The Trade Comovement Puzzle and the margins of International Trade

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Abstract

Countries that trade more with each other tend to have more correlated business cycles. Yet, traditional international business cycle models predict a much weaker connection between trade and output comovement. We propose that international technology diffusion through trade in varieties may be driving this comovement, by increasing the correlation of TFP. Our hypothesis is that business cycles should be more correlated for countries that trade a wider variety of goods rather than larger quantities of already traded goods. We find empirical support for this hypothesis. When we decompose trade into its extensive and intensive margins, we find that the extensive margin explains most of the trade-output and trade-TFP comovement. This finding is striking given that the extensive margin only accounts for one third of total trade. We then develop a 3-country model of innovation and adoption, in which TFP correlation increases with trade in varieties, and show with a numerical exercise that the proposed mechanism increases business cycle synchronization with respect to traditional models.

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1 Introduction

Countries that trade more with each other tend to have more correlated business cycles (Frankel and Rose (1998)). Yet, traditional international business cycle (IBC) models predict a much weaker connection between trade and output comovement.[1] Kose and Yi (2006) propose several solutions to what they call the 'trade comovement puzzle'. In particular, they find that TFP shocks are more correlated across countries that trade more with each other. They also show that calibrations of the standard model including this fact are able to fully capture the output-trade comovement observed empirically. However, the underlying mechanisms connecting trade and TFP comovement remain unexplained.

We propose that international technology diffusion through trade in varieties may be driving TFP comovement. Indeed, a recent literature shows that technology adoption is able to explain differences in TFP growth across countries (Broda, Greenfield, and Weinstein (2006) and Santacreu (2009)). In autarky, a country's TFP depends only on its domestic technology (Romer (1990)). When, instead, trade is allowed, TFP also depends on foreign technologies that are embodied in the imported goods. Hence, trade in varieties induces a process of international diffusion through which countries benefit from each others' technological innovations. Based on this premise, our hypothesis is that business cycles should be more correlated for countries that trade a wider variety of goods rather than larger quantities of already traded goods.[2]

We find empirical support for this hypothesis. We decompose trade intensity into its extensive and intensive margins and run the Frankel and Rose (1998) regressions on

[1] In standard IBC models, driven by productivity shocks, two opposite forces determine the trade-output comovement. First, more trade leads to more synchronization by increasing the demand for foreign products ('demand complementarity' effect) Second, more integration induces a stronger reallocation effect towards the most productive country, decreasing the synchronization ('resource-shifting' effect). When markets are complete, the latter effect dominates. In addition to the standard channels, a third effect has an ambiguous sign: the 'terms of trade effect'. An economy experiencing a positive productivity shock benefits from lower prices and increases its market share relative to foreign economies, reducing the business cycle synchronization. However, foreign economies also benefit from cheaper imports, which increases the business cycle synchronization. Which effect dominates depends on the elasticity of substitution between domestic or foreign intermediate goods, as well as the share of imported intermediate goods in the foreign economies.

[2] Studying the trade liberalization episode in India in 1991, Goldberg, Khandelwal, Pavcnik, and Topalova (2009) and Goldberg, Khandelwal, Pavcnik, and Topalova (2010), show that imports of varieties generate static and dynamic gains from trade, and increase productivity at the plant level.

both.[3] We find that the extensive margin explains most of the trade-output and trade-TFP comovement, while the intensive margin plays only a marginal role. This finding is striking given that the extensive margin only accounts for one third of total trade. The results hold both at high and medium frequencies.

We then develop a three-country model of international business cycles with the following features.[4] First, we assume trade in differentiated intermediate and capital goods.[5] Second, the dynamics of TFP are mainly driven by adoption of technological innovations (Santacreu (2009)). This is the key mechanism we propose to explain the 'trade comovement puzzle'. Third, two types of costs induce variations in trade: iceberg transport costs, which affect mainly the intensive margin of trade, and entry-regulations fixed costs, which affect mainly its extensive margin.

Production involves love-for-variety à la Ethier (1982) to capture the effect of the extensive margin of trade on growth rates. In each country, a firm produces a non-traded final good using domestic and foreign intermediate goods (varieties). The efficiency of final production is determined by the number of varieties used. In each country, new varieties are introduced through an exogenous innovation process that allows for spillover effects: firms learn from both domestic and imported intermediate goods (this is the so–called "variety in–variety out model" in Goldberg, Khandelwal, Pavcnik, and Topalova (2009) and Goldberg, Khandelwal, Pavcnik, and Topalova (2010)). Domestic innovations are immediately available to domestic firms. However, foreign innovations must be adopted first to become productive in the final sector, and adoption is modeled as an exogenous process, which is affected by entry regulation costs.

A decrease in trade costs between two countries increases their bilateral extensive margin of trade, inducing technology transfers and an increase in their TFP. In our model, two channels strengthen the correlation of TFP growth between the two coun-

[3]The extensive margin refers to how much trade is driven by the number of products, whereas the intensive margin refers to the amount of each product that is traded.

[4]The choice of a 3-country model is based on Kose and Yi (2006)'s argument that in a two-country model, one of the countries would be the rest of world and so the model would overstate the impact of one country on the other. A 3-country model can also help to take the third-country effect into account.

[5]The structure of international trade in the last decade has shifted towards intermediate and capital goods explaining a higher share (78% of total trade corresponds to capital (14%) and intermediate inputs (64%), and only 22% corresponds to consumption goods). A similar decomposition in consumption, capital and intermediate goods is obtained when instead of trade flows one considers the number of goods traded

tries: a direct channel working through the traditional demand-supply spillover effect, and an indirect channel that affects TFP through the international diffusion of technologies embodied in the variety of traded goods. Models that ignore the extensive margin of trade do not capture this indirect channel.

Finally, we perform a numerical exercise in which we change the bilateral trade intensity by varying transport costs (both variable and fixed). The exercise shows that modelling explicitly the extensive margin of trade, generates higher business cycle synchronization than standard international bussiness cycle models.

Several strands of literature have tackled the ‘trade comovement puzzle’. First, and as mentioned earlier, Kose and Yi (2006) document that TFP shocks are more correlated across countries that trade more with each other, but they do not model explicitly this mechanism. Others emphasize the role of intermediate inputs in increasing plant-level productivity after trade liberalization (e.g., Goldberg, Khandelwal, Pavcnik, Topalova (2009, 2010), Kugler and Verhoogen (forthcoming), Manova and Zhang (2011)). Our paper builds upon this literature by proposing a mechanism through which TFP is more correlated across pairs of countries that trade a wider variety of goods. Our main innovation is to disentangle the effect of the extensive margin and intensive margin of trade on the comovement of TFP growth and output growth.

Another strand of literature studies the role of vertical linkages, both empirically (Di Giovanni and Levchenko (2009) and Burstein, Kurz, and Tesar (2008)), and theoretically (Arkolakis and Ramanarayanan (2009)). This literature also explores the role of traded intermediate inputs. However, they study amplification effects arising from multiple stages of production. For example, Di Giovanni and Levchenko (2009) find that sectors that trade more with each other have more correlated cycles. Our analysis allows for a simple form of vertical linkages, and shows that this channel alone cannot fully capture the trade-comovement observed empirically.

