Unbalanced Trade:
Is Growing Dispersion from Financial or Trade Reforms?*

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Abstract

We study the reasons for the large, coincident increases in unbalanced international trade and overall trade from 1970 to 2019. We show that these two salient features–a rise in net and gross international trade–are largely a consequence of a reduction in intratemporal trade barriers rather than a substantial reduction in the frictions on intertemporal trade or greater asymmetries in business cycles. Beyond explaining changes in the distribution of gross and net trade, the decline in intratemporal trade frictions is consistent with a fall in the dispersion across countries in other key macro time series, including the real exchange rate, terms of trade, export-import ratio, relative spending, and relative GDP.

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1 Introduction

Global trade has grown substantially unbalanced since the 1970s. Countries now run larger trade deficits and surpluses than 50 years ago. As shown in Figure 1, the distribution of trade balances for 183 countries in the 1970s is more tightly centered around zero than that in the 2010s. The median absolute deviation from balanced trade nearly doubles from 5.4 percent to 9.4 percent. While global trade imbalances have been rising, their underlying driving forces are still not well understood. Consequently, these trade imbalances have become politically contentious and have affected policies.[1] The aim of this paper is to quantify the key economic forces that have led to the large increase in trade imbalances globally over the period from 1970 to 2019.

Our paper makes three contributions. First, we offer a novel way to organize the changes in the distribution of economic activity over time. Specifically, we study how the cross-sectional dispersion in key macroeconomic times series–output, expenditures, relative prices and net trade–change over time and with trade. Second, we develop a stochastic multi-country model with a rich set of trade and financial frictions to confront these changes. The model has some of the rich heterogeneity from the quantitative trade literature along with uncertainty and the key features in the business cycle literature used to study international transmission. And third, we emphasize the key role of the elasticity of the export-import ratio and the growing synchronization in domestic expenditures in the identification of the structural changes in the global economy between trade and financial reforms in explaining changes in cross-country borrowing and lending over time.

Fundamentally, there are three requirements for a country to have unbalanced trade. First, it must actually trade goods or services. There is no trade between Earth and Mars, so trade is balanced between the planets. Second, countries must trade financial assets, as these assets are needed to finance trade surpluses or deficits. Third, a country must have a reason to run a trade surplus or deficit. This arises from countries facing different economic conditions, either in the past, present, or future. Thus, changes in the distribution of unbalanced trade across countries can reflect changes in these three conditions: trade

[1]For instance, since Donald Trump was elected U.S. President, U.S. trade policy has changed with a goal of reducing the U.S.'s persistent and large trade deficit.

barriers, financial frictions, or asymmetric business cycles across countries.

Out of these three, a few observations suggest that the change in trade barriers is the main driver of increased trade imbalances. First, we do not find any evidence that country-specific shocks to TFP have become more pronounced over time. Second, there is a strong correlation between the growth in trade imbalances and trade integration in the data. Figure 2 scatters the dispersion of cross-country net trade–measured as trade balance to GDP (hereafter, TBY)–against the scale of gross trade, measured by the mean trade share of GDP (hereafter, TRY), for each year from 1970 to 2019. There is a positive relationship summarized by the regression line.[2] Third, that declines in international trade barriers can explain rising borrowing and lending is intuitive since a country closed to international trade is also closed to intertemporal trade. As a country removes barriers to trade in goods and services, the impact of business cycle asymmetries on intertemporal trade and the trade balance will be amplified.

We evaluate the relative contribution of trade and financial integration on the rise of global trade imbalances. We focus on these two aspects of global integration as the main forces that could determine larger movements in both net and gross trade flows. We begin with the observation that features of the movements in the TBY—their size, volatility, and persistence—have changed over time. We propose a simple decomposition of the widening imbalances in TBY that suggests most of these changes are attributed to a larger scale of trade rather than the movements in trade balance as a share of *trade*. Indeed, as a share of trade, we find that dispersion in net trade flows has fallen considerably over time.

We then show how the changes in the trade balance as a share of trade are related to changes in the distribution of economic activity across countries. Following Alessandria and Choi (2021), we leverage the benchmark Armington trade model, which is the core trade block in nearly all international macro models with more than one good. This decomposition allows us to study how the key properties of international macroeconomic variables related to borrowing and lending have changed with trade integration. We show that over time

[2]The positive relationship between dispersion in the net trade and the level of gross trade also holds in the time series for individual countries. In the lower panel of Figure 2, we take each country as a unit of observation and scatter the standard deviation of the TBY against the average TRY. Here too, we find a positive relationship, albeit with less explanatory power and some important outliers.

movements in international relative prices, relative income, and relative expenditures have also become more muted. In some sense, countries are more synchronized than before and so there is less incentive to run trade imbalances. Moreover, the increase in synchronization helps to discern between the effects of financial and trade integration, as these different types of integration differ along this dimension and lead to different predictions in standard models.

To examine the role of trade and financial frictions when the trade balance fluctuates with the shocks generating business cycles, we develop a general equilibrium model of business cycles, international trade, and integration. Our model extends the canonical real business cycle model of Backus et al. (1994) to include many heterogeneous countries experiencing shocks to TFP, financial frictions, and trade barriers. The goods produced in each country are imperfect substitutes and can be traded subject to iceberg shipping costs. Reducing these shipping costs increases trade. We follow Schmitt-Grohé and Uribe (2003) and assume countries can borrow and lend a non-contingent bond at a country-specific interest rate that increases with debt. Unlike most work that sets this elasticity to induce stationarity, we discipline this friction by the movements in net trade flows across countries and over time. We capture financial integration with shocks that reduce the elasticity of borrowing rates to debt.

To be consistent with the data, our model includes two additional trade frictions and an additional financial shock. First, we assume that each country faces an adjustment friction on its import share. This allows the model to capture the slow adjustment to the business cycle and trade integration shocks emphasized in the literature (Ruhl, 2008). Second, we assume that firms charge destination-specific markups that vary with the real exchange rate. This feature allows us to generate incomplete pass-through of exchange rate movements and match the movements in the terms of trade as well as real and nominal net trade flows (Burstein and Gopinath, 2014). Third, we include shocks to the interest rate gap between countries. Itskhoki and Mukhin (2021) suggest that these uncovered interest parity shocks are necessary to capture the high volatility of the real exchange rate, while Mac Mullen and Woo (2023) emphasize these shocks must be paired with dynamic trade adjustment and trade cost shocks to capture net trade flows and business cycle transmission.

We interpret the international time series on business cycles and trade through an 18 country variation of our model with global and country-specific shocks to productivity, trade costs, and financial frictions. The global shocks to trade barriers and cross-border financial frictions drive the global changes in trade integration and cross-country borrowing and lending. They also interact with the country-specific shocks to capture the changing nature of cross-border economic activity. To capture these changes in business cycles requires us to take a second order approximation of the model.

The model is calibrated to be consistent with key features of business cycles as well as the distribution of economic activity across countries and over time. Our model matches successfully the observed increase in the dispersion of the trade balance to GDP with trade, and the fall in the dispersion in the export-import ratio, relative prices, and spending with trade. We show that most of these patterns arise from a decline in global shipping costs, or what we call trade integration. In a counterfactual case when we do not vary the financial friction to international borrowing, the observed pattern changes little. However when we do not vary trade frictions, we are unable to increase the level of trade nor explain how the cross-country nature of economic activity changes with international trade. Moreover, net trade flows become too dispersed for a given level of trade. Reducing financial frictions generates large asymmetries in the distribution of economic activity across countries that are not present in the data.

In summary, our analysis offers several new ways to study the international time series on business cycles and integration. On the data side, guided by theory, we offer several new decompositions of the changing nature of business cycles that are related to trade. We argue that these decompositions are useful for identifying the changes in the source of the changes in the structure of the global economy. On the model side, we build a large multi-country model and estimate the key parameters. Unlike other work that focuses on two countries with uncertainty or many countries under perfect foresight, our analysis has both elements. Moreover, we emphasize that high-order perturbation methods are important to accurately quantify the relationship between trade and financial integration. Our model analysis enables an accounting of the empirical relationships we've uncovered on the changing nature of the macroeconomy with trade integration.

Section 2 explains how our paper relates to previous work. In section 3 we document several features of the data and describe how the distribution of economic activity across countries has changed as the scale of trade increases. In section 4 we develop a stochastic multi-country model. In section 5 we relate the properties of the model to the data. We show how changes in intratemporal and intertemporal trade frictions affect the properties of business cycles. We also demonstrate the key role of some of our modelling assumptions about trade dynamics, pricing, the process on trade shocks, the asset structure of trade, and solution method. Section 6 concludes.

2 Related Literature

Our paper relates to an extensive literature on the determinants of international capital flows. Early work on cross border capital flows focused on the high correlation between domestic savings and investment rates, following Feldstein and Horioka (1980). Tesar (1991) shows that the saving-investment puzzle is substantially mitigated when there are barriers to international trade. An expansive literature attributes the high correlation to financial market incompleteness (Bai and Zhang, 2010). Gourinchas and Jeanne (2013) also study the dynamics of capital flows from 1980 to 2000.

Our work also relates to literature on international risk sharing. Lewis (1996) uses a large sample of countries to demonstrate the lack of international risk sharing. Backus and Smith (1993) test international risk sharing with consumption and real exchange rate data. Heathcote and Perri (2004) study the decline in consumption co-movement between the United States and Europe following an increase in cross-border equity flows. Heathcote and Perri (2013) study how cross-border equity flows increase with reductions in trade costs. Bai and Zhang (2012) explains why there is little improvement in international risk sharing among developed and emerging economies after an increase in international debt flows. Our paper considers both trade and financial frictions in a many country general equilibrium model. We use the salient features of cross-country capital flows, relative prices, and trade integration to disentangle the importance of the two frictions.

A more recent literature attributes the growth in trade imbalances to financial asymmetries across countries. For instance, Choi et al. (2008) and Kehoe et al. (2018) attribute the rise in U.S. borrowing and China's lending to differences in the discount factor across countries. Likewise, Mendoza et al. (2009) attribute these different financial conditions to differences in the country-specific idiosyncratic risk in the presence of market incompleteness, while Caballero et al. (2008) emphasize differences in the ability of countries to produce safe assets. Most analyses abstract from changes in trade integration over time and often focus on one-good models.[3] For example, Ohanian et al. (2018, 2023) study the determinants of capital flows across different regions of the world in overlapping windows to our sample in a one good model.

Our paper expands on recent efforts to bridge the gap between international trade and international macroeconomics and finance. Starting with Obstfeld and Rogoff (2000), a series of papers have explored the role of trade barriers in aggregate fluctuations and international capital flows, (Alessandria and Choi, 2021, Barattieri, 2014, Eaton et al., 2016, Fitzgerald, 2012, and Mac Mullen and Woo, 2023). Most closely related is Alessandria and Choi (2021) who study the role of trade integration in explaining the growing trade deficits of the U.S. over time in a two country model of the U.S. and the rest of the world. That model is estimated to match the path of business cycles and trade integration. Here we consider the effects of integration and borrowing and lending for a much broader set of countries. Our model also includes capital and a richer set of financial shocks.

Our paper departs from the large multi-country models that since Dekle et al. (2007) largely treat trade balances as exogenous shocks. In this spirit, several recent papers also study the effects of trade integration on cross border financial flows in many country international trade models (see Reyes-Heroles, 2016 and Sposi, 2022).[4] Unlike these papers, which focus on a perfect foresight economy, we explicitly allow for uncertainty about trade policy and aggregate shocks. These added features are necessary to capture the nature of business cycles and the impact of uncertainty on international risk sharing and capital flows. Our

[3]Recent prominent examples of analyses of current account dynamics in one-good models include Atkeson et al. (2022) and Mendoza and Quadrini (2023).

[4]Cuñat and Zymek (2024) also study imbalances but focus more on the source of bilateral imbalances rather than the growth in aggregate imbalances. Dix-Carneiro et al. (2023) study the dynamics of trade integration in a model of labor adjustment and unbalanced trade. Kleinman et al. (2023) also study a multi-country model of capital and trade flows but with different capital market frictions and focus on transition dynamics.

model also brings in several important frictions related to trade adjustment and pricing that are common in the international macro literature and matter for our quantification.

Building on the work of Kose and Yi (2006), several papers have studied how business cycles have changed with trade integration (Caselli et al., 2019; Bonadio et al., 2021; Miyamoto and Nguyen, 2024; Avila-Montealegre and Mix, 2024). Our paper differs in its focus on the changes in the distribution of trade imbalances[5] and the distribution of economic activity across countries as well as in our modelling of trade as a stochastic process and explicitly accounting for the transition to a more open economy.

3 Empirics

To better understand the driving forces behind cross-country borrowing and lending, we investigate the relationship between net and gross trade flows across countries and over time, as well as their interaction with macroeconomic asymmetries across countries. We organize our analysis using the constant elasticity of substitution (CES) demand system from the standard Armington trade model. From that framework it is clear that net trade flows are related to cross-country asymmetries, summarized by relative prices and relative expenditures, and the level of trade. We then turn to the data to show that while net flows as a share of GDP have become more dispersed over time, this is due to an increase in gross trade rather than an increase net trade flows as a share of trade. Moreover, asymmetries in business cycles have become smaller over time. The moments from this analysis are our model targets.

3.1 Organizing Structure

Following Alessandria and Choi (2021), we organize our empirical work around a constant elasticity of substitution (CES) demand system. This system assumes that net trade flows are tightly linked to gross trade flows, relative prices, relative expenditures, and trade wedges. Here trade wedges are the deviations from theoretically predicted movements in net trade

[5] Much of this literature explicitly abstracts from trade imbalances, see Caselli et al. (2019); Bonadio et al. (2021).

flows (Levchenko et al., 2010) that can be attributed to changes in trade costs and tastes.

