COMOVEMENT IN GDP TRENDS AND CYCLES AMONG TRADING PARTNERS

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ABSTRACT

It has long been recognized that business cycle comovement is greater between countries that trade intensively with one another. Surprisingly, no one has previously examined the relationship between trade intensity and comovement of shocks to the trend level of output. Contrary to the result for cyclical fluctuations, we find that comovement of shocks to trend levels of real GDP is significantly weaker among countries that trade intensively with one another. We also find that the influence of trade on comovement between shocks to trends has remained stable, or become stronger in recent decades, while the role of trade in generating cyclical comovement has diminished steadily over time. In short, we find that international trade relationships have a substantial impact on comovement of shocks to output trends across countries, and these effects stand in stark contrast to the conventional wisdom regarding cyclical comovement.

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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 trade.[1]

Unlike the empirical relationship, the theoretical relationship between output comovement and trade is ambiguous. A positive shock in one country can generate increased demand for foreign goods, so that the foreign country also experiences an increase in output (i.e., the demand channel). On the other hand, the positive shock in one country may cause production to be reallocated away from foreign suppliers, so that foreign production declines. Also, if countries supply goods and services to international markets by specializing in their own comparative advantaged industries, then shocks to specific sectors may be less correlated among strong trading partners (i.e., supply channels). For business cycle fluctuations, the evidence to date suggests that the demand channel dominates such that trade strengthens comovement patterns.

Surprisingly, no one has previously examined the relationship between trade intensity and comovement of shocks to countries' trend levels of output. This omission is important, as changes in GDP trends are potentially driven by different types of shocks than are business cycle fluctuations. The propagation of these shocks across national borders, and the relationship of this propagation to trade linkages, may also differ. In particular, the effect of trade on the long-run distribution of suppliers across countries and sectors (the supply channels) may be more important when explaining cross-country correlations in shocks to GDP trends. Thus, the sole focus of the existing literature on business cycle fluctuations may

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

give an incomplete picture of the relationship between trade intensity and the comovement of output across countries.

Contrary to the result for cyclical fluctuations, we find that the correlation between shocks to GDP trends is significantly *weaker* among G7 countries that trade intensively with one another.[2] The negative association between trade and trend comovement is quantitatively important. A one-standard deviation increase in trade intensity between countries reduces the correlation in shocks to their output trend by approximately one-third of a standard deviation. We also find that the influence of international trade on comovement in shocks to the trend has remained stable, or become stronger in recent decades, while the role of trade in generating cyclical comovement has diminished steadily over time. Finally, we find that the effect of trade on trend comovement is significant only for G7 country pairs. This is consistent with the results for cyclical comovement in Kose et al. (2003) and Calderon et al. (2007) who provide evidence that the effect of trade on cyclical comovement is much weaker among lower income trade partners. In short, we find that international trade relationships have a substantial impact on comovement between countries' shocks to output trends, and the direction of these effects stand in stark contrast to the conventional wisdom regarding the effect of trade on cyclical comovement.

Beyond the implications for the relevance of demand or supply mechanisms for the transmission of shocks across countries, our results are also important as they speak to a quantitatively significant source of output fluctuations. In particular, the evidence shows that shocks to output trends contribute substantially to the variance of quarterly real GDP growth. For the majority of countries in our sample, shocks to the trend account for over half the overall variation in quarterly real GDP growth over time, and the observed comovement patterns for trends are persistent over each decade in our sample.[3] Thus, the capacity of trade to

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[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. Trade is associated with weaker comovement, rather than stronger negative correlations.

[3]On the other hand, Doyle and Faust (2005) demonstrate that cyclical comovement patterns among G7 nations have become weaker in recent decades.

decouple trend fluctuations across countries is of important policy relevance.

The specifics of our data and estimation methodology are as follows. We gather quarterly real GDP and bilateral trade flow data for 21 developed countries for the years 1980 to 2010 from the IMF's *International Financial Statistics* and *Direction of Trade Statistics*. The set of countries in our data set is similar to that used in previous comovement studies, so that differences in results for trends and cycles cannot be attributed to selection.[4] To obtain a measure of the trend and business cycle component of real GDP we use an unobserved-components model, which has been used extensively in the literature as a tool for trend and business cycle measurement.[5] The unobserved-components model identifies trend vs. business cycle fluctuations by assuming 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 business cycle component is the deviation of real GDP from this stochastic trend, and represents transitory fluctuations in the series. A key advantage of the unobserved-components approach for our purposes is its explicit characterization of both trend and cyclical components, each of which is needed for our empirical analysis. Other popular approaches for measuring business cycle variation, such as the band-pass filter of Baxter and King (1999) or first differencing, do not provide an explicit definition or measure of the trend component.

