Journal of International Economics 94 (2014) 239–247

Contents lists available at ScienceDirect

Journal of International Economics

journal homepage: www.elsevier.com/locate/jie

Comovement in GDP trends and cycles among trading partners☆

Bruce A. Blonigen [a,b,*], Jeremy Piger [a], Nicholas Sly [a]

[a] Department of Economics, University of Oregon, Eugene, OR 97403-1285, United States
[b] NBER, United States

ARTICLE INFO

Article history:
Received 6 June 2012
Received in revised form 28 June 2014
Accepted 30 June 2014
Available online 6 July 2014

JEL classification:
F42
C22
E32

Keywords:
Output comovement
International business cycles
Trade linkages

ABSTRACT

It has long been recognized that business cycle comovement is greater between countries that trade more intensively with one another. However, nations face shocks to both the cyclical and trend components of their GDP series. Contrary to the result for cyclical fluctuations, we find comovement of shocks to the trend component of real GDP is weaker among countries that trade more intensively with one another. We simulate changes in ten-year output growth correlations corresponding to the estimated effects of trade and show that the impact of trade on trend comovement is quantitatively more important than its effect on cyclical comovement.

1. Introduction

It has long been recognized that business cycle comovement is greater between countries that trade more with one another. Frankel and Rose (1998) first demonstrated stronger correlations between business cycle fluctuations in real GDP for trading partners. A large ensuing literature has demonstrated that this result is robust to the inclusion of a battery of additional explanatory variables, country-pair effects, and is also present for intra-industry and infra-national trades.[1]

However, business cycle fluctuations are not the only, or even dominant, source of output growth fluctuations for many countries. Shocks to the trend component of aggregate output, which we define as shocks that have permanent effects on output levels, are also of primary importance. Indeed, shocks to the trend account for over half the variance of quarterly real GDP growth for the majority of countries in our sample. The extent of comovement in GDP trends is also substantial; the median absolute correlation between quarterly trend shocks is 0.3 over our sample period, and thus the capacity of trade to transmit trend shocks is of important policy relevance. In addition, because shocks to the trend have permanent effects on the level of output, while cyclical fluctuations have only transitory effects, trend shocks will be the dominant source of comovement in long-horizon output growth. We can then expect that any changes in correlations of long-horizon output growth work principally through changes in trend shock comovement. Given these facts, it is surprising that the existing literature has focused exclusively on transitory cyclical shocks. Our goal in this analysis is to empirically assess the impact of trade on comovement between shocks to countries' trend levels of output.

Our paper's main contribution is to demonstrate that, contrary to the standard result for cyclical fluctuations, the correlation between shocks to GDP trends is significantly *weaker* among G7 countries that trade more intensively with one another.[2] The negative association between trade openness and trend comovement is quantitatively important. A one-standard deviation increase in trade intensity between countries reduces the correlation in shocks to their output trends by approximately one-third of a standard deviation. Having estimated the effect of trade on comovement in both cyclical fluctuations and trend shocks, we then perform a simulation experiment to quantify the relative importance of

☆ We appreciate helpful comments from the editor, Ariel Burstein, and two referees. We benefited from discussions at various stages with Linda Goldberg, Jean Imbs, Timothy Kehoe, Andrei Levchenko, and John Romalis. We also thank Jason Query for his data assistance. Any remaining errors are our own.

* Corresponding author at: 1285 University of Oregon, Department of Econonics, Eugene, Or 97403-1285 USA.

E-mail addresses: bruceb@uoregon.edu (B.A. Blonigen), jpiger@uoregon.edu (J. Piger), sly@uoregon.edu (N. Sly).

[1] See for example Baxter and Kouparitsas (2005), Burstein et al. (2008), Levchenko and di Giovanni (2010), and Clark and van Wincoop (2001).

[2] As with cyclical comovement, the average correlation in trend fluctuations across all country-pairs is positive, with very few country-pairs experiencing negative correlations across the entire sample. Thus the negative impact of trade on the correlation between GDP trend fluctuations indicates a movement in correlations toward zero, or weaker comovement, on average.

http://dx.doi.org/10.1016/j.jinteco.2014.06.008
0022-1996/

each effect on comovement in overall output growth. We find the negative effect of trade on trend comovement is quantitatively more important for explaining ten-year output growth correlations. For countries outside the G7, we find no relationship between trade openness and trend comovement. This finding that the effect of trade openness on trend comovement is relatively more important for G7 country pairs is also consistent with the standard results for cyclical comovement in Kose et al. (2003, 2008).

Our analysis requires that we obtain distinct measures of the trend and cyclical components of real GDP. To estimate these separate components of each nation's output series we use an unobserved-components model that identifies trend versus cyclical fluctuations by assuming that the trend represents the accumulation of the permanent effects of shocks to the level of real GDP, which is equivalent to the stochastic trend in real GDP. The cyclical component is the deviation of real GDP from this stochastic trend, and represents transitory fluctuations in the series. The unobserved-components model has been used extensively as a tool for trend and business cycle measurement,[3] and avoids issues associated with deterministic detrending and band-pass filters.[4] Having estimated shocks to nations' output trends, we construct our key dependent variable as the correlation between changes in the trend component of quarterly real GDP observed over the years 1980 to 2010 for 210 country-pairs.

We take several steps to ensure that the effect of trade on comovement that we identify is not due to other underlying factors. To avoid spuriously attributing common shocks across countries that occur within a period to the effect of trade linkages, we construct a panel of comovement periods for three distinct decades and control for decade fixed effects. By constructing a panel of comovement periods within each country-pair we can also include pair fixed effects, which accounts for *inter alia*, relative asset market completeness between countries. Relevant to our context, Ghironi (2006) and Baxter and Crucini (1995) find the differential output response to productivity shocks between complete and incomplete asset market structures is much larger when the shocks are permanent. Given our focus on the transmission of permanent shocks, constructing a panel of comovement periods and including pair-level effects to account for the nature of asset markets is likely important. The substantial literature on cyclical comovement suggests other factors that may contribute to comovement in output levels. Our empirical strategy incorporates these alternative channels which could potentially obfuscate the consequences of international trade.[5] The main result regarding weaker trend comovement among trading partners is robust to the inclusion of these other potential determinants of comovement patterns.

The next section describes our methodology for estimating trend and cyclical fluctuations for the GDP series of each country, the calculation of comovement between country-pairs, and our empirical specification linking comovement to trade intensity. Section 3 presents the results for the effects of trade on comovement patterns, and presents a simulation exercise to quantify the effects of trade on trend comovement. The final section concludes.

2. Empirical strategy

Our analysis proceeds in two steps. First, we separate changes in the real GDP series for each country into trend and business cycle components, and calculate cross-country correlations for the fluctuations in both of these components. Second, we relate these correlations to trade intensity between country-pairs. This section provides details about each step of our empirical strategy.

