figure 1, the collapse in trade has been unprecedentedly severe during the latest downturn. Specifically, the largest decline in international trade by 44% was documented during the 4th quarter of 2009, while the second in rank recession period associated with severe declines in international trade was the dot-com recession of 2001, where trade declined by 16%.

In order to examine the synchronization of international trade we obtain a time-varying measure of international trade correlations based on 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

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

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

$$H_t = D_t R_t D_t, \quad (3)$$

where  $\mu_t = (\mu_{1,t}, \dots, \mu_{7,t})'$  is the conditional mean vector of  $y_t$ , which is specified to follow an autoregressive process of order 12.  $\epsilon_t$  is the vector of residuals based on the information set,  $\Omega$ ,

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<sup>1</sup>The results presented below are qualitatively identical to different transformations such as monthly trade series as a share of monthly industrial production,  $(X + M)/IP$ , detrended HP-filtered series, or converted in real US dollars. Even when looking at exports or imports individually rather than their sum, our results remain highly robust. These results are available upon request.

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  $7 \times 7$  identity matrix.  $D_t = \text{diag}(h_{1,1,t}^{1/2}, \dots, h_{7,7,t}^{1/2})'$  is a diagonal matrix of square root conditional variances, where  $h_{i,i,t}$  follow univariate GARCH processes, and  $R_t$  is a symmetric  $7 \times 7$  matrix containing the time-varying conditional correlations given by

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

or

$$\rho_{i,j,t} = \frac{q_{i,j,t}}{\sqrt{q_{i,i,t}q_{j,j,t}}}, \quad (5)$$

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

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

where  $u_t = (u_{1,t}, \dots, u_{7,t})'$  is the vector of standardized residuals;  $\bar{Q}$  is the unconditional covariance matrix of  $u_t$ , and  $\alpha$  and  $\beta$  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. According to Table 1, all dynamic conditional correlations are significant at the 1% level. In line with the gravity model reasoning, the estimated correlations are large and significant for countries in close geographical proximity, such as the European countries and the US and Canada. For instance, the highest estimated correlations exist between Germany and France, UK and France, and US and Canada, while the lowest between Canada and Japan, Germany and Japan, and France and Japan.

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 2 plots the pairwise dynamic conditional correlations, obtained from the DCC model, along with periods of negative trade growth in the G7 and US recessions. According to this figure, international trade correlations reached a peak during the latest downturn of 2007-2009,

while declined during the downturn of the 1980s. Note also that, despite fluctuations, a gently increasing trend emerges from this figure, indicating that international trade is becoming more synchronized over time.

Given these initial observations of international trade correlation dynamics during collapses of international trade and US recessions from Figure 2, we now formally test the hypothesis that collapses in international trade are indeed (de)synchronized during downturns of economic activity. 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 that to ensure our dependent variable is not confined to the interval  $[-1, 1]$ ,<sup>2</sup> and estimate panel regressions of the form

$$dc_{i,j,t} = \alpha_{i,j} + \beta Trend + \gamma ng_t + \delta rec_t + \epsilon_{i,j,t}, \quad (7)$$

where  $\alpha_{i,j}$  are cross-section fixed-effects,  $Trend$  is a linear time trend,  $ng_t$  denotes a dummy variable that is equal to 1 if the year-on-year growth rate of trade was negative for at least 3 consecutive months, and 0 otherwise; and  $rec_t$  denotes a dummy variable that is equal to 1 if the US economy was in a recession in month  $t$ , and 0 otherwise.

Table 2 presents the results of model (7). According to Columns (1) and (3) of Table 2, periods of negative trade growth and US recessions, respectively, are on average associated with significant increases in international trade co-movements. Nevertheless, results under Columns (2) and (4) of Table 2 suggest that international trade correlations behave heterogeneously during individual negative growth trade periods and US recessions, respectively. Under column (2) we estimate Equation (7) with the dummy variable  $ng_{1975} = 1$  for the period of negative trade growth between 1975M5 to 1976M1 and zero otherwise.<sup>3</sup> According to our estimates under Column (2) of Table 2, the collapses of international trade during 1975 and 1993 were associated with a significant, albeit quantitatively small, increase in international trade synchronization. Specifically, conditional correlations increased on average by 0.04 and 0.06 points during the 1975 and 1993 trade collapses. On the contrary, the collapse of international trade during 1981 significantly reduced trade synchronization, while the 1991 and 2001 collapses had no significant effects. Nevertheless, during the trade collapse of 2008, international trade correlations increased to unprecedented levels compared to any other trade collapse occurred since the beginning of the 1960s. In particular, conditional correlations increased on average by 0.41 points during the latest collapse, which is not just statistically significant, but economically substantial too.