Our key dependent variable is the correlation between changes in the trend component of quarterly real GDP for each country pair. Bilateral trade intensity is measured as the total real valued trade flows between countries, divided by the sum of their real GDP levels. We take several steps to ensure that the comovement patterns we describe are due to international trade relationships, and not other underlying factors. To avoid issues associated with

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[4]Our sample produces the same stylized fact that trade exhibits a positive effect on cyclical comovement as found in previous studies.

[5]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 explicit 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).

potential trends in trade volumes between country-pairs over time, we calculate decade specific correlations for each country-pair, and control for decade fixed effects when estimating the effects of trade intensity. Country pairs may differ in their exposure to common shocks, as well as their incentives to trade with one another. Thus, we further include country-pair fixed effects when estimating the relationship between trade intensity and comovement. The substantial literature on cyclical comovement suggests other factors, such as patterns of industry specialization or membership in a currency union, that may contribute to comovement in output levels. Our empirical strategy incorporates these alternative channels which could potentially mitigate the consequences of international trade.[6] The key 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 across country-pairs, and the details of our empirical specification linking comovement to trade intensity. Section 3 describes our data sources and variable construction. Section 4 presents the results for the effects of trade on comovement patterns. 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

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[6]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 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; see Prasad et al. (2007). Blonigen and Piger (2011) demonstrate that the best predictors of foreign direct investment patterns between countries are those suggested by gravity models. Thus our fixed-effects strategies also captures the motives for nations to invest in one another.

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 vs. business cycle fluctuations, and corresponding methods to identify these defined components. Here, we define and identify trend vs. 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.[7] 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 pth order lag polynomial with all roots outside the complex unit circle, $v_{i,t} \sim$ i.i.d. $N\left(0, \sigma_{v_i}^2\right)$, and $\epsilon_{i,t} \sim$ i.i.d. $N\left(0, \sigma_{\epsilon_i}^2\right)$. 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 $\sigma_{v_i, \epsilon_i} = 0$.[8] The model in (1) – (3) is estimated

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

[8]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.

via maximum likelihood, and estimates of the unobserved trend and cycle components constructed using the Kalman Filter.

The UC model identifies trend vs. business cycle fluctuations by assuming 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 its stochastic trend. 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 and Nelson (1981) decomposition, which measures the business cycle from the forecastable variation in real GDP growth.[9] 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 equations (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

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[9]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 cycle as the Beveridge-Nelson decomposition.

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, bandpass filters will generate a cyclical component.[10] As will be seen in Section 4 below, this seemingly extreme example is relevant for the real GDP series of a number of countries in our sample, for which the trend dominates the variance of real GDP growth.

Another advantage of the UC approach for our purposes is its explicit representation of trend vs. cyclical components, estimates for both of which are required in our analysis. This makes interpretation of the components straightforward, and aids in the construction of variance decompositions designed to separate the sources of fluctuations in international real GDP growth. Such explicit characterizations of both trend and cycle are not always available from other popular filters. For example, the Baxter-King filter, while providing a clear definition and measure of the cyclical component, does not provide an explicit definition of the trend component.

The model for the trend component in (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 equation 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.[11] We then report results based on the UC model with either equation (2) or (4) by choosing that model that minimizes the Schwarz Information Criterion.