2.1. Estimating trends and cycles in real GDP

The trend and business cycle components of real GDP are not directly observed. A large existing literature provides several alternative definitions of trend versus business cycle fluctuations, and corresponding methods to identify these defined components. Here, we define and identify trend versus business cycle components in real GDP using an unobserved-components (UC) model. The UC model has a long history in macroeconometrics as a tool for business cycle measurement.[6] In the UC framework, log real GDP for country i in period t, denoted $y_{i,t}$, is additively divided into trend ($\tau_{i,t}$) and cyclical ($c_{i,t}$) components:

$$y_{i,t} = \tau_{i,t} + c_{i,t}. \tag{1}$$

The UC framework then specifies explicit equations for the trend and cyclical components. The trend component is specified as a random walk process, while the cyclical component follows a covariance stationary autoregressive (AR) process:

$$\tau_{i,t} = \mu_i + \tau_{i,t-1} + v_{i,t}, \tag{2}$$

$$\phi_i(L)c_{i,t} = \epsilon_{i,t}, \tag{3}$$

where $\phi_i(L)$ is a p^{th} order lag polynomial with all roots outside the complex unit circle, $v_{i,t} \sim \text{i.i.d. } N\left(0, \sigma^2_{v_i}\right)$, and $\epsilon_{i,t} \sim \text{i.i.d. } N\left(0, \sigma^2_{ilon_i}\right)$. Following the bulk of the existing literature on business cycle measurement with UC models, we make the assumption of independence between trend and cyclical shocks, such that $\sigma_{v_i,\epsilon_i} = 0$.[7] The model in Eqs. (1)–(3) is estimated via maximum likelihood, and estimates of the trend and cycle components are constructed using the Kalman Smoother.

The UC model identifies trend versus business cycle fluctuations by assuming that the trend represents the accumulation of the permanent effects of shocks to the level of real GDP. In other words, the trend in real GDP is equivalent to the stochastic trend in real GDP. The business cycle component is then the deviation of real GDP from this stochastic trend, and represents transitory fluctuations in the series. This identification strategy is consistent with a wide range of macroeconomic models in which business cycle variation represents temporary fluctuations in real GDP away from trend. As shown in Morley et al. (2003), the UC approach to detrending is also equivalent to the well-known Beveridge

[3] Examples of macroeconomic detrending using the unobserved-components framework include Harvey (1985), Watson (1986), Clark (1987), Harvey and Jaeger (1993), Kuttner (1994), Kim and Nelson (1999), Kim and Piger (2002) and Sinclair (2009). Also, as shown in Morley et al. (2003), the unobserved-components decomposition is consistent with the identification of trend and cyclical components used in the Beveridge and Nelson (1981) decomposition. For a recent example of measurement of macroeconomic trends using the Beveridge-Nelson decomposition, see Cogley and Sargent (2005).

[4] Other popular approaches to business cycle measurement used in the existing literature on the trade–comovement relationship, such as the band-pass filter of Baxter and King (1999) or first differencing, have been shown to produce measures of the business cycle that conflate transitory and permanent shocks. See, e.g., Cogley and Nason (1995) and Murray (2003). Thus, the existing literature can be interpreted as providing a mixture of the effects of trade on permanent and transitory output variation. Here, we separate out these effects, and show they are very different.

[5] Imbs (2004) and Imbs and Wacziarg (2003) argue that specialization patterns in output across countries independently affect comovement patterns. Baxter and Kouparitsas (2005) evaluate the robustness of other country-pair specific features in generating cyclical comovement and find strong support for the inclusion of gravity variables (e.g., geography), which partially determine trade flows. Our use of country-pair fixed effects subsumes these gravity variables. There is also evidence that investment linkages impact comovement (Prasad et al., 2007) as does the presence of foreign affiliates of multinationals firms located partner countries (Kleinert, et al. 2014). Blonigen and Piger (2011) demonstrate that the best predictors of foreign direct investment patterns and multinational firm activity between countries are those suggested by gravity models. Thus our fixed-effects strategies also capture motives for nations to invest in one another.

[6] Early examples of macroeconomic detrending using the UC framework include Harvey (1985), Watson (1986), and Clark (1987).

[7] See, e.g., Harvey (1985), Clark (1987) and Harvey and Jaeger (1993). Morley et al. (2003) provide analysis and application of UC models with correlated components.

and Nelson (1981) decomposition, which measures the business cycle from the forecastable variation in real GDP growth.[8] Rotemberg and Woodford (1996) argue that this forecastable variation makes up the essence of what it means for a macroeconomic variable to be "cyclical."

The existing literature investigating the relationship between trade intensity and business cycle comovement has taken multiple approaches to measure the business cycle component of real GDP, including deterministic detrending (linear or quadratic), the band-pass filters of Hodrick and Prescott (1997) and Baxter and King (1999), and first differencing. For our purposes, deterministic detrending is unsatisfactory, as we are interested in studying correlations between stochastic shocks to trend real GDP. Under the assumption of a deterministic trend, such stochastic shocks do not exist.

When real GDP contains a unit root, band-pass filters and first differencing will both produce a measure of the cyclical component that is partially influenced by shocks to the stochastic trend. For example, suppose that real GDP is generated by a stochastic process similar to Eqs. (1)–(3), then the first difference of real GDP and the business cycle component produced by a band-pass filter will be influenced by both the permanent and transitory shocks, v_t and ϵ_t. To the extent one believes that permanent shifts to real GDP appropriately belong in the trend of real GDP, this is problematic. As an example of this, Cogley and Nason (1995) and Murray (2003) demonstrate that if real GDP is itself a random walk, band-pass filters will generate a cyclical component.[9] As will be seen in Section 3 below, this seemingly extreme example is relevant to a number of countries in our sample, for which the trend dominates the variance of real GDP growth.

The model for the trend component in Eq. (2) implies a constant average growth rate of μ for the trend component of real GDP. To relax this restriction, for each country we also estimate a version of the model in which Eq. (2) is replaced with:

$$\tau_{i,t} = \mu_{i,0} + \mu_{i,1} D_{i,t} + \tau_{i,t-1} + v_{i,t}, \tag{4}$$

where $D_{i,t}$ is a dummy variable that is zero prior to the break date k_i, and one thereafter. This break date is estimated along with the other parameters of the model via maximum likelihood.[10] We then report results based on the UC model with either Eq. (2) or (4) by choosing that model that minimizes the Schwarz Information Criterion.