Finally, Drozd and Nosal (2008) propose that a low elasticity of substitution between domestic and foreign intermediate goods at business cycle frequencies can partly explain the trade-output comovement. In their model, frictions in the short-run to generate a low price elasticity that is compatible with the high long-run elasticity of substitution observed in the data. This model can capture 50% of the correlation between trade and output comovement found in the empirical studies. However, the empirical evidence of this mechanism is not well-established.

The paper is organized as follows. Section 2 updates the Frankel and Rose regressions for output comovement up to 2009, for a sample that includes developed and developing countries. Section 3 analyzes the relationship between output-comovement and TFP comovement and performs the Frankel and Rose regressions using the bilateral correlation of TFP growth as the dependent variable. In Section 4, we decompose the bilateral trade intensity on the extensive and intensive margins of trade and regress both the output and TFP comovement variables on the two margins of trade. Section 5 presents the model, which is calibrated in Section 6. Finally, Section 7 concludes.

2 Frankel and Rose revisited

We first update the Frankel and Rose (1998) regression up to 2009. Our updated sample spans from 1980 Q1 to 2009 Q4, and covers 30 countries (20 OECD countries, and 10 developing countries). Countries in our sample constitute about 75% of world GDP and 73% of world trade (as of year 2009).[6] The country list can be found in the Appendix.

Following Frankel and Rose (1998), we study the relationship between two key variables: bilateral trade intensity and bilateral correlations of real economic activity. Two different proxies are used to measure bilateral trade intensity. The first one relies only on international trade data:[7]

$$w_{ijt} = (X_{ij,t} + M_{ij,t})/(X_{it} + X_{jt} + M_{it} + M_{jt})$$

where $X_{ij,t}$ is the total nominal exports from country i to country j during period t, and X_{it} is the aggregate nominal exports to all countries from country i. M denotes

[6] We use the total PPP Converted GDP(G-K method, at current prices in milions I$) collected from the Pen World Table to calcuate the GDP shares. For the trade shares, data are collected from IMF Direction of Trade Statistics database.

[7] The bilateral trade data used to calculate trade intensity are obtained from the International Monetary Fund's Direction of Trade data set.

imports.[8]

We calculate the bilateral correlation between real GDP in country i and country j to measure real activity correlation at time t. For the OECD countries, the real GDP data are obtained from OECD quarterly national account database (series name: VOBARSA, Millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted). For the other countries, the quarterly real GDP data are taken from IMF International Financial Statistics, the GDP Volume series (2005=100).[9]

The output data are transformed in three different ways. First, we apply the Hodrick-Prescott ("HP") filter (using the traditional smoothing parameter of 1600) to the real GDP series. Second, we take first-differences of natural logarithms of the real GDP data to calculate the output growth rate. Finally, we apply the Band-Pass filter on the real output to remove the high frequency variations but retain frequencies between 32 and 120 quarters. The first two ways to de-trend the variables aim to capture business cycle frequencies, while the third aims to capture medium-term business frequencies (Comin and Gertler (2006)).[10]

After approriately transforming the data, the bilateral correlations for real activity are estimated between two countries over a given span of time. We begin by splitting our sample period into six subsamples of 5 years each, between 1980 and 2009.[11] For 30 countries, there are a total of 2610 observations (435 in the cross section and 6 in the time series). Taking the output growth rate as an example, we estimate the cor-

[8]An alternative index of trade intensities is calcuated as

$$w_{ijt}^2 = (X_{ij,t} + M_{ij,t})/(GDP_{it} + GDP_{jt})$$

The nominal GDP data (annul index in national currency) are collected from IMF International Financial Statistics. Because the trade data are in US dollars, we use official exchange rate(period average; when official exchange rate is not available, market exchange rate is used instead) to transform the nominal GDP in national currency into USD denominated data. It is difficult to say which indexis more appropriate to measure bilateral trade intensities.Therefore we conduct our study using both measures. Our results are robust to both measures of trade intensity. We only report the results for models using w_{ijt}^1 in this paper. The tables using w_{ijt}^2 as regressors are available upon request.

[9]For earlier sample periods, quarterly data are not available for some emerging markets. We then interpolate annual index (also from IFS) assuming real GDP is constant every quarter within a year. For robustness check, we try regressions using shorter sample period during which quarterly GDP data are available for all economies, and the results are consistent with what we obtain from the full sample analysis. The results are available upon request.

[10]The motivation for using the Band-pass filter will become more clear later.

[11]To accommendate possible measurement error, we also calculate pairwise output correlations for the entire sample period. The regression results are very similiar to what we obtained using 5-year correlations. The tables are available upon request.

relation between output growth for two countries i and j over each subsample period as $corr(\triangle y_{it}, \triangle y_{jt})$. The international trade data is at annual frequency, thus the trade intensities are calculated for each year, then we take natural logarithms. To match the frequency of bilateral output correlations, we take average of log trade intensities in each of the six subsamples.

We run the following regression, for the three measures of output (growth rates, HP-filter and BP-filter):

$$corr(\triangle y_{it}, \triangle y_{jt}) = \alpha + \beta log(w_{ijt}) + \varepsilon_{ijt}$$

The results are broadly consistent with the literature and robust to the inclusion of instrumental variables.[12] Table 1 collects the results for updated Frankel&Rose regression using distance as IV. We find that doubling the size of trade intensity leads to a 0.05 higher correlation of output growth (0.12 HP-filtered output and 0.15 BP-filtered output).

Table 1. Output correlation and the trade intensity:IV (2SLS) regression

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp},y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp},y_j^{bp})	Coef.
log(w_{ij})	0.139***	log(w_{ij})	0.081***	log(w_{ij})	0.240***
	(0.009)		(0.006)		(0.015)
Constant	1.095***	Constant	0.634***	Constant	1.506***
	(0.052)		(0.033)		(0.085)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**). Use log distance as IV.

3 Trade comovement and TFP

In this section we re-run Frankel and Rose (1998) regression using bilateral correlations of TFP as the dependent variable. Kose and Yi (2006) find that TFP shocks are more correlated across countries that trade more with each other.

[12] The natural instrument for trade intensity, as used by the literature, is distance.

Figure 1 shows the correlation between bilateral correlation of TFP growth and our measuere of trade intensity. Panel A shows a strong correlation between the two variables. We split the sample of countries in three different ways: North-North, North-South and South-South. The relation is stronger for North-South trade (Panel B) .