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

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

2.2 Variable Construction

For each country-pair in our sample, we require the correlation between trend fluctuations and the correlation between cyclical fluctuations for those countries. 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:

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

where $corr_d\left(\cdot\right)$ indicates the sample correlation coefficient measured using data in decade d, and $\widehat{c}_{i,t}$ and $\widehat{c}_{j,t}$ represent the Kalman filtered 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:

$$\rho_{ijd}^\tau = corr_d\left(\widehat{v}_{i,t}, \widehat{v}_{j,t}\right), \tag{6}$$

where $\widehat{v}_{i,t}$ and $\widehat{v}_{j,t}$ represent the Kalman filtered 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.[12]

Our choice of decades as the time-series unit of observation is driven by several factors. First, a longer time span provides a more precise estimate of the comovement relationship between any given country-pair. In addition, as shown by Leibovici and Waugh (2012) among others, international trade flows are strongly procyclical. Differences in bilateral trade flows over shorter time spans than a decade are more likely to reflect these cyclical fluctuations, rather that capturing the role of trade relationships in determining comovement patterns. Finally, the choice of decade matches the earlier literature; see for example Frankel and Rose (1998), Calderon et al. (2007) and Kose et al. (2003).

Section 3 below will describe the sources of the data necessary to compute our correlation and trade intensity variables. Here we present figures displaying averages of these variables across trading partners computed over time. In Figure 1 we plot the decade-average correlation between trend fluctuations in real GDP where the ten year period rolls forward on an annual basis. Trend comovement patterns are stable within the 1980s and the 1990s. However when the measured correlations begin to include years after 2000 (i.e., correlations calculated beginning in 1991) we see a slight increase in average comovement. Furthermore, when the time span begins to include periods after 2008, during the latest global recession, we see a sharp spike in average comovement patterns. Figure 2 plots 10-year averages in

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[12]Several previous studies have employed measures of trade intensity identical to equation (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 are 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.

trade intensity on a rolling basis, and shows that trade intensity has also been rising on aver-
age. Finally, Figures 1 and 2 demonstrate that both average trend correlations and average
trade intensity are higher for G7 country-pairs than for country-pairs involving a non-G7
country.

2.3   Estimating Comovement across Trading Partners

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

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

where $k = c, \tau$. As described in more detail in Section 3 below, our sample consists of 21
countries measured over the time period 1980-2010, which produces a panel dataset of 210
unique trading partners across 3 decades (1980-1989, 1990-1999, 2000-2010.) Although our
primary interest is in the correlations between permanent shocks, we also estimate (8) for
comovement in transitory (cyclical) shocks to verify that our sample is consistent with the
patterns highlighted previously in the literature.[13]

The variable δ_d is a decade specific fixed effect. Doyle and Faust (2005) estimated struc-
tural breaks in comovement statistics among G7 nations and found that cyclical comovement
became weaker over the period 1960-2002, while the results presented in Figure 1 demon-
strate that average trend correlations have become stronger since the late 1990s. Similarly,
improvements in communication and transportation technologies have allowed trade to grow
steadily over the sample period, as is shown in Figure 2. Decade specific fixed effects thus
protect us from estimating a spurious regression in the trade-comovement relationship. We
also include a full set of interactions between trade intensity and the decade effects to esti-

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[13]With two seemingly unrelated regressions estimated, individually with trend comovement and cycle co-
movement as the dependent variable, we also estimated a SUR system. Our conclusions are identical
whether whether we estimate the models individually are as a SUR system.

mate how the role of trade in generating comovement has changed over time.

Trade patterns are clearly related to the innate characteristics of each country-pair. For example the gravity model predicts that exogenous differences in geography and distance will cause bilateral trade patterns to vary.[14] The importance of gravity variables in generating comovement in countries GDP series is emphasized by Baxter and Kouparitsas (2005). There is also evidence that financial linkages may promote output comovement between countries; see Prasad et al. (2007), among others. Blonigen and Piger (2011) demonstrate that gravity variables are among the most robust predictors of foreign investment activities between countries. The term η_{ij} is a country-pair fixed effect included when we estimate (8) to account for the varying incentives for countries to trade and invest with one another, and any other fixed exposure to shocks in output between countries.

Previous studies have demonstrated that the impact of trade linkages on business cycle comovement varies across levels of industrial development. Kose et al. (2008) provide evidence that cyclical comovement relationships among G7 members differ systematically from non-G7 nations. Table 1 also makes it clear that average comovement varies across countries with different income levels (see also Figure 1), as does average trade intensity (see also Figure 2.) Furthermore, our results in Table 2 demonstrate that there is substantial heterogeneity across G7 vs. non-G7 countries in the proportion of the total variance of real GDP that is attributable to trend fluctuations. Concerning the estimation of the impact of trade on comovement, 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. To account for differences in comovement patterns across national income levels, and differences in the effect of trade, we estimate equation (8) separately for members and non-members of the G7.

