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Trade, Global Value Chains and GDP Comovemement

An Empirical Investigation

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Abstract

This paper provides up-to-date characterization of the association between trade and GDP comovement—also called the *trade comovement slope*—for 150 countries from 1962 to 2011. The paper shows that trade is significantly linked to more GDP correlation, either directly through bilateral trade, or indirectly when two countries trade with similar partners. This *trade network* effect is strong for countries in all income groups and provides an additional channel through which GDP fluctuations propagate through trade linkages. It also shows that countries of all income groups become more synchronized with high income countries when the content of their trade is more tilted towards inputs as opposed to final goods. Related to this point, the paper also uncovers a strong link between the stickiness of trade relationships and the extent to which countries experience synchronized GDP comovement. The results are robust to a wide range of different measures, to the inclusion of many fixed effects, changes in the sectoral composition of GDP, financial controls capturing crosscountry investments as well as bilateral financial claims.

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Trade, Global Value Chains and GDP Comovemement: An Empirical Investigation

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1 Introduction

What is the relationship between international trade and business cycle synchronization? Do Global Value Chains (GVCs) have a specific impact on the correlation of GDP and if so, does it vary by income group? Since the seminal paper by Frankel and Rose (1998), a very large empirical literature has studied the determinant of cross countries' GDP synchronization, showing that bilateral trade is an important and robust determinant of GDP correlation.[1]

The goal of this paper is to assess the link between trade proximity and GDP comovement on a large sample of **150** countries from **1962 to 2011**, including middle and low income countries. We estimate the *trade comovement* slope (TC-slope) using constructed panel data and controlling for both country-pair and time-window fixed effects, aiming to control for unobserved heterogeneity between countries (e.g distance, common borders, common language) and over time (e.g change in world trade conditions and/or policy).[2] Finally, we provide various robustness checks, including controls related to trade unions, sectoral composition as well as to financial interconnection of the banking sector and foreign direct investment. Broadly speaking, our results are *robust* to a wide range of specifications and trade indexes and highlight *important disparities* among country groups.

Our main findings can be classified as follows:

- **Trade proximity**, defined for each country-pair as total trade over total GDP, is correlated with more GDP comovement for the whole sample of countries **and** most of this correlation is explained by **trade in intermediate inputs** as opposed to trade in final goods.

  While the association between international trade and business cycle synchronization is not a new fact, the specific role of input trade points toward a dinstinctive role for Global Value Chains.[3]

- **Trade network**, defined as proximity in terms of trade partners, is shown to play a *key* role for all income groups with an especially strong association for low-income countries. The transmission of shocks across countries is multifaceted and cannot be studied

[1] Among *many* others, see Frankel and Rose (1998), Clark and van Wincoop (2001), Imbs (2004), Baxter and Kouparitsas (2005), Calderon et al. (2007), Inklaar et al. (2008b), Di Giovanni and Levchenko (2010), Ng (2010), Liao and Santacreu (2015), di Giovanni et al. (2016) and Duval et al. (2015).

[2] See, among others, the seminal work by Frankel and Rose (1998) and Kose and Yi (2001). In their paper, the sample of countries is mostly composed of high income countries.

[3] The analysis developed in this paper are similar to de Soyres and Gaillard (2019) in essence, but it includes more countries in order to investigate the association between GVCs and GDP comovement for all income groups and not only high income countries.

for each country-pair separately. In a world where production chains spread many countries, a third country can be a key component in the GDP synchronization of any pair. Hence, it is important to include a "network" variable in the analysis in order to account for such a mechanism, which is consistent with the importance of trade in input in the rise of cross-country inter-dependence.

- The link between trade proximity and GDP comovement is very strong for country-pairs including at least one high income country. For low income countries, this results means that integrating in Global Value Chains with high income economies could potentially lead to an increase in business cycle synchronization with those trade partners.

- The association is also linked to GDP volatility: country-pairs including at least one low volatility country are also those where the relationship between trade proximity and GDP correlation is significant. This is related to the second point, since high income countries also have less volatile GDP fluctuations (i.e. GDP level and GDP volatility are strongly negatively correlated).

- Using recent decomposition of trade flows based on precise value added accounting from Borin and Mancini (2019), we show that various indices of GVC participation are strongly related to GDP correlation across countries. The association between trade in input and GDP comovement holds using both gross trade and value added trade data. Moreover, intermediate input that are absorbed by the destination country seem to play a more important role for GDP fluctuation than inputs that are re-exported further.[4]

- Results are *robust to a number of controls*: we included constructed third country indices to control for common exposures to other trade partners, indices of similarity in the sectoral composition of GDP for each country-pair, as well as financial proximity indices such as foreign direct investment and bilateral financial interconnection indexes. In all cases, the main message emerging from the analysis does not change and cross-country production linkages, as proxied by trade in intermediate input, is associated with higher GDP co-movement, especially for all country-pairs that include a high-income country.

- Finally, based on a product characterization from Martin et al. (2018) that separates "sticky" from "non-sticky" products based on the duration of buyer-seller relationship,

[4]This finding shows that when considering cross-country production linkages, it could be misleading to only focus on the imported exports *that are re-exported further*. Indeed, since exports typically are a small part of total GDP, the impact of imported input on domestic production goes far beyond the impact on exports.

we show that trade in "sticky" products is also highly associated with GDP synchronization. This finding is indicative that rigid relationships in firm to firm trade contribute to the synchronization of business cycle across countries.

If the empirical association between bilateral trade and GDP comovement has long been known, the underlying economic mechanism leading to this relationship is still unclear. Using the workhorse IRBC with three countries, Kose and Yi (2006) have shown that the model can explain at most 10% of the *slope* between trade and business cycle synchronization, leading to what they called the *Trade Comovement Puzzle* (TCP). Since then, many papers have refined the puzzle, highlighting different ingredients that could bridge the gap between the data and the predictions of classic models.[5]

Relationship to the literature. Starting with Frankel and Rose (1998), a large number of papers have studied and confirmed the positive association between trade and GDP comovement in the cross-section.[6] This paper is mostly related to a few recent contributions. First, di Giovanni et al. (2016) uses a *cross-section* of French firms and presents evidence that international input-output linkages at the micro level are an important driver of the value added comovement observed at the macro level. Their evidence is in line with the findings of this paper and supports the role of Global Value Chains in the synchronization of GDP fluctuations across countries.[7] Second, Liao and Santacreu (2015) is the first to study the importance of the extensive margin for GDP and TFP synchronization and shows that changes in the number of products traded across countries (rather than the average shipment per product) plays an important role in the synchronization of GDP. Third, Calderon et al. (2007) investigate the relationship between trade and business cycle comovement for both developed and developing countries. Based on cross sectional estimates, they find that the impact of trade integration on business cycles is higher for industrial countries than for developing countries. Fourth, our paper is related to a recent series of paper developing accounting and theoretical frameworks to measure GVC participation, including Bems et al. (2011), Johnson (2018) and Borin and

[5]For a quantitative solution of the Trade Comovement Puzzle, see de Soyres and Gaillard (2019) where it is shown that production linkages *alone* is not sufficient for a macro model to deliver a trade co-movement slope in line with the data.

[6]See papers cited for instance in footnote 2.

[7]Relatedly, Burstein et al. (2008) uses a cross section of trade flows between US multinationals and their affiliates as well as trade between the United States and Mexican maquiladoras to measure production-sharing trade and its link with the business cycle. Moreover, Ng (2010) uses cross-country data from 30 countries and shows that bilateral production fragmentation has a positive effect on business cycle comovement. The concept of bilateral production fragmentation used is different from this paper as it takes into account only a subset of trade in intermediates, namely imported inputs that are then further embodied in exports. Moreover, the cross section nature of the analysis does not allow neither for dyadic nor time windows fixed effects.

Mancini (2019).

Finally, the segmentation of production across countries does not only impact the synchronization of GDP but also inflation (Auer et al. (2017), Auer et al. (Fort)). GVCs also impact the trade elasticities (Amiti et al. (2014), Gunnella et al. (2019), de Soyres et al. (2018)) as well as the extent to which regional trade agreement divert trade flows with the rest of the world (de Soyres et al. (2019)).

2 Data Sources

GDP. We use GDP data from the Word Development Indicators of the World Bank. It is measured using constant 2010 prices in US dollars.[8] For our analysis, GDP series need to be filtered in order to extract the business cycle component from the trend. We use three different filtering methods that capture different but related information. Our main filter is the standard Hodrick-Prescott filter (HP) with a smoothing parameter of 100 which is consistent with the yearly frequency of our data. Such a transformation allows us to capture the standard business cycle fluctuations.[9] Second, we also use a Baxter and King filter (BK) to isolate medium-term fluctuations in the spirit of Comin and Gertler (2006a).[10] Finally, we also present results with a more "agnostic" transformation which is a simple log-first difference. Such a measure of growth rate accounts for both the cyclical and the trend components embodied in any year-to-year fluctuation, but it is sometimes considered as less sensitive to researcher's assumptions and preferences regarding the parameters of the filtering method.

Trade Proximity. We collect data on bilateral trade flows from the Observatory of Economic Complexity (MIT). This database covers 215 countries over the period 1962-2014. The data are classified according the 4-digit Standard International Trade Classification (SITC), Revision 2. Only products and commodities are considered. Then, we aggregate these bilateral trade flows at the country-level.

To classify trade flows into final and intermediate goods, we use a concordance table from SITC Rev. 2 to Broad Economic Categories (BEC).[11] We then classify goods into five categories: primary, semi-finished goods, parts and components, capital goods, consumption goods, and a residual category called goods non-specified. We group these categories into intermediate

[8] We used the data serie called "NY.GDP.MKTP.KD"

[9] With this setting, we mostly keep fluctuations that have a frequency between 8 and 32 quarters.