<sup>2</sup>The results are not sensitive to this transformation though.

<sup>3</sup> $ng_{1981}$ ,  $ng_{1991}$ ,  $ng_{1993}$ ,  $ng_{2001}$  and  $rec_{2008}$  are defined analogously for the periods 1981M1-1983M7, 1991M6-1992M1, 1992M11-1993M10, 2001M3-2002M5 and 2008M10-2009M10, respectively.

A similar qualitative picture emerges from Column (4) of Table 2. Here we check whether and to what extent international trade co-movements are linked to individual US recessions as defined by NBER. According to these results, we observe statistically significant decoupling effects of international trade during the 1969, 1981, 1990 and 2001 US recessions. In contrast, the US recession of 1980, and especially that of 2007-09 significantly increased international trade co-movements. The estimated conditional correlation regarding the latest recession receives a value of 0.17, and which is almost three times larger the one regarding the 1980 recession. Moreover, under each specification of model (7), the time trend turns out to be highly significant and positively signed, indicating that international trade synchronization increases over time on average. However, this increase occurs only slowly.

## 4 Conclusion

In this study we provide novel results on the extend of international trade synchronization during collapses of international trade and US recessions. Based on monthly data for the G7 economies over the period 1961-2011, we found rather idiosyncratic patterns of international trade synchronization during trade collapses and US recessions. During the great recession of 2007-2009, however, international trade experienced the most sudden, severe and globally synchronized collapse.

The statistical features of international trade synchronization during downturns of economic activity uncovered in this study, suggest that these intricate features and their repercussions need to be further examined under a framework similar to that in Imbs (2004), for instance. Such analysis will provide additional insights on the (unprecedented) collapses of international trade during (the latest) crises, and which has serious policy implications for international trade. A detailed analysis of these issues remain an interesting avenue which we leave for future research.