Our decomposition of the trade balance has two steps. First, we mechanically decompose[6] the trade balance as a share of GDP into two terms: trade share of GDP and the ratio of trade balance to trade,

$$\underbrace{\frac{X-M}{Y}}_{TBY} = \frac{X-M}{X+M} \cdot \underbrace{\frac{X+M}{Y}}_{TRY} \tag{1}$$

where X is home exports to the rest of world (henceforth, ROW), M is home imports from ROW, and Y is GDP. The ratio of the trade balance to trade is closely approximated by one half of the log of the ratio of exports to imports,

$$\frac{X-M}{X+M} \approx 0.5 \ln \frac{X}{M}.$$

Second, we further decompose the export-import ratio, $\ln X/M$, using the Armington model, the standard trade block in most multi-good international macro models. In this model with imperfectly substitutable home and foreign goods and a CES demand system, exports and imports are given by

$$X = \omega^* \left(\frac{p\tau^*}{P^*}\right)^{-\gamma} D^*, \qquad M = \omega \left(\frac{p^*\tau}{P}\right)^{-\gamma} D,$$

where γ is the elasticity of substitution between home and foreign goods (the Armington elasticity), ω denotes the taste or bias for imports, τ is an ad valorem trade cost or tariff, p is the price of the differentiated good before any trade cost or tariff, P is the price level in domestic, D is domestic spending on tradables, and an asterisk refers to the foreign analogues to a home variable. Notice we allow the cost of exporting to differ from importing, i.e. $\tau \neq \tau^*$. Defining the real exchange rate, $rer = \ln P^*/P$, terms of trade, $tot = \ln p/p^*$, trade wedge, $\xi = \ln(\omega\tau^{-\gamma})$, and expenditures, $d = \ln D$, we can rewrite the export-import ratio as

$$\ln \frac{X}{M} = (\xi^* - \xi) - \gamma(tot - rer) + (d^* - d). \tag{2}$$

[6]We focus on the decomposition in real trade flows, but this is easily extended to nominal terms.

Hence, the export-import ratio is determined by cross-country differences in trade wedges, international relative prices, differences in expenditures, and the Armington elasticity. Note that equation (2) holds regardless of the assumptions on the structure of asset or goods markets, even though these assumptions could influence prices and expenditures. Importantly, most terms have clear empirical counterparts.

3.2 Data

We study the properties of these determinants of the trade balance in a sample of 36 countries that includes both developed and emerging countries. We consider countries in the Penn World Table 10.0 for which we have data since 1970 and are covered in the broad basket of the Bank for International Settlements (BIS) Effective Exchange Rates. In Appendix B, we derive similar results for different samples of countries.

The red dashed line in Figure 3 shows that the median level of trade, TRY, rises over time. At the start of the sample in 1970, trade was about 26 percent of GDP. By 2019, trade had almost doubled to 51 percent of GDP. Trade grows persistently until the Great Recession, peaking at nearly 60 percent of GDP, but has since fallen. We also plot the dispersion in the trade balance, TBY, in solid blue, as measured by its annual interquartile range across countries. The two series are positively correlated. To further understand the role of trade in the widening trade imbalances, we construct a counterfactual measure of dispersion that holds the trade share constant for each country at its level in 1971. With this alternative measure, which is each country's trade balance as a share of trade, the positive relationship between dispersion in the trade balance and trade disappears. In fact, this measure of dispersion now falls over time. This suggests that the growth in the dispersion of the trade balance may be attributed to trade integration amplifying the movements in the trade balance to trade ratio.

The upper panel of Figure 2 presents this positive relationship between TBY dispersion, measured in nominal terms, and mean TRY in a scatter plot. That is, the increase in trade is associated with an increase in dispersion in borrowing and lending. The elasticity of dispersion to trade is about 11 percent. To compare, we scatter the annual cross-country dispersion of the log export-import ratio in the upper panel of Figure 4. Over time, the dispersion of the export-import ratio declines. The lower panel of Figure 4 shows that using the country as a unit of observation that the volatility of the export-import ratio also falls. Thus, similar to the annual cross-sectional evidence, net trade as a share of GDP becomes more dispersed with trade while the export-import ratio becomes less dispersed.

These two graphs imply that the growth in trade, rather than the increase in the trade balance over trade, accounts for the rising dispersion in the trade balance, based on the decomposition of equation (1). This result is consistent with our finding from the counterfactual in Figure 3.

We next use our theoretical decomposition from the Armington model to uncover the source of the decline in the cross-country dispersion in the export-import ratio with trade. Specifically, we construct measures of the cross-country dispersion of the terms of trade, real exchange rate, and domestic expenditures, which is the sum of consumption, investment, and government spending. For dispersion in relative expenditures, for each country we construct a measure of foreign expenditures using the country's BIS trade weights. Also, for relative prices, we focus on the annual changes rather than the levels. The first three graphs of Figure 5 present the scatter plots of these measures of dispersion against the mean trade share to GDP in each year. In all panels of Figure 5, we observe a negative relationship: as the trade share of GDP increases over time, dispersion in relative prices and relative spending falls.

It is worth noting that the growing dispersion in the trade balance, TBY, does not appear to be attributed to a change in the underlying productivity shocks. Figure 6 shows that the cross-country dispersion of TFP, measured with its interquartile range, has not increased during the last five decades. Aggregate output also becomes less dispersed across countries over time, as shown in the lower right panel of Figure 5.

Equation 2 shows that the importance of relative prices, expenditures, and trade costs depends on the Armington elasticity. Our decomposition of net trade flows into observables allows us to estimate the Armington elasticity by treating the trade wedge as a residual. This allows us to discipline the relative importance of relative prices and relative expenditures in net trade flows. Following Alessandria and Choi (2021), we consider three types of regressions: in levels, in first differences, and with an error correction term, to allow for different short-run and long-run trade adjustments. For each of the three types of regressions, we consider two cases, one with the constraint on the coefficient of short-run relative spending to be one as theory suggests, and the other where the coefficient is estimated. Using our panel of 36 countries during the period of 1970-2019, Table 1 reports the results.

The regression in levels does not fit the data very well. When estimated in the first differences, with and without the error correction term, the Armington elasticity is significant, around 0.23, regardless of how we treat the coefficient on expenditures. To distinguish short-run and long-run effects of relative prices on the export-import ratio, we consider the error correction model, which has a long tradition in trade elasticity estimation (see Hooper and Johnson, 2000). Columns (5) and (6) show that the long-run elasticity is higher than in the short run, closer to 3.5. The gap between the short-run and long-run Armington elasticity suggests we will need a model with a time-varying Armington elasticity lest we attribute movements in net trade to shocks.

3.3 Reduced Form Analysis

We now show that trade integration remains the key explanatory variable even when we bring other variables on global asymmetries into the analysis. Specifically, we undertake a reduced-form regression analysis that relates the time-series variation in the cross-country dispersion in the trade balance to the time-series variation in trade integration and other business cycle variables. Table 2 presents the results.

The share of trade to output, TRY, plays a crucial role in explaining the variation in dispersion in the trade balance, TBY, over time; it alone explains about 50 percent of the variation in the annual dispersion in the trade balance, as shown in the R-square of regression (1). Including other regressors, such as median output growth, output growth dispersion, real exchange rate dispersion, and oil prices, as in regressions (2)-(7), raises the explanatory power only marginally. Furthermore, excluding the trade share as in the regression (8)-(9) lowers the R-squared significantly. In all cases, the mean trade-to-output ratio is significant, implying a percentage point higher TRY is related to 0.18-0.21 percentage point higher dispersion in TBY.

A competing hypothesis is that financial integration that allows for larger foreign holdings of domestic assets has enabled more borrowing and lending. To explore this mechanism, we introduce a measure of gross financial flows from Milesi-Ferretti (2021), measured by the median annual gross position as a share of GDP, $\frac{A_{it}+L_{it}}{Y_{it}}$, where A_{it} denotes gross foreign assets, and L_{it} denotes gross foreign liabilities. For the median country, these gross positions have grown substantially over time, from about 50 percent in 1970 to 300 percent in 2019. In column (10), we see that this variable alone explains about 20% of the dynamics of the dispersion in borrowing and lending. However, when we include our trade measure too in column (11), we find trade to be more important, and financial integration now comes in negative, and the explanatory gain over including our trade measure alone is about nine percentage points.

In summary, we document that over time, the trade balance as a share of GDP has become more dispersed across countries owing primarily to increased trade integration. The trade balance as a share of GDP is linked to trade shares, relative prices, and relative spending across countries, according to standard theories. We find that neither relative price, relative spending, nor TFP can explain the growing disparities in trade balance because all three have declining dispersion over time. In relative terms, the world has seen a 'Great Moderation' in relative output, prices, and expenditures, as well as growing economic integration but widening dispersion in the trade balance.

4 Model

We now develop a multi-country variation of the canonical international business cycle model of Backus et al. (1994) that includes global and country-specific shocks to trade and financial frictions. In each country, there is a non-tradable final good used for consumption and investment, made by combining a different mix of imperfectly substitutable intermediates from all countries. Country-specific intermediates are produced using domestic capital and labor. There are country-specific shocks to the productivity of producing these intermediates. Trading these intermediates across countries is subject to a stochastic bilateral trade cost. We also incorporate adjustment costs in the use of intermediate imported inputs to produce the final good, and intermediate producers set a destination-specific price (pricing-to-market) as these have been shown to be crucial to explain the dynamic pattern between relative prices and relative trade flows (see Rabanal and Rubio-Ramirez, 2015 and Alessandria and Choi, 2021).

As our aim is to allow for changes in trade and financial barriers over time, we assume financial markets are incomplete.[7] We take the simplest model of financial market incompleteness that allows for cross-country borrowing and lending. As in Baxter and Crucini (1995), Heathcote and Perri (2002), and Schmitt-Grohé and Uribe (2003), the consumers can trade a non-contingent bond denominated in units of the final good of country 1. Beyond being non-contingent, the interest rate is debt-elastic so that taking on more debt increases the borrowing rate. We allow for shocks to the debt elasticity parameter to capture changes in financial integration. Following Devereux and Engel (2002), we introduce country-specific uncovered interest parity (UIP) shocks to the international borrowing rate that create an additional wedge between the returns to saving across countries. These shocks play a prominent role in recent quantitative studies of international transmission (Itskhoki and Mukhin, 2021).

Consumers Consumers in country n choose consumption, leisure, investment, and bonds to maximize welfare

$$\max \ E_0 \sum_{t=0}^{\infty} \beta^t u(c_{nt}, \bar{h}_n - h_{nt})$$

subject to a sequence of budget constraints

$$c_{nt} + i_{nt} + e_{nt} q_{nt} b_{nt+1} = w_{nt} h_{nt} + r_{nt}^k k_{nt} + e_{nt} b_{nt} + \Pi_{nt}$$

where $u(c_{nt}, \bar{h}_n - h_{nt}) = \frac{[c_{nt}^{\mu}(\bar{h}_n - h_{nt})^{1-\mu}]^{1-\sigma}}{1-\sigma}$, q_{nt} is the country-specific discount rate of a non-contingent bond denominated in units of country 1 consumption, $e_{nt} \equiv P_{1t}/P_{nt}$ is real exchange rate defined as the final good price relative to country 1, and Π_{nt} is the dividend

[7]With complete financial markets, we get similar results between trade integration and the dispersion of the trade balance, but with a higher level of overall trade imbalances.

payments from domestic firms. The evolution of the capital stock is given by

$$k_{nt+1} = (1-\delta_k)k_{nt} + i_t - \frac{\psi}{2}\left(\frac{k_{nt+1}}{k_{nt}} - 1\right)^2 k_{nt},$$

where we include a quadratic capital adjustment cost. Following Schmitt-Grohé and Uribe (2003), we assume the country faces an interest rate that depends on the endogenous world interest rate r_t, the debt of the country $-b_{nt}$, and a country-specific interest rate shock ϕ_{nt},

$$1/q_{nt} = r_t + F_t\left(e^{-(b_{nt}-\bar{b}_n)} - 1\right) + \left(e^{\phi_{nt}-1} - 1\right)$$

where F_t governs the interest rate elasticity to debt. Let λ_{nt} be the marginal utility of consumption. We can define the consumers' stochastic discount factor Λ_{nt} as $\Lambda_{nt} = \frac{\lambda_{nt}/P_{nt}}{\lambda_{0t}/P_{n0}}$.

Final good producers Final good producers are competitive and combine all home and foreign intermediates with a CES aggregator. To allow for the short-run response of trade to changes in relative prices to differ from the long-run one, we follow Ravn et al. (2010) and assume deep habits in import demand, which has the feature of habit formation in the level of individual goods. Specifically, the final good production D_{nt} in country n is given by

$$D_{nt} = \left\{\sum_{m=1}^{N} \omega_{nm}^{\frac{1}{\gamma}} \left[\frac{a_{nmt}}{(a_{nm,t-1}/D_{nt-1})^{\frac{\delta}{(1-\delta)}\frac{1}{(1-\gamma)}}}\right]^{\frac{\gamma-1}{\gamma}}\right\}^{\frac{\gamma}{\gamma-1}} \tag{3}$$

where a_{nmt} is the intermediate good produced in country m at time t, γ is the long-run elasticity, and the parameter δ determines the degree of deep habit. When $\delta = 0$ we recover the standard CES function.