The vector X_{ijd} incorporates several control variables suggested previously in the comove-

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

ment 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.[15] Baxter and Kouparitsas (2005) perform a general robustness analysis of the determinants of comovment across countries. They argue that in addition to gravity variables, membership in a currency union is a strong predictor of correlations in output fluctuations across countries. We include an indicator variable, CU_{ijd}, that equals one if country-pair ij belongs to a currency union during period d.

3 Data

GDP data come from the International Financial Statistics, made available by the IMF. For 21 countries, we observe quarterly output from 1980:Q1 to 2010:Q4.[16] A high frequency of observation is important for accurately measuring both variation in the business cycle and the trend, as some business cycle episodes last only a few quarters. Also, there is substantial evidence in the existing literature that trend fluctuations account for a significant portion of relatively high frequency fluctuations in real GDP growth.[17] We will present evidence consistent with this result for our sample of countries below. Previous studies have estimated comovement patterns for a longer time series, but generally have relied on annual data that subsume transitory fluctuations lasting only a few quarters. With quarterly data we have observations from 124 time periods for each country, and by restricting ourselves to the post-1980 period are able to include a relatively large number of countries from different regions

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[15]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.

[16]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.

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

of the world and at different stages of development.[18] 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 vs. cyclical comovement.

Information about bilateral trade flows come from the Direction of Trade Statistics. 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 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. Table 1 presents the summary statistics for the trade measures across time periods and across the samples of countries with and without G7 membership.[19]

4 Results

4.1 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 1990s. Two other countries, Spain and Italy, also

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[18]New Zealand is a slight exception in that we do not observe the real GDP series until mid 1982. Still, there are 118 quarters over three decades of observed GDP data for New Zealand.

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

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 on the stochastic shocks hitting the trend and business cycle components. The third and fourth 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 vs. 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 trend vs. the cycle we calculate variance decompositions. Note that from $(1) - (3)$, 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 vs. the cyclical component, the variance of quarterly output growth is then given by:

$$Var\left(\Delta y_{i,t}\right) = Var\left(\Delta \tau_{i,t}\right) + Var\left(\Delta c_{i,t}\right).$$

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, $Var\left(\Delta\tau_{i,t}\right) = \sigma_{vi}^2$, while $Var\left(\Delta c_{i,t}\right)$ can be recovered from the autoregressive specification of the cyclical component. Given these components, we then compute a variance decomposition for the proportion of quarterly output growth due to the trend component as $\Delta\tau_{i,t}/\left(\Delta\tau_{i,t} + \Delta c_{i,t}\right)$.

The final column of Table 1 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 value of this variance decomposition across countries is 0.58, indicating that more than half of the variance of quarterly real GDP growth comes from the trend component. Also, the variance decomposition is above 0.25 for all but two countries, Switzerland and Canada, and is above 0.75 for ten countries. There is also some evidence that the trend component is more important in non-G7 countries, for which the average variance decomposition is 0.65, vs. 0.45 for the G7 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, which further motivates our study of the relationship between trade intensity and trend fluctuation comovement. They also highlight 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 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.

4.2 Comovement and Trade Intensity

In this section we present results for the estimated 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 question of primary interest: how does trade influence the correlation between shocks to the trends in real GDP series across countries?

Table 3 reports estimates from the regression in (8), where the dependent variable is the correlation between cyclical fluctuations in real GDP, ρ_{ijd}^c. Robust standard errors are in parenthesis. For each specification we find that bilateral trade intensity leads to stronger correlations between cyclical fluctuations in output. Note that the average correlation between transitory shocks in output is positive across countries, so that the positive coefficient on trade indicates stronger positive correlations. 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. In column (3) we also allow the effect of trade to vary over time. The impact of trade on cyclical comovement has become significantly weaker over time, as is apparent from the negative coefficient on each interaction between trade and the decade effects. While the impact of trade on cyclical comovement is declining over time, we still estimate a positive and significant effect across the whole sample. An F-test supports the overall positive effect of trade on cyclical comovement at high levels of confidence.

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

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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 is also robust to these additional controls.