2.2. Variable construction

For each country-pair in our sample, we require the correlation between trend fluctuations and the correlation between cyclical fluctuations in aggregate output. Measured across all the country-pairs, these correlations then make up the cross-section for two different dependent variables used in our analysis. To create a time-series dimension to our sample, we measure correlations separately by decade. The correlation between cyclical fluctuations in countries i and j in decade d is given by

$$\rho^c_{ijd} = corr_d\left(\hat{c}_{i,t}, \hat{c}_{j,t}\right), \tag{5}$$

where $corr_d(\cdot)$ indicates the sample correlation coefficient measured using data in decade d, and $\hat{c}_{i,t}$ and $\hat{c}_{j,t}$ represent the Kalman smoothed estimates of the business cycle component for countries i and j respectively. For trend fluctuations, the level of the trend component contains a unit root by assumption, and second moments of this level are thus infinite. To study the correlation between trend fluctuations, we consider the correlation between first differences of the trend component. Given the random walk assumption for the trend component in (2), this is equivalent to considering the correlation between the permanent shocks to real GDP in the two countries:

$$\rho^\tau_{ijd} = corr_d\left(\hat{v}_{i,t}, \hat{v}_{j,t}\right), \tag{6}$$

where $\hat{v}_{i,t}$ and $\hat{v}_{j,t}$ represent the Kalman smoothed estimates of the shocks to the trend component for countries i and j.

Our goal is to relate comovement patterns to the strength of trade relationships across countries. As with previous studies of cyclical comovement we weight trade flows between countries by their respective GDP levels. The variable, $Trade_{ijd}$, measures trade between countries i and j during decade d, and is calculated by

$$Trade_{ijd} = \frac{1}{T_d}\sum_{t\in d}\left(\frac{X_{ijt}+M_{ijt}}{Y_{it}+Y_{jt}}\right), \tag{7}$$

where T_d is the total number of quarterly time periods observed in each decade d, $X_{ijt} + M_{ijt}$ is real valued exports plus imports between countries i and j expressed in \$US, and Y_{it} and Y_{jt} are real GDP for countries i and j expressed in \$US. Thus, this measure has the interpretation of the amount of trade between countries i and j relative to the total economic size of these two countries.[11]

Our choice of decades as the time-series unit of observation is driven by several factors. First, this time interval matches the earlier literature, for example Frankel and Rose (1998), Calderon et al. (2007) and Kose et al. (2003), which aids comparability of our results. Second, while a longer time interval holds the promise of more accurate estimates of output correlations, it also increases the probability of computing correlations over periods that include structural changes in international output processes. In their study of G7 business cycle correlations, Doyle and Faust (2005) find structural breaks in time-series processes for international real GDP series that correspond roughly to traditional decade definitions. This suggests decades as the maximum time period over which to compute correlations without contamination from structural breaks.

2.3. Data

GDP data come from the International Financial Statistics published by the International Monetary Fund (IMF). For 21 countries, we observe quarterly output from 1980:Q1 to 2010:Q4. By restricting ourselves to the post-1980 period we are able to include a relatively large number of countries from different regions of the world and at different stages of development.[12] The set of countries in our sample also corresponds to those studied in previous analyses of comovement, limiting the potential for sample selection to generate any differences in our results for trend versus cyclical comovement.

We choose to measure GDP quarterly, as there is substantial evidence in the existing literature that both the business cycle and trend components account for a substantial portion of quarterly fluctuations in international real GDP growth series.[13] We will present evidence consistent with this result for our sample of countries in Section 3 below. Previous studies have estimated cyclical comovement patterns for a longer time series, but generally have relied on annual data that can mask some of these important higher frequency fluctuations. For example,

[8] Specifically, Morley et al. (2003) show that given the same reduced form time-series model used to represent real GDP, the UC-based decomposition gives the same estimates of trend and cycles the Beveridge–Nelson decomposition.

[9] In the literature, this phenomenon is often, and not without controversy, referred to as a "spurious cycle." See, e.g., Cogley (2001) and Pedersen (2001).

[10] We assume that the break date does not occur in the initial or terminal 20% of the sample period.

[11] Several previous studies have employed measures of trade intensity identical to Eq. (7) except that nominal values of trade and GDP are used instead of real values. Such a measure only has an interpretation as a real measure of trade intensity when the proper deflator for the trade terms and each of the GDP terms is identical. If this is not true, and there is no reason to believe that it would be, then the trade intensity measure constructed using nominal data will be affected by various relative price level changes.

[12] The countries in our sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. New Zealand is a slight exception in that we do not observe the real GDP series until mid 1982.

[13] See, e.g., Cogley (1990), Morley et al. (2003), and Aguiar and Gopinath (2007).

annual data will average away business cycle episodes that last only a few quarters.

Information about bilateral trade flows comes from the Direction of Trade Statistics, also published by the IMF. We observe total imports and exports between country-pairs. Trade flows are expressed in nominal US dollars, which we deflate directly as described in Section 2.2 above. In several instances export values do not correspond precisely to import values reported by the destination country. Our results are insensitive to which country's reported value of trade is used for any given country-pair.[14]

Using the quarterly real GDP data we construct estimates of the cycle and trend components and the corresponding country-pair cycle and trend shock correlations as described in Sections 2.1 and 2.2 above. The correlations are computed for each of the three decades in the sample, 1980–1989, 1990–1999 and 2000–2010. The average bilateral trade intensity over each of these decades is also computed for each country-pair. The final data set is then a panel with 210 unique trading partners and 3 time series observations corresponding to the three decades in the sample. Table 1 presents summary statistics for the cycle correlation, trend shock correlation, and bilateral trade flow measure for the full sample, for each decade, and for country pairs where both are G7 members.

Table 1
Comovement summary statistics.

	Variable	Obs	Mean	Std. dev.	Min	Max
Full sample	Cycle corr	630	0.248	0.416	−0.950	0.986
	Trend corr	630	0.211	0.242	−0.422	0.793
	Trade	630	0.223	0.531	0	5.664
G7 nations	Cycle corr	63	0.513	0.473	−0.890	0.975
	Trend corr	63	0.234	0.299	−0.422	0.793
	Trade	63	0.961	1.194	0.057	5.664
80s	Cycle corr	210	0.285	0.435	−0.668	0.968
	Trend corr	210	0.115	0.179	−0.409	0.714
	Trade	210	0.187	0.448	0.001	4.374
90s	Cycle corr	210	0.099	0.396	−0.950	0.935
	Trend corr	210	0.105	0.209	−0.422	0.753
	Trade	210	0.229	0.547	0.001	5.490
00s	Cycle corr	210	0.359	0.371	−0.510	0.986
	Trend corr	210	0.414	0.195	−0.353	0.793
	Trade	210	0.252	0.588	0	5.664

2.4. Relating comovement to trade

To estimate the differences in comovement patterns across country-pairs with varying trade relationships we estimate the following regression equation:

$$\rho^h_{ijd} = \alpha + \beta Trade_{ijd} + \Gamma X_{ijd} + \eta_{ij} + \delta_d + \xi_{ijd} \tag{8}$$

where $h = c, \tau$. Our primary interest is in explaining variation in ρ^{τ}_{ijd}, the correlation between permanent trend shocks, across country pairs. However, we also estimate Eq. (8) where the dependent variable is the correlation between transitory (cyclical) shocks, that is ρ^c_{ijd}, to verify that our sample is consistent with the patterns highlighted previously in the literature.