Final goods producers at country n incur an iceberg trade costs, τ_{nmt}, when importing goods from country m. Taking as given the aggregate prices P_{nt} and the intermediate goods prices $\{p_{nmt}\}$, a final good producer chooses inputs $\{a_{nmt}\}$ to solve the following problem,

$$\max \quad E_0 \sum_t \Lambda_{nt}\left[P_{nt}D_{nt} - \sum_{m=1}^{N} p_{nmt}\tau_{nmt}a_{nmt}\right].$$

The implied demand function is given by

$$\ln \frac{a_{nmt}}{D_{nt}} = (1-\delta)\left[\ln \omega_{nm} - \gamma \ln \frac{p_{mnt}\tau_{mnt}}{P_{nt}}\right] + \delta \ln \frac{a_{nm,t-1}}{D_{nt-1}}. \tag{4}$$

Note that we assume that each final goods producer views $a_{nm,t-1}$ as an economy-wide value and does not internalize the impact of its current choice of $a_{nm,t}$ on future D_{nt+1}.

Consider a case with two countries $\{H, F\}$ and let variables with an asterisk denote foreign variables. Under the demand function (4), the export-import ratio equals,

$$\ln \frac{X_t}{M_t} = (1-\delta)\ln \frac{\omega^* \tau_t^{*-\gamma}}{\omega \tau_t^{-\gamma}} + (1-\delta)\gamma \ln\left(\frac{p_{Ft}}{p^*_{Ht}}\frac{P^*_t}{P_t}\right) + \delta \ln \frac{X_{t-1}}{M_{t-1}} - \delta \frac{D^*_{t-1}}{D_{t-1}} + \ln \frac{D^*_t}{D_t},$$

This condition closely relates to the ECM specification in the empirical section.

Intermediate good producers An intermediate goods producer uses domestic labor, h_{nt}, and capital, k_{nt}, to produce a differentiated product with a Cobb-Douglas production function $y_{nt} = z_{nt}k^{\alpha}_{nt}h^{1-\alpha}_{nt}$ where z_{nt} is the productivity. Taking as given the prices $(p_{nt}, P_{nt}, w_{nt}, r^k_{nk})$, a producer solves the following problem,

$$\max_{h_{nt},k_{nt}} \quad \frac{p_{nt}}{P_{nt}}y_{nt} - w_{nt}h_{nt} - r^k_{nt}k_{nt}.$$

In the data, the real exchange rate is more volatile than the terms of trade and this increased volatility has been attributed to pricing to market (PTM). As in Alessandria and Choi (2021), we take a simple approach to modeling PTM and assume that firms charge a markup over marginal cost that is a function of local market conditions proxied by the real exchange rate.[8] This pricing structure implies that when the dollar appreciates all firms selling in the U.S. charge high markups while all firms selling outside the U.S. would reduce their markup.[9]

[8] Alessandria and Kaboski (2011) and Drozd and Nosal (2012) show that a model with consumer search frictions yields price setting with these features.

[9] This formulation can be justified with a nested CES framework in which country specific varieties are differentiated and the markup depends on the real exchange rate in the way described above.

Specifically, the price of country n producer selling to country m, p_{mnt} is given by

$$\frac{p_{mnt}}{P_{mt}} = \frac{\gamma \left(\frac{P_{nt}/P_{mt}}{\overline{P_n/P_m}} \right)^{\theta}}{\gamma \left(\frac{P_{nt}/P_{mt}}{\overline{P_n/P_m}} \right)^{\theta} - 1} \cdot \frac{1}{z_{nt}} \left(\frac{1}{\alpha} \right)^{\alpha} \left(\frac{1}{1-\alpha} \right)^{1-\alpha} r_{nt}^{k\alpha} w_{nt}^{1-\alpha}$$

Equilibrium In equilibrium, consumers and firms in each country take as given prices and optimize their decisions. The following market clearing conditions hold: $D_{nt} = c_{nt} + i_{nt}$, $y_{nt} = \sum_m \tau_{mn,t} a_{mn,t}$, and $\sum_n b_{nt} = 0$.

5 Quantitative Analysis

Here we describe our parameterization of the model and how we choose parameters to match data moments on trade integration, trade balance dynamics, international relative prices, and business cycles. We then explore the workings of our model by turning off different sources of international integration. These experiments point to changes in international trade barriers mattering most for the growth in unbalanced trade across countries over time.

The model economy is calibrated to 18 asymmetric countries. This economy captures the key moments of our sample of 36 countries described in section 3. While this is a sparse representation of the world economy, we find that adding more countries does not alter the relationship between the cross-country dispersion in borrowing and lending and the mean trade share (see Appendix 5.4). The main challenge to including more countries is computational, as we need to take a second order approximation of the model to capture the changing nature of business cycles with trade and financial integration.

5.1 Parameterization

We choose the parameters in our model to match key features of the distribution of economic activity in the global economy over time. We begin by describing the stochastic process for shocks. We have shocks to bilateral trade costs, international financial frictions, and productivity. For most shocks we allow for common global shocks and country-specific shocks.

We assume the iceberg trade cost, $\tau_{nm,t}$, between any pair of countries n and m has two components, a common world trade shock, ξ_{ct}, and a differential trade cost shock, $\xi_{nm,t}$, which come in with the opposite sign for the two countries.[10] Specifically, for $n > m$,

$$\ln \tau_{nm,t} = \ln \xi_{ct} + 0.5 \ln \xi_{nm,t} \tag{5}$$

$$\ln \tau_{mn,t} = \ln \xi_{ct} - 0.5 \ln \xi_{nm,t} \tag{6}$$

where both the common and differential trade cost shocks follow an AR(1) process,

$$\begin{aligned} \xi_{ct} &= \bar{\xi}_c e^{\hat{\xi}_{ct}}, & \hat{\xi}_{ct} &= \rho_{\xi_c} \hat{\xi}_{ct-1} + \varepsilon_{\xi_{ct}}, & \varepsilon_{\xi_{ct}} &\sim N(0, \sigma_{\xi_c}), \\ \xi_{nm,t} &= \bar{\xi}_d e^{\hat{\xi}_{nm,t}}, & \hat{\xi}_{nm,t} &= \rho_{\xi_d} \hat{\xi}_{nm,t-1} + \varepsilon_{\xi_{nmt}}, & \varepsilon_{\xi_{nmt}} &\sim N(0, \sigma_{\xi_d}). \end{aligned}$$

Note that all the differential trade costs, $\xi_{nm,t}$ $\forall n > m$ share the same persistence, ρ_{ξ_d}, and volatility, σ_{ξ_d}. There is no trade cost within a country, i.e. $\tau_{nm,t} = 1$ for $n = m$.

There are two international financial frictions, $\{\phi_{nt}, F_t\}$. The interest rate shock, ϕ_{nt}, of country n is country-specific and follows an AR(1) process

$$\phi_{nt} = e^{\hat{\phi}_{nt}}, \quad \hat{\phi}_{nt} = \rho_\phi \hat{\phi}_{nt-1} + \varepsilon_{\phi_n t}, \quad \varepsilon_{\phi_n t} \sim N(0, \sigma_\phi). \tag{7}$$

The debt elasticity, F_t, is common to all countries, and it follows an AR(1) process around the steady state $\bar{F}$,

$$F_t = \bar{F} e^{\hat{F}_t}, \quad \hat{F}_t = \rho_F \hat{F}_{t-1} + \varepsilon_{Ft}, \quad \varepsilon_{Ft} \sim N(0, \sigma_F).$$

A country n's productivity shock is given as

$$\ln z_{nt} = \ln \bar{z}_n + \ln z_{ct} + \ln z_{dnt}.$$

It evolves around its steady state, $\bar{z}_n$, and is subject to the global shock, z_{ct}, and country-

[10] It is straightforward to add a bilateral common shock process to account for bilateral trade agreements.

specific shock, z_{dnt}, all which follow an AR(1) process,

$$\ln z_{ct} = \rho_{zc} \ln z_{ct-1} + \varepsilon_{zct}, \quad \varepsilon_{zct} \sim N(0, \sigma_{zc})$$
$$\ln z_{dnt} = \rho_{zd} \ln z_{dnt-1} + \varepsilon_{zdnt}, \quad \varepsilon_{zdt} \sim N(0, \sigma_{zd}).$$

5.2 Assigned and matched parameters

We divide the parameters into two groups. The first group is set externally, and the second group is estimated jointly to match the relevant cross-section and time-series moments. Table 3 reports the parameter values.

The first group includes the discount factor, β, capital share, α, depreciation rate, δ_k, the intertemporal elasticity of substitution, $1/\sigma$, the preference weights on consumption of foreign goods, ω_{mn}, the average debt, $\bar{b}_n$, and persistence parameters of the shocks, ρ_{ξ_c}, ρ_{ξ_d}, and ρ_{z_d}. Our model is an annual model, we therefore choose $\beta = 0.96$ to get the annual interest rate of 4%. The capital share α is 0.36, which is consistent with the labor share in the U.S. The depreciation rate is 10% annually. We set the intertemporal elasticity of substitution, $1/\sigma$, as 0.5, which implies a standard risk aversion of 2. The steady state debt level, $\bar{b}_n$, equals zero. We set the persistence of the common productivity shocks as $\sigma_{z_c} = 0.96$ and the persistence of the differential shocks as $\sigma_{z_d} = 0.98$, respectively, and conduct sensitivity analysis on them (Appendix C).

The 17 parameters in the second group we use to match moments are

$$\Theta_M = \{\bar{\xi}_c, \bar{z}_n, \gamma, \delta, \theta, \bar{F}, \rho_F, \sigma_F, \rho_\phi, \sigma_\phi, \rho_{\xi_c}, \sigma_{\xi_c}, \rho_{\xi_d}, \sigma_{\xi_d}, \sigma_{z_c}, \sigma_{z_d}, \psi\}. \tag{8}$$

We first choose common mean trade costs, $\bar{\xi}_c$, and mean productivity, $\bar{z}_n$, to generate the average observed trade share over output and the relative GDP of the countries, respectively, in the steady state of our model. Then we choose the remaining parameters jointly with the country-level business cycle moments and patterns of cross-country dispersion with trade. For the business cycle moments, we focus on a set of seven standard moments including the magnitude and persistence of output, consumption, and investment. We also consider standard open economy moments including the Backus-Smith condition and business cycle comovement. Moreover, we target six cross-sectional moments that relate to trade. That is, we consider the regression coefficients of TBY, export-import ratio, real exchange rate, and terms of trade in relation to TRY. The moments we target to pin down the parameters are presented in Table 4 along with the untargeted moments.

We solve our model using perturbation methods. As we are interested in the effect of shocks that alter the structure of business cycles, we require a second-order approximation of the model. With many countries, this greatly increases computational time. We construct the moments based on a 10,000 year simulation of the model. The cross-sectional moments are based on 50 year windows of our simulations. We take an indirect inference approach to identify the parameters, by choosing them to minimize the distance between the model moments and the data. The distance is calculated by the square of the quadratic norm. The model generates business cycle moments consistent with the data and captures the changing nature of business cycles with trade integration. We discuss the results and the features of the model delivering these results in the following sections.

Every parameter matters for the general equilibrium and affects all the moments. However, there is a clear correspondence between certain parameters and moments. The Armington elasticity, γ, disciplines the response of prices and matters for the comovement of integration and global dispersion in the trade balance. The resulting γ is 3.22. The pricing-to-market parameter, θ, governs the relative volatility of the terms of trade and real exchange rate. The input adjustment cost, δ, determines the differences between short- and long-run trade elasticities. When θ and δ equal zero, we have the standard model with no trade adjustment dynamics and complete pass-through. The estimation calls for positive values: $\theta = 0.28$ and $\delta = 0.94$. Both the financial friction, governed by debt elasticity, $\bar{F}$, and the UIP wedge, ϕ, and trade barrier, ξ_c, affect cross-border capital flows. A higher debt-elasticity $\bar{F}$ reduces intertemporal risk-sharing and lowers the volatility of the trade balance. It also allows the model to match the observed dispersion in export-import ratio. Its estimated steady state level is $\bar{F} = 2.12$, volatility is $\sigma_F = 0.02$, and persistence is $\rho_F = 0.87$. The process for the common trade barrier, ξ_c, governs the volatility and the autocorrelation of gross trade. The estimated common trade shock is $\sigma_{\xi_c} = 0.01$ and $\rho_{\xi_c} = 0.99$. The process for the differential trade barrier, ξ_d, matters for the volatility of the real exchange rate as well as consumption. We find that $\sigma_{\xi_d} = 0.05$ and $\rho_{\xi_d} = 0.99$. Global trade shocks are much more persistent than global changes in financial frictions. Common and differential productivity are related to the volatility of GDP and its cross-country correlation, respectively. Each of their volatility is $\sigma_{z_c} = 0.02$ and $\sigma_{z_d} = 0.04$. The capital adjustment cost parameter, ψ, is pinned down by the volatility of investment, which result in the value of $\psi = 10.10$.

In our benchmark estimation, we let the debt elasticity F, UIP wedge ϕ, and trade cost ξ_c vary over time, following the estimated process. For example, a global shock to the debt elasticity parameter is captures periods of high and low costs to international borrowing and lending. We then consider counterfactual cases when there are no changes in financial or trade frictions.

5.3 Model Results

Table 4 presents the targeted and untargeted moments. Figure 7 visualizes the upper panel of Table 4 with the scatter plots of the standard deviations with different levels of gross trade.

Our estimated model closely matches the observed changes in global trade balance dispersion with world trade integration. When the gross trade flows, measured with TRY, increase from 25% to 65%, dispersion in net capital flow, TBY, increases across countries, with the standard deviation increasing from 0.03 to about 0.1.

Moreover, high trade openness in the model leads to a lower dispersion in the export-import ratio as in the data. With a one percentage point increase in TRY, the dispersion in export-import ratio decreases by 0.39, both in model and data. The reason is that lower trade costs promote risk sharing and the reallocation of capital across countries. This leads to more dispersed net trade flows and aligned movement of exports and imports.