Table 1 reports that the standard deviation in trade flows is approximately 0.53 for the full sample of countries. Then using the preferred estimates of the relationship between trade and cyclical comovement in column (5) of Table 3, a one standard deviation increase in trade between the average country-pair will increase the correlation in their cyclical fluctuations in output by approximately 0.25, which is equivalent to 0.6 of a standard deviation in cyclical correlations. The magnitude of this effect for correlations between transitory shocks serves as a useful benchmark to compare our main results concerning trend comovement.

In Table 4 we turn to the primary focus of the paper: trend comovement. We present results for both the full sample of countries (columns 1-3), and for a sample that includes only country-pairs where both countries are a member of the G7 (columns 4-6). The results in Table 4 report drastically different effects of trade on the correlation between trend fluctuations than estimated for cyclical comovement. Each specification includes country-pair fixed effects to account for the potential to share common shocks, and the differences in the propensity of countries to trade or invest with one another. Robust standard errors are in parentheses. For the full sample, there is seemingly no statistically significant impact of trade on the correlation between shocks to trend levels of real GDP across countries. In fact, the point estimates for the overall effect of trade obtained in columns (1) through (3) are negative in certain decades, in contrast to the positive effect found for correlations in cyclical output.

Column (3) includes the full set of controls for other potential determinants of comovement. The indicator variables for the latter decades in our sample suggest there are increasing levels of comovement between trend fluctuations of output over time. The average correlation in trend fluctuations grew during the 90s, and again during the 00s when global recessions

have impacted all nations in our sample simultaneously. On the other hand the evidence for average changes in cyclical comovement in Table 3, and documented by Doyle and Faust (2005), find declining cyclical comovement over the 1980s and 1990s.

In columns (4) through (6) we find a statistically significant effect of trade on trend comovement for the G7 countries that is of the opposite direction from the effect on cyclical comovement. That is, greater trade intensity between countries *reduces* the correlation between permanent shocks to their GDP series. The negative estimates are maintained even when we introduce measures of relative GDP levels and currency union memebership that previous literature has suggested influence comovement in output across countries independently (column 6). Looking across all decades, the average effect of trade on trend correlations is -0.087, and an F-test rejects the hypothesis that trade has no effect on trend correlations (*p-value* < 0.05). In contrast to the declining effect of trade on cyclical comovement, the negative impact of trade on trend comovement is robust over time. Each interaction between trade and the decade effects are indistinguishable from zero, indicating no significant changes in the role of trade relationships over time.

Looking across columns (4) through (6) we find that trade has the effect of decoupling trend comovement relationships among G7 nations. The magnitude of the negative impact of trade on correlations between shocks to trend levels of output is substantial. Using the preferred estimates from column (6) that includes the full set of controls for the determinants of comovement patterns, the estimated effect of trade is approximately -0.087. Then taking from Table 1 the standard deviation in trade intensity for G7 nations, 1.19, our estimates imply that an increase in trade by a standard deviation reduces the correlation in trend fluctuations by 0.10. The size of this effect is equivalent to about 0.33 of a standard deviation in observed trend correlations. Furthermore, the evidence in Table 2 demonstrates that changes in the trend levels of real GDP series across countries are a substantial portion of the variation in their overall levels of output. Thus a reduction in correlations between shocks to the trend by one-third of a standard deviations corresponds to a significant amount

of economic activity.

In Figure 3 we plot the estimated relationship between trade and comovement across decades for both cyclical and trend correlations.[20] The effects on the vertical axis are measured in units equal to the corresponding standard deviation for trend and cyclical comovement. The dashed line illustrates the positive, and significantly declining, relationship between trade and business cycle comovement. The solid line represents the stable negative relationship between trade intensity and the correlation between shock to countries' trend levels of output. As mentioned above, the average effect of trade across all decades is significantly different from zero for both trend and cyclical comovement.

5   Discussion

Unlike the relationship between business cycle comovement and trade, there has been little thought given to why or how trade may affect the comovement of shocks to countries' GDP trends. Further exploration should seek to identify the potential reasons for this negative relationship. While such analysis goes beyond our study, we surmise that a possible explanation is tied to how (long-run) factors of production may adjust across sectors, or across borders, when countries are open to trade; i.e., the supply channel for the transmission of shocks to ouput trends.

Larger international trading opportunities can lead to specialization of the industrial structure within countries, as they each allocate more factors of production toward sectors corresponding to their respective comparative advantage. Hence, with more trade countries may exhibit larger differences in composition of output across sectors. Such differences in industrial structure due to specialization may then mean that shocks to GDP trends are less correlated across countries. For example, suppose that changes in output growth rates worldwide are concentrated in only a few sectors. If countries experience episodes of trade

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[20]The estimated effects in Figure 3 correspond to the preferred specifications in column (5) of Table 3 and column (6) in Table 4, which each include the full set of control variables.

liberalization, they will further specialize in sectors with different growth patterns over time. Thus, we would observe stronger trade relationships between countries that have less correlated shocks to their trend levels of aggregate output. Imbs and Wacziarg (2003) shows that business cycle comovement depends, in part, on the patterns of industrial specialization across countries, suggesting that trend comovment may also be related systematically the concentration of output across sectors. Costinot et al. (2011) also provide evidence that industry-specific shocks in productivity generate substantial changes in bilateral trade volumes, which is consistent with the potential to observe weaker output comovement across trading partners that specialize in industries that experience different shocks to their specific output trends.

In addition to the allocation of factors across industries, countries that trade with each other are also more likely to be open to reallocations of productive capital across borders. A positive shock to the trend level of GDP in one country may draw away investment and associated economic activity from the other country, so that the other country is less likely to experience the same positive shock to its own output trend. This would suggest a major role for intra-firm trade by multinationals in the transmission of shocks across borders. This mechanism would be consistent with our finding that the effect of trade openness on the correlation in shocks to GDP trends is mainly a G7 phenomenon, since the majority of worldwide FDI is into G7 nations.[21] Moreover, in developed countries intra-firm trade constitutes a substantial portion of overall bilateral trade volumes, suggesting that the role of multinational activity is a plausible mechanism by which trade mitigates trend comovement.[22] It is also likely that both supply channels, the reallocation of production across borders and across sectors, simultaneously induce trade to mitigate trend comovement. As Neary (2007) argues, in the long-run closer trade relationships can trigger reallocations of

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[21]The OECD reports that the G7 accounted for more than 73% of the absorption of total foreign investment flows among OECD nations in 2007.

[22]For example, the U.S. Census Bureau reports that in 2009 nearly 50% of all imports of consumption goods were from related parties of firms located in the United States. Interestingly, Kleinert et al. (2012) find evidence that the impact of trade on business cycle comovement is generated primarily via few multinational firms, who trade intensively with their parent firm host country.

production across countries via cross-border M&A in a manner that enhances the respective comparative advantages of each trading partner across sectors.

6 Conclusion

In the current volatile economic climate, heads of state 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 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 most countries in our sample, shocks to trend levels of output account for over half of the variation in their real GDP series. Thus the quantitative impact of closer trade relationships on trend comovement is large in terms of total economic activity. We also find that observed comovement in output trends has remained strong, and potentially increased over time, while cyclical comovement relationships have become weaker over the last 30 years.

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Figure 1
Rolling Average Correlations in real GDP Trend Fluctuations
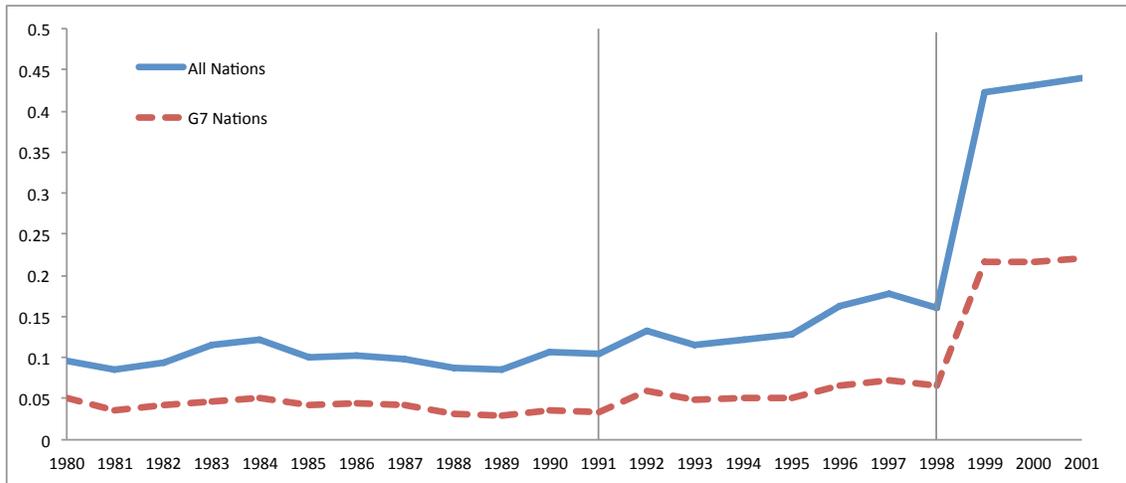

Date on horizontal axis indicates the earliest year for which a 10-year correlation is calculated.