The variable δ_d is a decade-specific fixed effect used to control for systematic changes across the sample in country-pair GDP movement correlations. Doyle and Faust (2005) estimated structural breaks in comovement statistics among G7 nations and found that, on average, cyclical comovement became weaker over the period 1960–2002. Table 1 confirms this result for cyclical correlations, but also shows a subsequent increase in average cyclical correlations during the 2000s. Table 1 also shows increases in the average correlation between trend shocks in the 2000s, after remaining stable in the 1980s and 1990s. Finally, Table 1 demonstrates that, on average, trade has grown steadily over the sample period. Decade-specific fixed effects spurious correlation from these patterns in the trade–comovement relationships we estimate. In addition, we also include a full set of interactions between trade intensity and the decade effects to investigate whether the role of trade in generating comovement has changed over time.

The term η_{ij} is a country-pair fixed effect included when we estimate Eq. (8) to account for the varying incentives for countries to trade and invest with one another, and other fixed characteristics between countries that influence comovement such as asset market structure. The gravity model predicts that exogenous differences in geography and distance will cause bilateral trade patterns to vary.[15] The importance of gravity variables in generating comovement in GDP series is emphasized by Baxter and Kouparitsas (2005) and Kose and Yi (2006). Moreover, Kose and Yi (2006) examine trade in a comovement in a multilateral framework, where the potential to trade with a third country influences the transmission of shock between any pair of countries. As shown by Redding and Venables (2004), among many others, country-pair fixed effects account for the relative price effects of international trade in a multi-country setting. Including pair-level fixed effects is also important to account for the relative completeness of asset markets between countries, which also influences the transmission of shocks. Particularly relevant to our context, Ghironi (2006) and Baxter and Crucini (1995) show the difference in output response to productivity shocks when there are complete versus incomplete asset market structures much larger when the shocks are permanent. Since we focus on the transmission of permanent output shocks between countries, our preferred specifications include pair-level fixed effects to account for the relative degree of asset market completeness.

We also estimate Eq. (8) separately for the sample of country pairs that involve two G7 member countries. Previous studies have demonstrated that the impact of trade linkages on business cycle comovement varies substantially across levels of industrial development; Calderon et al. (2007) provide evidence that the effect of trade on cyclical fluctuations is much different among developing countries than for high income nations, and Kose et al. (2003) demonstrate specifically the importance of estimating the effect of trade separately for G7 and non-G7 nations. Moreover, members of the G7 have undergone significant reductions in the volatility of their output series in the last several decades, which affects the measurement of how synchronized are the shocks to nations GDP series; see Stock and Watson (2005) for further discussion of this point. Also relevant to the current context, there is evidence that the type and composition of trade differ between small and large countries (i.e., G7 and non-G7 members).

The vector X_{ijd} incorporates several observable variables suggested previously in the comovement literature. Imbs and Wacziarg (2003) show that comovement patterns are systematically related to patterns of industry specialization. To account for similarity in specialization patterns, Imbs (2004) suggests controlling for the combined income levels, as well as differences in income, between country-pairs.[16] Rose and Engel (2002), and subsequent studies, argue that nations within a currency union exhibit stronger comovement in cyclical output. We include an indicator variable, CU_{ijd}, that equals one if country-pair *ij* belongs to a currency union during period *d*. In contrast Baxter and Kouparitsas (2005) perform a general robustness analysis of the determinants of comovement across countries. They argue that bilateral

[14] Note that the trade measures have been scaled (×100) to improve exposition of tables that report point estimates for the effects of trade on comovement patterns.

[15] Redding and Venables (2004) provide robust evidence on the effects of geography on international trade patterns.

[16] We note that our inclusion of relative income levels between countries does not conform exactly to the specification in Imbs (2004). He estimated a static model in a simultaneous equations framework, whereas here we exploit time series variation in the sample. Thus, the role of national incomes across our specifications differs somewhat.

trade is a robust predictor of business cycle comovement, while patterns of industrial specialization and membership in a currency union are not. We present evidence from specifications with and without these control variables and obtain similar results.

3. Results

3.1. Trend & cycle components of real GDP

Table 2 reports results regarding the estimated trend and cyclical components of real GDP across countries. The second column gives the estimate of μ_i, which has the interpretation of the average quarterly growth rate of the trend component for country i. For those countries where the model with a one-time structural break in μ is the preferred model, Table 2 reports the estimates of both $\mu_{i,0}$ and $\mu_{i,1}$, along with the estimated date of the structural break (in parenthesis). For most countries, average annualized trend growth rates range from between 1.6% to 3.2%. Korea displays faster growth than all other countries over the entire sample period, although this growth rate slows in the last decade of the sample period. During the first decade in the sample period, Japan also displays faster than typical trend growth, before slowing significantly at the start of the 1990s. Two other countries, Spain and Italy, also display evidence of a changing trend growth rate, which in both cases are growth slowdowns in the early to mid 2000s.

Our primary interest in this paper is the stochastic shocks to the trend and business cycle components. The second and third columns of Table 2 give the estimated standard deviation of these shocks, σ_{vi} and $\sigma_{\epsilon i}$. Comparing across countries, there are large differences in the estimated standard deviations for shocks to the trend component. Eight of the countries in the sample experience quarterly shocks to the trend component with a standard deviation of 4% of real GDP or higher on an annualized basis, while for seven others this standard deviation is below 2% of real GDP. For nearly all countries, shocks to the trend component are substantial, with Canada being the only case where trend shocks have a standard deviation less than 1% of real GDP. For shocks to the business cycle component there is more uniformity, although three countries, Mexico, New Zealand, and Norway, stand out for having larger than typical business cycle shocks.

A novel feature of our paper is the focus on the relationship between trade intensity and comovement in trend fluctuations. Thus, it is of particular interest to gauge the relative importance of the trend versus the cycle for generating variability in real GDP growth. If the trend component was relatively unimportant in this respect, the effect of trade on trend comovement would be of less interest. To measure the relative importance of the trend we calculate variance decompositions. Note that from Eq. (1), quarterly output growth can be expressed as $\Delta y_{i,t} = \Delta\tau_{i,t} + \Delta c_{i,t}$. Given the independence of shocks to the trend versus the cyclical component, the variance of quarterly output growth is then given by $Var(\Delta y_{i,t}) = Var(\Delta\tau_{i,t}) + Var(\Delta c_{i,t})$. Each of the components on the right hand side of this equation can be computed analytically using the estimates of the parameters of the unobserved-components model. In particular, $Var(\Delta\tau_{i,t}) = \sigma^2_{vi}$, while $Var(\Delta c_{i,t})$ can be recovered from the autoregressive specification of the cyclical component. Given these components, we then compute a decomposition for the proportion of the variance of quarterly output growth due to the trend component as $Var(\Delta\tau_{i,t})/(Var(\Delta\tau_{i,t}) + Var(\Delta c_{i,t}))$.