Our model also successfully produces the observed average volatility in the real exchange rate, terms of trade, and relative spending with economic integration. Higher economic integration also makes the relative prices less dispersed across countries. Relative spending becomes less dispersed when the world becomes more open, in both the data and the model.

Financial Integration and Global Dispersion: We now explore the role of changes in financial frictions in the aggregate behaviour of our model economy. To do so, we hold the financial frictions constant over time. Specifically, we eliminate shocks to the debt elasticity parameter and UIP ($\sigma_F = \sigma_\phi = 0$). Results are reported in the column "No financial integration" of Table 4 and in Figure 8. We find that overall dispersion in the trade balance as a share of GDP, TBY, is a bit lower and thus its elasticity with trade is a bit flatter. The movements of the export-import ratio, X/M, also become smaller. Relative prices are much less volatile, as can be seen with almost zero dispersion in RER and TOT across all levels of trade. Furthermore, without variations in financial frictions, the correlation between relative consumption and the real exchange rate becomes positive. Investment and consumption become less volatile. However, the absence of changes in intertemporal financial frictions matters little for the observed patterns in net and gross trade flows.

Most of the effect of financial integration is attributed to the shocks to the interest premium. In the column "No F shocks" of Table 4 and in Figure 8, we show a case when we only turn off the shocks to the debt elasticity ($\sigma_F = 0$) while keeping the UIP shocks. Almost all of the moments are very close to the baseline case. The dispersion in net trade to output, TRY, increases in gross trade. The volatilities of relative prices, spending, and output are relatively insensitive to the change in F. This shows that the UIP shock plays most of the role in generating volatility in net trade, relative prices, and the wedge between consumption and the real exchange rate. The important role of UIP shocks in the volatility of the real exchange rate is consistent with the work of Itskhoki and Mukhin (2021) and Mac Mullen and Woo (2023).

Trade Integration and Global Dispersion: We now discuss how global trade reforms influence the distribution of business cycles across countries. We eliminate shocks to the common trade shocks that influence the overall level of trade ($\sigma_{\xi_c} = 0$). Results are reported in the column "No trade integration" of Table 4 and in Figure 9. Without these common trade shocks, there are very minor changes in gross trade flows and we lose the significant relationship between net trade flows and trade. Indeed, the relationship between trade and net trade dispersion is almost vertical. Moreover, there are large changes in how our measures of dispersion vary with world trade and the model accounts very little of the variation between these measures and world trade (R^2 are very close to zero).

5.4 Robustness

We now consider how our modeling assumptions influence our results. We start by showing that our results are robust to allowing for the trading of a richer set of financial assets and altering the debt elasticity parameter with country size. We then consider the role of pricing-to-market, trade adjustment costs, the process of the trade cost, the number of countries, and the order of approximation in solving the model on the model's properties. For these exercises we adjust specific parameters without recalibrating the model. The results show that our main findings are robust to these alternative specifications.

Financial Market: We now show that allowing for a richer set of assets yields a similar qualitative relationship between trade integration and the changing nature of net trade flows.

Specifically, we introduce a complete set of contingent claims into our model. With this asset structure, we remove the UIP shocks. Now the model includes the familiar Backus-Smith condition $u_{ci}/P_i = \lambda_i u_{c1}/P_1$ where λ_i is set so that in steady state each country has balanced trade. The remaining parameters are the same as in our baseline calibration. The properties of the model with and without trade integration shocks are reported in the columns "Complete market" in Table 4.

While the model with complete markets is a worse fit to the data, it yields similar qualitative relations between net flows, both measured with the trade balance and export-import ratio, and trade over time. In terms of business cycles and international transmission, we find that consumption and investment are a bit smoother but output is bit more volatile and as we have mentioned the Backus-Smith condition now holds. Introducing complete markets increases net trade flows overall and the elasticity of the dispersion in TBY and export-import ratio with trade.

As before, shutting off the trade shocks yields a large positive relationship between dispersion in the export-import ratio and overall trade (Figure 12). The findings here suggest that changes in financial frictions that bring the world closer to the complete markets allocation should operate much like our model with a non-contingent bond with a falling debt elasticity parameter.

Debt Elasticity: We now show that allowing for a country-specific debt elasticity parameter yields similar predictions as our baseline model. Specifically, we make the interest rate to be elastic to the debt-to-productivity. That is, the interest rate of country n is now

$$1/q_{nt} = r_t + F_t \left(e^{-\left(\frac{b_{nt}}{\bar{z}_n} - \frac{\bar{b}_n}{\bar{z}_n}\right)} - 1 \right) + \left(e^{\phi_{nt}-1} - 1 \right)$$

where $\bar{z}_n$ denotes the steady state level of its productivity. We hold all other parameters constant. The results of this case are reported in the column "Debt elasticity" of Table 4.

This formulation of the debt elasticity friction makes it harder for the smaller countries to borrow and weakens the elasticity of TBY to trade at the country level. Consequently, the elasticity of dispersion of TBY and XM are brought closer to zero. Most other moments have modest changes and we expect that recalibrating the model should yield a marginally better fit to the data overall.

No PTM: To capture the movements in terms of trade and real exchange rate, we introduce a pricing-to-market (PTM) friction. We now eliminate this friction by setting the PTM parameter $\theta = 0$. The results are presented in the column "No PTM" of Table 4 and red circles in Figure 10. The model is a worse fit to the data on several moments, but our main focus on the relationship between net trade and trade integration is unchanged. However, the PTM friction is needed for the real exchange rate to be more volatile than the terms of trade. Moreover, the relationship with trade openness of the real exchange rate movements become weaker, as shown in the smaller slope of ΔRER (-0.06 vs -0.09). Finally, owing to the smaller elasticity of the real exchange rate with trade, the export-import ratio falls with trade about half as much as in the data (-0.21 vs -0.39).

No trade adjustment frictions: Trade takes time to adjust to shocks that move the exchange rate or trade barriers. We capture this feature by introducing a form of external habit in the aggregator. We show that these trade adjustment frictions dampen net trade flows over the business cycle. We now shut this force off by setting $\delta = 0$. Results are shown in the column "No trade adj" of Table 4 and yellow squares of Figure 10. Without the adjustment friction the short-run trade elasticity now is similar to the long-run trade elasticity, which is slightly lower than in our baseline. Aside from leading trade to adjust faster, there are modest changes in the model's business cycle properties. Business cycles are a bit more volatile with investment volatility growing fifty percent. Importantly, the elasticity of dispersion in the trade balance grows more strongly with the level of world trade than our baseline (0.25 vs 0.20). Moreover, the average level of dispersion in the export-import ratio increases substantially (0.77 vs 0.61).

Gradual trade reforms: Our analysis is focused on trade integration occurring through a mean-reverting process of global trade costs. In practice, most trade agreements involve phasing out tariffs in several largely linear steps. For instance, the 1967 GATT round had 5 annual steps, the 1980 GATT round had 7 annual steps, and the 1995 GATT round had 6 annual steps. Regional trade agreements like the European Community and NAFTA are similar. We now redo our analysis with these phaseouts by assuming the following alternative process for the common trade costs. These phaseouts lead to stronger role for trade integration in changing the nature of borrowing and lending than our baseline.

To generate persistent movements in trade growth from trade policy, we add a trend shock to the trade cost, ξ_c:

$$\xi_{ct} = (1-\rho_{\xi c}) \cdot \bar{\xi}_c + \rho_{\xi c} \cdot \xi_{ct-1} + \Delta_{t-1} + \varepsilon_{\xi_c t} \qquad \varepsilon_{\xi_c t} \sim N(0, \sigma_{\xi c}),$$
$$\Delta_t = \rho_\Delta \cdot \Delta_{t-1} + \varepsilon_{\Delta t} \qquad \varepsilon_{\xi_\Delta t} \sim N(0, \sigma_\Delta).$$

For this case, we set $\rho_{\xi c} = 1$ and let $\rho_\Delta = 0.75$. We eliminate the transitory common shocks, $\sigma_{\xi c} = 0$, and set the trend shock to equal 1 percent, $\sigma_\Delta = 0.01$. This captures the persistent movements of trade costs following phased-in reforms. We simulate the model for a 50 year period as in our data and focus on the realization of the shocks that induce world trade to increase from 20 to 70 percent.

In this case, the trade-to-output ratio, TRY, of each country evolves as in Figure 11. As shown in column "Phase-ins" of Table 4, TRY is more persistent than the baseline. The graph is displayed with green triangles in Figure 10. With this alternative structure, we find a slightly stronger relationship between trade integration and dispersion in the trade balance. The elasticity is slightly higher than in the benchmark case (0.24 vs 0.20). Moreover, the other moments including relative prices and quantities and business cycle moments are mostly unchanged with this process of trade reforms.

Number of countries: We focus on the properties of a model with 18 countries, which imposes a significant computation burden, particularly for our moment matching exercise. We show that our results on the source of the relationship between net flows and trade in the model are robust to the number of countries. In particular, we consider increasing the number of countries in the model to 22 countries, and evaluate how dispersion in net trade varies with different sources of integration. For more details, see Appendix D.

For our 22 country case we add 4 countries so that the original distribution of country sizes is similar to our baseline. All other parameters are the same. The result are depicted in Figure 13 and in Table 4 Column "22 countries." This model yields similar moments to our baseline 18 country model. In particular, the dispersions are slightly less elastic to trade, as there are more countries with varying sizes. In any case, however, the moments are all very close to the baseline case.

We also run counterfactual exercises without financial or trade integration. The model results are again consistent with our baseline case. Without financial integration, the dispersions in net trade and relative prices become smaller, while the range of gross trade is unaffected (yellow squares in Figure 13). On the other hand, without trade integration, the net trade gets excessively volatile and there is not enough increase in the gross trade (green triangles).

Computational Approach: We now show that alternative computation strategies yield qualitatively similar results. Recall that the estimated relationships between the dispersion of net flows and trade integration in the data are from a transition of a less integrated world to a more integrated world. To capture this transition requires solving the model with either a global solution or a high-order approximation. Alternatively we can solve the model in with a first-order approximation around different steady states with different levels of trade integration. That is, we combine the results from two simulations, each with high and low level of steady state common trade cost, $\bar{\xi}_c$. Aside from this trade parameter, the remaining parameters are same as in our baseline case.

Figure 14 and column "First order" show the results. As in our baseline case, with more trade dispersion in the trade balance-to-output rises, albeit at a slightly lower rate. Importantly, dispersion in export-import ratio falls a third less than the baseline case and the data. The pattern in the real exchange rate, terms of trade, domestic absorption, and output are also close with the baseline model.

However, within simulations around each steady state, we have found that using higher-order approximations leads to a much stronger positive relationship between the dispersion in capital flows and trade. Especially for export-import ratio, the dispersion is actually flat across different levels of trade within a simulation. This is also the case for the real exchange rate and terms of trade. We attribute the stronger relationship to two features. First, common trade shocks will have asymmetric effects across countries owing to openness[11] and second, the trade changes macroeconomic volatility through its interaction with other shocks.

6 Summary

We add to a growing literature that interprets the international time series on business cycles and trade integration through a dynamic stochastic general equilibrium model. This literature departs from the conventional approaches that treat trade and unbalanced trade as separate phenomena to be studied in isolation. Our approach allows us to study the changing nature of business cycles, economic integration, and the spatial allocation of economic activity. We argue that the rise in the level of international trade and cross border borrowing and lending from 1970 to 2019 have a common cause in the fall in the policy and technological barriers to moving goods across countries. The changing nature of business

[11]These asymmetric effects of global shocks are emphasized in Alessandria et al. (2017), Barattieri (2014), Ravikumar et al. (2019) and Ju et al. (2012).

cycles with trade is also consistent with this view.

We develop a multi-country variation of the canonical multi-good RBC model of Backus et al. (1994) with the usual business cycle shocks plus shocks to international trade barriers and financial frictions. When relating the model to the data, we show that most of the rise in borrowing and lending across countries over time is related to a fall in international trade barriers. With lower barriers on trade, it becomes easier to borrow and lend in response to a shock without inducing a larger movement in the real exchange rate or terms of trade as we see in the data. We find little evidence that cross border financial frictions have fallen or that countries are experiencing more asymmetric shocks. Indeed, these alternative explanations should have led to an increase in the dispersion of relatives prices and net trade flows as a share of overall trade rather than the moderation in the data.

We interpret the data through a model in which financial frictions between countries have little or no direct role on the level of trade and the level of trade has no direct effect on cross-border financial frictions. Certainly, there is some mixed evidence on the relationship of financial development on trade (Beck, 2003, Leibovici, 2021), but on balance, we view the evidence to be too weak for such a relationship to explain much of the growth in trade. Moreover, here we are considering how the variability of interest rates affects the overall level of trade and we know of no evidence of this channel. More likely, trade could also affect financial frictions as the capacity to borrow could be related to the ratio of debt relative to export revenue or the level of trade rather than the level of output. More work should be done to relate financial integration to trade integration in dynamic stochastic general equilibrium models and discipline the predictions of the models with data over long periods that show structural changes in international relations.