Figure 2
Rolling Average Trade Intensity

Date on horizontal axis indicates the earliest year for which a 10-year correlation is calculated.

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Figure 3

Estimated Effects of Trade on Comovement over Time
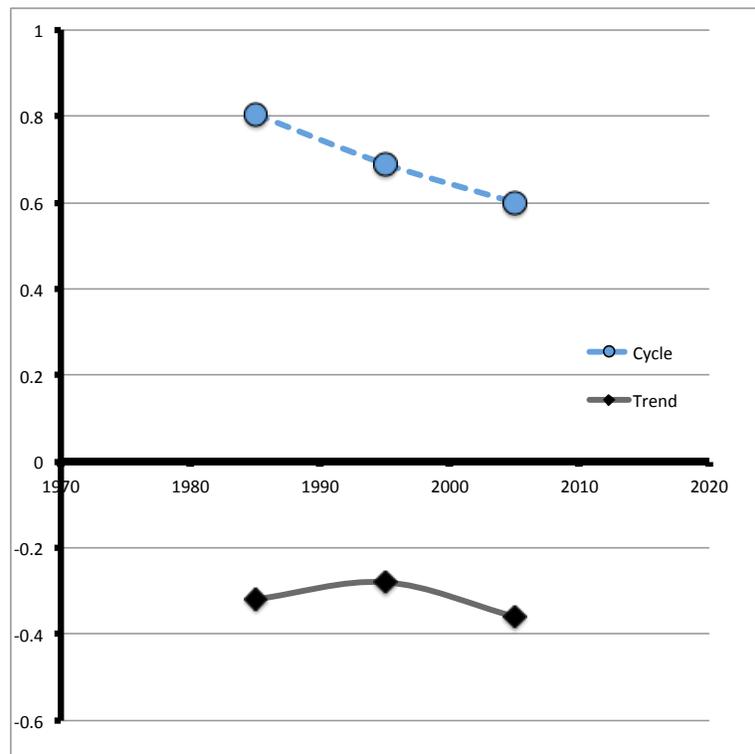
Units on vertical axis indicate the standard deviation change in correlations between fluctuations in real GDP series that result from a standard deviation increase in trade intensity.

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

Table 2
Trend and Cyclical Components of Quarterly Real GDP Series

	Country	Avg Trend Growth	StDev of Trend Shock	StDev of Cycle Shock	Frac. from Trend
			Trend & Cycle Components		Variance Decomposition
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***	0.0543
		(0.0398)	(0.043)	(0.0335)	(0.0794)
00s		0.0634*	0.084	0.0833***	0.593***
		(0.038)	(0.041)	(0.0308)	(0.199)
Trade x 90s			-0.252**†	-0.299***†	-0.292***†
			(0.109)	(0.11)	(0.107)
Trade x 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
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, †$F < 0.05$

Table 4
Trade and Trend Comovement

	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample of Countries			Only G7 Nations		
Trade	-0.012	0.015	0.002	-0.189*	-0.094*†	-0.079†
	(0.045)	(0.059)	(0.048)	(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 x 90s		-0.028	-0.014		0.0131†	0.0132†
		(0.030)	(0.027)		(0.040)	(0.033)
Trade x 00s		-0.012	-0.023		-0.0895***†	-0.0374†
		(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	0.117***	0.112***	0.689***	0.287***	0.204***	2.564***
	(0.012)	(0.015)	(0.169)	(0.073)	(0.053)	(0.532)
FEs	YES	YES	YES	YES	YES	YES
Observations	630	630	630	63	63	63
R-squared	0.474	0.475	0.504	0.742	0.787	0.853
Number of pair	210	210	210	21	21	21

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