The final column of Table 2 reports these variance decompositions, which reveal that the trend component contributes substantially to the overall variance of quarterly real GDP growth in most countries. The average share of the trend component in the variance decomposition across countries is 0.58. Also, the variance decomposition is above 0.25 for all but two countries, Switzerland and Canada, and is above 0.75 for ten countries. These results suggest that fluctuations in the trend component are a quantitatively significant source of total quarterly output fluctuations for a large number of countries.

This evidence also highlights the potential danger of using first differences or a band-pass filter to measure a business cycle component defined as the transitory fluctuations in economic activity. As was discussed in Section 2.1 above, such approaches to detrending will produce measures of the business cycle that mix permanent and transitory fluctuations. Given that the permanent component produces a substantial amount of quarterly real GDP fluctuations in our sample, this contamination could be significant. The unobserved-components method we use is explicitly designed to capture permanent vs. transitory variation, and is thus free of these issues.

3.2. Cyclical comovement and trade intensity

We now turn to estimating the relationship between trade and comovement patterns across countries. We first examine cyclical comovement patterns to confirm that our data sample and empirical strategies are consistent with previous studies. We then turn to our

Table 2
Trend and cyclical components of quarterly real GDP series.

	Country	Trend & Cycle components			Variance decomposition
		Avg trend growth	St. dev. of trend shock	St. dev. of cycle shock	Frac. from trend
Non-G7	Australia	0.008	0.005	0.005	0.40
	Austria	0.006	0.009	0.002	0.89
	Belgium	0.006	0.008	0.002	0.90
	Denmark	0.004	0.012	0.003	0.94
	Finland	0.006	0.011	0.005	0.65
	Korea (2000:1)	0.019, 0.010	0.013	0.001	0.89
	Mexico	0.006	0.011	0.010	0.47
	Netherlands	0.005	0.008	0.002	0.81
	New Zealand	0.007	0.012	0.014	0.32
	Norway	0.006	0.010	0.008	0.27
	Portugal	0.005	0.011	0.002	0.83
	Spain (2004:3)	0.007, 0.004	0.008	0.002	0.79
	Sweden	0.005	0.011	0.002	0.76
	Switzerland	0.004	0.003	0.004	0.12
G7	Canada	0.007	0.000	0.006	0.00
	France	0.005	0.003	0.003	0.45
	Germany	0.005	0.008	0.003	0.77
	Italy (2001:1)	0.004, 0.001	0.005	0.004	0.54
	Japan (1990:3)	0.012, 0.003	0.008	0.004	0.79
	United Kingdom	0.005	0.004	0.004	0.27
	United States	0.007	0.004	0.005	0.30

Table 3
Trade and cyclical comovement.

	(1)	(2)	(3)	(4)	(5)
Trade	0.167***	0.166***	0.304***,†	0.604***,†	0.634***,†
	(0.033)	(0.0303)	(0.083)	(0.172)	(0.159)
90s		−0.193***	−0.141***	−0.143***	0.054
		(0.0398)	(0.043)	(0.0335)	(0.0794)
00s		0.063*	0.084	0.083***	0.593***
		(0.038)	(0.041)	(0.0308)	(0.199)
Trade × 90s			−0.252**,†	−0.299***,†	−0.292***,†
			(0.109)	(0.11)	(0.107)
Trade × 00s			−0.119†	−0.192***,†	−0.192***,†
			(0.092)	(0.069)	(0.068)
SumGDP					−0.580***
					(0.215)
DiffGDP					0.0482
					(0.158)
Currency union					−0.136**
					(0.056)
Constant	0.211***	0.254***	0.228***	0.172***	0.839***
	(0.0169)	(0.030)	(0.032)	(0.036)	(0.244)
FEs	No	No	No	Yes	Yes
Observations	630	630	630	630	630
R-squared	0.045	0.114	0.129	0.208	0.229
Number of pair				210	210

Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
† $F < 0.05$.

question of primary interest: how does trade influence the correlation between trend shocks across countries?

Table 3 reports estimates from the regression in Eq. (8), where the dependent variable is the correlation between cyclical fluctuations in real GDP. Robust standard errors are in parenthesis. For each specification we find that bilateral trade intensity has a positive effect on cyclical fluctuations in output. Since the average correlation between cyclical components is positive across countries, the positive effect of trade indicates an increased correlation. These specifications and results are consistent with previous literature. In column (1) we include only measures of trade intensity to confirm the result first obtained by Frankel and Rose (1998). Doyle and Faust (2005) demonstrate that comovement patterns have become weaker in years prior to 2002, consistent with the negative estimate we obtain for the 90s decade effect in column (2). However, the recent global recession has lead to a sharp increase in cyclical comovement during the 2000s.

Column (4) introduces country-pair fixed effects to control for differences in the propensity of countries to trade and to share common shocks to GDP. Again, consistent with previous literature, we find that trade intensity is associated with stronger cyclical comovement patterns. Attributes specific to each country-pair appear to play a substantial role in comovement patterns. For example, the estimated effect of trade in the 1980s nearly doubles from 0.304 to 0.604 in column (4) once pair fixed effects are included, with comparable changes in the effect of trade in later decades. This suggests that relationship-specific effects may also be important cofactors when we examine comovement in GDP trends. Finally, in column (5) we introduce controls for country attributes that previous literature has suggested affect comovement relationships independently. The positive impact of trade on business cycle comovement is robust to these additional controls.

The preferred estimates from column (5) of Table 3, which includes the full set of controls, indicate that the average effect of the trade variable on cyclical correlations is 0.47. Table 1 reports that the standard deviation in trade flows is approximately 0.53 for the full sample of countries. Thus, a one standard deviation increase in trade between the average country-pair will increase the correlation in their cyclical fluctuations by approximately 0.25, which is equivalent to 0.6 of a standard deviation in cyclical correlations. This suggests that typical variation in trade is associated with non-trivial variation in cyclical correlations.