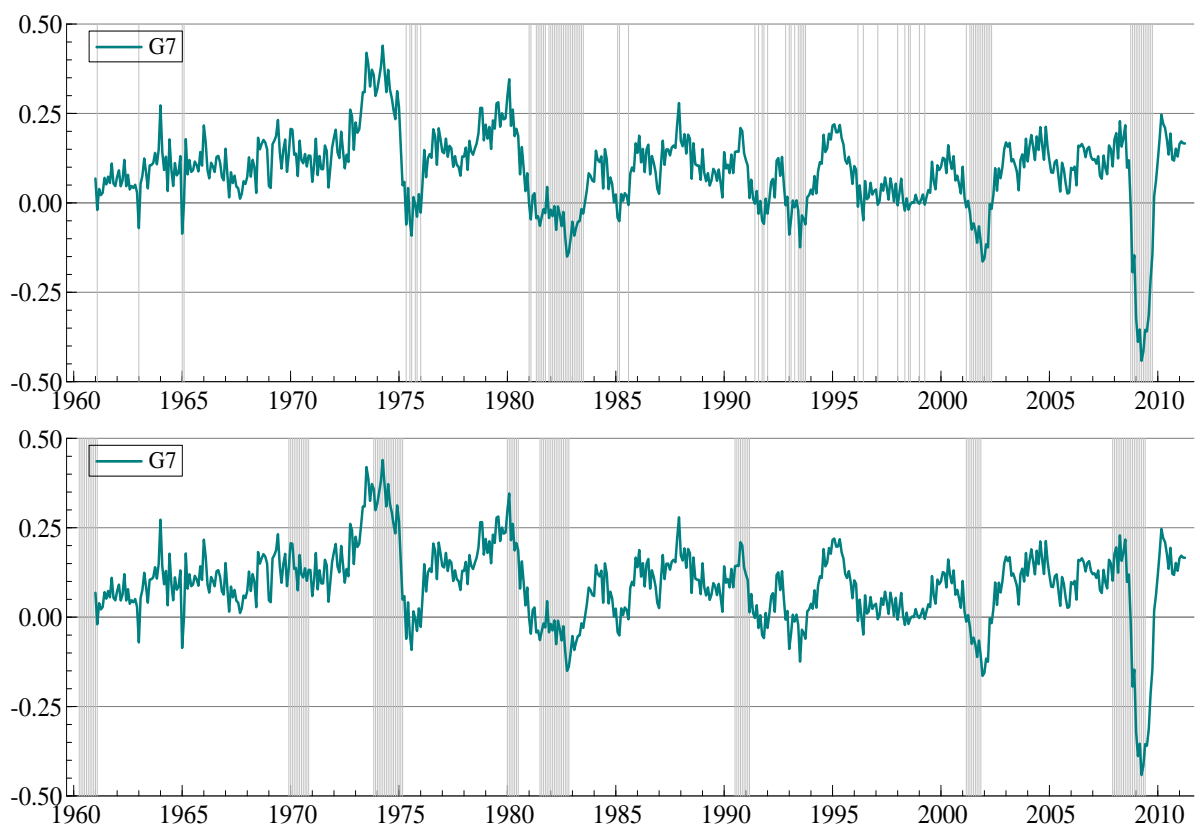
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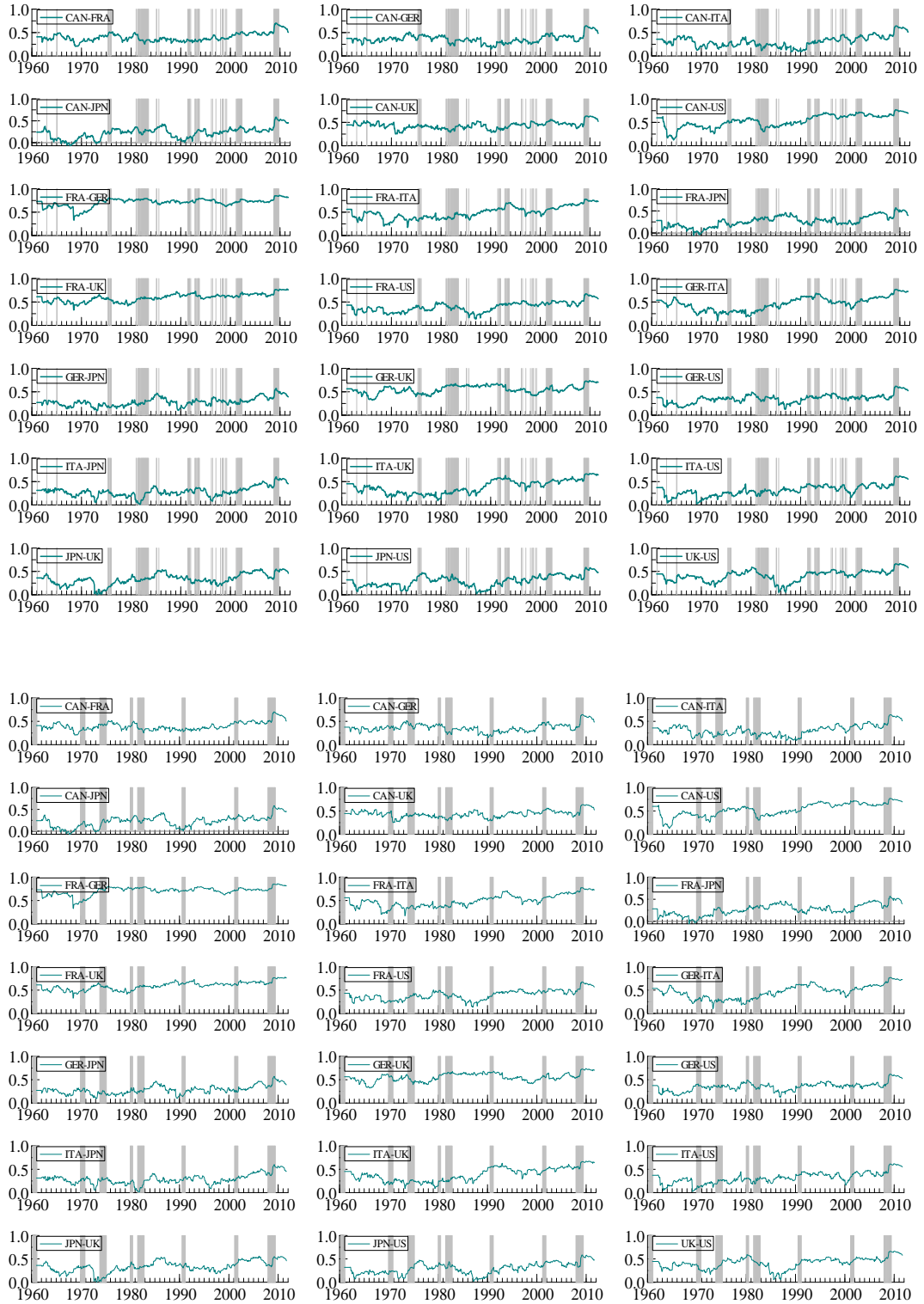
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Figure 1: G7 annualized growth rate of trade, Trade Collapse and US recessions