We then test empirically whether countries that trade more with each other have more correlated TFP. TFP in our paper is calculated as the Solow residual in a standard Cobb-Douglas production function. For each country i, taking logs of the production function:

$$\log(z_{it}) = \log(y_{it}) - \alpha \log(n_{it}) - (1-\alpha)\log(k_{it}) \tag{1}$$

Where z_{it} denotes the TFP, y_{it} is the real income, n_{it} measures the total employment, and k_{it}represents the real physical capital stock. We take the gross-fixed capital formation data from the IFS and employment index from IFS and OECD database.[13]The physical capital is constructed using the perpetual inventory method with a constant quarterly depreciation of 2.5%, assuming the initial capital stock is zero. The labor share of income in GDP, α, is set to be 0.64 for industrialized countries and 0.5 for emerging markets following the literature.[14]

We replicate the steps from Section 2 and transform TFP in three different ways: quarter-to-quarter growth rates, HP- filtered TFP and BP-filtered TFP. Then we estimates the bilateral correlations of the TFP for country i and j during each of the six subsamples. We run the following regression, for the three measures of TFP (growth rates, HP-filter and BP-filter):

$$corr(\triangle TFP_{it}, \triangle TFP_{jt}) = \alpha + \beta log(w_{ijt}) + \varepsilon_{ijt}$$

The results are consistent with the literature and robust to the inclusion of instrumen-

[13]For OECD countries, the gross-fixed capital formation data are series named VOBARSA(Millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted); the employment data is from OECD Labour Force Statistics (MEI) Dataset (All persons, Index OECD base year 2005=100, s.a.). For other countries, the data are from IFS database. The gross-fixed capital formation data are deflated by GDP deflator (2005=100, also from IFS database) to obtain the real capital formation data. For countries and periods when quarterly data are not available, we interpolate annual index assuming constant volume every quarter within a year. For robustness check, we find excluding the periods when quarterly data are not available does not affect our results.

[14]As a robustness check, we also calculate TFP for emerging markets using the same labor share as for industrialized couantries. It does not affect our results.

tal variables.[15] Quantitatively, the correlation between and trade intensity is stronger at medium term frequencies (BP-filter measure) than at business frequencies. This finding suggets that to match quantitatively the trade comovement found by Frankel and Rose (1998) , we need mechanisms that operate mainly in the medium term.

Table 2. TFP correlation and the trade intensity

Panel 1: HP-filtered TFP		Panel 2: TFP growth		Panel 3: BP-filtered TFP	
corr(tfp_i^{hp}, tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp}, tfp_j^{bp})	Coef.
$\log(w_{ij})$	0.064***	$\log(w_{ij})$	0.043***	$\log(w_{ij})$	0.131***
	(0.008)		(0.005)		(0.012)
Constant	0.563***	Constant	0.386***	Constant	1.274***
	(0.046)		(0.030)		(0.067)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**). Use log distance as IV.

4 Trade comovement and the margins of trade

In this section, we depart from standard empirical studies on the totaltrade comovement puzzle, and disentangle the effect of the bilateral extensive and intensive margins of trade on our two measures of real activities: GDP and TFP. As in previous sections, we explore the relationship, both at business frequencies (using growth rates and the HP-filter) and at medium frequencies (using the BP-filter). It has been argued by several authors in the literature that the EM of trade does not vary significantly at the business cycle frequency (Kehoe and Ruhl (2003)). For that reason, we follow Comin and Gertler (2006), and remove the high frequency variations of the data.

We use bilateral trade data at the 6-digit level of disaggregation (Harmonized System) from the UNcomtrade database and calculate the two margins of trade following two different methodologies. First we perform the Hummels and Klenow (2005) decomposition; then as robustness checks we count the number of varieties as the measure

[15] Drozd and Nosal (2008) replicate a similar regression

for the extensive margin of trade. The two sets of measures deliver similar results. Hummels and Klenow (2005) use Feenstra and Markusen (1994) methodology to incorporate new varieties into a country's import price index when preferences are C.E.S. In this setting, the import price index is effectively lowered when the set of goods expands. When comparing export prices for a country relative to a reference country requires an adjustment for the size of each exporter's goods set. The adjustment used by Hummels and Klenow (2005) is the extensive margin. For the case when i's shipments to j are a subset of k's shipments to j, the extensive margin is defined as :

$$EM_{ij} = \frac{\sum_{m \in I_{ij}} p_{kjm} x_{kjm}}{\sum_{m \in I} p_{kjm} x_{kjm}}$$

where I_{ij} is the set of observable categories in which country i has positive exports to j. The reference country k (which in our case is the rest of the world) has positive exports to j in all I categories. The extensive margin is a weighted count of i categories relative to k categories. If all categories are of equal importance, then the extensive margin is simply the fraction of categories in which i exports to j (categories are weighted by their importance in k exports to j).[16]

The corresponding intensive margin compares nominal shipments for i and k in a common set of goods. It is given by:

$$IM_{ij} = \frac{\sum_{m \in I_{ij}} p_{ijm} x_{ijm}}{\sum_{m \in I_{ij}} p_{kjm} x_{kjm}} \tag{2}$$

IM_{ij} equals i nominal exports relative to k nominal exports in those categories in which i exports to j.

The ratio of country i exports to j with respect to country k exports to j equals the product of the two margins.

$$OV_{ij} = EM_{ij} IM_{ij} \tag{3}$$

where OV_{ij} is the overall trade from country i to country j relative to trade from the

[16]This is different than using count data to compute the EM and IM. We will use count data for robustness check later, and we conclude that the results are very similar.

rest of the world to country j.

Taking logs, we obtain the following expression

$$log(OV_{ij}) = log(EM_{ij}) + log(IM_{ij}) \tag{4}$$

We use the formulas above to compute the contribution of both margins of trade to overall trade and obtain that, for the average country, the IM accounts for more than 75% of the overall trade.

Next, we classify the 5-digit goods in 3 categories: consumption, intermediate and capital goods, and regress the correlation of our three measures of output against the log of the ratio of country i to country k exports to j for intermediate and capital goods.

$$\rho(\Delta y_{it}, \Delta y_{jt}) = \beta_{OV} log(OV_{ij,t}) + \varepsilon_{jm,t} \tag{5}$$

Since trade is an endogenous variable, we run instrumental variables regressions, using distance as the instrument for overall trade. Our results are consistent with the results obtained in the updated Frankel and Rose (1998) regression.

Table 3. Instrumental variables (2SLS) regression

Only use capital and intermediate goods to calculate OV_{ij}

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp}, y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp}, y_j^{bp})	Coef.
log(OV_{ij})	0.115***	log(OV_{ij})	0.067***	log(OV_{ij})	0.197***
	(0.006)		(0.004)		(0.010)
Constant	0.851***	Constant	0.492***	Constant	1.084***
	(0.028)		(0.017)		(0.045)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**). Use log distance as IV.

We then analyze the contribution of the different margins of trade on output comovement by running the following regressions:

$$\rho(\Delta y_{it}, \Delta y_{jt}) = \beta_{EM} log(EM_{ij,t}) + \beta_{IM} log(IM_{ij,t}) + \varepsilon_{ij,t} \tag{6}$$

We need to find instruments for the extensive and intensive margins of trade. In a trade model with variable and fixed trade costs, the IM is mainly affected by the iceberg transport cost, whereas the EM is mainly affected by the fixed cost to entering a new market. Therefore, we use distance as the instrument for the intensive margin. For the extensive margin, we followHelpman, Melitz, and Rubinstein (2008) who use country-level data on the regulation costs of firm entry, collected and analyzed by Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2002). These entry costs are measured via their effects on the number of days, the number of legal procedures, and the relative cost (as percent of GDP per capita) needed for an entrepreneur to legally start operating a business. Our indicator of pair-wise trade costs in constructed by adding both the importing and exporting entry regulation costs. In particular, we use the relative costs as a percentage of GDP per capita, so that these cost measures can be compared across countries. [17]

By construction, these bilateral variables reflect regulation costs, that predominantly affect the fixed costs of trade and should not depend on the volume of exports to a particular country.

We then we run an IV regression of the correlation of both TFP and GDP on the extensive and intensive margins of trade. We find that the EM has a positive and significant effect on the comovement of business cycles across pairs of countries for the three measures of output, whereas the IM has a lower and non-significant effect. The results are stronger when the BP-filter is used in the analysis. Indeed, the coefficients double with respect to the case in which HP-filtered or growth GDP is used, indicating a stronger relationship between business cycle synchronization and international trade at medium-term frequencies.

[17]Helpman, Melitz, and Rubinstein (2008) use as an alternative the number of days and procedures ias a measure of entry costs, but find that the jointly defined indicator variable had substantially more explanatory power. In addition, entry regulation costs could be correlated with the variable trade cost distance. However, Helpman, Melitz, and Rubinstein (2008) add country fixed effects in the first stage regression and show that this is not the case.

Table 4. Instrumental variables (2SLS) regression with EM and IM

Using Klenow and Hummels' decomposition method

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp},y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp},y_j^{bp})	Coef.
$\log(EM_{ij})$	0.309***	$\log(EM_{ij})$	0.196***	$\log(EM_{ij})$	0.593***
	(0.042)		(0.027)		(0.036)
$\log(IM_{ij})$	0.031	$\log(IM_{ij})$	0.011	$\log(IM_{ij})$	0.028
	(0.021)		(0.013)		(0.036)
Constant	0.644***	Constant	0.354***	Constant	0.662***
	(0.059)		(0.037)		(0.101)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**). log distance and log of entry cost as IVs.

Similarly, we investigate the contribution of the different margins of trade on TFP comovement by running the following regression:

$$\rho(\Delta TFP_{it}, \Delta TFP_{jt}) = \beta_{EM} log(EM_{ij,t}) + \beta_{IM} log(IM_{ij,t}) + \varepsilon_{ij,t} \qquad (7)$$

Again, we use iceberg transport cost and fixed cost as instrumental variables in above regression. Similar to what we find from output-trade comovement analysis, the results show that only the extensive margin has a positive and significant effect on the comovement of TFP across borders, while the IM has a negative or a non-significant effect.[18]

[18] Similar results on the effect of changes of trade costs on the different margins of trade have been obtained by Dutt, Mihov, Van Zandt, and Ossa (2011) in the context of the WTO. They show that the effect is almost exclusively on the extensive product margin of trade, while it has a negligible or even a negative impact on the intensive margin.

Table 5. TFP correlation on EM and IM

Using Klenow and Hummels' decomposition method

Panel 1: HP-filtered TFP		Panel 2: TFP growth		Panel 3: BP-filtered TFP	
corr(tfp_i^{hp}, tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp}, tfp_j^{bp})	Coef.
$\log(EM_{ij})$	0.275***	$\log(EM_{ij})$	0.181***	$\log(EM_{ij})$	0.557***
	(0.037)		(0.024)		(0.062)
$\log(IM_{ij})$	-0.042*	$\log(IM_{ij})$	-0.027*	$\log(IM_{ij})$	-0.084**
	(0.018)		(0.012)		(0.030)
Constant	0.215***	Constant	0.154***	Constant	0.568***
	(0.051)		(0.034)		0.568***

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).
log distance and log of entry cost as IVs.

The empirical evidence suggests that to understand the connections between international trade and business cycle synchronization we should look at the extensive margin of trade. At the same time, we need a model in which iceberg transport costs and fixed costs generate the necessary variation for the IM and EM of trade flows.

5 The model

5.1 Final Production

In each country $i = 1, \ldots, I$, a perfectly competitive firm, henceforth final producer, uses traded intermediate goods, both domestic and foreign, to produce a non-traded final good. We introduce the standard Armington assumption of goods being differentiated by source of exports, that is, countries exogenously specialize in different sets of goods. As it is standard in the literature, we define a variety nj as an intermediate good j produced in country n. Intermediate products are combined according to the CES production function

$$
Y_{it} = \left(\sum_{n=1}^{M} \int_{j=0}^{A_{nt}^{i}} (b_{njt}^{i})(x_{njt}^{i})^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}
$$

where Y_{it} is the quantity of final good produced in country i, A_{nt}^{i} is the number of intermediate goods that country i imports from country n, b_{njt}^{i} are the so-called Armington weights and represent the share of country i's spending on intermediate good j from country n, x_{njt}^{i} is the quantity of variety nj imported by country i, $\sigma > 1$ is the elasticity of substitution across varieties (which are perfect substitutes when $\sigma \to \infty$).

The final producer chooses x_{njt}^{i} to maximize his profit

$$
\Pi_{it} = P_{it} Y_{it} - \sum_{n=1}^{M} \int_{j=0}^{A_{nt}^{i}} p_{njt}^{i} x_{njt}^{i} dj
$$

where p_{njt}^{i} is the price of variety nj that is sold in country i, and P_{it} is the price index for the final good, which takes the CES form

$$
P_{it} = \left(\sum_{n=i}^{I} \int_{j=1}^{A_{nt}^{i}} (b_{njt}^{i})^{\sigma} \left(p_{njt}^{i}\right)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}
$$

and b_{njt}^{i} is the expenditure share in variety nj. This implies the following demand for variety nj

$$
x_{njt}^{i} = (b_{njt}^{i})^{\sigma} \left(\frac{p_{njt}^{i}}{P_{it}} \right)^{-\sigma} Y_{it}
$$

Total spending by country i on variety nj is

5.2 Intermediate Production

In each country $n = 1, \ldots, I$ a continuum of monopolistically competitive firms produce a good j using labor and capital according to a Cobb-Douglas production function

$$
y_{njt} = (k_{njt})^{\alpha} (l_{njt})^{1-\alpha}
$$

where y_{njt} is the quantity of good j that country n produces, k_{njt} is the amount of capital that is rented to the households, and l_{njt} is the amount of labor employed to produce that quantity, with the share of capital on output $\alpha \in (0,1)$. Note that all intermediate producers in a country have the same productivity, irrespective of the good they produce. The firm j chooses amount of l_{njt} and k_{njt} to minimize

$$w_{nt} l_{njt} + R_{nt} k_{njt}$$

s.t

$$y_{njt} = (k_{njt})^{\alpha} (l_{njt})^{1-\alpha}$$

To solve the problem, assume

$$\mathscr{L} = w_{nt} l_{njt} + R_{nt} k_{njt} - \lambda [y_{njt} - (k_{njt})^{\alpha} (l_{njt})^{1-\alpha}]$$

F.O.C.

$$\frac{\partial \mathscr{L}}{\partial l_{njt}} : w_{nt} - \lambda (1-\alpha) \frac{y_{njt}}{l_{njt}} = 0$$

$$\frac{\partial \mathscr{L}}{\partial k_{njt}} : R_{nt} - \lambda \alpha \frac{y_{njt}}{k_{njt}} = 0$$

Where

$$\lambda = mc_{njt}$$

Therefore

$$w_{nt} = mc_{njt} (1-\alpha) \frac{y_{njt}}{l_{njt}}$$

$$R_{nt} = mc_{njt} \alpha \frac{y_{njt}}{k_{njt}}$$

and

$$mc_{njt} = (\frac{w_{nt}}{1-\alpha})^{1-\alpha} (\frac{R_{nt}}{\alpha})^{\alpha}$$

Intermediate producers take the demand by final producers, determined in the last section, and set a price that is a constant mark-up over that cost. Prices can differ across countries. Markets are segmented due to iceberg transport costs: for products shipped from country n to $i \neq n$, the transport cost is $d_n^i > 1$, with $d_i^i = 1$. We use mgc_{njt} to denote the marginal cost,

$$mc_{njt}^{i} = d_{n}^{i} mc_{njt}$$

Firm j in country n will maximize

$$\pi_{njt}^{i} = (P_{njt}^{i} - mc_{njt}^{i}) x_{njt}^{i}$$

s.t.

$$x_{njt}^{i} = \left(\frac{p_{njt}^{i}}{P_{it}} \right)^{-\sigma} Y_{it}$$

F.O.C

$$x_{njt}^{i} + (P_{njt}^{i} - mc_{njt}^{i}) \frac{\partial x_{njt}^{i}}{\partial P_{njt}^{i}} = 0$$

Where

$$\frac{\partial x_{njt}^{i}}{\partial P_{njt}^{i}} = -\sigma (P_{njt}^{i})^{-\sigma-1} P_{it}^{\sigma} Y_{it}$$

Therefore

$$P_{njt}^{i} = \frac{\sigma}{\sigma - 1} mc_{njt} d_{n}^{i}$$

5.3 Embodied Technological Progress: Innovation and Adoption

Innovation:

Let Z_{nt} denote the stock of domestic developed technology in country n, also the total number of intermediate producers in country n at time t, and $Z_{wt} = \sum_{n=1}^{M} Z_{nt}$ the total number of technology available in the whole world. New technologies arrive exogenously to the economy according to the following process:

$$Z_{nt+1} = Z_{nt}(1 + \bar{a}) exp(\varepsilon_{nt}^{z})$$

and

$$\varepsilon_{nt}^{z} = \rho_{n} \varepsilon_{nt-1} + u_{nt}$$

Notice that $\frac{Z_{nt+1}}{Z_{nt}}$-1 grows at $\bar{a}$ in steady state.

where T_{nt} is the total number of technologies available for production in country i (innovators learn from what they have produced and from what they have imported), and u_{nt} is a white noise.

In steady state, we will have

$$g_z^* = \frac{T_{nt}}{Z_{wt}}\bar{a}$$

Adoption:

New technologies become productive only when they are adopted.

$$\Delta A_{nt}^i = \varepsilon_{nt}^i (Z_{nt} - A_{nt}^i)$$

We assume that the adoption process is instantaneous within a country but it takes time across countries. That is, once a new technology arrives to the economy, it is immediately ready to be used by the final producers in that country. However the diffusion of technologies to a foreign country follows a random process ε_{nt}^i, which is the rate at which a good that has been invented by country n is adopted by country i,

$$\varepsilon_{nt}^i = \bar{\varepsilon}_{in} \frac{A_{nt}^i}{Z_{nt}} exp(e_{nt}^i)$$

where $\bar{\varepsilon}_{in}$ is a country-pair specific parameter that reflects entry regulation costs or barriers to adoption. A higher value for this parameters implies lower regulation costs. In steady state, the rate of doption is determined uniquely by the entry regulation costs.

In steady state,

$$g_a^* = \frac{A_{nt+1}^i - A_{nt}^i}{A_{nt}^i} = (\frac{A_{nt}^i}{Z_{nt}})(\frac{Z_{nt}}{A_{nt}^i} - 1) = 1 - \frac{A_{nt}^i}{Z_{nt}}$$

Therefore

$$g_a^* = g_z^*$$

5.4 Households

In each country $i = 1, \ldots, M$, a representative household consumes a non-traded final good, supplies labor, capital and saves. The household maximizes the life-time expected utility function

$$U_t(C_{it}, C_{it+1}, \dots) = E_t \sum_{s=t}^{\infty} \beta^s (\log(C_{is}) - \frac{L_{is}^{\psi+1}}{\psi+1})$$

subject to the budget constraint

$$P_{it}C_{it} + P_{it}^k I_{it} = \omega_{it} L_{it} + \Pi_{it}^T + R_{it} K_{it}$$

where C_{it} is consumption, $\beta \in (0,1)$ is the discount factor, P_{it} is the price index, ω_{it} is the wage, L_{it} is labor supply, Π_{it}^T are the firms' profits, R_{it} is the rental price of capital, $P_{it}^k$is the price of capital, K_{it} is the supply of capital, which is accumulated through the standard law of motion

$$K_{it} = (1-\delta)K_{i,t-1} + I_{it}$$

Let

$$\mathscr{L} = \sum_{s=t}^{\infty} \beta^s (\log(C_{is}) - \frac{L_{is}^{\psi+1}}{\psi+1}) - \lambda_t [\omega_{it} L_{it} + \Pi_{it}^T + R_{it} K_{it} - P_{it} C_{it} - Q_{it}(K_{it} - (1-\delta)K_{i,t-1})]$$

F.O.C.

$$\frac{C_{i,t+1}}{C_{it}} = \frac{\lambda_t}{\lambda_{t+1}} \frac{P_{it}}{P_{i,t+1}}$$

$$L_{it}^{\psi} = \lambda_t w_{it}$$

$$Q_{it} = \frac{\lambda_{t+1}}{\lambda_t} [R_{it+1} + (1-\delta) Q_{it+1}]$$

5.5 Market Clearing Conditions

5.5.1 Resource Constraint

Final output is used for consumption, innovation and adoption.

$$Y_{it} = C_{it} + I_{it}$$

5.5.2 Trade Balance

There is financial autarky in the model. Therefore, trade is balanced every period, and the total value of exports in one country has to equal the total value of imports.

$$\sum_{i=1}^{M} \int_{j=0}^{A_{nt}^{i}} p_{njt}^{i} x_{njt}^{i} dj = \sum_{n=1}^{M} \int_{j=0}^{A_{it}^{n}} p_{ijt}^{n} x_{ijt}^{n} dj.$$

5.5.3 Intermediate goods market clearing

$$y_{njt} = \sum_{i=1}^{M} \int_{j=0}^{A_{nt}^{i}} x_{njt}^{i} dj$$

5.5.4 Labor market clearing

$$L_{nt} = \int_{j=0}^{Z_{nt}} l_{njt} dj$$

6 The Equations in equilibrium

6.1 Equilirium

$$Z_{nt} x_{nt} = \sum_{i=1}^{M} A_{nt}^{i} x_{nt}^{i} \tag{8}$$

$$x_{nt}^{i} = \left(\frac{P_{nt}^{i}}{P_{it}}\right)^{1-\sigma} X_{it} \tag{9}$$

$$W_{nt} * l_{nt} = (1-\alpha) x_{nt} * \frac{\sigma - 1}{\sigma} \tag{10}$$

$$R_{nt} * k_{nt} = \alpha * x_{nt} * \frac{\sigma - 1}{\sigma} \tag{11}$$

$$mc_{nt} = (\frac{w_{nt}}{1-\alpha})^{1-\alpha}(\frac{R_{nt}}{\alpha})^{\alpha} \tag{12}$$

$$P_{nt}^{i} = \frac{\sigma}{\sigma-1} mc_{nt} d_{n}^{i} \tag{13}$$

$$X_{nt} = C_{nt} + I_{nt} \tag{14}$$

$$\frac{1}{P_{nt}} I_{nt} = K_{n,t+1} - (1-\delta) K_{nt} \tag{15}$$

$$\sum_{i \neq n}^{M} A_{nt}^{i} x_{nt}^{i} = \sum_{i \neq n}^{M} A_{it}^{n} x_{it}^{n} \tag{16}$$

$$\triangle Z_{nt} = Z_{nt} * \varepsilon_{nt}^{z} \tag{17}$$

$$\triangle A_{nt}^{i} = \varepsilon_{nt}^{i} (Z_{nt} - A_{nt}^{i}) \tag{18}$$

$$\varepsilon_{nt}^{i} = \bar{\varepsilon}_{n}^{i} \frac{A_{nt}^{i}}{Z_{nt}} exp\{e_{nt}^{i}\} \tag{19}$$

$$P_{nt} = (\sum_{i=1}^{M} A_{it}^{n} (p_{it}^{n})^{1-\sigma})^{\frac{1}{1-\sigma}} \tag{20}$$

$$L_{nt}^{\psi} = \frac{w_{nt}}{C_{nt}} \tag{21}$$

$$\frac{C_{n,t+1}}{C_{nt}} = \beta \frac{R_{n,t+1} + (1-\delta) P_{n,t+1}}{P_{nt}} \tag{22}$$

$$L_{nt} = Z_{nt} * l_{nt} \tag{23}$$

$$K_{nt} = Z_{nt} k_{nt} \tag{24}$$

6.2 Shock Process

$$\varepsilon_{nt}^{z} = \rho_n^z \varepsilon_{nt-1}^{z} + u_{nt}^{z} + \bar{a} \tag{25}$$

$$e_{nt}^{i} = \rho_{in} e_{n,t-1}^{i} + u_{int} \tag{26}$$

Both u_{nt}^{z} and u_{int} are normally distributed.

7 Experiments

In this section, we perform a simple numerical exercise to understand how the mechanisms of our model work. This is not a proper calibration exercise, which we will explore in a more complete version of the paper. Instead, we now consider a version with exogenous growth, in which the number of innovations and adopted varieties remains constant in steady state. As a result, in steady state every country adopts all the varieties innovated in the world, and there is convergence both in the levels and in the growth rates across countries. We follow previous studies and set values for the standard parameters (σ, ϕ,δ, α), and then we vary the parameters corresponding to iceberg transport costs, $\tau = d - 1$, and the rate of adoption ε between two countries (higher ε implies lower fixed entry cost). Changes in these parameters induce variations on both margins of trade: the iceberg transport cost affects mainly the intensive margin, while the rate of adoption (the inverse of entry cost)affects mainly the extensive margin of trade.

We compute changes in the correlation of GDP growth per pair of countries, changes in the bilateral trade intensity and the corresponding changes in the bilateral extensive and intensive margins of trade that are induced by changes in either the iceberg transport costs (τ) or the fixed entry costs (inverse of the adoption rateε). In Table 6, we see that reductions in trade costs, either iceberg transport costs or fixed entry costs, both increase the pair-wise correlation of output growth and the bilateral trade intensity. Changes in

τ (rows) affect mainly the intensive margin of trade, whereas changes in ε (columns) affect mainly the extensive margin of trade.

Table 6. Decrease in transport costs

	$\varepsilon = 0.2$				$\varepsilon = 0.6$				$\varepsilon = 0.8$			
	Corr_y	TI	EM	IM	Corr_y	TI	EM	IM	Corr_y	TI	EM	IM
$\tau = 0.2$	0.20	1.43	0.11	1.32	0.23	1.50	0.17	1.33	0.25	1.53	0.20	1.33
$\tau = 0$	0.22	1.54	0.12	1.42	0.25	1.61	0.18	1.43	0.27	1.64	0.21	1.43

Table 7 shows the effect of a decrease in the iceberg transport costs from $\tau = 0.2$ to $\tau = 0$, and for different rates of technology adoption, measured by ε . For a given rate of adoption ε, both the correlation of output growth and the trade intensity increase, but mainly through the intensive margin of trade. The extensive margin of trade also increases, and the effect is stronger for higher rates of adoption. This suggests that pairs of countries with faster adoption rates (higher ε) will experience higher increases in the output growth comovement after a decrease in transport costs.

Table 7. Decrease in iceberg transport costs

($\tau = 0.2$ to $\tau = 0$)

	ΔCorr_y	ΔTI	ΔEM	ΔIM
$\varepsilon = 0.2$	0.023	0.11	0.008	0.10
$\varepsilon = 0.6$	0.021	0.12	0.011	0.10
$\varepsilon = 0.8$	0.020	0.12	0.013	0.10

In Table 8, we analyze the effect of a decrease in entry regulation costs (i.e. an increase in the rate of adoption) from $\varepsilon = 0.2$ to $\varepsilon = 0.6$, for different values of the iceberg cost. Both the pair-wise correlation increases and trade intensity increase, mainly driven by the extensive margin of trade. The impact seems to be independent of the level of iceberg costs. Changes in trade induced by changes in the entry regulation costs have an important effect on synchronizing business cycles through the extensive margin. Models that ignore this margin miss an important channel through which cycles are synchronized across countries.

Table 8. Increase in adoption rate

$\varepsilon = 0.2$ to $\varepsilon = 0.6$

	ΔCorr_y	ΔTI	ΔEM	ΔIM
$\tau = 0.2$	0.027	0.065	0.06	0.006
$\tau = 0$	0.025	0.070	0.06	0.006

8 Conclusion

TO BE WRITTEN

Appendix A

Solving the model

We re-write the model in real terms so that in each country i the nominal variables are normalized by P_{Nt} The equations to solve the model are:

1. Demand by final producers (Y_{it}): $y^i_{nt} = (b^i_{nt})^{\sigma} \left(\frac{p^i_{njt}}{P_{it}}\right)^{-\sigma} Y_{it}$ (where p^i_{nt} is really $\frac{p^i_{nt}}{P_{3t}}$ and $\frac{P_{it}}{P_{3t}}$

2. Price of intermediate producers (p^i_{nt}): $p^i_{nt} = \frac{\sigma}{\sigma-1}(mc^i_{nt} d^i_n)$

3. Marginal cost for intermediate producers (mc^i_{nt}): $mc^i_{njt} = (\frac{R^k_{nt}}{\alpha})^{\alpha}(\frac{w_{nt}}{1-\alpha})^{1-\alpha}$

4. Demand for capital by intermediate producers (R^k_{nt}): $p^i_{nt} y^i_{nt} = \alpha R^k_{nt} k^i_{nt}$

5. Total demand for capital (k^i_{nt}): $K_{nt} = \sum_i A^i_{nt} k^i_{nt}$

6. Demand for labor by intermediate producers (w_{nt}): $p^i_{nt} y^i_{nt} = (1-\alpha) w_{nt} l^i_{nt}$

7. Total demand for labor (l^i_{nt}): $L_{nt} = \sum_i A^i_{nt} l^i_{nt}$

8. Investment (K_{nt}): $I_{it} = K_{it} - (1-\delta) K_{\text{i,t-1}}$

9. Output (I_{nt}): $Y_{it} = C_{it} + I_{it}$

10. Consumption (C_{nt}): $\frac{1}{\beta}\frac{C_{i,t+1}}{C_{it}} = \frac{P_{it}}{P_{i,t+1}} R_{i,t+1}$
11. Labor supply (L_{nt}): $P_{it}C_{it} = w_{it}L_{it}^{\phi}$
12. Law of motion for price of capital (P_{it}^k): $P_{it}^k = \frac{R_{i,t+1}^k + P_{i,t+1}^k}{R_{it}}$
13. Non-arbitrage condition (R_{it}): $R_{it} = R_{it}^k$
14. Trade balance (we get the prices from here) (P_{it}): $\sum_{i=1}^I A_{nt}^i p_{nt}^i x_{nt}^i = \sum_{n=1}^I A_{it}^n p_{it}^n x_{it}^n$; Prices: $P_{it} = \left(\sum_{n=i}^I A_{int}\left(p_{nt}^i\right)\right)^{\frac{1}{1-\sigma}}$ Prices are determined by the trade balance equation
15. Innovation (Z_{it}): $Z_{it} = \alpha_i^R T_{i,t-1} exp(g_z \varepsilon_{it})$
16. Adoption (A_{int}): $\Delta A_{int} = \varepsilon_{int}(Z_{nt} - A_{int})$ with $\varepsilon_{int} = \bar{\varepsilon}_{in} exp(u_{int})$

We need to write the model in a stationary way. In steady state, ε_{nt}^i is constant, and Z_{nt} and A_{nt}^i grow at the same rate g_z. Consumption and investment grow at the same rate of final output, which grows at $\frac{\sigma}{\sigma-1}g_z$. Other rations in steady state are:

- $\frac{A_{int}}{Z_{nt}} = \frac{\varepsilon_{in}}{g_a + \varepsilon_{in}}$
- $\frac{Z_i(1+g_z)}{T_i} = \alpha_i^R$
- $\frac{I_i}{K_i} = g_k + \delta$
- $R_i = \frac{1+g_c}{\beta}$
- $g_k = g_y$
- Algorithm to compute relative prices: From price equation, demand for intermediate producers and trade balance equation.

Stationarized variable to use:

- $\frac{P_{int}x_{int}}{P_{it}Y_{it}}$
- $\frac{A_{int}}{Z_{3t}}$

We are going to start with an exogenous growth model, that is, we assume that the number of varieties remains constant in steady state, which implies that in steady state all countries end up adopting all the varieties. This is easy to do the log-linearization of the model because the only trend that we need to take care of is the disembodied technology trend.

Log-linearized model and Steady State:

1. $x_{int} = (1-\sigma)(p_{int} - p_{it})$
2. $p_{int} = mc_{int} + d_{int}$
3. $x_{int} = r^k_{nt} + k_{int}$
4. $K_{nt} = \sum_i (k_{int} + a_{int}) \frac{A_{in}k_{in}}{K_n}$
5. $x_{int} = w_{nt} + a_{int}$
6. $L_{nt} = \sum_i (l_{int} + a_{int}) \frac{A_{in}l_{in}}{L_n}$
7. $(g_k + \delta)I_{nt} = (1+g_k)K_{n,t+1} + (1-\delta)K_{nt}$
8. $c_{i,t+1} - c_{it} + g_t = r_{it} - w_{3t} + w_{3,t+1}$
9. $c_{it} = w_{it} + \phi L_{it}$
10. $r_{it} = r^k_{it}$
11. $r_{it} + \frac{P_k}{R} p^k_{it} = r^k_{i,t+1} + \frac{P_k}{R} p^k_{i,t+1}$ with $\frac{P_k}{R_k} = \frac{1}{R-1}$ and $R = \frac{1+g_c}{\beta}$
12. $z_{i,t+1} = t_{it} + \varepsilon_{it}$
13. $t_{it} = z_{it} + (I-1)\sum_n a_{int}$
14. $a_{in,t+1} = a_{int} + \varepsilon_{in}(z_{nt} - a_{int})$
15. $\sum_i \frac{A_{in}x_{in}}{P_iY_i}(a_{int} + x_{int}) = \sum_n \frac{A_{ni}x_{ni}}{P_nY_n}(a_{nit} + x_{nit}) \frac{P_nY_n}{P_iY_i}$
16. Algorithm based on: expression for P_i and expression for x_{in} and trade balance equation.

Appendix B: Tables

Table 9. Instrumental variables (2SLS) regression with EM and IM

Using Count Data

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp},y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp},y_j^{bp})	Coef.
$\log(EM_{ij})$	0.348***	$\log(EM_{ij})$	0.229***	$\log(EM_{ij})$	0.701***
	(0.063)		(0.041)		(0.108)
$\log(IM_{ij})$	-0.067	$\log(IM_{ij})$	-0.063	$\log(IM_{ij})$	-0.201*
	(0.056)		(0.036)		(0.095)
Constant	1.528***	Constant	0.954***	Constant	2.502***
	(0.166)		(0.108)		(0.284)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs.

Table 10. TFP correlation on EM and IM

Using Count Data

Panel 1: HP-filtered TFP		Panel 2: TFP growth		Panel 3: BP-filtered TFP	
corr(tfp_i^{hp},tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp},tfp_j^{bp})	Coef.
$\log(EM_{ij})$	0.362***	$\log(EM_{ij})$	0.241***	$\log(EM_{ij})$	0.744***
	(0.061)		(0.041)		(0.100)
$\log(IM_{ij})$	-0.197***	$\log(IM_{ij})$	-0.133***	$\log(IM_{ij})$	-0.415***
	(0.054)		(0.036)		(0.088)
Constant	1.303***	Constant	0.867***	Constant	2.759***
	(0.162)		(0.107)		(0.262)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs.

Table 11. Instrumental variables (2SLS) regression with EM and IM

Using Klenow and Hummels' decomposition method

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp}, y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp}, y_j^{bp})	Coef.
$\log(EM_{ij})$ +$\log(EM_{ji})$	0.155***		0.098***		0.296***
	(0.029)		(0.018)		(0.049)
$\log(IM_{ij})$ +$\log(IM_{ji})$	0.016		0.006		0.014
	(0.014)		(0.009)		(0.024)
Constant	0.644***	Constant	0.354***	Constant	0.662***
	(0.080)		(0.051)		(0.136)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs.

Table 12. Instrumental variables (2SLS) regression with EM and IM

Using Klenow and Hummels' decomposition method

Panel 1: HP-filtered TFP		Panel 2: TFP growth		Panel 3: BP-filtered TFP	
corr(tfp_i^{hp}, tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp}, tfp_j^{bp})	Coef.
$\log(EM_{ij})$ +$\log(EM_{ji})$	0.138***		0.091***		0.279***
	(0.025)		(0.017)		(0.042)
$\log(IM_{ij})$ +$\log(IM_{ji})$	-0.021		-0.013		-0.042*
	(0.012)		(0.008)		(0.021)
Constant	0.215**		0.154**		0.568***
	(0.071)		(0.047)		(0.118)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs.

Table 13. Instrumental variables (2SLS) regression with EM and IM

Using count data

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp},y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp},y_j^{bp})	Coef.
$\log(EM_{ij})$ +$\log(EM_{ji})$	0.355***		0.237**		0.736***
	(0.106)		(0.073)		(0.194)
$\log(IM_{ij})$ +$\log(IM_{ji})$	-0.216*		-0.157*		-0.495*
	(0.108)		(0.074)		(0.197)
Constant	2.097***	Constant	1.340***	Constant	3.731***
	(0.440)		(0.301)		(0.805)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs.

Table 14. Instrumental variables (2SLS) regression with EM and IM

Using count data

Panel 1: HP-filtered TFP		Panel 2: TFP growth		Panel 3: BP-filtered TFP	
corr(tfp_i^{hp},tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp},tfp_j^{bp})	Coef.
$\log(EM_{ij})$ +$\log(EM_{ji})$	0.365**		0.249**		0.793**
	(0.118)		(0.080)		(0.221)
$\log(IM_{ij})$ +$\log(IM_{ji})$	-0.298*		-0.205*		-0.660*
	(0.120)		(0.081)		(0.224)
Constant	1.870***		1.269***		4.095**
	(0.488)		(0.331)		(0.914)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs.

Table 15. Output correlation and the trade intensity normalized by GDP: IV (2SLS) regression

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp},y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp},y_j^{bp})	Coef.
$\log(w_{ij})$	0.123***	$\log(w_{ij})$	0.071***	$\log(w_{ij})$	0.213***
	(0.006)		(0.004)		(0.010)
Constant	0.977***	Constant	0.565***	Constant	1.304***
	(0.030)		(0.019)		(0.055)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

Use log distance as IV. Trade intensities are measured by $w_{ijt}^2 = (X_{ij,t} + M_{ij,t})/(GDP_{it} + GDP_{jt})$.

Table 16. Output correlation and the trade intensity normalized by GDP: IV (2SLS) regression

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(tfp_i^{hp}, tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp}, tfp_j^{bp})	Coef.
$\log(w_{ij})$	0.057***	$\log(w_{ij})$	0.038***	$\log(w_{ij})$	0.117***
	(0.005)		(0.003)		(0.008)
Constant	0.510***	Constant	0.349***	Constant	1.164***
	(0.027)		(0.018)		(0.044)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

Use log distance as IV. Trade intensities are measured by $w_{ijt}^2 = (X_{ij,t} + M_{ij,t})/(GDP_{it} + GDP_{jt})$.

Table 17. Output correlation and the trade intensity:IV (2SLS) regression

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp}, y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp}, y_j^{bp})	Coef.
$\log(w_{ij})$	0.186***		0.121***		0.220***
	(0.011)		(0.007)		(0.020)
Constant	1.331***		0.845***		1.363***
	(0.060)		(0.037)		(0.111)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

Use log distance as IV, trade intensity is normalized by total bilateral trade, and averaged over 1985-2009. Bilateral correlations are calculated using sample from 1985 to 2009.

Table 18. TFP correlation and the trade intensity:IV (2SLS) regression

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(tfp_i^{hp},tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp},tfp_j^{bp})	Coef.
$\log(w_{ij})$	0.091***		0.064***		0.108***
	(0.011)		(0.008)		(0.014)
Constant	1.306***		1.196***		1.431***
	(0.063)		(0.045)		(0.079)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

Use log distance as IV, trade intensity is normalized by total bilateral trade, and averaged over 1985-2009. Bilateral correlations are calculated using sample from 1985 to 2009.

Table 19. Instrumental variables (2SLS) regression with EM and IM

Using Klenow and Hummels' decomposition method

Panel 1: HP-filtered output		Panel 2: Output growth		Panel 3: BP-filtered output	
corr(y_i^{hp},y_j^{hp})	Coef.	corr($\Delta y_i, \Delta y_j$)	Coef.	corr(y_i^{bp},y_j^{bp})	Coef.
$\log(EM_{ij})$	0.232***		0.167***		0.205**
	(0.035)		(0.023)		(0.063)
$\log(IM_{ij})$	0.009		-0.001		0.040
	(0.017)		(0.011)		(0.031)
Constant	0.662***	Constant	0.375***	Constant	0.721***
	(0.099)		(0.065)		(0.176)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs. Trade intensity is normalized by total bilateral trade, and averag

over 1985-2009. Bilateral correlations are calculated using sample from 1985 to 2009.

Table 20. Instrumental variables (2SLS) regression with EM and IM

Using Klenow and Hummels' decomposition method

Panel 1: HP-filtered TFP		Panel 2: TFP growth		Panel 3: BP-filtered TFP	
corr(tfp_i^{hp}, tfp_j^{hp})	Coef.	corr($\Delta tfp_i, \Delta tfp_j$)	Coef.	corr(tfp_i^{bp}, tfp_j^{bp})	Coef.
$\log(EM_{ij})$	0.266***		0.211***		0.244**
	(0.035)		(0.026)		(0.041)
$\log(IM_{ij})$	-0.062***		-0.053***		-0.042*
	(0.017)		(0.013)		(0.020)
Constant	0.651***		0.686***		0.808**
	(0.098)		(0.074)		(0.114)

Note: Standard errors in parentheses. Significance at the 1% (5%) level is indicated by ***(**).

log distance and log of entry cost as IVs. Trade intensity is normalized by total bilateral trade, and averag

over 1985-2009. Bilateral correlations are calculated using sample from 1985 to 2009.

Table 21. Country List

Developed Countries	Developing Countries
Australia	China
Austria	Hong Kong, SAR
Canada	India
Denmark	Argentina
Germany	Brazil
Finland	Korea
France	Philippines
Greece	Singapore
Ireland	Indonesia
Italy	Malaysia
Japan	
Netherlands	
New Zealand	
Norway	
Portugal	
Spain	
Sweden	
Switzerland	
United Kingdom	
United States	

Source: UN classification

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