[10] We keep fluctuations between 32 and 200 quarters, following Comin and Gertler (2006a)

[11] The concordance table from SITC Rev2 to BEC can be found on the UN Trade Statistics webpage: https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp.

and final goods as follows: intermediate goods are primary goods, semi-finished goods, parts and components; and final goods are consumption goods and capital goods.

We use two disaggregations. In the first, trade flows are divided into capital goods, intermediate inputs and consumption. In the second, we divide trade flows into intermediate inputs, final goods and primary goods. We construct index for trade proximity (TP) as follows. For given aggregate bilateral trade flows (total, intermediate input or final goods) between a country i and a country j, we define:

$$TP_{ijt} = \frac{T_{i \to j,t} + T_{j \to i,t}}{GDP_{it} + GDP_{jt}} \tag{1}$$

where $T_{j \to j}$ is the export value from country j to country i.

Measure of GVC participation based on Value Added. One of the main purposes in this paper is to identify production linkages between countries. Over the past decade, several accounting and theoretical framework have been developed to measure GVC participation. In this paper, we use the recent GVC indicators from Borin and Mancini (2019). They offer a new toolkit for value-added accounting of trade flows at the aggregate, bilateral, and sectoral levels that can be used to investigate a broad set of empirical questions—including in this case an assessment of the global inflation synchronization.

Product Stickiness. Another related feature of GVCs is their relational aspect. Some products are associated with a higher degree of rigidity in the buyer–seller relationships, which is sometimes associated with a high degree of product customization to integrate within the same production process. Martin et al. (2018) propose a measure of business relationships' stickiness based on the duration of firm-to-firm trade and use firm level data in France to measure a "stickiness" index for more than 4,000 HS6 products. We use their classification to separate trade flow into their "sticky" and "non-sticky" parts, based on the products that are traded.

Financial Proximity. Financial interconnection could impact GDP comovement in a way that is not related to international trade. We use data consolidated banking statistics from the Bank for International Settlement to construct an index of financial proximity.[12] We use the total bilateral cross-border claims (including bank and non-bank sectors for all maturities) between

[12]The dataset is available here: https://stats.bis.org/.

a country i and j to construct an index of financial proximity (FP), such that:

$$FP_{ijt} = \frac{C_{i \to j,t} + C_{j \to i,t}}{GDP_{it} + GDP_{jt}} \tag{2}$$

where here $C_{i \to j,t}$ refers to total cross-border claims from country i to country j.

Foreign Direct Investments. Data from the UNCTAD's Bilateral FDI Statistics provides up-to-date and systematic FDI data for 206 economies around the world, covering inflows, outflows, inward stock and outward stock by region and economy.[13] We use the inflows and outflows in order to construct a bilateral financial integration (FI) controls, such that:

$$FI_{ijt} = \frac{FDI_{i \to j,t} + FDI_{j \to i,t}}{GDP_{it} + GDP_{jt}} \tag{3}$$

Sectoral composition. If shocks have a sectoral component, then two countries that tend to specialized over time in the same sectors could have an increase in business cycle comovements over and beyond any trade effects. in order to account for such a mechanism, we create an index of "*proximity in sectoral composition*" based on the World Development Indicators. We use the share in value added of main sectors: service and agricultural sectors and we decompose manufacturing sectors into 7 main sub-sectors.[14] We then compute the following index:

$$index\_sector_{ij} = 1 - \frac{1}{2} \sum_k \left| share\_GDP_i^k - share\_GDP_j^k \right| \tag{4}$$

where k refers to a particular sector. Pairs of country with very similar sectoral composition have an index close to 1, while countries that completely specialize in different sectors would have an index of 0.

Third country index. We finally attempt to control for third country effect. This is motivated by the fact that two countries trading mostly with similar partners are likely to comove. We

[13] Data are in principle collected from national sources. In order to cover the entire world, where data are not available from national sources, data from partner countries (mirror data) as well as from other international organizations have also been used. Data can be downloaded on the UNCTAD website.

[14] This includes textile, industry, machinery, chemical, high-tech, food and tabacco, other. Data are available here: https://databank.worldbank.org/data/source/.

construct two indexes on the import side and the export side, such that:

$$third_{IM}(i,j) = 1 - \frac{1}{2}\sum_k \left| \frac{im(i,k)}{IM(i)} - \frac{im(j,k)}{IM(j)} \right| \tag{5}$$

$$third_{EX}(i,j) = 1 - \frac{1}{2}\sum_k \left| \frac{ex(i,k)}{EX(i)} - \frac{ex(j,k)}{EX(j)} \right| \tag{6}$$

where $im(i,k)$ defines total import flows from country i to country k and $IM(i)$ the total import flows in country i. With this index, country-pairs with very similar trade partners have an index close to 1. We proceed similarly for the export index.

Using data for 150 countries over the period 1962-2011, we construct a panel data including the above average indexes for each country-pairs and over time windows of 10 years each. Due to missing data, the sample including FDI and BIS indexes are only available for a sub-sample of periods and countries. Table 1 summarizes the number of observations in our sample:

Table. 1. Number of observations (country-pairs) in each sample per time window.

Time window	corr GDP $+ TP$	corr GDP $+ TP + FI$	corr GDP $+ TP + FP$
1962-1971	983	-	-
1972-1981	1586	-	-
1982-1991	2241	153	858
1992-2001	4957	276	1293
2002-2011	6060	633	1572
Total	15827	1062	3723

Throughout this report, we follow the literature assessing the empirical relationship between trade proximity and GDP comovement. First, we test this relationship using total trade proximity and GDP correlation, transformed using logged and filters (HP-filter, BK-filter and first difference (FD)). Using different measures of trade and a variety of controls presented in the next sections, we estimate the following equations:

$$\text{corr GDP}_{ijt}^{filtered} = \beta_1 \ln(TP_{ijt}^{total}) + controls_{ijt} + CP_{ij} + TW_t + \epsilon_{ijt} \tag{7}$$

Second, we focus on the specific role of Global Value Chains as opposed to "traditional trade flows" in the strong association between trade and GDP comovement. More precisely, we empirically test the relationship using dis-aggregated trade data and separate trade flows

into different components including intermediate inputs, final goods and capital goods.[15] This separation has been shown to play an important role in previous papers. Most notably, using a smaller set of countries and time coverage, Burstein et al. (2008), di Giovanni et al. (2016) and de Soyres and Gaillard (2019) have shown that production sharing and/or trade in intermediate inputs is particularly important for the observed trade comovement slope. Our main results are derived from estimating equation 8 below, although a number or other specifications are presented as robustness:

$$\text{corr GDP}_{ijt}^{filtered} = \beta_1 \ln(TP_{ijt}^{inputs}) + \beta_2 \ln(TP_{ijt}^{final}) + controls_{ijt} + CP_{ij} + TW_t + \epsilon_{ijt} \tag{8}$$

3 Main Results

3.1 Evolution of GDP comovement

We first briefly document the evolution of GDP comovement across income groups since the last decades. In Figure 1 we show the evolution of the average GDP correlation between countries in a given income group with countries in other income groups (or the same). It shows an important rise in GDP comovement since the 90s between countries in the high and middle income group. Low income countries do not experience the recent large increase in GDP correlation with respect to other income groups.

[15] We sometimes combine trade in capital goods and intermediate inputs.

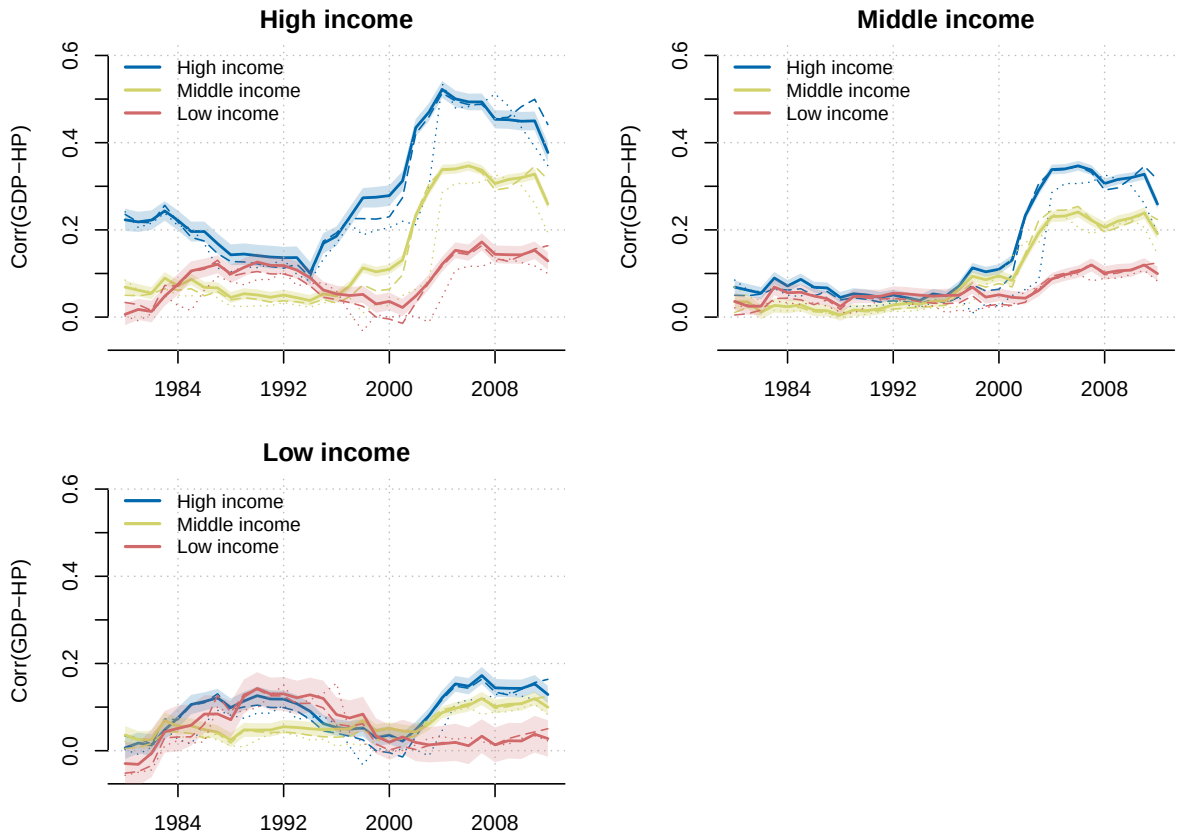


Figure 1. Average GDP co-movement for the three considered income groups. Country-pairs correlation are computed over a time window of 10 years. The figure displays the middle period of the time window.