3.3. Trend comovement and trade intensity

In Table 4 we turn to the primary focus of the paper: trend comovement. We present results for both the full sample of countries

Table 4
Trade and trend comovement.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full sample of countries				G7 nations			
Trade	0.223*	−0.012	0.015	0.002	−0.086	−0.189*	−0.094*,†	−0.079†
	(0.131)	(0.045)	(0.059)	(0.048)	(0.152)	(0.094)	(0.051)	(0.051)
90s		−0.0101	−0.005	0.162***		−0.0536	−0.0813	0.643***
		(0.018)	(0.019)	(0.048)		(0.067)	(0.083)	(0.193)
00s		0.300***	0.301***	0.704***		0.439***	0.517***	1.98***
		(0.018)	(0.020)	(0.118)		(0.043)	(0.043)	(0.361)
Trade × 90s			−0.028	−0.014			0.013†	0.013†
			(0.030)	(0.027)			(0.040)	(0.033)
Trade × 00s			−0.012	−0.023			−0.090***,†	−0.037†
			(0.032)	(0.028)			(0.019)	(0.023)
SumGDP				−0.495***				−1.93***
				(0.143)				(0.444)
DiffGDP				0.092				−0.033
				(0.094)				(0.289)
Currency union				0.103***				−0.241***
				(0.038)				(0.066)
Constant	0.162***	0.117***	0.112***	0.689***	.316**	0.287***	0.204***	2.564***
	(0.029)	(0.012)	(0.015)	(0.169)	(0.146)	(0.073)	(0.053)	(0.532)
FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	630	630	630	630	63	63	63	63
R-squared	0.014	0.474	0.475	0.504	0.003	0.742	0.787	0.853
Number of pair	210	210	210	210	21	21	21	21

Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
† $F < 0.05$.

Table 5
Trade and trend comovement: different sample periods.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1980–2005			1980–2008			1980–2010		
Trade	−0.246***	−0.240***	−0.121***	−0.181***	−0.179***	−0.076*	−0.191***	−0.188***	−0.079**
	(0.048)	(0.039)	(0.041)	(0.032)	(0.032)	(0.040)	(0.035)	(0.035)	(0.036)
1990s	−0.011	−0.013	0.870***	−0.03	−0.03	0.674***	−0.027	−0.028	0.643***
	(0.064)	(0.066)	(0.196)	(0.065)	(0.066)	(0.135)	(0.064)	(0.065)	(0.139)
2000s	0.152***	0.165***	1.770***	0.454***	0.456***	1.798***	0.510***	0.512***	1.796***
	(0.045)	(0.046)	(0.311)	(0.046)	(0.047)	(0.246)	(0.043)	(0.044)	(0.261)
Currency Union		−0.111**	−0.233***		−0.013	−0.130**		−0.022	−0.141**
		(0.052)	(0.046)		(0.039)	(0.051)		(0.044)	(0.053)
Sum GDP			−0.024***			−0.019***			−0.018***
			(0.004)			(0.003)			(0.003)
GDP diff			−0.009			−0.012*			−0.014*
			(0.008)			(0.007)			(0.007)
Constant	0.250***	0.246***	3.244***	0.216***	0.215***	2.618***	0.221***	0.220***	2.517***
	(0.035)	(0.028)	(0.533)	(0.023)	(0.022)	(0.378)	(0.027)	(0.026)	(0.370)
No. Obs.	63	63	63	63	63	63	63	63	63
R2	0.254	0.267	0.502	0.729	0.729	0.818	0.77	0.77	0.85
No. Pairs	21	21	21	21	21	21	21	21	21

Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

(columns 1–4), and for a sample that includes only country-pairs where both countries are a member of the G7 (columns 5–8). Each specification includes country-pair fixed effects. Robust standard errors are in parentheses.

The results in Table 4 for the effects of trade on the correlation between trend fluctuations are drastically different than those estimated for cyclical comovement. For the full sample, there is a positive and marginally statistically significant impact of trade on trend comovement when no controls are included beyond the fixed effects (column 1). However, this significance disappears when the decade effects are added (column 2), suggesting unaccounted for trends in the correlation and trade variable are driving the results in column (1). More importantly, the point estimate for the effect of trade is negative in column (2), in contrast to the positive effect found for correlations in cyclical output. In column (3) we allow the effect of trade to vary across decades, while in column (4) additional controls are added. In both cases the effect of trade is statistically insignificant, and is estimated to be negative in certain decades.

When we restrict attention to G7 country pairs (columns 5–8), we find a consistently large and negative effect of trade on trend comovement. This effect is statistically significant for those regressions that include controls beyond fixed effects (columns 6–8). Focusing on the preferred estimates from the regression reported in column (8), which includes the full set of controls, the average effect of the trade variable on trend comovement across decades is −0.087, and an F-test of the hypothesis that trade has no effect on trend correlations in any decade is rejected (p - value < 0.05). The average correlation in trend shocks for these country pairs is positive, indicating that greater trade intensity leads to *weaker* comovement. This is in sharp contrast to the documented association between greater trade intensity and increased cyclical comovement.[17]

From Table 1, the standard deviation of trade flows is approximately 1.19 for the sample of G7 countries, meaning that a one standard deviation increase in trade between the average country-pair will reduce the correlation in their trend shocks by approximately 0.10. This is equivalent to 0.33 of a standard deviation in trend shock correlations. While somewhat smaller than the similarly defined effect on cyclical correlations of 0.6 of a standard deviation, this effect is still substantial. Further, the relative size of these effects does not necessarily imply the relative importance of the trend versus cycle in determining the effect of trade on overall output growth correlation. This will depend on additional factors, including the relative importance of the trend versus cycle in contributing to overall output variation, as well as the horizon over which we measure output growth correlations. In the next section we explore the effect of trade on overall output comovement via a simulation experiment.

Our sample period extends to 2010 and so includes the period of the global recession and the observed great trade collapse in 2008–2009. Given that these periods are outliers in terms of the shocks nations received, the observed degree of comovement, and the observed volume of trade, it is worthwhile to examine the robustness of our results to the exclusion of these time periods. In Table 5 we estimate our preferred specifications where the 2000s decade is restricted to include 2000q1–2005q4 (columns 1–3) and 2000q1–2008q4 (columns 4–6.) Given that the definition of the 2000s decade changes across these different sample periods, we omit the interaction between trade volumes and decade effects and focus solely on the average effect of trade over the whole period. For the sake of comparison, columns (7)–(9) report estimates of the average effect of trade over the entire sample period.

Regardless of whether the periods of the latest global recession and ensuring great trade collapse are omitted, we continue to find that trade linkages have a negative and significant impact on the transmission of shocks to trend levels of output among G7 countries. In fact, the preferred estimate in column (3) when comovement in the 2000s decade is calculated between 2000q1 and 2005q4 is −0.121, which is larger in magnitude than the estimated effect of trade of −0.079 when the outlying periods in the later part of the decade are included in column (9). If anything this suggests that these outliers in the data work against finding our main result, though we note that the estimated effects are not statistically different from one another.

3.4. Quantifying the effect of trade on output comovement

Tables 3 and 4 suggest that trade has a statistically significant effect on both cyclical and trend shock correlations. Because we have estimated the impact of trade linkages on the comovement of both cyclical

[17] Here we have focused on the trend component of real GDP, which we have measured as the stochastic trend component of this series. However, there is a large literature that documents that the real GDP series for many G7 countries shares a common stochastic trend with the investment and consumption series for the same country (e.g., King et al. (1991) and Harvey and Mills (2005).) Thus, our results regarding the relationship between trade and the comovement of trend fluctuations in real GDP can also be interpreted as the relationship between trade and the comovement of trend fluctuations in consumption or investment.

Table 6
Simulation of effect of trade on output correlations.

Simulation parameters		Output growth correlation (change from baseline)	
Change in correlation from Baseline	Fraction of quarterly output growth variance due to trend	Quarterly output growth	Ten-year output growth
1–4	0.25	0.18	0.06
Increase in cycle	0.50	0.12	0.03
Correlation of 0.25	0.75	0.06	0.01
1–4	0.25	−0.03	−0.08
Reduction in trend	0.50	−0.06	−0.09
Shock correlation of 0.10	0.75	−0.08	−0.10

Notes: "quarterly output growth correlation" is the correlation of simulated quarterly output growth for the two countries. "Ten-year output growth correlation" is the correlation of simulated 10-year output growth for the two countries. The changes in cycle and trend shock correlations considered are based on the estimated effect of a one standard deviation increase in trade intensity.

fluctuations and trend shocks, we can decompose the effect of trade on the comovement of overall output growth between countries. In this section we report results of a simulation experiment to quantify the extent to which typical changes in these correlations due to changes in trade intensity pass through to changes in output growth correlations. These results demonstrate that the extent of such pass-through depends on whether we measure output growth over shorter versus longer-run horizons.

A standard measure of output growth comovement for two countries is the correlation in quarterly output growth, which we term a short-run comovement measure. For this measure, both transitory cyclical shocks and permanent trend shocks are important for understanding the effect of trade on comovement, with the relative contribution of each depending on the magnitude of the effects of trade on cyclical versus trend shock correlations, as well as the relative importance of the trend versus cyclical component in driving the variance of quarterly output growth. Again, as was demonstrated in Table 2, for many countries the trend component accounts for the majority of quarterly output growth variance. Thus, in these cases, the change in the correlation of quarterly output growth induced by a change in trade could be more substantially driven by the change in trend shock correlation, even if the change in trend shock correlation was relatively small as compared to the change in the cyclical correlation.

Alternatively, we may be interested in comovement of output growth over a long horizon (such as a decade.) Because shocks to the trend component correspond to permanent changes in real GDP, while cyclical variation is transitory in its effects on output, trend shock correlations should be more important than cyclical correlations in determining these long-horizon output growth correlations. This will be true regardless of the importance of trend versus cyclical fluctuations in determining the variance of short-horizon output growth. Thus, for correlations in long-horizon output growth, we would expect the effects of trade to work primarily through the effect on trend shock correlations.

To provide a numerical example of the effects of trade on output comovement, we conduct a simulation experiment. We simulate quarterly real GDP series for two hypothetical countries over one decade, where each series follows a UC process as in Eqs. (1)–(3), and each UC process is calibrated with identical parameters. We choose parameters to match low, medium, and high cases for the fraction of quarterly output growth variance accounted for by the trend component; these cases correspond to 0.25, 0.50 and 0.75 for this fraction. Over 100,000 such simulations, we compute the correlation in simulated quarterly output growth, as well as the correlation in simulated ten-year output growth for the two countries.[18] We begin with a baseline experiment in which we set the correlation between trend shocks and the correlation between cyclical components each equal to 0.50. We then consider two additional experiments meant to assess the marginal effects of a one standard deviation increase in trade intensity, which in the first experiment raises the cyclical correlation by 0.25 and in the second lowers the trend shock correlation by 0.10.

Table 6 presents the changes (relative to the baseline experiment) in the correlation of short-run and long-run output growth that are generated by the change in the cyclical or trend shock correlation. The third column of Table 6 shows that the pass-through of changes in cyclical and trend shock correlations to quarterly output growth correlations depends substantially on the fraction of quarterly output growth variance due to the trend component. Specifically, when the fraction of quarterly output growth variance due to the trend component is low, an increase of 0.25 in the cyclical correlation is substantially passed through to quarterly output growth correlations, increasing this correlation by 0.18. However a decrease of 0.10 in trend shock correlations resulting from greater trade intensity has very little effect, decreasing quarterly output growth correlations by only 0.03. The opposite is true when the fraction of quarterly output growth variance due to the trend component is high. It is notable that in this latter case, the marginal effect of the change in the trend shock correlation on the quarterly output growth correlation is larger than that for the change in the cyclical correlation, despite the fact that the change in the cyclical correlation corresponding to a standard deviation increase in trade intensity is substantially larger.

The final column of Table 6 shows that the change in the trend shock correlation passes through substantially to long-horizon output growth correlations. Regardless of the extent to which the trend component accounts for the variance of quarterly output growth, the correlation in ten-year output growth falls by roughly 0.10 as a result of the decrease in trend shock correlations of 0.10. This is in contrast to the increase in the cyclical correlation, which has a very little marginal effect on correlation in long-horizon output growth. Although previous studies of comovement in output across countries have focused exclusively on cyclical correlations, these results highlight the importance of changes in trend shock correlations over the long-run, due to the fact that trend shocks reflect permanent changes in output levels.

4. Conclusion

In the current volatile economic climate, policymakers are increasingly focused on the policies established in countries with which they have close economic relationships. International trade linkages can potentially transmit episodes of output contraction across borders. The results presented here suggest that such concerns are less warranted when considering long-run, permanent, changes in real GDP. While trade has been shown to increase cyclical comovement between countries, here we have found that closer trade relationships reduce the correlation between shocks to G7 countries' trend levels of output. For

[18] Each simulation yields 40 realizations of quarterly output growth for each country, and one realization of ten-year output growth for each country. The correlation for quarterly output growth is then computed based on 400,000 realizations of quarterly output growth, and 100,000 realizations of ten-year output growth.

countries outside the G7, we find no statistically significant effect of trade intensity on trend comovement.

Our evidence suggests that the effect of trade on trend comovement in the G7 is of substantial economic importance. For many countries in our sample, shocks to trend levels of output account for over half of the variation in their quarterly real GDP growth, so that changes in trend shock correlations will pass through to significant changes in output growth correlations for many country pairs. Also, while cyclical fluctuations have only transitory effects on output levels, trend shocks have permanent effects, meaning that fluctuations in output levels over longer horizons will be dominated by the trend. As a consequence, comovement in long-horizon output growth across countries will be driven by correlations in trend shocks, rather than business cycle correlations.

References

Aguiar, Mark, Gopinath, Gita, 2007. Emerging market business cycles: the cycle is the trend. J. Polit. Econ. 115 (1).

Baxter, Marianne, Crucini, Mario J., 1995. Business cycles and the asset structure of foreign trade. Int. Econ. Rev. 36, 821–853.

Baxter, Marianne, King, Robert G., 1999. Measuring business cycles: Approximate band-pass filters for economic time series. Rev. Econ. Stat. 81 (4), 575–593.

Baxter, Marianne, Kouparitsas, Michael A., 2005. Determinants of business cycle comovement: a robust analysis. J. Monet. Econ. 52 (1), 113–157.

Beveridge, Stephen, Nelson, Charles R., 1981. A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the "business cycle". J. Monet. Econ. 7 (2), 151–174.

Blonigen, Bruce A., Piger, Jeremy, 2011. Determinants of foreign direct investment. NBER Working Paper 16704.

Burstein, Ariel, Kurz, Christopher, Tesar, Linda L., 2008. Trade, production sharing and the international transmission of business cycles. J. Monet. Econ. 55, 775–795.

Calderon, Cesar, Chong, Alberto, Stein, Ernesto, 2007. Trade intensity and business cycle synchronization: are developing countries different. J. Int. Econ. 71 (1), 2–21.

Clark, Peter K., 1987. The cyclical component of economic activity. Q. J. Econ. 102 (4), 797–814.

Clark, Todd E., van Wincoop, Eric, 2001. Borders and business cycles. J. Int. Econ. 55, 59–85.

Cogley, Timothy, 1990. International evidence on the size of the random walk in output. J. Polit. Econ. 98, 501–518.

Cogley, Timothy, 2001. Alternative definitions of the business cycle and their implications for business cycle models: a reply to Torben Mark Pedersen. J. Econ. Dyn. Control. 25 (8), 1103–1107.

Cogley, Timothy, Nason, James M., 1995. Effects of the Hodrick–Prescott filter on trend and difference stationary time series: implications for business cycle research. J. Econ. Dyn. Control. 19 (1–2), 253–278.

Cogley, Timothy, Sargent, Thomas J., 2005. Drifts and volatilities: monetary policies and outcomes in the post WWII US. Rev. Econ. Dyn. 8 (2), 262–303.

Doyle, Brian M., Faust, Jon, 2005. Breaks in the variability and comovement of G-7 economic growth. Rev. Econ. Stat. 87 (4), 721–740.

Frankel, Jeffrey A., Rose, Andrew K., 1998. The endogeneity of optimum currency area criteria. Econ. J. 108 (449), 1009–1025.

Ghironi, Fabio, 2006. Macroeconomic Interdependence under incomplete markets. J Int. Econ. 70 (2), 428–450.

Harvey, Andrew C., 1985. Trends and cycles in macroeconomic time series. J. Bus. Econ. Stat. 3 (3), 216–227.

Harvey, Andrew C., Jaeger, A., 1993. Stylized facts and the business cycle. J. Appl. Econ. 8 (3), 231–247.

Harvey, Andrew C., Mills, Terrance C., 2005. Evidence for common features in G7 macroeconomic time series. Appl. Econ. 37 (2), 165–175.

Hodrick, Robert J., Prescott, Edward C., 1997. Postwar U.S. business cycles: an empirical investigation. J. Money Credit Bank. 29 (1), 1–16.

Imbs, Jean, 2004. Trade, finance specialization and synchronization. Rev. Econ. Stat. 86 (3), 723–734.

Imbs, Jean, Wacziarg, Romain, 2003. Stages of diversification. Am. Econ. Rev. 93 (1), 63–86.

Kim, Chang-Jin, Nelson, Charles R., 1999. Friedman's plucking model of business fluctuations: tests and estimates of permanent and transitory components. J. Money Credit Bank. 31 (3), 317–334.

Kim, Chang-Jin, Piger, Jeremy, 2002. Common stochastic trends, common cycles, and asymmetry in economic fluctuations. J. Monet. Econ. 49 (6), 1189–1211.

King, Robert G., Plosser, Charles I., Stock, James H., Watson, Mark W., 1991. Stochastic trends and economic fluctuations. Am. Econ. Rev. 81 (4), 819–840.

Kleinert, Jörn, Martin, Julien, Toubal, Farid, 2014. The Few Leading the Many: Foreign Affiliates and Business Cycle Comovement. mimeo Paris School of Economics.

Kose, M. Ayhan, Yi, 2006. Can the standard international business cycle model explain the relation between trade and comovement? J. Int. Econ. 68 (2), 267–295.

Kose, M. Ayhan, Prasad, Eswar S., Terrones, Macro E., 2003. How does globalization affect the synchronization of business cycles. Am. Econ. Rev. 93 (2), 57–62.

Kose, M. Ayhan, Otrok, Christopher, Whiteman, Charles, 2008. Understanding the evolution of world business cycles. J. Int. Econ. 75 (1), 110–130.

Kuttner, Kenneth N., 1994. Estimating potential output as a latent variable. J. Bus. Econ. Stat. 12 (3), 361–368.

Levchenko, Andrei, di Giovanni, Julian, 2010. Putting the parts together: trade, vertical linkages and business cycle comovement. Am. Econ. J. Macroecon. 2 (2), 95–124.

Morley, James C., Nelson, Charles R., Zivot, Eric, 2003. Why are the Beveridge–Nelson and unobserved-components decompositions of GDP so different? Rev. Econ. Stat. 85 (2), 235–243.

Murray, Christian J., 2003. Cyclical properties of Baxter–King filtered time series. Rev. Econ. Stat. 85 (2), 472–476.

Pedersen, Torben Mark, 2001. The Hodrick–Prescott filter, the Slutzky effect, and the distortionary effect of filters. J. Econ. Dyn. Control. 25 (8), 1081–1101.

Prasad, Eswar S., Rogoff, Kenneth, Wei, Shang-Jin, Kose, M. Ayhan, 2007. Financial globalization, growth and volatility in developing countries. In: Harrison, Ann E. (Ed.), Globalization and Poverty, number 457–516. National Bureau of Economic Research, Inc.

Redding, Stephen, Venables, Anthony J., 2004. Economic geography and international inequality. J. Int. Econ. 62, 53–82.

Rose, Andrew K., Engel, Charles, 2002. Currency unions and international integration. J. Money Credit Bank. 34 (4).

Rotemberg, Julio J., Woodford, Michael, 1996. Real-business-cycle models and the forecastable movements in output, hours, and consumption. Am. Econ. Rev. 86 (1), 71–89.

Sinclair, Tara M., 2009. The relationships between permanent and transitory movements in U.S. output and the unemployment rate. J. Money Credit Bank. 41 (2–3), 529–542.

Stock, James H., Watson, Mark W., 2005. Understanding changes in business cycle dynamics. J. Eur. Econ. Assoc. 3 (5), 968–1006.

Watson, Mark W., 1986. Univariate detrending methods with stochastic trends. J. Monet. Econ. 18 (1), 49–75.