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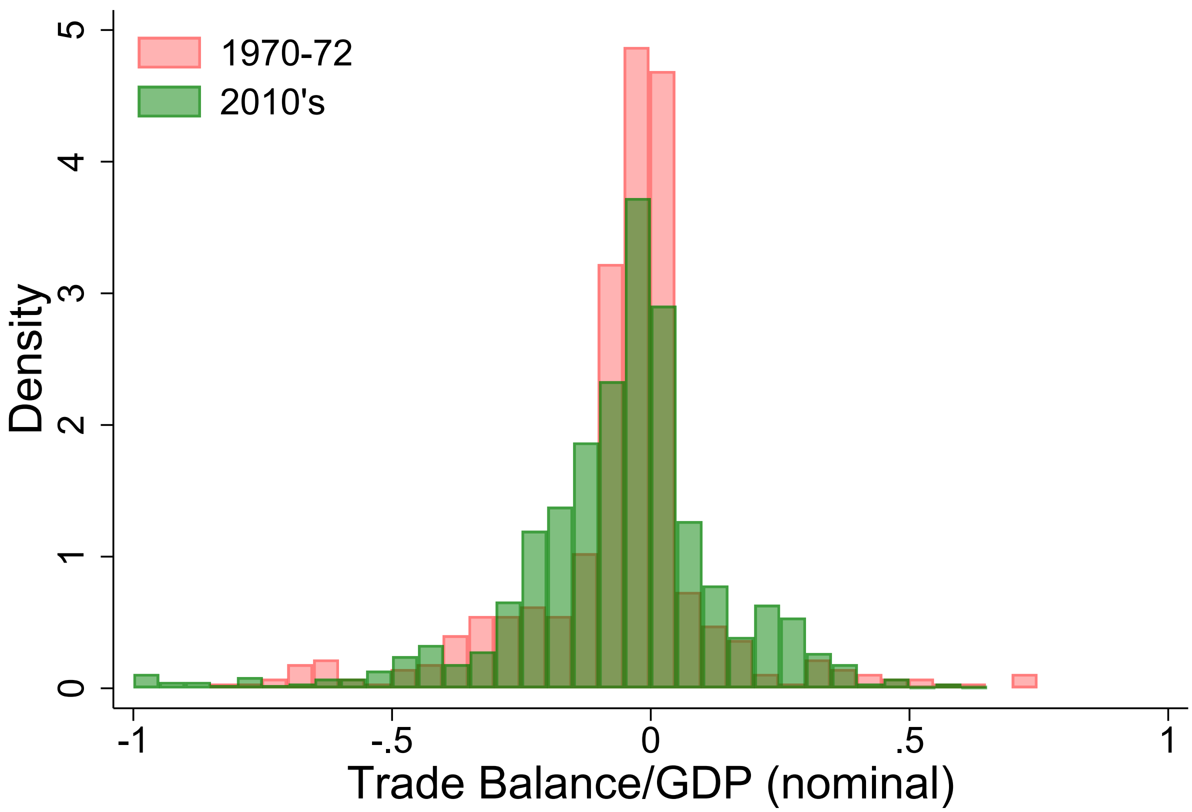
Figures and Tables

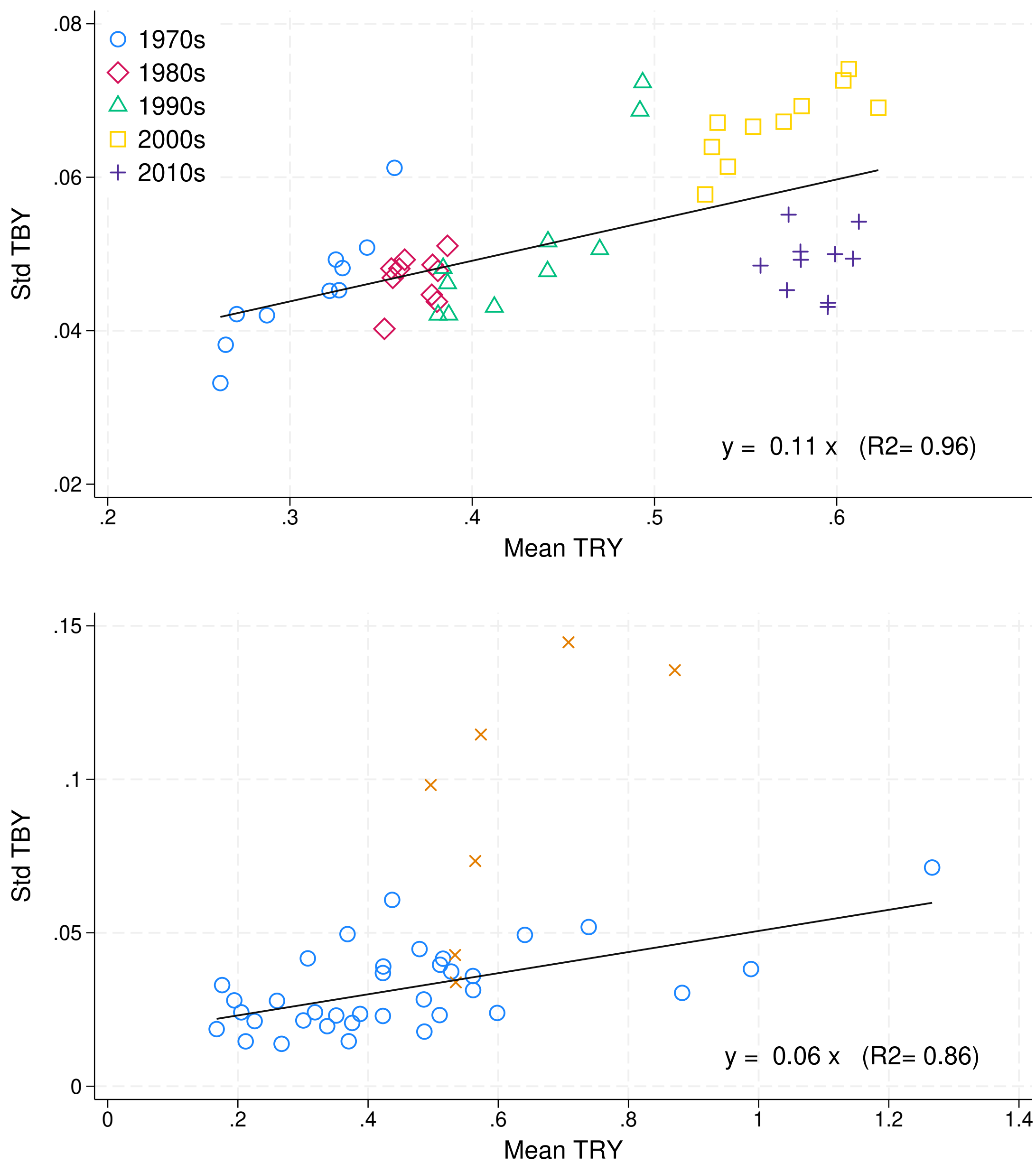
Figure 1: Distribution of Trade Balance: 1970s vs 2010s



Note: PWT10 National Accounts, 183 countries

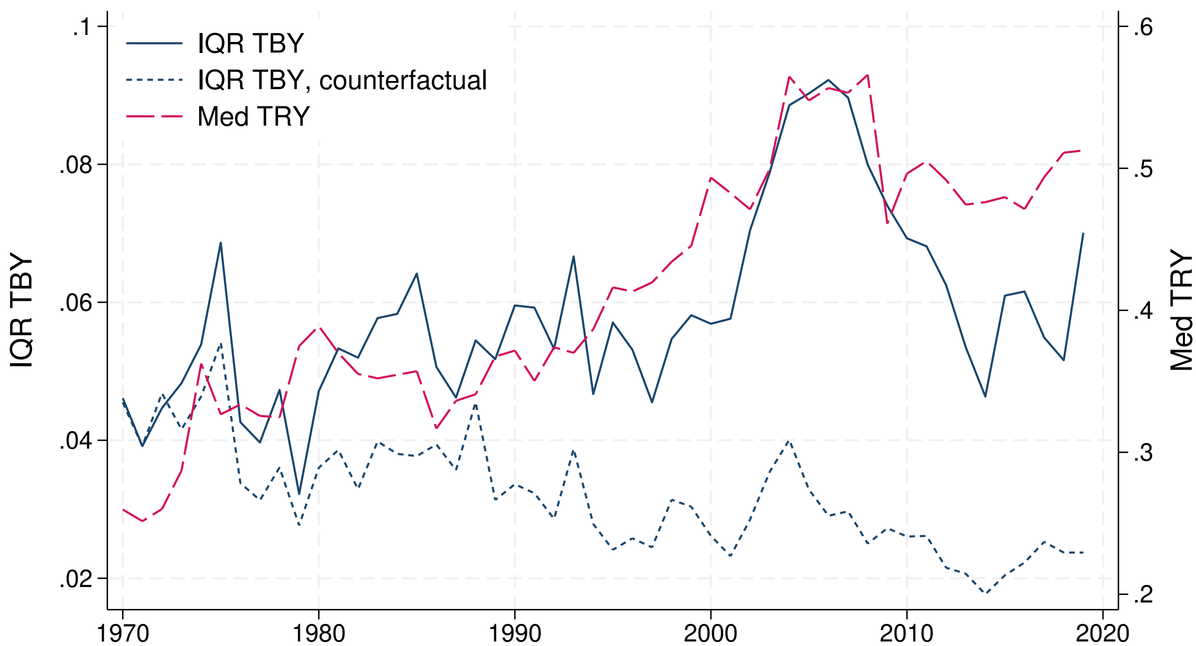
Notes: Comparison of the distribution of the trade balance as a share of GDP between the 1970-1972 and 2010-2019, measured in nominal terms. The trade balance as a share of GDP equals $TBY_n = (X_n - M_n)/Y_n$ and is based on 183 countries from the Penn World Tables version 10 National Accounts data.

Figure 2: Trade Balance Dispersion and Trade: Over Time and Across Countries



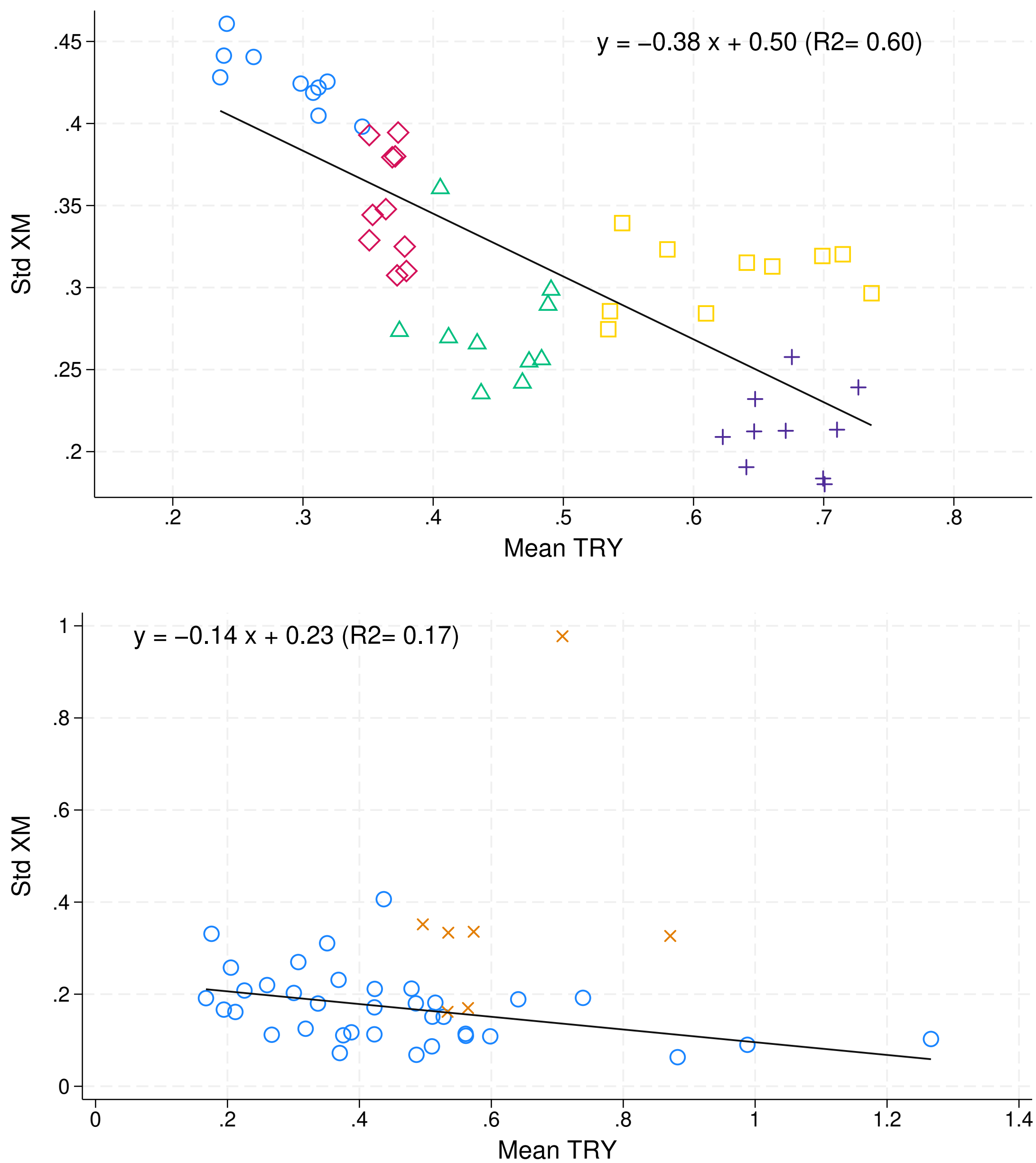
Notes: The upper panel plots cross-country moments for each year, with decades presented in different colors. The lower panel shows the time series moments for each country. The x-markers in the lower panel represent countries with measurement concerns that are not included in our baseline sample and are not taken into account for the regression.

Figure 3: Trade Balance Dispersion and Trade



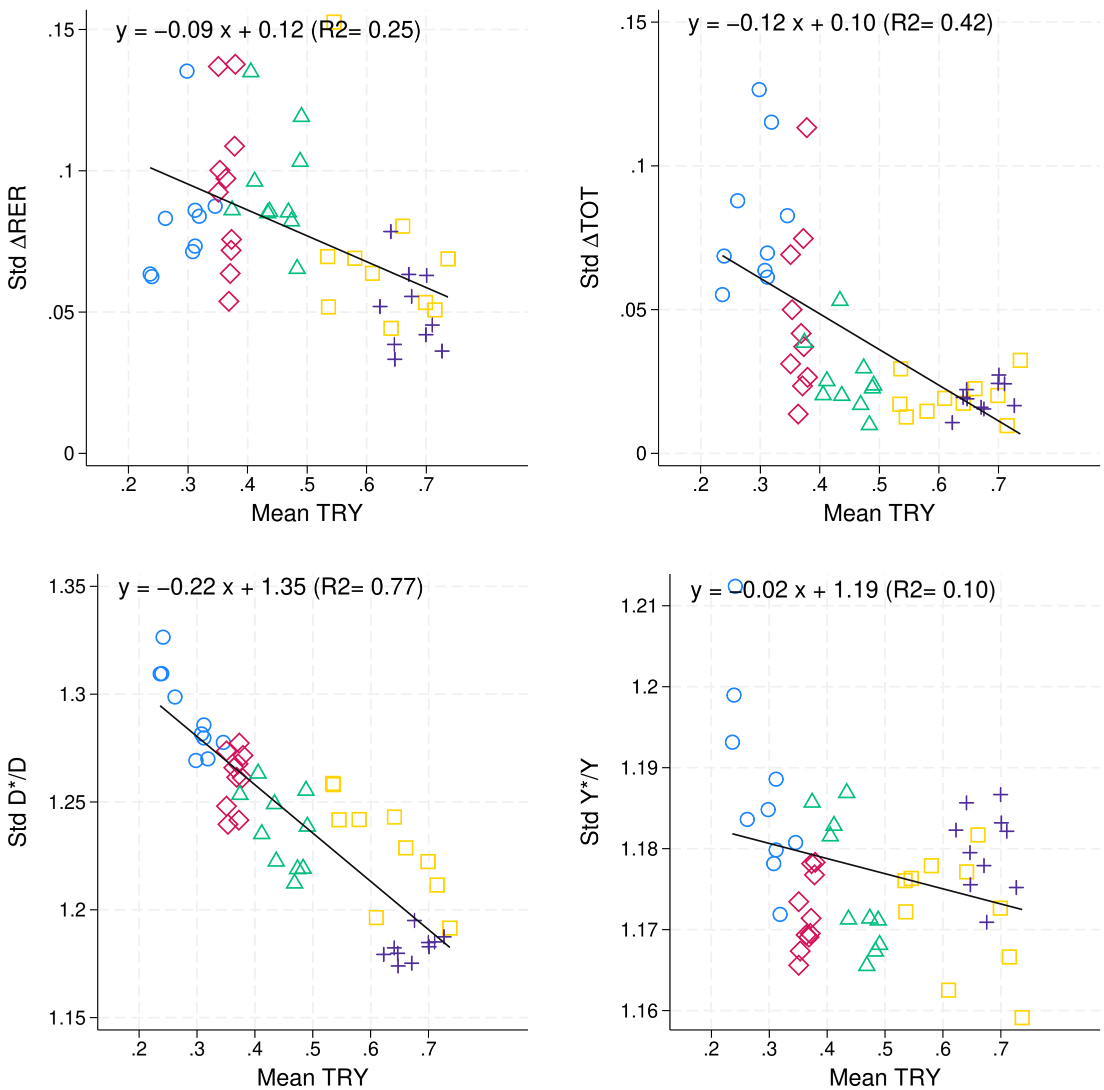
Notes: The figure plots interquartile range of TBY median of TRY. The counterfactual TBY is calculated by fixing the TRY at the 1971 level for each country. The moments are calculated based on our baseline sample of 36 countries.

Figure 4: Net Trade Flow Dispersion and Trade: Over Time and Across Countries



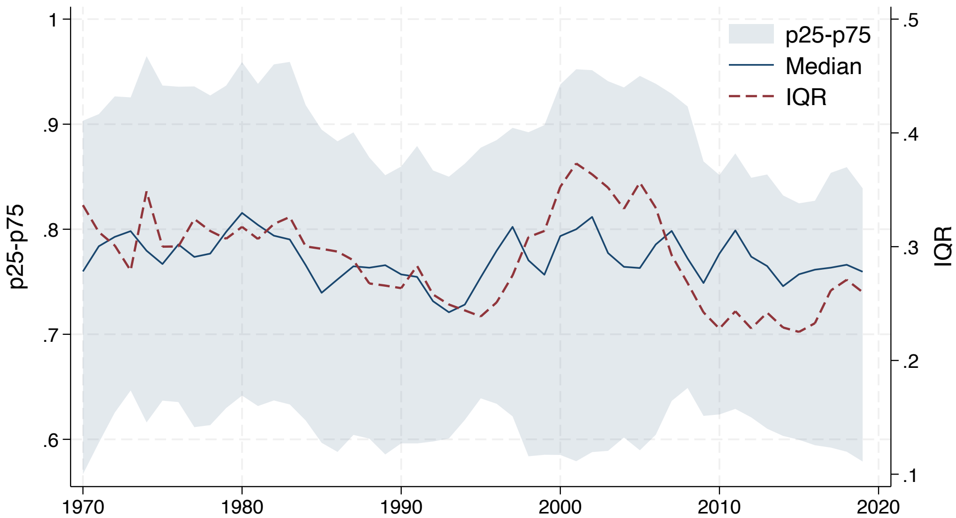
Notes: The upper panel plots cross-country moments for each year, with decades presented in different colors. The lower panel shows the time series moments for each country. The x-markers in the lower panel represent countries with measurement concerns that are not included in our baseline sample and are not taken into account for the regression.

Figure 5: Macroeconomic Dispersion and Trade



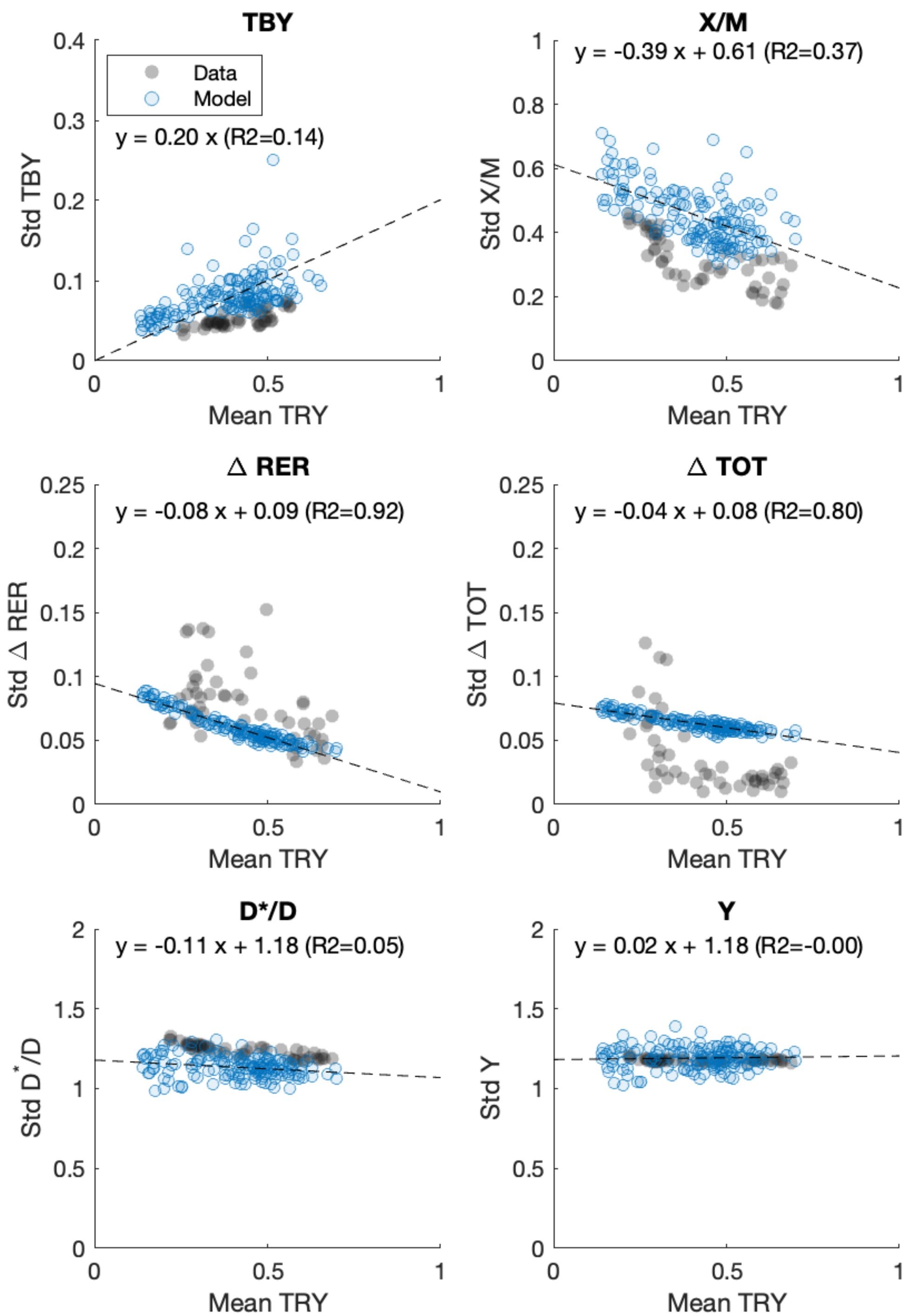
Notes: The graphs plot cross-country moments for each year, with decades presented in different colors. The dispersion is measured by the standard deviation of each variable.

Figure 6: TFP Dispersion



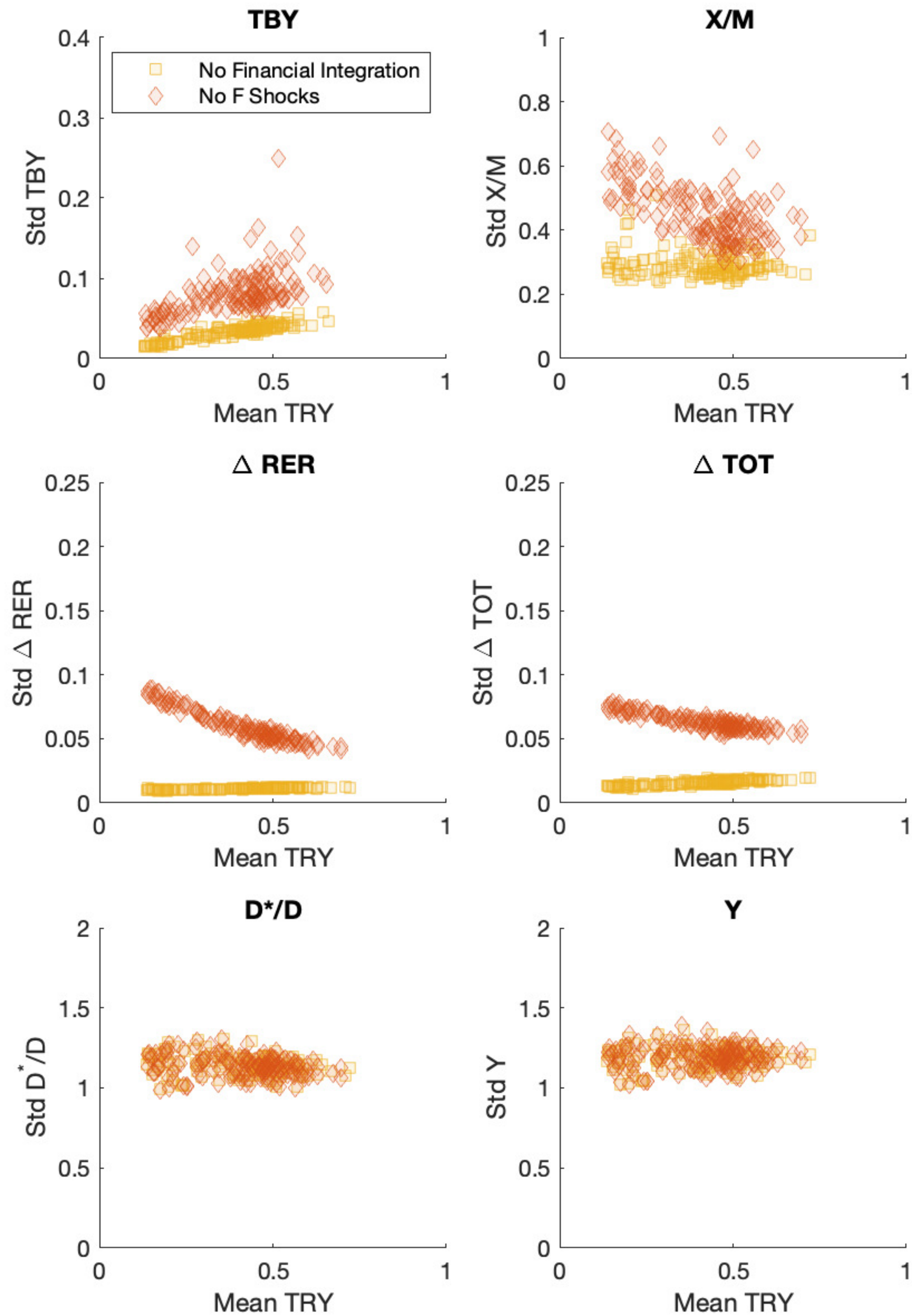
Notes: The graph shows the 25-75 percentile (left axis) and the size of the interquartile range (right axis) of TFP level at current PPPs across countries in our baseline sample.

Figure 7: Global Dispersion and Trade



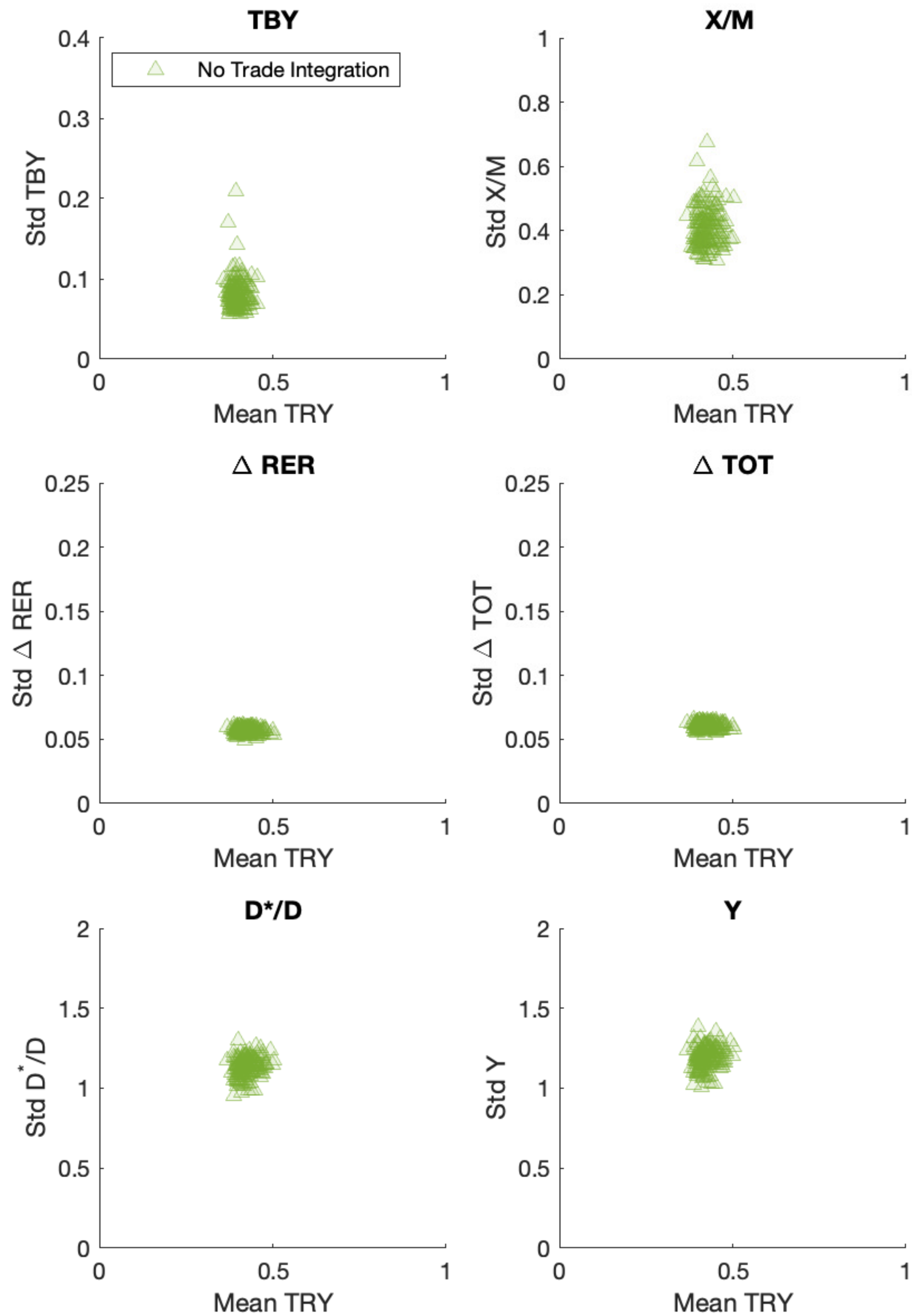
Notes: In each graph, y-axis is the standard deviation, x-axis is trade share over output. The black dots show the data, and the blue dots show the baseline model prediction. The dashed line shows the fitted line for the baseline model results.

Figure 8: Global Dispersion and Trade
No Financial Integration



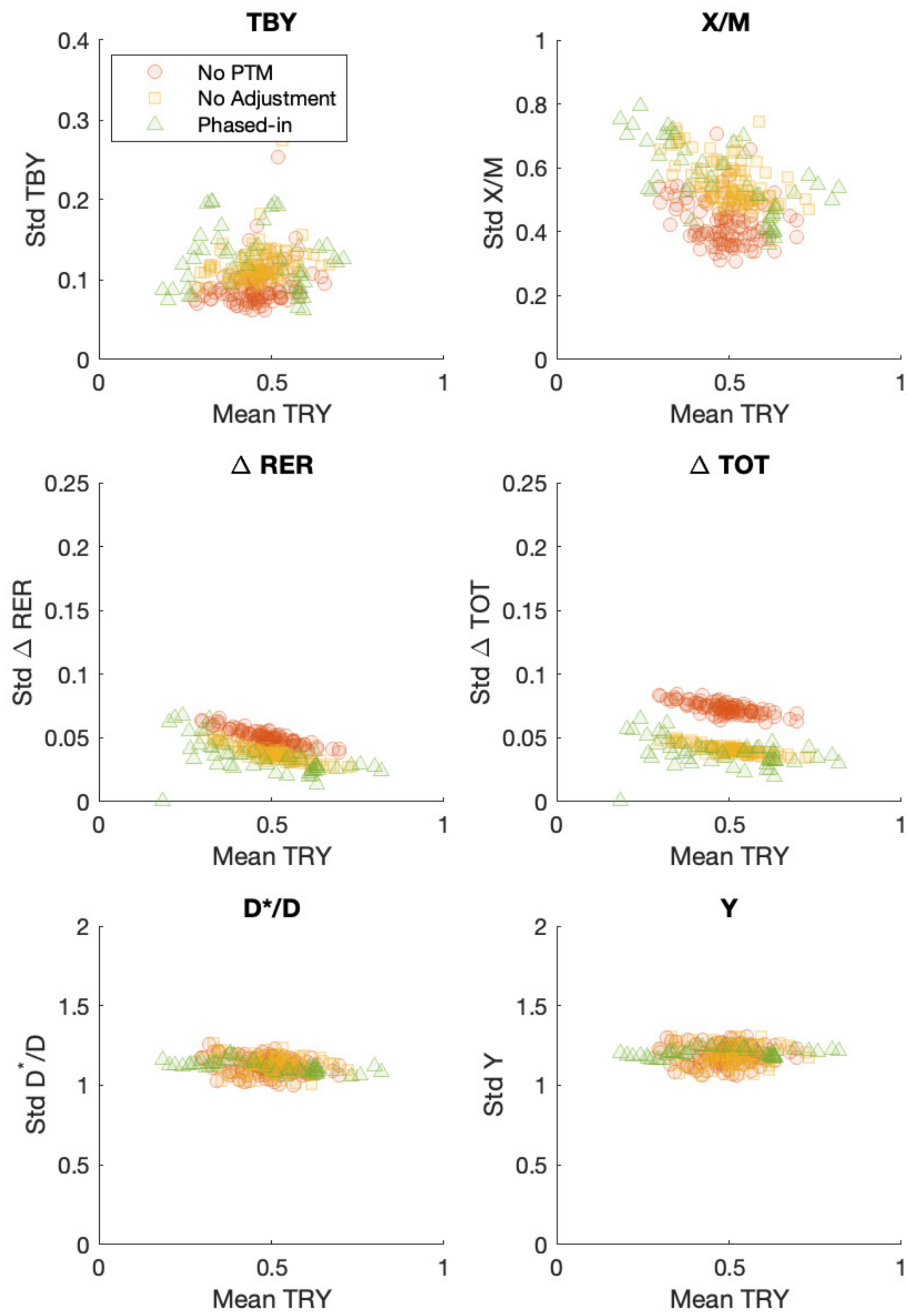
Notes: In each graph, y-axis is the standard deviation, x-axis is the trade share over output. The yellow square dots are when there is no financial integration, or $\sigma_F = \sigma_\phi = 0$, and the red diamond dots are when there is no integration coming from the changes in debt elasticity, or $\sigma_F = 0$.

Figure 9: Global Dispersion and Trade
No Trade Integration



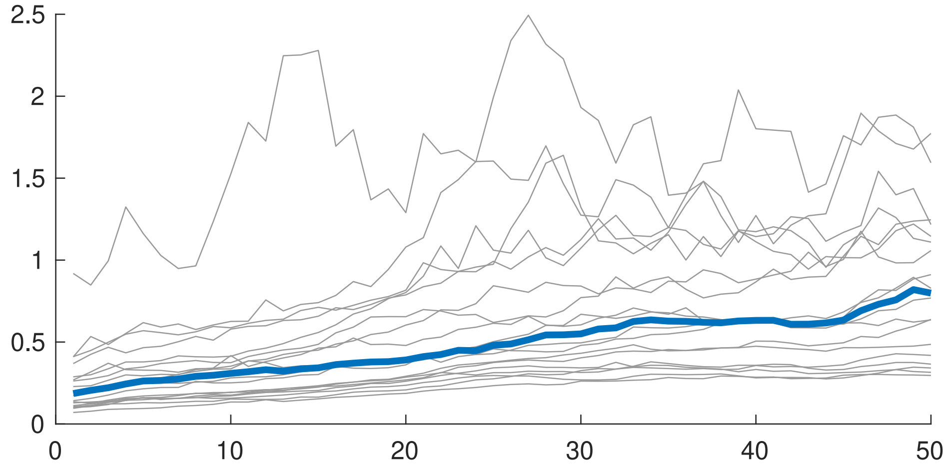
Notes: In each graph, y-axis is the standard deviation, x-axis is the trade share over output. The green triangle dots are those without trade integration, or $\sigma_{\xi_c} = 0$.

Figure 10: Sensitivity to Trade Frictions



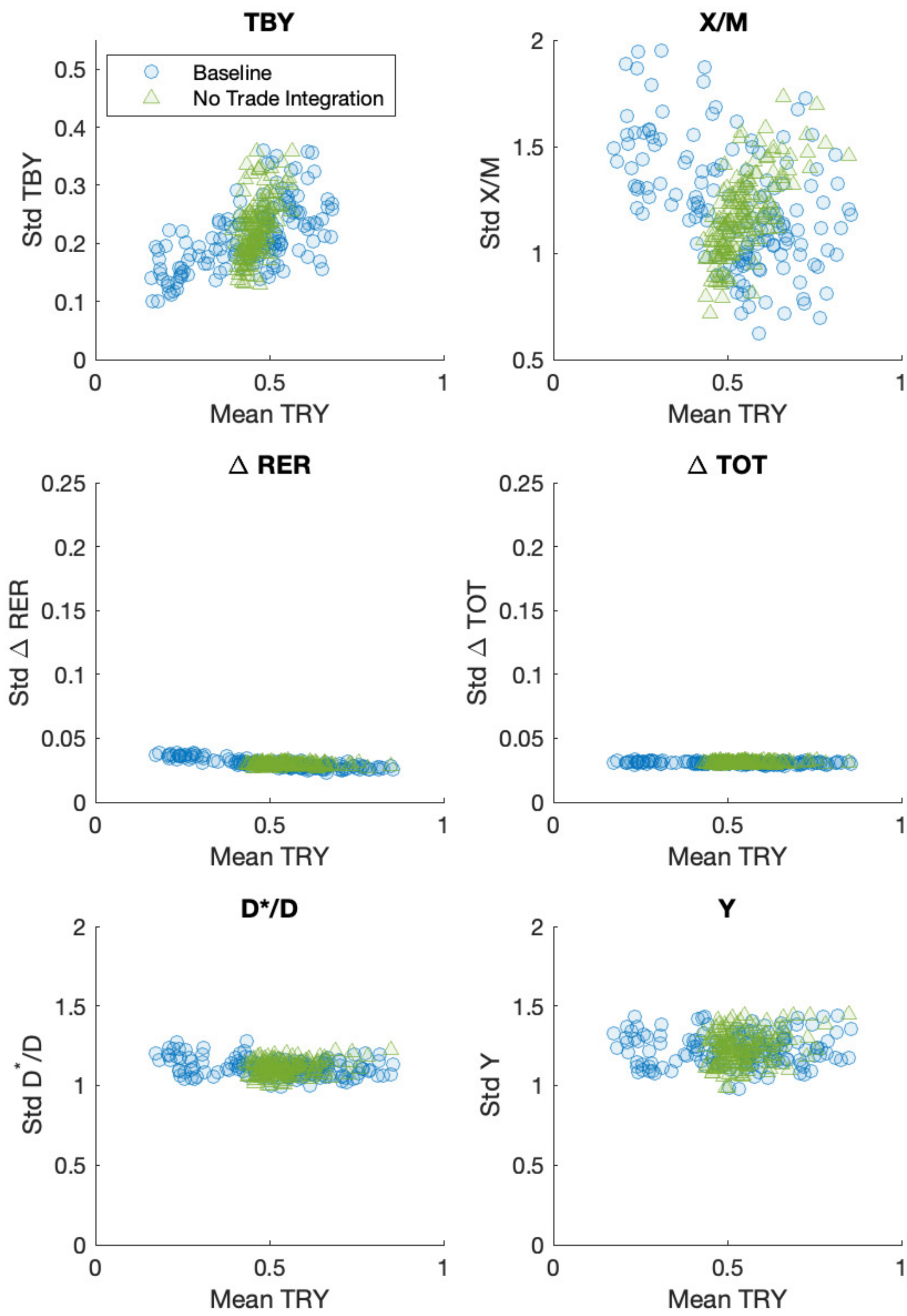
Notes: In each graph, y-axis is the standard deviation, x-axis is trade share over output.