In figure 2, we focus in the United States and China and observe that those countries experienced a dramatic increase in the correlation between their GDP and the World's total GDP (above 0.2 in average after 2000).[16] Those increased cross-country correlations are important features of economic fluctuations and it seems relevant to precisely investigate the determinants of those evolution. In the rest of this paper, we attempt to isolate the specific relationship between trade linkages and GDP correlation.

[16]Note that there is also a mechanical effect due to China's growth: in 1980 China represented only 2.3% of World's GDP (when accounting for PPP), while the share rose to more than 17% in 2016. For the US, the effect is reverse with the share decreasing by a third between 1980 and 2016.

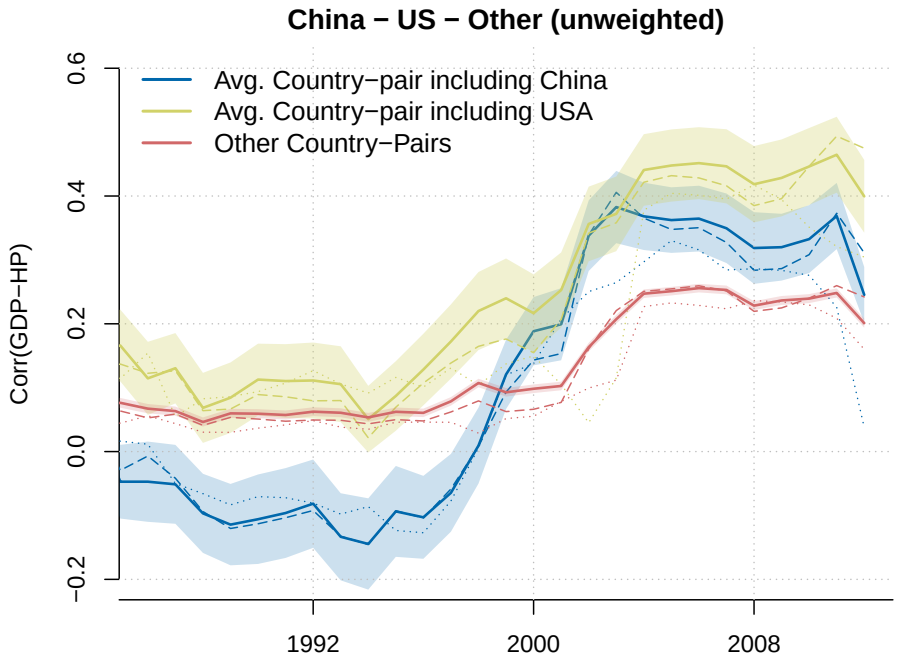


Figure 2. Source: WDR 2020 team, based on World Bank's World Development Indicators (database). Note: The blue line represents the average of all pair-wise GDP correlation taken over all country-pairs that include China. The orange line represents the average taken over all countries that include the United States. The grey line represents country-pairs that contain neither the United States nor China. The date corresponds to the midpoint of a 10-year rolling window.

3.2 Link Between Trade and GDP Co movement: overview

In figure 3, we show the linear relationship (in cross-section) between total trade intensity and GDP correlation. An increase in trade intensity is significantly associated with more GDP co movement. Figure 4 refines this analysis and captures the changes in intermediate input trade as opposed to total trade. As a first pass, and without controlling for country-pair specific and time window specific characteristics, we observe a positive relationship between trade in intermediate inputs and GDP synchronization. The objective of the following analysis is to test, in a more formal and rigorous way, the empirical relationship between trade proximity (separated between final goods and intermediate inputs) and GDP co-movement, controlling for unobserved heterogeneity (through fixed effects), financial integration, sectoral composition and trade network (through third country indexes).

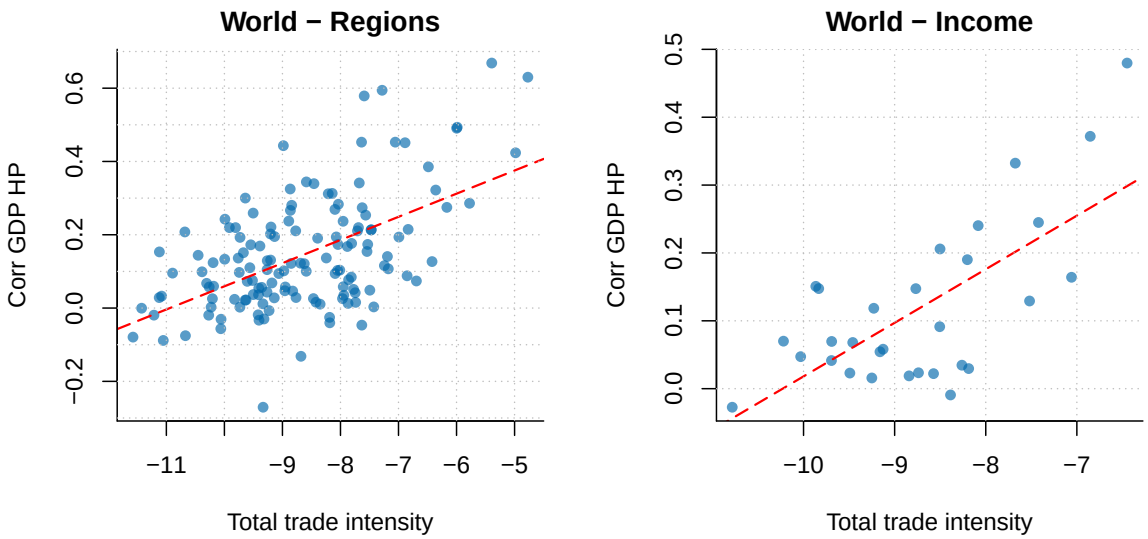


Figure 3. Logged and HP-filtered GDP correlation and total trade intensity between region groups (left panel) income groups (right panel).

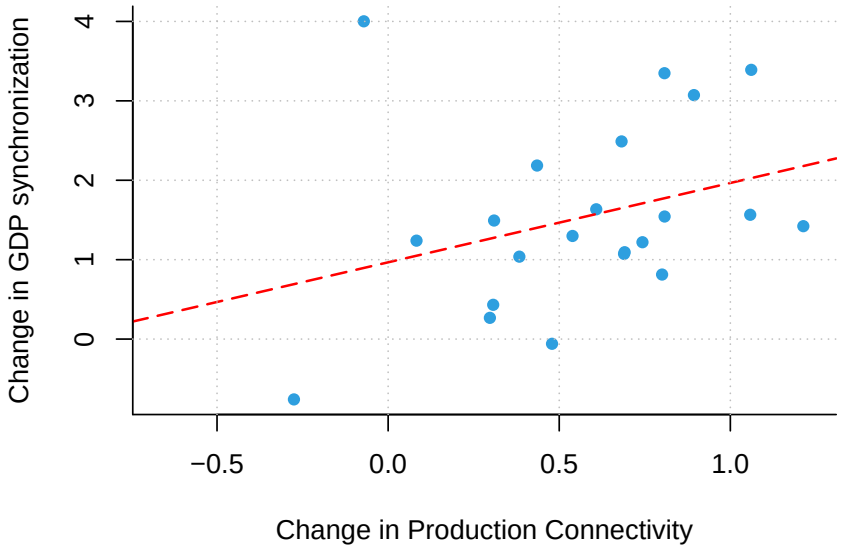


Figure 4. WDR 2020 team, based on World Bank's World Development Indicators (database) and World Integrated Trade Solution (database). Note: Each dot represents a pair of regions—for example, East Asia and Pacific and Sub-Saharan Africa, and Latin America and Caribbean and South Asia are two different observations). The horizontal axis measures the change over time in production connectivity defined as the total trade in intermediates as a share of GDP of both regions. The vertical axis measures the proportional change in GDP correlation over time.

3.3 Trade proximity and GDP correlation

Pairs of countries could have correlated business cycles due to a variety of factors that are not necessarily linked to international trade. For example, it might be the case that shocks have a strong geographical component so that country-pairs located close to one another would co-move for any level of trade. In order to account for such mechanisms, we introduce country-pair fixed effects which control for any time invariant factor for each country-pair such as distance, common language, common border, former colonial ties, etc... This means that we use only the *within* country-pair variations to identify the effect of trade and GVC participation on GDP synchronization.

Moreover, different time windows could be characterized by different aggregate correlation among all country pairs. This could be due for instance to some global shocks affecting all countries in some specific time windows. We account for this possibility by adding time windows fixed effects in order to control for possible unobserved factors that are common across country pairs for each time window.