Notes: Shaded grey areas in the upper panel denote months of negative trade growth, while in the lower panel US recessions as defined by the National Bureau of Economic Research (NBER).

Figure 2: Estimated Conditional Correlations



Notes: The figure shows the estimated correlations of trade growth in the G7 countries. Shaded grey areas in the upper panel denote months of negative trade growth, while in the lower panel US recessions as defined by NBER.

Table 1: Estimation Results of AR(12)-DCC models, Period: 1961M1 - 2011M9

$\rho$	CAN	FRA	GER	ITA	JPN	UK
FRA	0.4093*** (0.0618)					
GER	0.3756*** (0.0692)	0.7296*** (0.0378)				
ITA	0.3579*** (0.0736)	0.5609*** (0.0598)	0.5364*** (0.0652)			
JPN	0.2423*** (0.0727)	0.2826*** (0.0722)	0.2717*** (0.0670)	0.3132*** (0.0711)		
UK	0.4459*** (0.0654)	0.6112*** (0.0497)	0.5624*** (0.0530)	0.4543*** (0.0724)	0.3602*** (0.0673)	
US	0.5980*** (0.0576)	0.4329*** (0.0630)	0.3756*** (0.0684)	0.3722*** (0.0806)	0.3199*** (0.0713)	0.4460*** (0.0623)
$\alpha$			0.0267 (0.0032)***			
$\beta$			0.9493 (0.0078)***			
df			12.528 (2.0666)***			
Log-Lik	6603.55					
$H(10)$	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. \*\*\*, \*\* and \* denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. The functions of the Akaike (AIC), Schwarz Bayesian (SBC) and the Hannan Quinn (HQC) criteria are:

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

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

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

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

Table 2: International Trade Collapse Synchronization

Variable	(1)	(2)	(3)	(4)
<i>ng</i>	0.0491*** (0.0059)			
<i>ng</i> <sub>1975</sub>		0.0370** (0.0165)		
<i>ng</i> <sub>1981</sub>		-0.0283*** (0.0082)		
<i>ng</i> <sub>1991</sub>		0.0061 (0.0155)		
<i>ng</i> <sub>1993</sub>		0.0561*** (0.0139)		
<i>ng</i> <sub>2001</sub>		0.0120 (0.0086)		
<i>ng</i> <sub>2008</sub>		0.4060*** (0.0120)		
<i>rec</i>			0.0117** (0.0059)	
<i>rec</i> <sub>1969</sub>				-0.0619*** (0.0141)
<i>rec</i> <sub>1973</sub>				-0.0133 (0.0104)
<i>rec</i> <sub>1980</sub>				0.0587*** (0.0190)
<i>rec</i> <sub>1981</sub>				-0.0694*** (0.0112)
<i>rec</i> <sub>1990</sub>				-0.0905*** (0.0171)
<i>rec</i> <sub>2001</sub>				-0.0431*** (0.0106)
<i>rec</i> <sub>2007</sub>				0.1719*** (0.0143)
<i>trend</i>	0.0009*** (0.0000)	0.0009*** (0.0000)	0.0009*** (0.0000)	0.0009*** (0.0000)
<i>N</i>	12789	12789	12789	12789
<i>R</i> <sup>2</sup>	0.7152	0.7323	0.7136	0.7205

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 statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively.