Board of Governors of the Federal Reserve System

International Finance Discussion Papers

Number 1306

December 2020

Common Trade Exposure and Business Cycle Comovement

Oscar Avila-Montealegre and Carter Mix

Please cite this paper as:
Avila-Montealegre, Oscar and Carter Mix (2020). "Common Trade Exposure and Business Cycle Comovement," International Finance Discussion Papers 1306. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/IFDP.2020.1306.

Common Trade Exposure and Business Cycle Comovement

Oscar Avila-Montealegre Carter Mix*

Abstract: A large empirical literature has shown that countries that trade more with each other have more correlated business cycles. We show that previous estimates of this relationship are biased upward because they ignore common trade exposure to other countries. When we account for common trade exposure to foreign business cycles, we find that (1) the effect of bilateral trade on business cycle comovement falls by roughly 25 percent and (2) common exposure is a significant driver of business cycle comovement. A standard international real business cycle model is qualitatively consistent with these facts but fails to reproduce their magnitudes. Past studies have used models that allow for productivity shock transmission through trade to strengthen the relationship between trade and comovement. We find that productivity shock transmission increases business cycle comovement largely because of a country-pair's common trade exposure to other countries rather than because of bilateral trade. When we allow for stronger transmission between small open economies than other country-pairs, comovement increases both from bilateral trade and common exposure, similar to the data.

Keywords: trade, business cycles, open economy macroeconomics
JEL Classification: F1, E32, F41, F44

*We are thankful for comments from George Alessandria, Yan Bai, Dan Lu, and from audiences at Midwest Macroeconomics Conference (2019), the Central Bank of Colombia, and the University of Rochester. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors or of any other person associated with the Federal Reserve System or the Central Bank of Colombia

1 Introduction

A large literature starting with Frankel and Rose (1998) argues that countries that trade more with each other have more correlated business cycles – a phenomenon known as trade comovement. But most studies ignore the countries' common trade exposure to other trade partners, which acts as an indirect source of business cycle comovement: If two countries are highly exposed to a common partner, they face similar foreign shocks and comove more. We explore the effects of bilateral trade and common trade exposure to foreign business cycles (common exposure) on a country-pair's business cycle comovement.

Our paper makes both empirical and theoretical contributions. Empirically, we document two facts: (1) Omitting common exposure from the analysis biases the estimated trade-comovement relation upward, and (2) bilateral trade and common trade exposure are both important sources of business cycle comovement. The total effect of trade on business cycle comovement, which includes effects from both bilateral trade and common trade exposure, is much larger than reported in studies that exclude the common exposure channel. Theoretically, we show that attempts to reconcile trade-comovement and standard international models by allowing productivity shocks to be passed on to other countries through trade actually work through the indirect channel of common exposure to third parties rather than through bilateral trade.

As an illustrative example of the key empirical issue, consider Mexico and Canada. Between 1990 and 2016 bilateral trade between Mexico and Canada accounted for less than 3 percent of their total trade, but their trade with the United States over the same period accounted for almost 70 percent of their total trade. Consistent with the trade-comovement relation in the empirical literature, measures of gross domestic product (GDP) comovement between Canada and the United States and Mexico and the United States are high – 0.8 and 0.57, respectively – by our measure. As a result, GDP comovement between Canada and Mexico is also high, about 0.4, even though they trade little with each other. Ignoring Canada and Mexico's common exposure to the United States would lead us to overestimate the effect of their bilateral trade on comovement.

A simple ordinary least squares (OLS) regression confirms that country-pairs with higher bilateral trade and common exposure to foreign cycles exhibit greater business cycle comovement. To get the causal effect of bilateral trade on output comovement, we follow Frankel and Rose (1998) and instrument trade using gravity determinants such as distance, common language, and so on. To get the causal effect of common exposure on output comovement, we restrict our sample to use only country-pairs of small open economies (SOEs), for which the cycle of their trading partners is exogenous. For this sample, increasing bilateral trade by one standard deviation raises output comovement by 2.9 percentage points (p.p.) while increasing common exposure by one standard deviation raises output comovement by 4.0 p.p. We call the additional comovement coming from common exposure *trade-partner comovement* as it often results from exposure to similar countries. Omitting common exposure from the regression raises the estimated effect of bilateral trade on business cycle comovement by roughly a third.

Kose and Yi (2001) show that a standard three-country international real business cycle (IRBC) model exhibits much smaller – but still positive – trade comovement than we see in the data. We expand upon their work by using a *four*-country IRBC model, which can be calibrated to match both bilateral trade intensity and trade-partner similarity between any two countries, and show that the model is once again qualitatively consistent with the empirical facts but cannot reproduce their magnitudes. The failure of the model to reproduce the magnitude of trade-partner-comovement is a new puzzle in the literature. This failure arises because SOEs are subject to large idiosyncratic total factor productivity (TFP) shocks in the baseline calibration. With smaller idiosyncratic shocks, each country's business cycle is more strongly affected by its trading partners and countries equally exposed to third parties have higher comovement.

Kose and Yi (2006) show that if TFP shocks are more correlated as trade increases, the model can produce trade comovement that is closer to the data. Following this result, other researchers have tried to endogenize TFP transmission through trade and have had success increasing trade comovement.[1] We include exogenous TFP transmission through trade in our model and show that the resulting increase in output comovement actually works through the country-pair's common exposure to other countries rather than through bilateral trade; estimated trade-partner comovement gets much closer to its value in the data than does trade comovement. Correlated TFP shocks solve the trade-partner-comovement puzzle but not the trade-comovement puzzle.

TFP transmission fails to increase trade comovement because bilateral trade between

[1] See the next section for more details.

most countries is small compared with their total trade, so TFP transmission from the rest of the world (ROW) far outweighs TFP transmission from any one trading partner. If two countries trade with similar third parties, then TFP transmission increases their comovement mostly from this channel. Because countries that trade more with each other also trade with similar partners, the effect is misinterpreted as an increase in trade comovement when common exposure is excluded from the analysis.

Our results suggest that a theory that explains trade comovement will need new mechanisms beyond TFP transmission through trade. For our limited analysis of SOEs, scaling up TFP transmission between SOEs compared with transmission between other country-pairs can solve both puzzles as even small differences in bilateral trade intensities between SOE country-pairs yield stronger TFP transmission. This solution keeps the model close to the standard IRBC model with TFP shocks, but other shocks or mechanisms may also increase business cycle transmission from bilateral trade.

In section 2, we present a brief literature review. Section 3 reports the empirical results for the trade- and trade-partner-comovement relations. In section 4, we describe the multi-country model. We report the calibration technique and the quantitative results in section 5. Section 6 concludes.

2 Related Literature

Using data for 20 industrialized economies, Frankel and Rose (1998) find that increasing trade intensity by one standard deviation raises output comovement by 13 p.p. For a broader set of countries and a longer period, Calderon et al. (2007) find a positive but smaller effect of bilateral trade on output comovement: Increasing bilateral trade by one standard deviation raises output comovement by between 2 and 8 p.p. Other studies that support the positive relation between trade and business cycle comovement are Canova and Dellas (1993), Imbs (2000), Clark and Van Wincoop (2001), Otto et al. (2001), Imbs (2004), Baxter and Kouparitsas (2005), Doyle and Faust (2005) and Blonigen et al. (2014). The results in our paper confirm that bilateral trade intensity is a key driver of business cycle comovement, but out paper also explores the indirect channel of common trade exposure to foreign business cycles. In that sense, our paper is closely related to de Soyres and Gaillard (2020), who show that similarity in trade networks increases business cycle comovement. Their paper complements our empirical results. Our paper explores how a standard IRBC model can be reconciled to these facts.

From a theoretical perspective, Kose and Yi (2001) assess whether the standard IRBC framework can replicate the trade-comovement relation. The authors extend the Backus et al. (1992) and Backus et al. (1994) model to include three countries and endogenous transportation costs. They simulate a drop in trade costs that raises goods market integration and analyze its effects on output synchronization. They find, as we do, that the model is qualitatively consistent with the trade-comovement relation but fails to reproduce its magnitude. This failure, known as the trade-comovement puzzle, has motivated a growing theoretical literature. Kose and Yi (2006) show that with correlated productivity shocks the model is able to alleviate the puzzle, and many researchers have since tried to endogenize this channel by modeling multiple sectors and stages (see Ambler et al. (2002), Burstein et al. (2008), Arkolakis and Ramanarayanan (2009), and Johnson (2014)). Johnson (2014) shows that with correlated productivity shocks, the model generates a strong trade-comovement relation in the goods sector but zero correlations for services and, thus, low aggregate correlations. From a micro perspective, di Giovanni et al. (2018) document that trade and multinational linkages are important sources of output correlations between a firm and a particular country. Cravino and Levchenko (2016), who show that multinational firms contribute to the transmission of shocks across countries, reinforce this evidence. The presence of multinationals and vertical integration provide empirical evidence that may justify the inclusion of more correlated shocks in standard IRBC models. Our paper shows that while all these mechanisms may help to increase comovement, they are more likely to do so through a country-pair's common exposure to other countries rather than through bilateral trade.

Lowering the trade elasticity has also been shown to strengthen the trade-comovement relation, as in Heathcote and Perri (2002), Kose and Yi (2006), and Burstein et al. (2008), but is not enough to solve the puzzle. Drozd et al. (2020) show that modeling the disconnect between the low short and the high long run trade elasticity is a promising avenue in resolving the trade-comovement puzzle. We will perform all of our theoretical analyses using two different trade elasticities from the literature.

3 Data and Empirical Analysis

Estimating the trade-comovement and trade-partner-comovement relations requires information on bilateral trade flows and GDP. Feenstra et al. (2005) provides nominal bilateral imports in US dollars, and the World Development Indicators (WDI) from the World Bank includes information on GDP and its components in nominal and real terms. Following the trade-comovement literature, we also gather information on economic development, trade openness, and population, which is also available in the WDI. The Centre d'Études Prospectives Et d'Informations Internationales (CEPII) database provides information on gravity determinants such as distance, common language, colony relations, and geographic characteristics. The final set of variables includes bilateral trade agreements from the Economic Integration Agreement Data Sheet. Most of the information is available at the annual level since 1962. To get a balanced panel with a richer set of countries, we focus on the period from 1990 to 2016.

3.1 Indicators

For the empirical exercise, we define three indicators: business cycle (or output) comovement, bilateral trade intensity, and common exposure to foreign cycles. Output comovement for two countries is defined as the correlation between the cyclical component of their annual real GDP from 1990 to 2016 (ΔGDP_{it}), as in equation 1.

$$Comov_{i,j} = Corr(\Delta GDP_{it}, \Delta GDP_{jt}). \tag{1}$$

We use the method presented in Hamilton (2018) to get the cyclical component of GDP at the business cycle frequency. Namely, $\Delta GDP_{i,t+2}$ is the estimated residual of the regression

$$\ln GDP_{it} = \beta_0 + \beta_1 \ln GDP_{i,t-2} + \epsilon_{it},$$

performed separately for each country.

Frankel and Rose (1998) measure bilateral trade intensity both as the ratio between bilateral trade and the sum of the nominal GDP (equation 2) or as the ratio between bilateral trade and total trade (equation 3)

$$TI^{GDP}_{i,j} = \frac{X_{i,j} + M_{i,j} + X_{j,i} + M_{j,i}}{Y_i + Y_j} \tag{2}$$

$$TI_{i,j}^{trade} = \frac{X_{i,j} + M_{i,j} + X_{j,i} + M_{j,i}}{X_i + M_i + X_j + M_j}, \tag{3}$$

where $X_{i,j}$ and $M_{i,j}$ are exports and imports from country i to country j, respectively, and X_i and M_i are total exports and imports of country i.[2] In the empirical analysis, we use the average trade intensities from 1990 to 2016.

To measure common exposure, we first calculate the trade-partner cycle of each country as the weighted average of the cycle of its trading partners, equation 4. Each trading partner's cycle is weighted by the country's share of trade with that partner in 1990. We calculate common exposure to foreign business cycles for countries i and j as the correlation between their trade-partner cycles, equation 5.

$$TPC_i = \sum_n s_{i,n} \Delta GDP_n \tag{4}$$

$$s_{i,n} = \frac{X_{i,n,1990} + M_{i,n,1990}}{X_{i,1990} + M_{i,1990}}$$

$$Comov_{i,j}^{TPC} = Corr(TPC_i, TPC_j) \tag{5}$$

We also use an indicator that measures trade-partner similarity and that is highly correlated with common trade exposure to calibrate the model. To measure similarity, we calculate the fraction of country i's total trade with each country n— $s_{i,n}$ from above. For two countries i and j, trade partner similarity $TPS_{i,j}$ is the sum of the absolute differences of the trade shares $s_{i,n}$ and $s_{j,n}$ for each country $n \neq i, j$ as in equation 6. The TPS measure takes values between 0 and 2. A TPS of 0 indicates identical trade shares with all external partners (high similarity), and a TPS of 2 indicates that none of i's trading partners trade with j and vice versa (low similarity). By construction, countries with more similar trading partners (a lower TPS value) will also have higher common trade exposure to foreign cycles.

$$TPS_{i,j} = \sum_{n \neq j,i} |s_{i,n} - s_{j,n}| \tag{6}$$

[2] Bilateral export and import data from both countries are used. Reported exports and imports between two countries tend to differ because imports generally include freight and insurance costs and because of statistical error. By including both countries' data, our measure essentially takes the average of the reported exports and imports in each country.

Figure 1 plots the distribution of TPS for a sample of more than 10,000 country-pairs in 1990. On average, TPS takes a value of 1.23. Country-pairs that are close to the mean are France and Costa Rica and Angola and Burkina Faso. Mexico and Canada have the most similar trade partners (TPS = 0.20), while Saint Kitts and Nevis Islands and Yemen have the least similar (TPS = 1.93). Other country-pairs with similar trade partners include Dominican Republic and Mexico, Costa Rica and Honduras, Guatemala and Salvador, Sweden and Denmark, Japan and South Korea, and France and Italy, all of which have a TPS below 0.3. Clearly, country-pairs with the lowest levels of TPS tend to be close geographically, just as country-pairs with higher bilateral trade tend to be closer.[3]

3.2 Trade Comovement

Consider a simple empirical relationship between comovement and trade intensity:

$$Comov_{i,j} = \alpha_1 TI_{i,j}^{gdp} + \alpha_i + \alpha_j + \alpha_2 Z_{i,j} + v_{i,j} \tag{7}$$

where α_i, α_j are country fixed effects and $Z_{i,j}$ includes interactions for levels of development and trade agreements. The residual is $v_{i,j}$.

We estimate this relationship using OLS. Column 1 of Table 1 reports the standardized coefficient for trade intensity. As expected, there is a positive and significant correlation between bilateral trade and output synchronization. As Frankel and Rose (1998) highlight, trade intensity and business cycle comovement are endogenously determined. On the one hand, countries that trade more with each other may be subject to similar disturbances and the transmission of shocks between countries may be stronger. On the other hand, economies that are more synchronized may have more incentives to boost their trade. To get the causal effect of trade intensity on output comovement, Frankel and Rose (1998) instrument bilateral trade using gravity determinants. Here, we follow a similar approach and instrument trade intensity by estimating the following equation:

$$TI_{i,j}^{gdp} = \beta_0 + \beta_1 X_i + \beta_2 X_j + \beta_3 X_{i,j} + \epsilon_{i,j} \tag{8}$$

where X_i, X_j include country-specific characteristics such as population, latitude, longitude, area, and an indicator for being landlocked, and $X_{i,j}$ include bilateral distance in kilometers

[3]The relationship between distance and TPS is explored more fully in Appendix C.

and indicators for common language, common border, colony relations, and common region. Table 2 reports the results for the OLS regression for equation 8. As in other studies, gravity determinants have significant explanatory power on bilateral trade intensity. In a second stage, we estimate the trade-comovement relation:

$$Comov_{i,j} = \alpha_1 \widehat{TI}_{i,j}^{gdp} + \alpha_i + \alpha_j + \alpha_2 Z_{i,j} + v_{i,j} \tag{9}$$

where $\widehat{TI}_{i,j}^{gdp}$ is the predicted level of trade intensity and the rest of the variables are defined as in equation 7. Column 3 of table 1 reports the regression results for equation 9. As in the simple OLS, there is a positive and significant relation between trade intensity and business cycle comovement: Increasing bilateral trade by one standard deviation raises output comovement by 3.3 p.p.

3.3 Trade Comovement and Trade-Partner Comovement

We extend equation 7 to include common trade exposure as an additional control. Two outcomes are expected. First, common exposure should increase output comovement. Second, the effect of bilateral trade should fall as countries with more similar trade partners also tend to have higher bilateral trade, meaning that some of the effect of common trade partners was being captured by bilateral trade in the trade-comovement regressions from the previous section. In other words, the trade-comovement relation is upward biased because common exposure is an omitted variable. The new estimating equation (shown here as the second-stage regression) is

$$Comov_{i,j} = \alpha_1 \widehat{TI}_{i,j}^{gdp} + \gamma Comov_{i,j}^{TPC} + \alpha_i + \alpha_j + \alpha_2 Z_{i,j} + v_{i,j} \tag{10}$$

Table 1 reports the estimated coefficients of bilateral trade and common exposure. In all cases, the coefficients are standardized to facilitate interpretation. Columns 1 and 2 are the results from a simple OLS regression, and columns 3 and 4 are those from instrumenting bilateral trade, as in equation 8. Adding common exposure as an additional control reduces the effect of bilateral trade by between 20 and 30 percent. The effect of common exposure is positive and significant, meaning that common trade partners are an important source of business cycle comovement. Finally, the combined effect of bilateral trade and common trade exposure on output comovement is much larger than the isolated effect of bilateral trade in regressions that exclude common exposure; trade has a larger effect on output comovement than previously thought.

To get the causal effect of common exposure on output comovement, we focus on small open economy (SOE) country-pairs. A SOE is unlikely to affect the business cycle of its trading partners so the common exposure between two SOEs is exogenous to their business cycle comovement. This exogeneity does not hold for a big country like the United States. The United States affects the business cycles of Mexico and many of their common trade partners so common exposure to foreign business cycles is not exogenous to output comovement between Mexico and the United States. We define SOE country-pairs as pairs in which both countries have a share of the world GDP less than 0.5 percent in 1990 and for which the pair's bilateral trade share is less than 10 percent. The latter assumption ensures that one SOE does not affect the trade-partner cycle of the other.

The Columns 5 and 6 of Table 1 report the regression results when including only SOE country-pairs. Consistent with the previous cases, including common exposure lowers the effect of bilateral trade about 25 percent. Increasing trade intensity by one standard deviation raises output comovement by 2.7 pp, while increasing common exposure raises comovement by 5.1 pp. Once again, the combined effect of trade on output comovement is larger than reported in previous studies that ignore common trade exposure.

Our results are robust to using different methods of detrending GDP data (HP filter, growth rates, band-pass filter), performing the analysis over different periods, using various weighting schemes to estimate foreign business cycles, excluding the 2007-09 global recession, using additional controls, and accounting for intra-industry trade. For details see Appendix D.

4 Model

Kose and Yi (2001) showed that an IRBC model could not reproduce the size of trade-comovement seen in the data, and Kose and Yi (2006) modified the model to include correlated TFP with transmission through trade to alleviate the trade-comovement puzzle. In this section, we show that the IRBC model is also inconsistent with the trade-partner-comovement puzzle. As in Kose and Yi (2006), correlated TFP increases business cycle comovement, but we show that the increase comes mostly through a country-pair's common exposure to other countries and not directly through higher bilateral trade.

The model is close to the set-up proposed by Kose and Yi (2006) but with four countries and constant iceberg costs (meaning that there is no role for a transportation sector). Each economy produces one differentiated intermediate good that can be traded subject to an iceberg cost τ. That is, for every unit of domestic goods that arrives in a foreign market, the home country sends $\tau > 1$ units of the good. Domestic capital and labor are combined to produce intermediate goods in each country, and foreign and domestic intermediates are aggregated to produce non-traded investment and consumption final goods. As in Heathcote and Perri (2002), countries cannot trade financial assets.

4.1 Households

Each country has a representative consumer that chooses consumption $C_{i,t}$, leisure $1 - L_{i,t}$, investment $I_{i,t}$, and physical capital $K_{i,t+1}$ to maximize lifetime utility over consumption and leisure subject to a budget constraint. We assume investment is subject to adjustment costs. The country i consumer's problem is

$$U(C_{i,t}, L_{i,t}) = \max \sum_{t=0}^{\infty} \beta^t \frac{[C_{it}^{\mu}(1 - L_{i,t})^{1-\mu}]^{1-\gamma}}{1-\gamma} \tag{11}$$

subject to

$$P_{i,t}^{c}\left(C_{i,t} + I_{i,t}\right) = w_{i,t}L_{i,t} + r_{i,t}K_{i,t} \tag{12}$$

$$K_{i,t+1} = I_{i,t} + (1-\delta)K_{i,t} - \frac{\phi_{k,i}}{2}\left(\frac{I_{i,t}}{K_{i,t}} - \delta\right)^2 \tag{13}$$

where μ is the relative preference for consumption in the intratemporal utility, β is the discount factor, $1/\gamma$ is the intertemporal elasticity of substitution, and $\phi_{k,i}$ determines the adjustment costs for capital. $w_i, r_i, andP_i^c$ are the prices of labor, capital, and consumption and investment. Each household has a fixed endowment of labor normalized to 1.

4.2 Intermediate Goods and Transportation Costs

Intermediate goods are produced by competitive firms that use capital and labor. Each country produces a differentiated good traded in both domestic and foreign markets. The problem of the representative firm in country i is to maximize profits by choosing capital and labor:

$$\max_{K_{i,t},L_{i,t}} P^x_{i,t} Y_{i,t} - r_{i,t} K_{i,t} - w_{i,t} L_{i,t} \tag{14}$$

$P^x_{i,t}$ is the free-on-board or factory gate price of the intermediate good produced in country i, and $Y_{i,t}$ is the production of the intermediate good in country i, which is represented by a Cobb-Douglas production function with a constant capital share α and TFP $z_{i,t}$, equation 15. TFP follows an auto-retrogressive process as in equation 16,

$$Y_{i,t} = z_{i,t} K^{\alpha}_{i,t} L^{1-\alpha}_{i,t} \tag{15}$$

$$log(z_{i,t}) = (1 - \rho_z) log(z_{i,ss}) + \rho_z log(z_{i,t}) + \epsilon_{i,t} \tag{16}$$

where $\rho_z \in (0, 1)$, $z_{i,ss}$ is the steady state value for the TFP, and $\epsilon_{i,t}$ is a normally distributed random variable with mean zero and variance σ^2_i.

The market clearing condition in each period for producers of intermediate goods in country i is:

$$Y_{i,t} = \sum_{j}^{N} Y_{ij,t}. \tag{17}$$

When the intermediate goods are exported to another country, they are subject to an iceberg cost. The optimal price of an intermediate good produced in country i and sent to country j is $P_{i,j} = \tau_{i,j} P^x_i$ where $\tau_{i,j}$ is the iceberg cost.

4.3 Final Goods

Competitive firms in the final goods sectors combine domestic and foreign intermediates to produce non-traded consumption and investment goods. The firms in country i maximize profits given by equation 18:

$$\max_{\{X_{ji,t}\}} P^c_{i,t} \left(\sum_j \omega_{ji}^{1/\sigma} X_{ji,t}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} - \sum_j P_{ji,t} X_{ji,t} \tag{18}$$

where σ is the elasticity of substitution between home and foreign intermediates and ω_{ij} are Armington weights that determine how important domestic and foreign varieties are for the production of final goods (home-bias). Finally, the market clearing condition for the final goods is given by

$$C_{i,t} + I_{i,t} = \left(\sum_j \omega_{ji}^{1/\sigma} X_{ji,t}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{19}$$

4.4 Competitive Equilibrium

Under financial autarky, a competitive equilibrium is a set of prices $\{P^c_{i,t}, w_{i,t}, r_{i,t}, P^x_{i,t}, P_{ji,t}\}_{i,j}$ and allocations $\{C_{i,t}, K_{i,t+1}, L_{i,t+1}, I_{i,t+1}, Y_{i,t}, Y_{ij,t}, X_{ij,t}\}_{i,j}$ such that for the exogenous productivity process z_{i,t_i} the following conditions hold:

- Given prices $\{P^c_{i,t}, w_{i,t}, r_{i,t}\}_i$, consumers maximize their utility by choosing $\{C_{i,t}, L_{i,t}, K_{i,t+1}, I_{i,t}\}_i$ subject to their budget constraint and the capital law of motion.
- Given prices $\{P^x_{i,t}, r_{i,t}, w_{i,t}\}_i$, intermediate goods producer maximize profits by choosing $\{K_{i,t}, L_{i,t}\}_i$.
- Given prices $\{P^c_{i,t}, P^x_{ji,t}\}_{i,j}$, final goods producers maximize profits by choosing $\{X_{ji,t}\}_{i,j}$.
- Labor, intermediate goods, and final goods markets clear.

5 Calibration and Simulations

5.1 Calibration

The model is calibrated to reproduce the empirical distributions of trade intensity and trade partner similarity in SOEs, and to target some average moments in the data, such as the relative size of SOEs and the trade openness in SOEs and the ROW. The data consist of 99 SOEs (4,725 unique country pairs). To reduce the scale of the model, we assume there are four countries, two small and two ROW, and perform the calibration and simulation exercises 4,725 times. Most of the parameters are taken directly from Kose and Yi (2006) and are reported in Table 3. Consistent with the Penn World Tables (PWTs), the productivity levels are normalized to 1.0 in the two SOEs and set to 1.5 in the ROWs.

We present our results with two different elasticities of substitution, $\sigma = 1.5$ and $\sigma = 0.7$. The higher elasticity is typical in other business cycle studies such as Backus et al. (1992) and Kose and Yi (2006), while Heathcote and Perri (2002) and Kose and Yi (2001) show that a lower elasticity yields more business cycle comovement because foreign goods are more complementary to domestic production.

The rest of the parameters, the 12 Armington weights, determine bilateral trade between all countries. Assuming that the SOEs and the ROWs are symmetric in some ways reduces the number of parameters to six. Specifically, we assume that home bias is the same in both SOEs, $\omega_{SOE_1,SOE_1} = \omega_{SOE_2,SOE_2}$, and in the two ROWs, $\omega_{ROW_1,ROW_1} = \omega_{ROW_2,ROW_2}$. Similarly, we assume that the two SOEs are equally exposed to each other such that, $\omega_{SOE_1,SOE_2} = \omega_{SOE_2,SOE_1}$, and that SOE_1 is exposed to ROW_1 the same way SOE_2 is to ROW_2, $\omega_{SOE_1,ROW_1} = \omega_{SOE_2,ROW_2}$. Finally, we assume that ROW_1 is exposed to SOE_1 as ROW_2 is to SOE_2, $\omega_{ROW_1,SOE_1} = \omega_{ROW_2,SOE_2}$, and that SOEs are similarly exposed to their opposite ROW, $\omega_{SOE_1,ROW_2} = \omega_{SOE_2,ROW_1}$. For each country-pair in the data, the six remaining Armington weights are calibrated to match

1. the bilateral trade intensity of the pair (both dividing by GDP and total trade, 2 moments)
2. trade partner similarity of the pair (1 moment)
3. average trade openness in SOEs and the ROW (2 moments)
4. average relative size between SOEs and the ROW (1 moment).

To make things simple, we carry out the calibration in two steps. First, we calibrate the parameters to match the average moments from the data. Then, for each country pair we re-calibrate the values of ω_{SOE_1,SOE_2} and ω_{SOE_1,ROW_1} to match the observed trade intensity and trade partner similarity. Because recalibrating the Armington weights for each country is costly, we only calculate the weights that correspond to the minimum and maximum values of trade intensity and trade-partner similarity in the data. We then scale the weights for each country pair according to its place in the distribution. Notice that if we had only three countries, as in Kose and Yi (2006), we would be unable to match both bilateral trade intensity and trade partner similarity.

Table 4 reports the targeted moments and their model counterpart for a country-pair with average trade intensity and trade partner similarity; the model does well replicating the data. For the pair-specific trade intensity and trade partner similarity, we report the root mean square error (RMSE) for the model versus the data in the last two rows of Table 4. Again, the model matches the data well. Table 5 reports the calibrated Armington weights for the average country-pair. SOEs tend to rely on trade more than the ROW, as reflected in the lower home bias (ω_{ii}). SOEs also trade less with each other, reflected in low values for the Armington weight on goods from the other SOE. The Armington weights for goods produced in each of the ROW countries replicates the trade partner similarity observed in the data. For the mean country-pair, SOE_1 is more exposed to ROW_1, and SOE_2 is more exposed to ROW_2.

The calibration uses trade partner similarity rather than common exposure because common exposure is determined endogenously in the model by fluctuations in GDP among the country-pair's trade partners. From a simple OLS regression of trade-partner-similarity (TPS) on common exposure we find that that countries with more similar trading partners have more common trade exposure to foreign cycles, as expected. The coefficient for this regression is significant at the 1 percent level and equal to negative 0.31, with an R^2 of 19 percent. The advantage of the TPS is that it can be easily mapped into the model by changing the importance of foreign intermediates in the production of domestic final goods.

The last set of parameters describes the productivity process in the intermediate goods sector. Using the productivity levels reported in the PWTs we extract the cyclical component of productivity and estimate a first-order auto-regressive process for each SOE, as in equation 20. The estimated persistence $\widehat{\rho_{i,1}}$ and standard deviation of the error term, $\hat{\sigma}_i$, are used to simulate the model. For the ROW, we assume that productivity behaves as in the United States, and for the countries with no data in the PWTs, we use the mean process for SOEs.

$$TFP_{i,t}^{hp} = \rho_0 + \rho_{i,1} TFP_{i,t-1}^{hp} + \epsilon_{i,t} \tag{20}$$

5.2 Simulations

For each country-pair the model is simulated for 1,000 periods and the last 27 are used to calculate output comovement, common exposure, and other business cycle moments. As in the data, GDP components are logged detrended using the method in Hamilton (2018). To get the causal effect of bilateral trade on output comovement, we use the value of trade intensity in the steady state. Using the 4,725 observations we estimate the trade-comovement and trade-partner comovement relations, as in equation 10. Table 6 reports the estimated coefficients from the simulations. Both coefficients are positive and significant, and adding common exposure in the regression decreases the effect of trade intensity as in the data. However, the estimated coefficients are much smaller than in the data. As noted by Table 7, another failure of the model is the low volatility of GDP components.

The model gets the qualitative relations because trade transmits business cycle fluctuations. As explained in Drozd et al. (2020), there are two forces that affect the trade-comovement relationship: *substitution* and *income* effect. A positive productivity shock in the foreign country increases the supply of the foreign intermediate and lowers its price. Since the home country uses foreign intermediates to produce consumption and investment goods, cheaper intermediates boosts the domestic production at home and increases the demand for labor and investment, creating a positive relationship between trade and comovement. This effect is the substitution effect and is stronger if home and foreign intermediates are less substitutable. The income effect works in the opposite direction, a positive productivity shock abroad creates a wealth effect at home by improving the terms of trade. Higher income reduces the labor supply and has a negative effect on capital accumulation and production, which weakens the link between trade and comovement. In the current model, the income effect is too strong so that our trade-comovement coefficient is much smaller than in the data.

In addition to these two forces, our model with four countries has an additional source of comovement if the two SOEs are similarly exposed to the larger countries. The common exposure coefficient in the regression, however, is also much smaller than in the data. The relation in the model is weak because idiosyncratic productivity shocks in SOEs are a major source of SOE output fluctuations. If two countries had no productivity shocks and were equally exposed to a third country, they would face the same forces and their output would be highly correlated. Indeed, when we estimate the relations in a version of the model with no productivity shocks in SOEs, we get a trade-partner-comovement coefficient more than six times larger than in the data. Any modification that decreases the idiosyncratic volatility of TFP shocks would therefore bring the model closer to the estimated trade-partner-comovement from the data.

5.3 TFP Transmission and Trade Comovement

We modify our benchmark model to include correlated TFP shocks and countercyclical trade barriers. Kose and Yi (2006) show that correlated TFP shocks increase the model's ability to match the estimated trade-comovement in the data. We find that while correlated shocks do increase comovement, the increase comes primarily from the indirect channel of common exposure to other countries.

We assume that a country's productivity shock is partially transmitted to other countries and that the strength of transmission depends on how important a country is for its trading partner, which is captured by the parameter ω_{ij}. The shock to TFP for country i at time t is therefore

$$\epsilon_{i,t} = \tilde{\epsilon}_{i,t} + \nu \sum_{j \neq i} \omega_{ji} \tilde{\epsilon}_{j,t} \tag{21}$$

where $\tilde{\epsilon}_{i,t}$ are shocks that originate in country i. The parameter ν scales the impact of foreign shocks. Previously, we had obtained the volatility of the TFP shock $\epsilon_{i,t}$ for countries in our analysis. Now we solve for the volatilities of the new TFP shocks $\tilde{\epsilon}_{i,t}$ that guarantee that $\epsilon_{i,t}$ has the same volatility as the data. The variance of $\epsilon_{i,t}$ is

$$\sigma_i^2 = \tilde{\sigma}_i^2 + \nu^2 \sum_{j \neq i} \omega_{ji}^2 \tilde{\sigma}_j^2$$

where $\tilde{\epsilon}_{i,t}$ has variance $\tilde{\sigma}_i^2$. The volatilities $\tilde{\sigma}$ that solve the problem are

$$\tilde{\sigma}^2 = A^{-1}\sigma^2$$

where

$$A = \nu^2 \begin{bmatrix} \frac{1}{\nu^2} & \omega_{21}^2 & \omega_{31}^2 & \omega_{41}^2 \\ \omega_{12}^2 & \frac{1}{\nu^2} & \omega_{32}^2 & \omega_{42}^2 \\ \omega_{13}^2 & \omega_{23}^2 & \frac{1}{\nu^2} & \omega_{43}^2 \\ \omega_{14}^2 & \omega_{24}^2 & \omega_{34}^2 & \frac{1}{\nu^2} \end{bmatrix},$$

σ^2 is

$$\sigma^2 = \begin{bmatrix} \sigma_1^2 \\ \sigma_2^2 \\ \sigma_3^2 \\ \sigma_4^2 \end{bmatrix}$$

with $\tilde{\sigma}^2$ similarly defined.

The correct volatilities can be solved for any value of ν. The larger is ν, the smaller are the idiosyncratic volatilities $\tilde{\sigma}$ for each country. Because large volatilities in SOEs caused the low trade-partner comovement in the model, we choose ν to be its largest value that still guarantees all variances remain nonnegative. For the high elasticity case, we get $\nu = 2.3$. For the low elasticity case, $\nu = 5.5$. Though some country-specific volatilities are significantly reduced, the standard deviation of the average SOE's idiosyncratic shock falls by only between 5 and 7 percent.

To get more volatility in trade, we assume trade barriers (iceberg costs) are negatively correlated with productivity shocks, as in equation 22. The parameters κ_i and κ_j are adjusted to increase the volatility of exports and imports to be close to the volatility in the data. The countercyclicality of trade barriers is consistent with a model in which a shipping industry with finite cargo space chooses prices to maximize profits. When productivity is high, more goods are being traded and the cost of shipping those goods increases.[4]

$$log(\tau_{ij,t}) = log(\tau_{ij,ss}) - (\kappa_i \epsilon_{i,t} + \kappa_j \epsilon_{j,t}) \tag{22}$$

The model with countercyclical trade barriers has more volatility in investment and trade flows as shown in column (3) of Table 7. Countercyclical barriers, however, do nothing to improve or hinder trade- or trade-partner comovement; the coefficients from a model with only correlated TFP shocks (not shown) are almost identical to those with correlated TFP shocks and countercyclical barriers, which we discuss next.

Columns 5 and 6 of Table 6 report the coefficients for the trade-comovement and trade-partner-comovement relations in the modified model. As in the benchmark case, increasing trade intensity or common trade exposure has a positive effect on business cycle comovement. With correlated productivity shocks (and the implied lower idiosyncratic volatilities in SOEs), the trade-partner-comovement relation in the model is much closer to the data. The effect of trade intensity, however, remains far below its value in the data.

When we exclude common exposure from the regression on model-simulated data, the modified model shows much higher trade-comovement, moving from 0.3 to 1.5 in the high elasticity model and from 0.5 to 1.3 in the low elasticity model, which accounts for 38 ($\frac{1.5-0.3}{3.5-0.3}$) and 27 ($\frac{1.3-0.5}{3.5-0.5}$) percent of the discrepancy between the benchmark model and the data. Indeed, this is the point of Kose and Yi (2006) and other models that endogenize TFP transmission. But when we control for common exposure, the trade-comovement coefficient rises by much less from the benchmark model and accounts for only 20 ($\frac{0.6-0.1}{2.6-0.1}$) and 21 ($\frac{0.7-0.2}{2.6-0.2}$) for the low and high elasticity models. By contrast, the trade-partner-comovement coefficients in the new model rise by much more, accounting for 77 and 41 percent of the discrepancy in trade-partner-comovement between the benchmark model and the data. Therefore, TFP transmission through trade mainly increases comovement through common foreign exposure rather than directly

[4] We could also get more volatility in trade by making trade intensive in capital goods. The results are similar.

through bilateral trade, especially for the model with a higher elasticity.

The reason that TFP transmission works mainly through common exposure is that the bilateral trade exposure between SOEs – and indeed between most country-pairs – is small in comparison with exposure to the ROW. In our model, the parameter ω_{SOE_1,SOE_2}, which pins down bilateral trade between the SOEs, are low in calibration (between 0 and 0.038). With the correlated productivity shocks introduced earlier, shocks in one SOE have almost no direct effect on the other SOE's productivity, so the model fails to generate trade comovement directly through bilateral trade. The values for ω_{SOE_i,ROW_i} are bigger, so comovement between SOEs increases if they have common exposure to the ROW countries. If we exclude common exposure from the regression, this effect looks like an increase in comovement because of bilateral trade because bilateral trade and common exposure are positively correlated.

Our results suggest that TFP transmission through trade mostly addresses the indirect channel of trade and business cycle comovement. Attempts to solve the trade-comovement puzzle in the literature will benefit from additional mechanisms that allow for stronger business cycle transmission through bilateral trade rather than through common exposure to foreign countries.

For example, one change we could make in our model is to assume that transmission of productivity shocks between SOEs is higher than between other country pairs:

$$log(z_{i,t}) = (1-\rho_{z,i})log(z_{i,ss}) + \rho_{z,i}log(z_{i,t}) + \tilde{\epsilon}_{i,t} + \sum_{j\neq i} \nu_{ij}\omega_{ji}\tilde{\epsilon}_{j,t} \tag{23}$$

where ν_{ij} is 10 times larger when both i and j are SOEs.[5] One might justify such an assumption by considering that SOEs with high bilateral trade are likely affected similarly by changes in commodity prices, which can have a big influence on SOE cycles. To differentiate between the two assumptions on correlated productivity, we call this one *biased productivity shocks.*

The coefficients for the trade-comovement and trade-partner-comovement relations with biased productivity shocks are reported in columns 7 and 8 of Table 6. The trade-comovement coefficient is now much closer to the data. With a higher elasticity, the trade-comovement coefficient is 3.0 (versus 2.7 in the data) and the trade-partner-comovement coefficient is 4.8 (versus 5.1 in the data). With a lower elasticity, the trade-comovement cofficient is 3.7 and the trade-partner-comovement coefficient is 3.3. Other shocks or mechanisms may

[5]Once again, idiosyncratic volatilities are chosen to match the volatilities from the data and ν is selected to guarantee nonnegative variance for all countries.

achieve a similar outcome, but this solution is meant (1) to preserve the IRBC structure with TFP shocks in each country, and (2) to illustrate that scaling up the effect of bilateral trade on business cycle transmission relative to the effect of common trade exposure is key to solving the puzzles.

6 Conclusion

We argue that common trade exposure to foreign business cycles is an important source of output comovement, especially in SOEs. Our empirical results suggest that measures of the trade-comovement relation that omit common exposure are biased upward and that the total effect of trade on output comovement is larger than previously thought due to common exposure. On the theoretical side, we document that a standard international real business cycle model is qualitatively consistent with the trade-comovement and trade-partner-comovement relations but fails to replicate their magnitudes. Incorporating TFP transmission through trade increases comovement but mostly through a country-pair's common trade exposure to other countries rather than through bilateral trade. A solution to the trade-comovement and trade-partner-comovement puzzles needs therefore to scale up transmission of business cycles through bilateral trade. We propose one solution to these puzzles that preserves the IRBC framework, but more research must be done to endogenize transmission mechanisms that solve the puzzles. For instance, SOEs that trade with higher bilateral trade or are in similar geographic areas are subject to other common shocks (such as fluctuations in the terms of trade) that may increase comovement.

References

Ambler, S., Cardia, E., and Zimmermann, C. (2002). International transmission of the business cycle in a multi-sector model. *European Economic Review*, 46(2):273–300.

Arkolakis, C. and Ramanarayanan, A. (2009). Vertical specialization and international business cycle synchronization. *The Scandinavian Journal of Economics*, 111(4):655–680.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1992). International real business cycles. *Journal of Political Economy*, 100(4):745–775.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1994). Dynamics of the trade balance and the terms of trade: The j-curve? *The American Economic Review*, 84(1):84–103.

Baxter, M. and King, R. G. (1999). Measuring business cycles: Approximate band-pass filters for economic time series. *Review of Economics and Statistics*, 81(4):575–593.

Baxter, M. and Kouparitsas, M. A. (2005). Determinants of business cycle comovement: A robust analysis. *Journal of Monetary Economics*, 52(1):113–157.

Blonigen, B. A., Piger, J., and Sly, N. (2014). Comovement in gdp trends and cycles among trading partners. *Journal of International Economics*, 94(2):239–247.

Burstein, A., Kurz, C., and Tesar, L. (2008). Trade, production sharing, and the international transmission of business cycles. *Journal of Monetary Economics*, 55(4):775–795.

Calderon, C., Chong, A., and Stein, E. (2007). Trade intensity and business cycle synchronization: Are developing countries any different? *Journal of International Economics*, 71(1):2–21.

Canova, F. and Dellas, H. (1993). Trade interdependence and the international business cycle. *Journal of International Economics*, 34(1–2):23–47.

Clark, T. E. and Van Wincoop, E. (2001). Borders and business cycles. *Journal of International Economics*, 55(1):59–85.

Cravino, J. and Levchenko, A. A. (2016). Multinational firms and international business cycle transmission. *The Quarterly Journal of Economics*, 132(2):921–962.

de Soyres, F. and Gaillard, A. (2020). Global trade and gdp co-movement. *International Finance Discussion Papers*, 1282.

di Giovanni, J., Levchenko, A. A., and Mejean, I. (2018). The micro origins of international business-cycle comovement. *American Economic Review*, 108(1):82–108.

Doyle, B. M. and Faust, J. (2005). Breaks in the variability and comovement of g-7 economic growth. *Review of Economics and Statistics*, 87(4):721–740.

Drozd, L. A., Kolbin, S., Nosal, J. B., et al. (2020). The trade-comovement puzzle. *American Economic Journal: Macroeconomics*, forthcoming.

Feenstra, R. C., Lipsey, R. E., Deng, H., Ma, A. C., and Mo, H. (2005). World trade flows: 1962-2000. Technical report, National Bureau of Economic Research.

Frankel, J. A. and Rose, A. K. (1998). The endogenity of the optimum currency area criteria. *The Economic Journal*, 108(449):1009–1025.

Grubel, H. G. and Lloyd, P. J. (1971). The empirical measurement of intra-industry trade. *Economic Record*, 47(4):494–517.

Hamilton, J. D. (2018). Why you should never use the hodrick-prescott filter. *Review of Economics and Statistics*, 100(5):831–843.

Heathcote, J. and Perri, F. (2002). Financial autarky and international business cycles. *Journal of Monetary Economics*, 49(3):601–627.

Imbs, J. (2000). *Sectors and the OECD business cycle*, volume 2473. Centre for Economic Policy Research.

Imbs, J. (2004). Trade, finance, specialization, and synchronization. *Review of Economics and Statistics*, 86(3):723–734.

Johnson, R. C. (2014). Trade in intermediate inputs and business cycle comovement. *American Economic Journal: Macroeconomics*, 6(4):39–83.

Kose, M. A. and Yi, K.-M. (2001). International trade and business cycles: Is vertical specialization the missing link? *American Economic Review*, 91(2):371–375.

Kose, M. A. and Yi, K.-M. (2006). Can the standard international business cycle model explain the relation between trade and comovement? *Journal of international Economics*, 68(2):267–295.

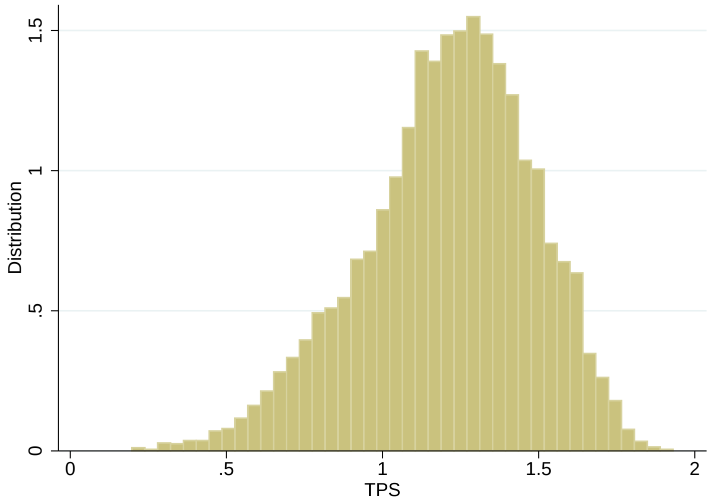
Mendoza, E. G. (1995). The terms of trade, the real exchange rate, and economic fluctuations. *International Economic Review*, 36(1):101–137.

Otto, G., Voss, G. M., and Willard, L. (2001). *Understanding OECD output correlations*. Reserve Bank of Australia Sydney.

Schmitt-Grohé, S. and Uribe, M. (2018). How important are terms-of-trade shocks? *International Economic Review*, 59(1):85–111.

A Figures

Figure 1: Trade-Partner Similarity



B Tables

Table 1: Trade Comovement and Trade-Partner Comovement

	OLS		IV		SOE-IV	
	(1)	(2)	(3)	(4)	(5)	(6)
$+1_{SD}$ TI_{GDP}	2.4***	1.9***	3.3***	2.4***	3.6***	2.7***
	(0.2)	(0.2)	(0.2)	(0.3)	(0.3)	(0.3)
$+1_{SD}$ $Comov_{TPC}$		5.9***		5.6***		5.1***
		(0.4)		(0.4)		(0.5)
N	15262	15262	15262	15262	9448	9448
R^2	0.28	0.29	0.28	0.29	0.22	0.22

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, standard errors in parentheses

OLS stands for ordinary least squares, IV for instrumental variable, SOE for small open economy, TI_{GDP} for trade intensity, and $Comov_{TPC}$ for common exposure to foreign cycles. The coefficients report the expected percentage point increase in business cycle comovement for a one standard deviation increase in the relevant regressor. The prefix $+1_{SD}$ in this and other tables are meant to notify the reader of this normalization of regression coefficients.

Table 2: First stage regression - Trade intensity

	Full Sample		SOE	
Variable	Sign	Significant 1%	Sign	Significant 1%
Distance	-	✓	-	✓
Region	+	✓	+	✓
Border	+	✓	+	✓
Language	+	✓	+	✓
Country	+	✓	+	✓
Colony	0	✗	+	✓
Population	+	✓	+	✓
Landlocked	-	✓	-	✓
Latitude	+	✓	0	✗
Longitude	+	✓	+	✓
Area	0	✗	-	✓
N	15262		9448	
R^2	0.147		0.118	

Table 3: Calibrated parameters

Parameter	Definition	Value	Source
μ	Share of consumption	0.34	KY
γ	Risk aversion	2	KY
β	Discount factor	0.96	KY
α	Capital share	1/3	KY
δ	Depreciation	0.1	KY
σ	Elast. of Subs	1.5	KY
$\tau_{i,j}$	Iceberg costs	1.2	KY
ϕ_k	Capital adjustment	0.0	Calibrated

KY indicates parameter value was taken from Kose and Yi (2006).

Table 4: Targeted Moments

Variable	(1) Data	(2) High Elast.	(3) Low Elast.
TI_{gdp}	0.00046	0.00041	0.00039
TI_{trade}	0.00059	0.00053	0.00051
TPS	1.26	1.26	1.26
TO_{SOE}	0.78	0.78	0.78
TO_{ROW}	0.37	0.37	0.37
GDP_{SOE}/GDP_{ROW}	0.064	0.064	0.064
$RMSE_{TI}$		0.0000437	0.000076
$RMSE_{TPS}$		0.0041171	0.002046

Top panel shows moments for the mean country-pair in the data and the model. The bottom panel shows the root mean square error (RMSE) for trade-partner similarity and trade intensity across all country-pairs relative to the data.

Table 5: Calibrated Parameters (mean country-pair)

Demand	Source	High Elast. (1)	Low Elast. (2)
SOE$_i$	SOE$_i$	0.39	0.74
	SOE$_j$	0.0001	0.0004
	ROW$_i$	0.40	0.17
	ROW$_j$	0.21	0.10
ROW$_i$	ROW$_i$	0.81	0.81
	SOE_i	0.009	0.005
	SOE_j	0.0004	0.0003
	ROW_j	0.18	0.14

Table 6: Trade Intensity, Common Exposure, and Comovement in the Model

High elasticity: $\sigma = 1.5$								
	Data		Model					
			Benchmark		+TFP+τ		+TFP$_{bias}$+τ	
$+1_{SD}$ TI_{gdp}	3.6***	2.7***	0.3***	0.1**	1.5***	0.6**	4.1***	3.0***
	(0.3)	(0.3)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
$+1_{SD}$ $Comov_{TPC}$		5.1***		0.6***		4.0***		4.8***
		(0.5)		(0.1)		(0.1)		(0.1)

Low elasticity: $\sigma = 0.7$								
	Data		Model					
			Benchmark		+TFP+τ		+TFP$_{bias}$+τ	
$+1_{SD}$ TI_{gdp}	3.6***	2.7***	0.5***	0.2***	1.3***	0.7***	4.4***	3.7***
	(0.3)	(0.3)	(0.1)	(<0.1)	(0.1)	(0.1)	(0.1)	(0.1)
$+1_{SD}$ $Comov_{TPC}$		5.1***		1.3***		2.8***		3.3***
		(0.5)		(<0.1)		(0.1)		(0.1)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TFP indicates that the model has correlated productivity shocks, TFP$_{bias}$ that shocks are more correlated between SOEs given the level of trade flows, and τ that trade barriers are countercyclical.

Table 7: Volatility Relative to GDP Volatility

High elasticity: $\sigma = 1.5$				
Variable	Data	Model		
		Benchmark	+TFP+τ	+TFP$_{bias}$+τ
C	1.32	0.31	0.51	0.82
I	3.06	2.45	4.51	2.98
X	2.21	0.83	2.20	2.10
M	2.51	0.31	2.39	2.24

Low elasticity: $\sigma = 0.7$				
Variable	Data	Model		
		Benchmark	+TFP+τ	+TFP$_{bias}$+τ
C	1.32	0.11	1.24	1.19
I	3.06	0.92	2.83	2.71
X	2.21	1.35	2.27	2.24
M	2.51	0.65	2.29	2.25

TFP indicates that the model has correlated productivity shocks, TFP$_{bias}$ that shocks are more correlated between SOEs given the level of trade flows, and τ that trade barriers are countercyclical.

C TPS and Distance

On average country-pairs, within the same continent have a lower TPS value than countries in different regions, 1.01 versus 1.27. Columns (1) and (2) of table 8 report a simple OLS regression between TPS and an indicator for common continent. It shows that country-pairs in the same continent are more likely to have similar exposure to their trading partners. By comparing the regions, we observe that Europe is the continent with the lowest TPS, 0.76, while Africa is the one with the highest, 1.1. Not surprisingly, these results are consistent with the levels of regional trade integration. Finally, to support the relationship between geography and TPS, we analyze the relation between distance and trade-partner similarity. As shown in Figure (2) there is a positive association between these variables. Since distance is exogenous, it can be argued that closer countries are more likely to have more similar trading partners. This relation is statistically significant, as reported in the last two columns of Table 8.

Figure 2: Trade-Partner Similarity and Distance

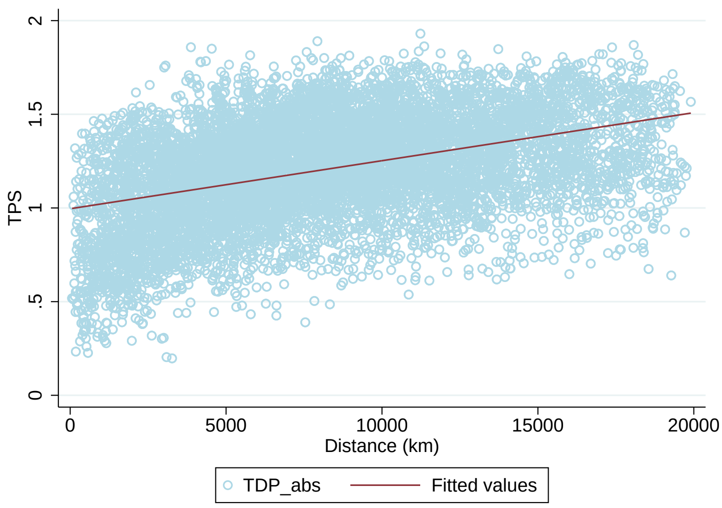


Table 8: Trade-Partner Similarity, Distance, and Common Continent

	(1)	(2)	(3)	(4)
	TPS	*TPS*	*TPS*	*TPS*
Continent	-0.256***	-0.273***		
	(0.005)	(0.003)		
Dist			0.173***	0.193***
			(0.002)	(0.002)
Reporter/Partner FE	No	Yes	No	Yes
N	16760	16760	16760	16760
R^2	0.157	0.581	0.233	0.644

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

D Robustness checks

The first two columns of table 9 report the coefficients for the trade-comovement and trade-partner comovement after applying band pass filters to GDP, as suggested by Baxter and King (1999) and Baxter and Kouparitsas (2005). Similar to the previous case, bilateral trade and common exposure have a positive and significant effect on business cycle comovement. After controlling for common exposure the effect of bilateral trade drops by more than 10%, and the contribution of common foreign demand is positive and significant. Columns 3 through 6 of table 9 show that these results are also consistent if the cycle is calculated as the first difference of the log-GDP or using a Hodrick-Prescott filter. In all cases the regressions are estimated after instrumenting for bilateral trade and are only for the group of small open economies.

Table 9 also reports other robustness checks on the original data that used the Hamilton method to detrend. We include synchronization of the terms of trade (TOT) as an additional control, columns 7 and 8. As suggested by Mendoza (1995) and Schmitt-Grohé and Uribe (2018) the TOT represent an additional source of fluctuations in SOEs. This last extension reduces the sample size, but the results still hold qualitatively. In this case, the effect of trade combines three forces, bilateral trade, common trade partners, and the terms of trade.

Following Calderon et al. (2007), we control for the impact of intra-industry trade.

Grubel and Lloyd (1971) propose an indicator that measures if two countries are trading the same kind of goods. Using a 4-Digit imports from Feenstra et al. (2005) we calculate the following indicator for each country-pair:

$$GLI_{i,j} = 1 - \left(\sum_k |x^k_{i,j} - m^k_{i,j}| / \sum_k (x^k_{i,j} + m^k_{i,j}) \right), \tag{24}$$

where $x^k_{i,j}$ and $m^k_{i,j}$ are exports from country i to country j and imports from country i to country j, respectively, and k represents the industry. Data are not available for all countries and the sample size shrinks considerably for SOEs. Columns 9 and 10 of table 9 report the coefficients for the trade-comovement and trade-partner comovement relations. As in previous cases, both relations are positive and significant. Also, after controlling for common trade partners the effect of bilateral trade falls.

Columns 11 and 12 (bottom panel) extend the time period from 1962 to 2016. This extension reduces the size of the sample of SOEs by more than half but the results still hold. Columns 13 and 14 show the results when GDP movements during the Global Financial Crisis (2007-09) are not included. Columns 15 through 18 use various timing for the trade shares that weight foreign GDP to get the trade partner cycle. Whether we use mean trade shares over the whole sample or even changing trade shares over time, the results are the same. Finally, we extend the Hamilton regression used to detrend the data to include an additional lag, columns 19 and 20. In all cases, the results hold.

Table 9: Trade Comovement and Trade-Partner Comovement - Robustness

	Baxter and King			Log-Diff	Hodrick-Prescott		TOT		GLI	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$+1_{SD}\ TI_{GDP}$	3.2***	2.8***	2.9***	2.5***	3.5***	2.6***	4.8***	3.8***	5.9***	4.5***
	(0.3)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.4)	(0.4)	(0.8)	(0.8)
$+1_{SD}\ Comov_{TPC}$		2.2***		2.7***		5.0***		4.6***		4.4***
		(0.5)		(0.5)		(0.5)		(0.7)		(0.8)
$+1_{SD}\ Comov_{TOT}$								2.8***		
								(0.4)		
N	9448	9448	9448	9448	9448	9448	3386	3386	1516	1516
R^2	0.28	0.28	0.16	0.16	0.19	0.20	0.21	0.23	0.37	0.38
	1962-2016			No Recession	Moving shares		Mean shares		Two lags	
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
$+1_{SD}\ TI_{GDP}$	4.9***	4.2***	3.7***	2.6***	3.6***	2.7***	3.6***	2.8***	3.5***	2.8***
	(0.5)	(0.6)	(0.4)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
$+1_{SD}\ Comov_{TPC}$		1.8**		5.3***		4.4***		3.8***		3.7***
		(0.9)		(0.5)		(0.4)		(0.4)		(0.5)
N	2150	2150	9448	9448	9448	9448	9448	9448	9448	9448
R^2	0.28	0.29	0.15	0.16	0.22	0.22	0.22	0.22	0.24	0.24

* $p < .10$, ** $p < .05$, *** $p < .01$
Coefficients and standard errors are in percentage points.

All robustness checks are for the IV regression using only SOEs. TOT stands for terms of trade and GLI for intra-industry trade index.