Table 2 shows the results using the whole sample of countries with the five considered time windows.[17] According to the point estimates, given a ratio of median trade in intermediate inputs between the time windows (2002-2011) and (1972-1981) of 3.6, this increase would have rised GDP correlation by 0.02. Moreover, moving from the 25th to the 75th percentile of trade proximity in intermediate inputs implies an increase of GDP correlation of about 0.05. Finally, an interesting feature of the results is the significant effect of the third country index concerning exports, positive and significant for all the specification. According to the point estimate using HP-filtered GDP, increasing the third export index from 0 (no common partner) to 1 (exactly the same share of trades with partners) increases GDP correlation of about 0.2. Put differently, moving from the from the 25th to the 75th percentile of the third index in export implies an increase in GDP correlation of 0.04, a non negligible increase, highlighting the potential key role of *trade network* in generating GDP correlation.

Those aggregate results, however, hide a significant amount of heterogeneity among income groups that one could uncover. In table 3, we show the results of the regressions when at least one country in the country pair belongs respectively to the high, middle and low income group. Results show that the trade comovement slope, mostly through trade in intermediate inputs, is significant and positive when trade occurs with a country among the high income group. However, even if the value of point estimates display the same pattern for other in-

[17] Results are robust when taking four time windows, excluding the Great Recession.

Table. 2. Trade and GDP comovement: All countries

	corr GDP^{HP}		corr ΔGDP		corr GDP^{BK}	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln\left(TP_{I+K}\right)$	**0.015*****		**0.018*****		**0.015*****	
	(0.005)		(0.005)		(0.005)	
$\ln\left(TP_{inputs}\right)$		**0.014****		**0.015*****		**0.013****
		(0.005)		(0.005)		(0.005)
$\ln\left(TP_{final}\right)$	0.006	0.008	0.004	0.005	0.005	0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\ln\left(TP_{capital}\right)$		−0.003		0.0001		−0.002
		(0.004)		(0.004)		(0.004)
$third_{IM}$	0.018	0.023	0.116*	0.121*	0.036	0.041
	(0.063)	(0.063)	(0.062)	(0.062)	(0.064)	(0.064)
$third_{EX}$	**0.192*****	**0.194*****	**0.133*****	**0.135*****	**0.140*****	**0.142*****
	(0.052)	(0.052)	(0.051)	(0.051)	(0.052)	(0.052)
CP FE	Yes	Yes	Yes	Yes	Yes	Yes
TW FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	15,827	15,827	15,827	15,827	15,827	15,827
R^2	0.204	0.204	0.185	0.185	0.213	0.213

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

come groups, the significance of those estimate drops markedly.[18,19] Moreover, according to the point estimate (combining third country effect on exports and imports), this third country effect is stronger as the level of income is lower. In other words, a country among the low income group is more correlated with another country when the two countries trade with similar partners.

Notice, however, that results for the low income group becomes significant without third country indexes, with trade in intermediate and capital goods being strongly associated with GDP comovement while trade in final good is not. Table table 4 provide additional insight on such decomposition. In appendix, we also perform a country-centric exercise (as opposed to a country-pair analysis in the main text) and study the link between trade and the correlation

[18]Those results are robust to alternative trade proximity indexes, such as $TP_{ijt} = \max\left(\frac{T_{i\to j,t}+T_{j\to i,t}}{GDP_{it}}, \frac{T_{i\to j,t}+T_{j\to i,t}}{GDP_{jt}}\right)$.

[19]Notice that without controlling for time windows fixed effects (table 15 in appendix), estimates for trade in intermediate inputs and trade in final goods for country pairs including a high income country rise respectively to 0.087 and 0.025, both significant. This estimate for trade in inputs would imply a difference of GDP correlation of about 0.28 between the 25th and the 75th of trade in intermediate inputs, and an increase of 0.11 given the ratio of median trade in intermediate inputs.

between each country's GDP with the World's GDP. The results are robust to such a specification.[20] Finally, additional analysis presented in appendix also show that our findings are virtually identical when separating inputs and capital trade index proximity.

Table. 3. Separating by Income Groups

	corr GDP^{HP}			corr ΔGDP			corr GDP^{BK}		
Include X inc.	High	Middle	Low	High	Middle	Low	High	Middle	Low
$\ln(TP_{I+K})$	**0.019*****	-0.001	0.018	**0.023*****	**0.011**$*$	0.010	**0.019*****	0.002	0.015
	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)
$\ln(TP_{final})$	**0.012****	0.007	-0.007	0.002	0.006	-0.002	0.008	0.005	-0.012
	(0.006)	(0.006)	(0.010)	(0.006)	(0.005)	(0.010)	(0.006)	(0.006)	(0.010)
$third_{IM}$	0.075	-0.054	0.091	0.098	0.040	**0.525*****	0.096	**-0.129***	**0.288****
	(0.072)	(0.078)	(0.132)	(0.072)	(0.076)	(0.135)	(0.074)	(0.078)	(0.159)
$third_{ex}$	**0.221*****	**0.224*****	**0.262****	**0.190*****	**0.180*****	**0.206***	**0.168*****	**0.193*****	0.159
	(0.059)	(0.064)	(0.108)	(0.059)	(0.062)	(0.110)	(0.060)	(0.064)	(0.109)
CP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TW FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11,597	11,216	2,814	11,597	11,216	2,814	11,597	11,216	2,814
R^2	0.214	0.227	0.057	0.189	0.199	0.051	0.215	0.245	0.064

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

Table. 4. Separating by Income Groups: without third index

	corr GDP^{HP}			corr GDP^{BK}			corr ΔGDP		
Include X inc.	High	Middle	Low	High	Middle	Low	High	Middle	Low
$\ln(TP_{I+K})$	**0.023*****	0.002	**0.021***	**0.023*****	0.003	**0.019***	**0.028*****	**0.013****	0.018
	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)
$\ln(TP_{final})$	**0.015*****	0.009	-0.006	**0.011***	0.006	-0.009	0.004	0.008	0.002
	(0.006)	(0.006)	(0.010)	(0.006)	(0.006)	(0.010)	(0.006)	(0.005)	(0.010)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11,597	11,216	2,814	11,597	11,216	2,814	11,597	11,216	2,814
R^2	0.212	0.225	0.052	0.213	0.244	0.058	0.188	0.197	0.035

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

[20] Surprisingly, the relationship between trade in intermediate inputs proximity and correlation with world GDP is significant and negative for the whole sample.

3.4 Control for Changes in Sectoral Composition

The analysis presented above hints toward a significant link between trade in intermediate inputs and GDP comovement, especially for all country-pairs that include a high-income country. With country-pair fixed effect, our estimation already controls for time invariant elements at the country-pair level such as distance, common language, and many other elements. Moreover, time windows fixed effects capture global changes over time that affect all country pairs in the same way. However, it is important to recognize that there are time-varying characteristics that could well impact GDP co-movement in a different way for different country-pairs.

To account for such element, we will now incorporate time varying covariates at the country-pair level that control for observable changes that could potentially affect GDP synchronization over and beyond the pure effect of trade. The first element we include is the "sectoral composition" of each economy. If shocks have an important sectoral component, then two economies that gradually converge in terms of sectoral composition would mechanically experience an increase in their synchronization even if they do not trade. The exact definition of the variable we include was described in section 2, and it is worthwhile to note that using such variables comes at a cost, as it decreases notably the size of our sample and hence the amount of variation we can use to identify the effect of trade. This reduction of the sample is especially large for low income countries, and the amount of observations (i.e. country-pair $\times$ time windows) including at least one low income countries drops to 375.

In table 5, we present the results of our analysis for different income groups. The main insight from this specification lies in the fact that controlling for economies' sectoral composition does not seem to change the results. As noted previously, all pairs with at least one high income countries seem to feature a strong association between trade in inputs and business cycle co-movement. One interesting difference is the reduced significance of the "network" variables, which is indicative of the fact that third country effect are likely to be correlated with similarity in sectoral composition at the country-pair level.

Furthermore, table 6 focuses only on country-pairs that include at least one high income country. Since the sample size changes markedly when we include our controls for sectoral composition, we also re-ran the regression without this control for the same sample in order to be able to contrast the results and have a sense of how much the inclusion of such a variable changes the results. It is interesting to notice how little the point estimates change once the sectoral index is included in the estimation.

Table. 5. Separating by Income Groups: with sector index control.

	corr GDP^{HP}			corr GDP^{BK}			corr ΔGDP		
Include X inc.	High	Middle	Low	High	Middle	Low	High	Middle	Low
$\ln(Trade_{K+I})$	**0.036****	0.008	0.006	**0.039****	0.013	0.035	**0.050*****	**0.032***	0.010
	(0.018)	(0.017)	(0.050)	(0.018)	(0.017)	(0.050)	(0.018)	(0.017)	(0.057)
$\ln(Trade_{finals})$	0.014	0.009	−0.022	−0.001	0.004	0.001	−0.015	−0.005	0.021
	(0.017)	(0.015)	(0.039)	(0.017)	(0.015)	(0.039)	(0.018)	(0.015)	(0.045)
sector index	0.064	−0.194	**2.597*****	0.220	−0.135	**2.437*****	0.091	−0.102	**2.245****
	(0.216)	(0.239)	(0.822)	(0.215)	(0.233)	(0.824)	(0.220)	(0.230)	(0.940)
$third_{EX}$	0.019	−0.108	0.885	0.113	−0.015	0.264	0.225	−0.182	**1.604***
	(0.195)	(0.179)	(0.713)	(0.195)	(0.174)	(0.714)	(0.199)	(0.172)	(0.815)
$third_{IM}$	−0.114	0.035	**−1.873*****	−0.202	−0.056	**−1.564*****	−0.133	−0.031	**−1.149****
	(0.213)	(0.222)	(0.505)	(0.212)	(0.217)	(0.506)	(0.217)	(0.214)	(0.578)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,243	3,249	375	3,243	3,249	375	3,243	3,249	375
R^2	0.377	0.346	0.343	0.397	0.386	0.351	0.337	0.318	0.184

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

Table. 6. Separating by Income Groups: control with sector index High income countries.

	corr GDP^{HP}		corr ΔFD		corr GDP^{BK}	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(Trade_{K+I})$	**0.037****	**0.036****	**0.051*****	**0.050*****	**0.042****	**0.039****
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
$\ln(Trade_{finals})$	0.014	0.014	−0.015	−0.015	0.0003	−0.001
	(0.017)	(0.017)	(0.018)	(0.018)	(0.017)	(0.017)
sector index		0.064		0.091		0.220
		(0.216)		(0.220)		(0.215)
$third_{EX}$	0.016	0.019	0.220	0.225	0.102	0.113
	(0.195)	(0.195)	(0.198)	(0.199)	(0.194)	(0.195)
$third_{IM}$	−0.116	−0.114	−0.137	−0.133	−0.212	−0.202
	(0.213)	(0.213)	(0.216)	(0.217)	(0.212)	(0.212)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	3,243	3,243	3,243	3,243	3,243	3,243
R^2	0.377	0.377	0.337	0.337	0.396	0.397

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

3.5 Financial interconnection

As shown in Kalemli-Ozcan et al. (2013), financial interconnection is significantly (and *negatively*) associated with GDP comovements. They show that, in periods without financial crises, an increase in bilateral banking linkages is associated with *more divergent* output cycles. Such a result is consistent with a *resource shifting hypothesis* where an integration of capital market between two countries means that global savings are invested in the countries with the highest marginal productivity of capital – at the expense of investment in the rest of the world. in other words, if savings can be allocated across borders, then a positive technological shock in one country relative to its partners creates an inflow of capital into this country at the expense of other economies.

In this section, we test the empirical trade co-movement relationship while controlling for financial interconnection. Table 7 presents the results with country pairs where information on bilateral financial linkages are available using cross country claims from the Bank of International Settlements (see section 2). Results show that once we control for such financial interconnections, trade and GDP comovement remain significant and positive correlated.[21]

Table. 7. The impact of financial integration: Bank for International Settlements

	corr GDP^{HP}				corr GDP^{BK}				corr ΔGDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\ln(TP)$	**0.056*****	**0.059*****			**0.046*****	**0.051*****			0.013	0.018		
	(0.017)	(0.017)			(0.017)	(0.018)			(0.017)	(0.018)		
$\ln(TP_{I+K})$			**0.032****	**0.035****			**0.032***	**0.035****			0.010	0.013
			(0.016)	(0.016)			(0.017)	(0.017)			(0.017)	(0.017)
$\ln(TP_{final})$			0.023*	0.024*			0.011	0.013			−0.006	−0.004
			(0.014)	(0.014)			(0.014)	(0.014)			(0.014)	(0.014)
$\ln(FP)$		−0.007		−0.007		−0.010		−0.010		−0.011		−0.010
		(0.008)		(0.008)		(0.008)		(0.008)		(0.008)		(0.008)
$third_{EX}$	**0.376*****	**0.382*****	**0.381*****	**0.387*****	0.187	0.196	0.197	0.205	**0.417*****	**0.426*****	**0.435*****	**0.443*****
	(0.131)	(0.131)	(0.131)	(0.131)	(0.135)	(0.135)	(0.135)	(0.135)	(0.137)	(0.137)	(0.137)	(0.138)
$third_{IM}$	**0.521*****	**0.528*****	**0.535*****	**0.543*****	**0.549*****	**0.560*****	**0.559*****	**0.570*****	**0.417****	**0.429*****	**0.426*****	**0.437*****
	(0.156)	(0.156)	(0.156)	(0.156)	(0.160)	(0.160)	(0.160)	(0.161)	(0.164)	(0.164)	(0.164)	(0.164)
CP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TW FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,723	3,723	3,723	3,723	3,723	3,723	3,723	3,723	3,723	3,723	3,723	3,723
R^2	0.346	0.346	0.346	0.346	0.344	0.345	0.344	0.345	0.289	0.289	0.289	0.289

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

[21] Notice however that we do not find that more bilateral financial linkage is correlated with GDP comovement. However, as compared to Kalemli-Ozcan et al. (2013), we rely solely on gross bilateral claims for all sectors and instruments while they focus on the banking sector and net bilateral claims, which is possible to construct only for a small sample of countries. Still, consistent with their findings, the point estimate is negative.

Another potential source of bias in our results could lie in the importance of cross country investments in the form of *Foreign Direct Investments*. In table 8, we investigate the robustness of our findings to the inclusion of FDI links using UNCTAD's data. We find that accounting for cross-country investments only reinforces the specific role of trade in intermediate inputs in the increase of GDP comovement within the country-pairs included in our sample. However, because the coverage of such data is limited, it is important to keep in mind that the sample is different than in previous analysis – see table 1 for an overview of data coverage for each country pair. Over and beyond the role of Global Value Chains, our results highlight the negative but insignificant relationship between Foreign Direct Investments with GDP comovement.

Table. 8. The impact of financial integration: Foreign Direct Investment

	corr GDP^{HP}				corr GDP^{BK}				corr ΔGDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\ln(TP)$	**0.121****	**0.161****			0.095	**0.133****			−0.001	0.053		
	(0.060)	(0.068)			(0.061)	(0.068)			(0.059)	(0.065)		
$\ln(TP_{I+K})$			**0.179*****	**0.198*****			**0.169*****	**0.183*****			0.078	**0.108***
			(0.059)	(0.068)			(0.060)	(0.068)			(0.058)	(0.065)
$\ln(TP_{final})$			−0.108**	−0.079			−0.128**	−0.094*			−0.111**	−0.077
			(0.050)	(0.054)			(0.051)	(0.054)			(0.049)	(0.051)
$\ln(FI)$		−0.021		−0.021		−0.020		−0.020		−0.021		−0.022
		(0.017)		(0.017)		(0.017)		(0.017)		(0.017)		(0.017)
$third_{EX}$	**0.868****	**1.293*****	**0.910****	**1.259*****	**0.883****	**1.311*****	**0.930****	**1.276*****	**1.505*****	**1.800*****	**1.529*****	**1.758*****
	(0.401)	(0.430)	(0.400)	(0.432)	(0.408)	(0.432)	(0.406)	(0.434)	(0.396)	(0.413)	(0.395)	(0.415)
$third_{IM}$	0.246	0.353	0.282	0.372	0.073	0.204	0.109	0.219	−0.160	−0.104	−0.144	−0.106
	(0.475)	(0.503)	(0.472)	(0.501)	(0.483)	(0.506)	(0.478)	(0.503)	(0.469)	(0.483)	(0.466)	(0.481)
CP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TW FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,062	928	1,062	928	1,062	928	1,062	928	1,062	928	1,062	928
R^2	0.472	0.480	0.480	0.485	0.467	0.479	0.478	0.485	0.501	0.515	0.508	0.519

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

3.6 Other GVC measures

Recent advances in data collection and theoretical decomposition of trade flows have shown the various ways of measuring GVC participation.[22] In this paper, we use Borin and Mancini (2019), which proposes a new toolkit for value-added accounting of trade flows at aggregate, bilateral and sectoral level. As in Koopman et al. (2014), trade flows are decomposed into the components described in figure 5.

[22] In particular, see Bems et al. (2011) and Johnson (2018)

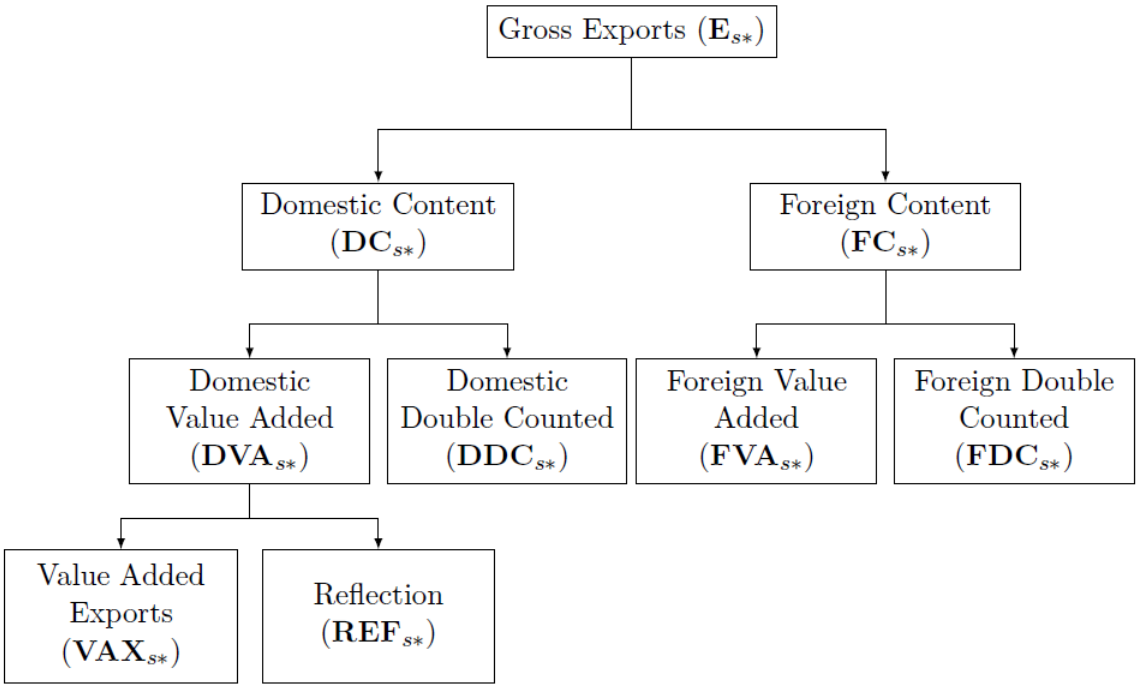


Figure 5. Source: Borin and Mancini (2019), based on Koopman et al. (2014). Decomposition of Gross Trade Flows into its Value-Added and Double Counting components

Based on this decomposition, we analyze the association between GDP co-movement and several indices of GVC participation and trade sub-flows which are defined as described below.

First, we use a decomposition of exports based on gross flows:

- ***Gexp_fin*** is the part of gross exports that are final goods and hence are directly absorbed by the importer. It contains both domestic and foreign value added.
- ***Gexp_int*** is the part of share of gross exports that are intermediate inputs but are also directly absorbed by the importer, which means those are elements which are used in the destination production process and ultimately absorbed by consumer in the importing countries (i.e. not re-exported further). It contains both domestic and foreign value added.
- ***GEREF = Gross Exports - dagexp_int - dagexp_fin***.
  This is the share of gross exports that are re-exported further. It contains both domestic and foreign value added.

Second, we define an alternative decomposition based on value added flows:

- ***DVA*** is the *total* amount of domestic value added embedded in gross exports.

- ***DVAx_fin*** is the domestic value added embedded in gross trade flows and exported as final goods. By definition, this component of the gross trade flows is directly absorbed by the importer.

- ***DVAx_int*** is the domestic value added embedded in gross trade flows, exported as intermediate inputs and absorbed by the importer (i.e. it accounts for the part that is either directly absorbed as well as the part which is re-exported further by the direct partner but is still ultimately re-imported back in the destination country for absorption).

- ***DVARF = DVA - davax_int - davax_fin***.
  It corresponds to the share of domestic value added in exports that is not absorbed by the direct importer. Note that this part of the DVA can be absorbed in any third country in the world, or back in the origin country. This is sometimes referred to as the forward index of GVC participation.

Finally, we define GVC participation indices as follows:

- ***gvcb = Foreign Value Added + Foreign Double Counting Terms***.
  This is the foreign content of exports and is sometimes referred to as the backward index of GVC participation.

- ***gvce = gvcb + DVARF***
  This first index of GVC participation accounts for both backward and forward GVC participation and is the sum of foreign content in export as well as the domestic content of export that are re-exported further.

- ***gvc_broad*** = gross exports - *davax_fin*.
  This second index of GVC participation is broader than the previous one as it also includes ***davax_int***. This index measures all exports that are either intermediate inputs or foreign content. It only excludes from gross trade flows the share of domestic value added that is exported as final good and directly consumed by the destination consumers.

Results using GVC participation index are presented in table 9, where all indices are based on bi-directional flows and are deflated by the sum of GDP in origin and destination countries, which ensures consistence with equation 1 and the whole literature on the topic. Columns

(2) and (4) show that using only *within* country pair variations and controlling for aggregate time windows factors, an increase in GVC participation is significantly related to an increase in GDP co-movement at business cycle frequency.

Table. 9. Global Value Chain: Robustness

	corr GDP^{HP}			
	(1)	(2)	(3)	(4)
ln(*gvce*)	**0.029*****	0.013		
	(0.002)	(0.015)		
ln(*gvc_broad*)			**0.027*****	**0.036****
			(0.002)	(0.016)
Country-Pair FE	No	Yes	No	Yes
Time Window FE	No	Yes	No	Yes
N	17,210	17,210	17,224	17,224
R^2	0.046	0.176	0.043	0.176

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation. Data are from 1990 to 2009, with two time-windows of 10 years.

In table 10, we use the decomposition of both gross exports and value added exports to investigate the role of three different parts of the export flows: the final goods absorbed by consumers in the destination country, the intermediate goods that are used in the destination country for production and absorbed in this very same country, and finally the intermediates that are re-exported further. For all filtering method featured in table 10 (Hodrick-Prescott, Baxter-King or simple first difference), a consistent message emerges from our analysis: for both gross and value added flows, the only part of total trade that is strongly and significantly related to GDP synchronization is trade in intermediate inputs that are *not* re-exported further.[23]

The different results between imported input used for domestic production and imported input that are re-exported further is interesting because it sheds light on the difference between two concept: "cross-country produiction", and "Global Value Chains". Since GDP is the sum of domestic value-added produced in a country, its fluctuations are tightly linked

[23]Notice that the results are not significant when taking into account only the sub-sample with country-pairs with at least one high income country. However, the point estimates are still positive for intermediate inputs.

to the fluctuations of the supply of primary factors of production such as labor and capital. In this sense, the link between trade in inputs and GDP co-movement between two countries comes from the *complementarity* between foreign and domestic factors of production and is not necessarily related to the share of domestic production that is re-exported. Since production for the domestic market is typically much larger that production for exports, it is only natural that the former has more impact on GDP movement than the latter. Finally, the table highlights the importance of *trade network* with significant and positive relationship between the third index and GDP correlation.

Table. 10. Global Value Chain: All countries

	corr GDP^{HP}		corr GDP^{BK}		corr ΔGDP	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(DVAx\_fin)$	0.015		0.045**		0.048**	
	(0.022)		(0.021)		(0.021)	
$\ln(DVAx\_int)$	**0.090*****		**0.105*****		**0.108*****	
	(0.028)		(0.028)		(0.028)	
$\ln(DVARF)$	−0.109***		−0.145***		−0.136***	
	(0.025)		(0.025)		(0.025)	
$\ln(Gexp\_fin)$		0.008		0.039		0.026
		(0.025)		(0.024)		(0.024)
$\ln(Gexp\_int)$		**0.117*****		**0.141*****		**0.152*****
		(0.036)		(0.036)		(0.036)
$\ln(GEREF)$		−0.108***		−0.153***		−0.144***
		(0.027)		(0.027)		(0.027)
$third_{ex}$	**0.158****	**0.156****	**0.121****	**0.118****	0.093	0.093
	(0.061)	(0.061)	(0.060)	(0.060)	(0.060)	(0.060)
$third_{IM}$	−0.050	−0.048	−0.072	−0.068	−0.010	0.004
	(0.076)	(0.075)	(0.075)	(0.074)	(0.075)	(0.074)
Country-Pair FE	Yes	Yes	No	Yes	No	Yes
Time Window FE	Yes	Yes	No	Yes	No	Yes
N	17,120	17,224	17,120	17,224	17,120	17,224
R^2	0.179	0.178	0.203	0.202	0.179	0.178

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.
Data are from 1990 to 2009, with two time-windows: 1990-1999 and 2000-2009.

3.7 Trade in Sticky products

As argued in Antras (2016), the nature of buyer-seller relationship is an important element in Global Value Chains development. Some products are associated with a higher degree of rigidity in the buyer–seller relationships, which is sometimes associated with a high degree of product customization to integrate within the same production process. Based on Martin et al.

(2018), we separate trade flows into two components: (i) the trade flow of products that are considered as "sticky" and hence are associated with rigidity in the buyer-seller relationship, and (ii) the trade flow in products that are "not sticky". We categorize as "sticky" all products that belong to the top 25% percentile in terms of stickiness as estimated by Martin et al. (2018).[24] We first show graphically in figure 6 the relationship between the long term change in GDP co-movement to the long term change in trade flows in *sticky products* and *non-sticky products* over 20 years from 1995 to 2014. From this, a significant positive slopes emerge for sticky trade and GDP fluctuations, while there is no positive relationship between non sticky trade and GDP correlations. We then estimate the role of sticky trade controlling for time windows and country-pairs fixed effects, with:

$$\text{corr GDP}_{ijt}^{filtered} = \beta_1 \ln(TP_{ijt}^{non\ sticky}) + \beta_2 \ln(TP_{ijt}^{sticky}) + controls_{ijt} + TW_t + CP_{ij} + \epsilon_{ijt} \quad (9)$$

Table 11 presents the results of our analysis and shows that the "relational" aspect of trade flows (defined as the degree of stickiness in trade flows) is an important element driving the positive association between trade and GDP correlation for country-pairs including at least a high income country. Indeed, for those country-pairs, trade in sticky products is significantly associated with more GDP correlation (for HP filter and First Difference), while non-sticky products are not.

Table. 11. Trade stickiness and GDP comovement

	corr GDP^{HP}		corr GDP^{BK}		corr ΔGDP	
Include X inc.	All	High	All	High	All	High
$\ln(TP^{non\ sticky})$	$-$**0.009***	0.002	$-$**0.012****	-0.0003	$-$**0.012****	-0.005
	(0.005)	(0.007)	(0.005)	(0.008)	(0.005)	(0.007)
$\ln(TP^{sticky})$	0.001	**0.011***	-0.001	0.010	0.003	**0.019*****
	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes	Yes	Yes	Yes
N	15,445	9,004	15,445	9,004	15,445	9,004
R^2	0.099	0.148	0.118	0.177	0.166	0.261
Notes:	*p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.					

The great financial crisis, which was associated with both large disruptions in buyer-seller relationships and a synchronized drop in GDP in many countries, could influence the results

[24]Notice that this specification also mirror the distinction between trade in intermediate inputs and trade in final goods. Indeed, as mentioned in Martin et al. (2018), products with a low degree of "measured stickiness" tend to belong to BEC classifications associated to final goods (like cars and consumer goods).

of our analysis. To test the robustness of our findings, we run a specification that excludes the financial crisis. Results are presented in table 12 and show that focusing on non-crisis time strongly increases the significance of our findings, namely that trade in sticky products is linked in the data with an increase in business cycle comovement.

Table. 12. Trade Stickiness and GDP correlation – without the financial crisis

	corr GDP^{HP}		corr GDP^{BK}		corr ΔGDP	
Include X inc.	All	High	All	High	All	High
$\ln(TP^{non\ sticky})$	0.006**	0.008*	0.005	0.007*	0.005	0.007*
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
$\ln(TP^{sticky})$	0.013***	0.014***	0.014***	0.012***	0.014***	0.012***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
N	7,229	4,347	7,229	4,347	7,229	4,347
R^2	0.037	0.050	0.036	0.048	0.036	0.048

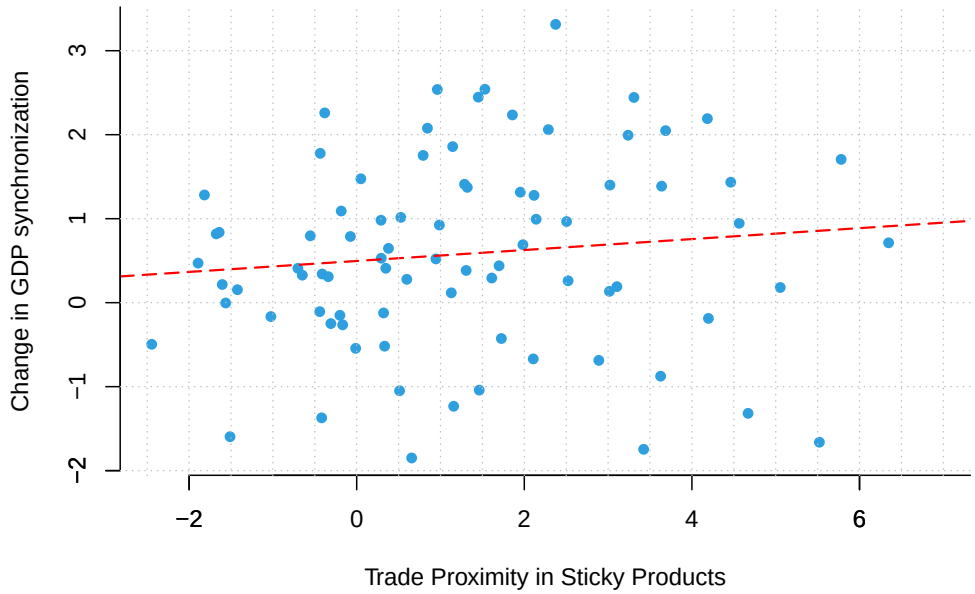
Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

4 Conclusion

This paper provides up-to-date characterization of the association between trade and GDP comovement – also called the *trade comovement slope* – for a large sample of 150 countries over 5 time windows. We show that trade plays a particular role, either directly or indirectly. Directly when two countries trade among each other, in particular when trade flows are composed of intermediate inputs. This direct trade effect is particularly strong and significant for country pairs that include one high income countries. Indirectly when two countries trade with similar partners. This *trade network* effect is strong for all income groups and highlights the systemic nature of propagation of international business cycles through trade linkages.

The specific role of trade in intermediate input is indicative of a peculiar role for Global Value Chains in transmitting shocks between countries. Our results show that countries of all income groups become more synchronized with high income countries when the content of their trade is more tilted towards inputs as opposed to final goods. Related to this point, we also uncover a strong link between the stickiness of trade relationships and the extent to which countries experience synchronized GDP comovement. Indeed, any change in the composition of trade flow towards an increase in "sticky" products is strongly associated with higher business cycle comovement.

Finally, we show that results hold for a wide range of different measures, among volatility groups and are robust to the inclusion of many fixed effects as well as country-pair co-variates such as changes in the sectoral composition of GDP, financial controls capturing cross-country investments as well as bilateral financial claims.



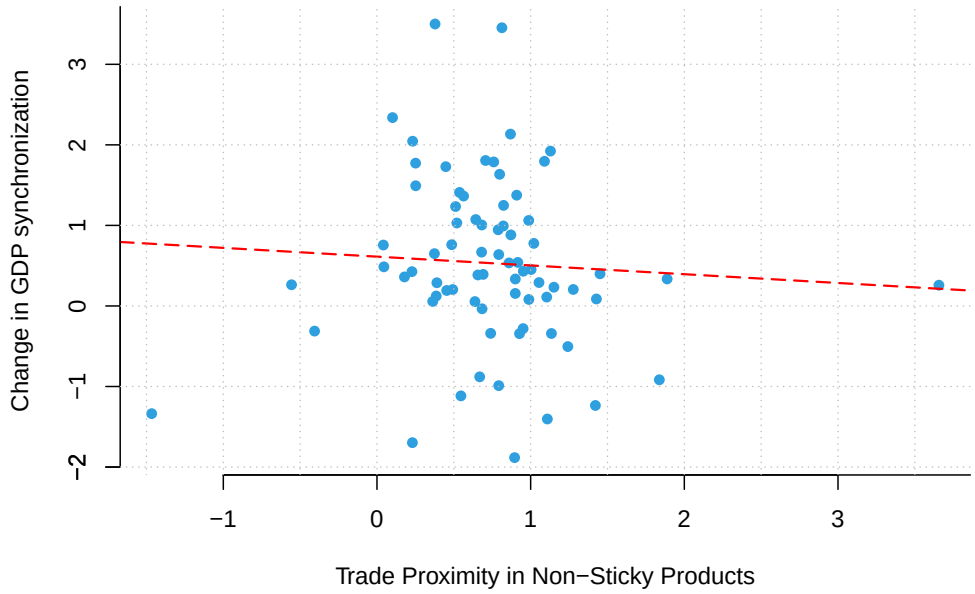


Figure 6. Change in sticky trade (top panel) and non-sticky trade (bottom panel) and change in GDP synchrony. Each dot represents a region-income pair and the difference between the 2005-2014 and the 1995-2004 time windows. Source: WDR 2020 team, based on World Bank's World Development Indicators (database) and a classification of sticky vs. non sticky trade from Martin et al. (2018).

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A Data

Summary Statistics.

Table. 13

Statistic	Pctl(25)	Pctl(75)	Median	Min	Max	Mean	St. Dev.
corr GDP^{HP}	−0.088	0.502	0.215	−0.918	0.974	0.194	0.391
corr GDP^{BK}	−0.097	0.490	0.207	−0.963	0.973	0.187	0.391
corr ΔGDP	−0.099	0.469	0.197	−0.912	0.974	0.178	0.379
TP_{total}	0.00002	0.0003	0.0001	0.00000	0.095	0.001	0.002
$\ln\left(TP_{inputs}\right)$	−11.780	−8.544	−10.124	−20.042	−2.609	−10.219	2.342
$\ln\left(TP_{final}\right)$	−12.891	−9.680	−11.208	−21.922	−3.973	−11.345	2.330
$\ln\left(TP_{capital}\right)$	−13.642	−10.378	−12.041	−22.681	−4.008	−12.046	2.404
$third_{ex}$	0.313	0.529	0.414	0.045	0.923	0.424	0.153
$third_{IM}$	0.362	0.567	0.456	0.112	0.934	0.469	0.143

A.1 Trade comovement slope and GDP volatility

GDP - volatility and income group. We also test the trade comovement slope using a different classification for countries. We split countries into three groups of equal importance according to their GDP volatility (measured as coefficient of variation). Broadly speaking, our results still show the importance of trade, in particular for trade in intermediate inputs when trade occurs with a country among the low volatility group, as shown in table 14. Results for countries in the middle volatility group is also positive and significant for trade in inputs, while we do not find clear pattern when trade occur with a country among the high volatility group.[25]

A.2 Without time windows fixed effects

We present in table 15 the results for each income group without time windows fixed effects. For all specification, trade in intermediate inputs is significant and positive.

A.3 Alternative dis-aggregation

We also provide results an alternative classification disentangling primary goods, intermediate inputs and final goods in table 16 and 17. The results are found robust when we bring together

[25]It should be notice that there is a correlation between income level and volatility. High income countries are more represented in the low income volatility group.

Table. 14. Trade Comovement; volatility group

	corr GDP^{HP}			corr ΔGDP			corr GDP^{BK}		
Include X income	High	Middle	Low	High	Middle	Low	High	Middle	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\ln(TP_{inputs})$	0.010	**0.013****	**0.023****	**0.013***	**0.015****	0.013	**0.012***	0.009	**0.023****
	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)	(0.010)
$\ln(TP_{final})$	0.007	**0.014****	0.007	0.004	**0.011***	0.004	0.007	**0.012****	0.004
	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)
$\ln(TP_{capital})$	−0.004	−0.007	−0.009	−0.001	−0.004	−0.005	−0.003	−0.006	−0.006
	(0.005)	(0.005)	(0.008)	(0.005)	(0.005)	(0.008)	(0.005)	(0.005)	(0.008)
$third_{IM}$	−0.056	0.098	0.048	0.047	**0.214*****	0.050	−0.079	0.097	0.127
	(0.083)	(0.076)	(0.113)	(0.080)	(0.075)	(0.113)	(0.084)	(0.077)	(0.114)
$third_{EX}$	**0.364*****	**0.162****	0.044	**0.223*****	**0.140****	0.020	**0.291*****	**0.111***	0.003
	(0.066)	(0.064)	(0.088)	(0.064)	(0.063)	(0.088)	(0.066)	(0.065)	(0.089)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	9,861	10,424	5,667	9,861	10,424	5,667	9,861	10,424	5,667
R^2	0.216	0.186	0.248	0.201	0.173	0.218	0.225	0.192	0.253

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

Table. 15. Separating by Income Groups: without time windows fixed effects.

	corr GDP^{HP}			corr ΔGDP			corr GDP^{BK}		
Include X income	High	Middle	Low	High	Middle	Low	High	Middle	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\ln(TP_{I+K})$	**0.088*****	**0.075*****	**0.039*****	**0.089*****	**0.080*****	**0.039*****	**0.087*****	**0.077*****	**0.026****
	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)
$\ln(TP_{final})$	**0.033*****	**0.042*****	0.007	**0.029*****	**0.040*****	0.004	**0.022*****	**0.036*****	0.009
	(0.006)	(0.006)	(0.010)	(0.006)	(0.006)	(0.010)	(0.006)	(0.005)	(0.010)
$third_{EX}$	−**0.256*****	−**0.295*****	0.116	−**0.327*****	−**0.344*****	0.016	−**0.239*****	−**0.259*****	−0.019
	(0.061)	(0.067)	(0.104)	(0.062)	(0.067)	(0.105)	(0.060)	(0.064)	(0.105)
$third_{IM}$	−**0.373*****	−**0.442*****	0.170	−**0.361*****	−**0.533*****	**0.348*****	−**0.312*****	−**0.291*****	**0.488*****
	(0.076)	(0.083)	(0.130)	(0.078)	(0.084)	(0.132)	(0.075)	(0.080)	(0.132)
CP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TW FE	No	No	No	No	No	No	No	No	No
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11,597	11,216	2,814	11,597	11,216	2,814	11,597	11,216	2,814
R^2	0.088	0.088	0.019	0.084	0.093	0.021	0.087	0.086	0.021

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

intermediate inputs and primary goods, with estimates close to what are shown in the main report, when combining capital and intermediate inputs. Again, the role of *trade network* is strong under this specification, with a significant and positive correlation between third indexes and GDP comovement.

Table. 16. All countries: alternative disaggregation.

	corr GDP^{HP}	corr ΔGDP	corr GDP^{BK}
	(1)	(2)	(3)
$\ln(TP_{inputs})$	0.002	0.004	0.003
	(0.005)	(0.005)	(0.005)
$\ln(TP_{consumption})$	**0.009***	**0.009***	**0.009***
	(0.005)	(0.005)	(0.005)
$\ln(TP_{primary})$	0.004	**0.006***	0.003
	(0.003)	(0.003)	(0.003)
$third_{IM}$	0.023	**0.118***	0.040
	(0.063)	(0.062)	(0.064)
$third_{EX}$	**0.201*****	**0.137*****	**0.147*****
	(0.052)	(0.051)	(0.052)
Country-Pair FE	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
N	15,827	15,827	15,827
R^2	0.203	0.185	0.212

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

Table. 17. All countries – alternative disaggregation.

	corr GDP^{HP}	corr GDP^{BK}	corr ΔGDP
	(1)	(2)	(3)
$\ln(TP_{inputs+primary})$	**0.017*****	**0.016*****	**0.018*****
	(0.005)	(0.005)	(0.005)
$\ln(TP_{consumption})$	0.004	0.005	0.006
	(0.005)	(0.005)	(0.005)
$third_{IM}$	0.014	0.032	**0.111***
	(0.063)	(0.064)	(0.062)
$third_{EX}$	**0.190*****	**0.136*****	**0.128****
	(0.052)	(0.052)	(0.051)
Country-Pair FE	Yes	Yes	Yes
Time Window FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
N	15,827	15,827	15,827
R^2	0.204	0.213	0.185

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

Finally, in table 18 we present the results of using this alternative trade classification and

separating the results by income groups. The key insight from our paper is preserved with this specification with production linkages, as proxied by trade in intermediate and primary goods, being an important driver of GDP co-movement while trade in final goods having a non significant impact. Again, those results are especially true for all country-pairs that include at least one high-income country.

Table. 18. Robustness with Third Country index and alternative Trade classification

	corr_HP			corr_BK			corr_FD		
	High	Middle	Low	High	Middle	Low	High	Middle	Low
	(1)	(3)	(5)	(7)	(9)	(11)	(13)	(15)	(17)
$\ln(TP_{Inputs+primary})$	0.023***	0.009	0.012	0.021***	0.011*	0.009	0.025***	0.016***	0.009
	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)
$\ln(TP_{consumption})$	0.007	−0.002	−0.004	0.007	−0.003	−0.008	0.004	0.002	−0.004
	(0.006)	(0.006)	(0.011)	(0.006)	(0.006)	(0.011)	(0.006)	(0.005)	(0.011)
$third_{IM}$	0.064	−0.061	0.098	0.086	−0.136*	0.291**	0.083	0.032	0.532***
	(0.072)	(0.078)	(0.132)	(0.074)	(0.078)	(0.133)	(0.072)	(0.076)	(0.134)
$third_{EX}$	0.222***	0.226***	0.260**	0.164***	0.193***	0.157	0.176***	0.180***	0.204*
	(0.059)	(0.064)	(0.108)	(0.060)	(0.064)	(0.109)	(0.059)	(0.062)	(0.110)
CP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TW FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11,597	11,216	2,814	11,597	11,216	2,814	11,597	11,216	2,814
R^2	0.213	0.227	0.056	0.215	0.245	0.063	0.190	0.199	0.051

Notes: *p<0.1; **p<0.05; ***p<0.01. In parenthesis: std. deviation.

A.4 GDP correlation: selected countries

As presented in the main text, GDP comovement across all country-pairs increased strongly over the past few decades. In figure 7, we illustrate how this aggregate surge actually hides a lot of heterogeneity. For example, looking at the comovement of Nigerian GDP with all other countries in the world, we see that the synchronization actually decreased between 1960 and 2008.

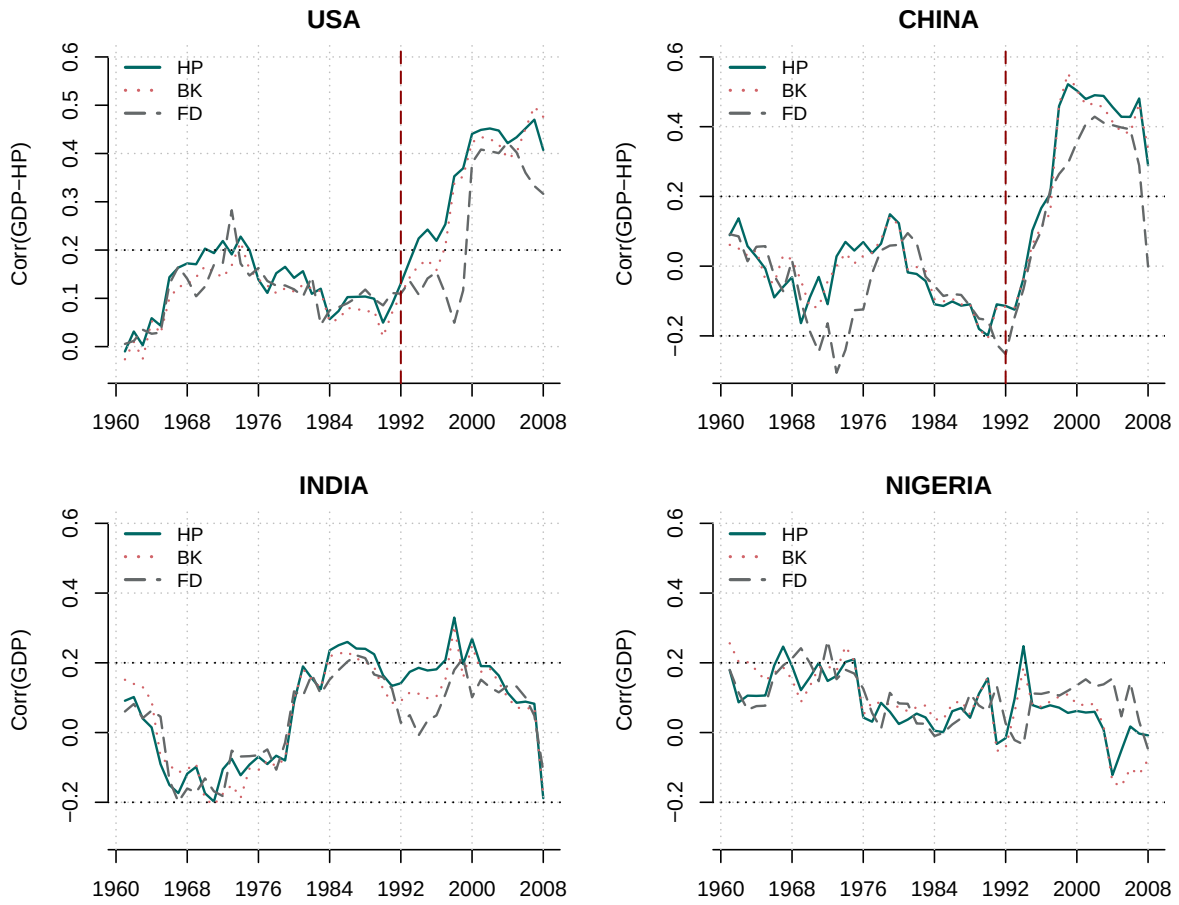

Figure 7. Average GDP correlation with the rest of the world for the US, China, India and Nigeria.