Figure 11: Path of TRY during Phased-in Reforms



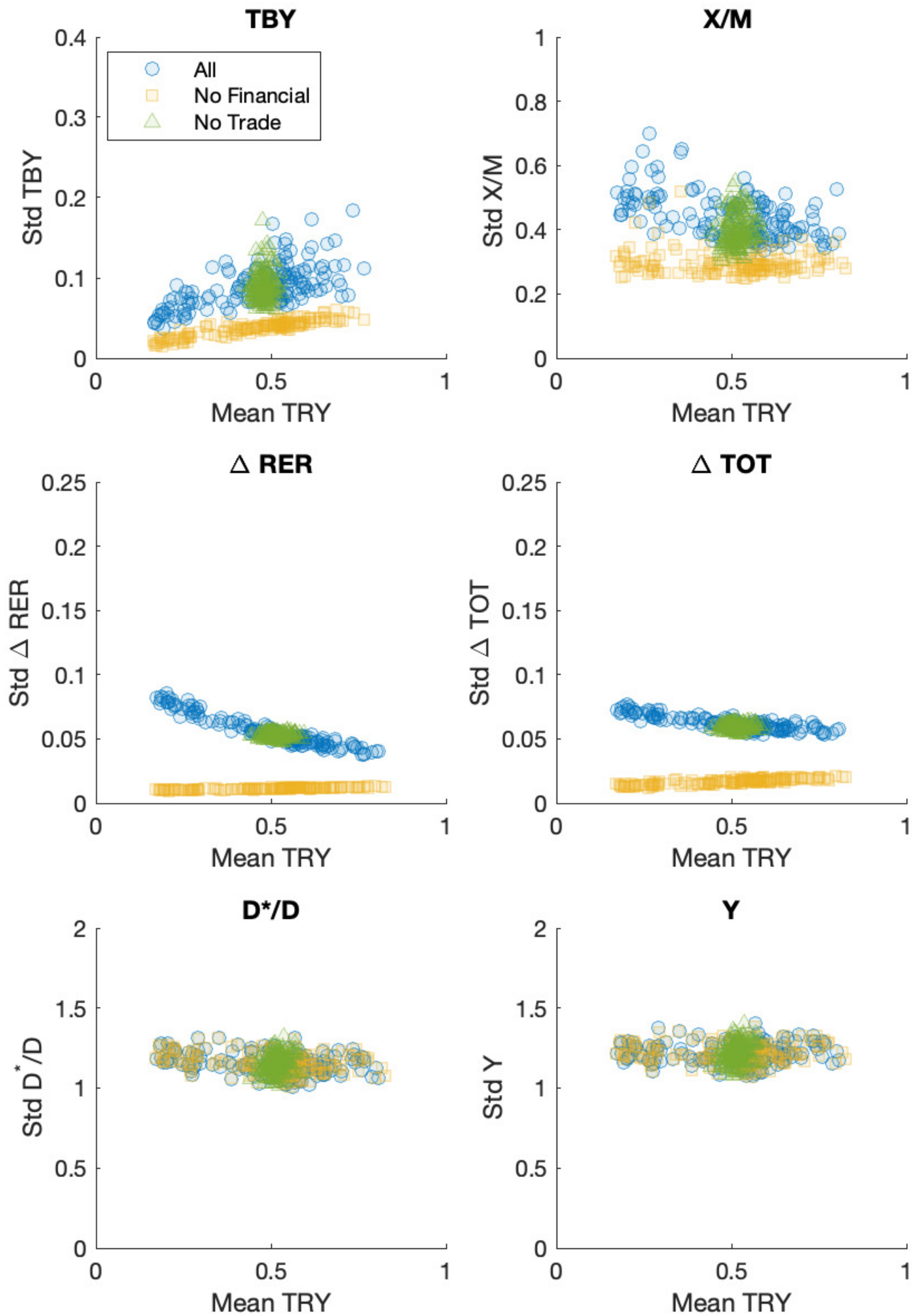
Notes: The light black lines show the time path of each country's trade-to-output ratio, TRY, when we simulate the model with a trend shock to the common trade cost. The thick blue line shows the median across countries.

Figure 12: Sensitivity to Complete Market



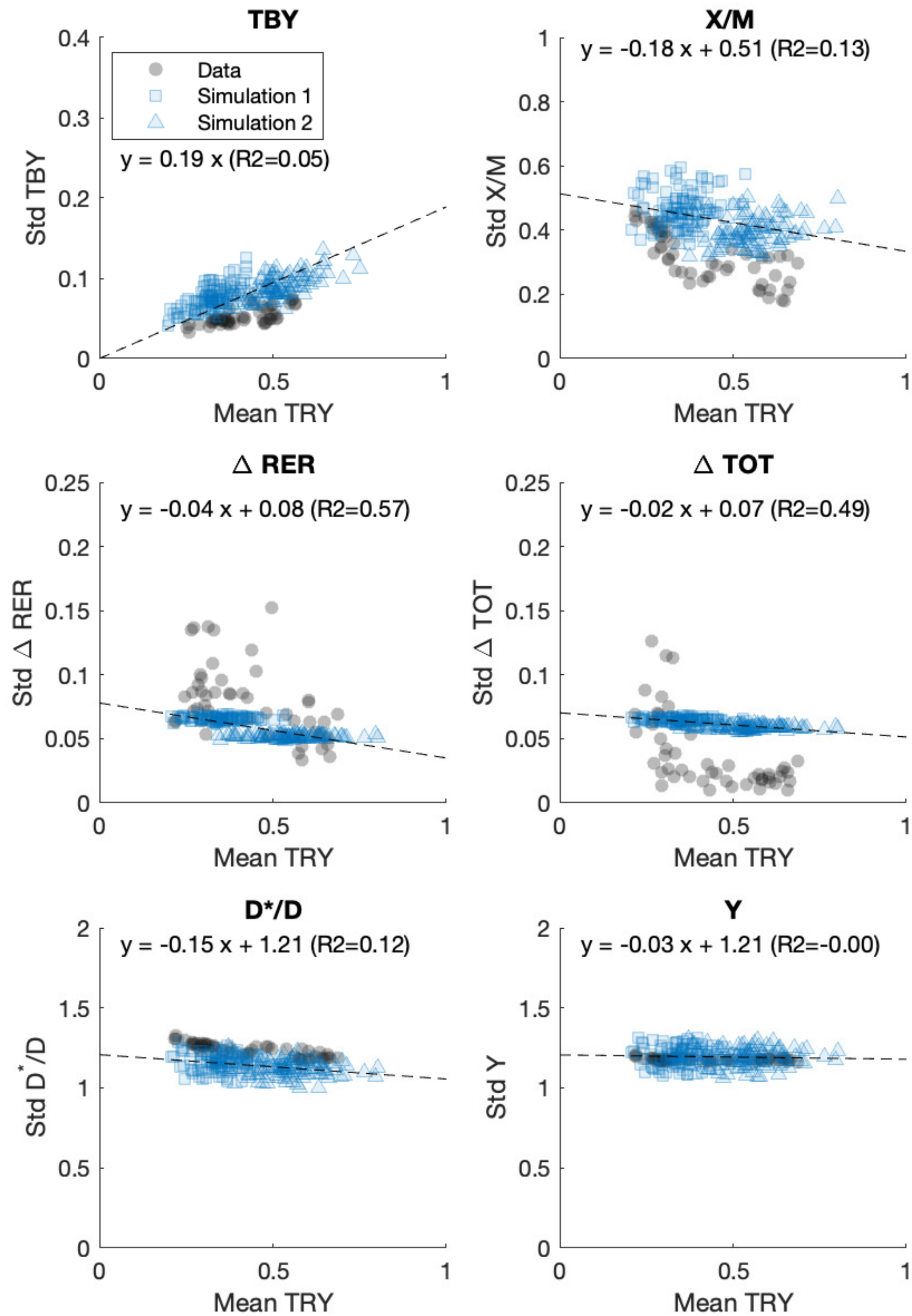
Notes: The graph shows the standard deviations net trade in relation to the mean of the gross trade. The blue dots show the model prediction with the complete financial market. The green triangle dots are those with the complete market but without trade integration, or $\sigma_{\xi_c} = 0$.

Figure 13: Sensitivity to Number of Countries



Notes: The graph shows the standard deviations net trade in relation to the mean of the gross trade. The blue dots show the model prediction when we run the model 22 countries using our baseline parameters. The yellow square dots are when there is no financial integration, or $\sigma_F = \sigma_\phi = 0$, and the green triangle dots are those without trade integration, or $\sigma_{\xi_c} = 0$.

Figure 14: Sensitivity to Computational Approach
First order approximation vs. Data



Notes: In each graph, y-axis is the standard deviation, x-axis is trade share over output. The model results are based on a first order approximation around two different levels of openness. The black line shows the model results.

Table 1: Estimation of Armington Elasticity

	Level		Difference		ECM	
	(1)	(2)	(3)	(4)	(5)	(6)
SR price	0.0588	0.107***	0.234***	0.232***	0.244***	0.237***
	(0.0587)	(0.0203)	(0.0355)	(0.0360)	(0.0357)	(0.0359)
SR spending	*1*†	0.00121	*1*†	1.019***	*1*†	1.058***
		(0.00578)		(0.0720)		(0.0743)
Adjustment					0.00614**	0.00621**
					(0.00218)	(0.00218)
LR price					3.306*	3.455*
					(1.551)	(1.595)
Observations	1750	1750	1715	1715	1715	1715
R-squared	-10.66	0.0255	0.277	0.278	0.286	0.286

Notes: Data from Penn World Table 10.0, 1970-2019 with 36 countries. Superscript † denotes that the coefficient is not estimated but is set to 1 as the theory suggests. ECM stands for the error correction model: $\Delta \ln X_t/M_t = \beta + \gamma_{SR}\Delta p_t^r + \Delta d_t^r - \alpha(\ln X_{t-1}/M_{t-1} - \gamma_{LR} p_{t-1}^r - d_{t-1}^r)$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Cross-sectional Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$Med(TRY)$	0.100***	0.101***	0.093***	0.104***	0.126***	0.097***	0.118***				0.212***
	(0.016)	(0.016)	(0.017)	(0.016)	(0.022)	(0.016)	(0.027)				(0.041)
$Med(\Delta \ln Y)$		0.060				0.067	0.073	0.078	0.068		
		(0.066)				(0.061)	(0.067)	(0.083)	(0.084)		
$Med(\Delta \ln Y_{-1})$		0.044				0.037	0.002	0.055	0.114		
		(0.070)				(0.067)	(0.081)	(0.082)	(0.081)		
ln Oil Price			0.005			0.006	0.004	0.018***	0.016***		
			(0.003)			(0.004)	(0.004)	(0.006)	(0.005)		
$\sigma(\Delta \ln Y)$				0.215	0.131	0.180	0.114	0.017	0.205		
				(0.166)	(0.166)	(0.144)	(0.153)	(0.172)	(0.171)		
$\sigma(\Delta \ln Y_{-1})$				0.074	0.101	0.008	0.049	-0.104	-0.142		
				(0.157)	(0.156)	(0.162)	(0.167)	(0.211)	(0.206)		
$\sigma(\Delta \ln RER)$					0.125*		0.092		-0.202**		
					(0.062)		(0.077)		(0.099)		
$\sigma(\Delta \ln RER_{-1})$					0.096		0.096		-0.155*		
					(0.077)		(0.092)		(0.090)		
$Med((A+L)/Y)$										0.013***	-0.021***
										(0.003)	(0.006)
Observations	48	48	48	48	48	48	48	48	48	48	48
R-squared	0.494	0.515	0.508	0.521	0.549	0.550	0.567	0.172	0.301	0.296	0.588

Notes: The dependent variable is the dispersion in trade balance to output ratio, TBY, measured by its interquartile range. Data is from Penn World Table 10.0, during 1970-2019 with 36 countries. Med denotes median, and σ denotes the interquartile range. Oil price is an annual average of imported crude oil price ($/barrel, real) (US EIA). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Calibrated Parameters

Parameters		Value
Externally Calibrated		
β	Discount factor	0.96
α	Capital share	0.36
δ_k	Capital depreciation rate	0.10
$1/\sigma$	Intertemporal elasticity of substitution	0.50
μ	Weight on consumption	0.37
ω_{mn}	Weight on each foreign good	0.25
ω_{nn}	Weight on home goods	0.25
$\bar{b}_n$	Mean debt	0
ρ_{z_c}	Common productivity persistence	0.96
ρ_{z_d}	Differential productivity persistence	0.98
$\bar{\xi}_d$	Mean differential trade cost	1
Internally Calibrated		
γ	Armington elasticity	3.22
δ	Habit in import demand	0.94
θ	RER-elasticity of PTM	0.28
ψ	Capital adjustment cost	10.10
F	Debt-elasticity of interest rate	2.12
σ_F	Debt-elasticity shock volatility	0.02
ρ_F	Debt-elasticity shock persistence	0.87
σ_ϕ	Interest rate shock volatility	0.02
ρ_ϕ	Interest rate shock persistence	0.94
$\bar{\xi}_c$	Mean common trade cost	
ρ_{ξ_c}	Common trade cost persistence	0.99
σ_{ξ_c}	Common trade cost shock volatility	0.01
σ_{ξ_d}	Differential trade cost shock volatility	0.05
ρ_{ξ_d}	Differential trade cost persistence	0.96
$\bar{z}_n$	Mean productivity	0.8693^n
		$n \in \{0, 1, 2 \cdots, 17\}$
σ_{z_d}	Differential productivity volatility	0.04
σ_{z_c}	Common productivity volatility	0.02

Table 4: Model Results

		Data	Baseline	No financial integration	No F shocks	No trade integration	Complete market	No PTM	No trade adjustment	Phased-in reforms	22 countries	First order	Debt elasticity
Integration and Cross-country Dispersion													
TBY	slope	0.11	$0.20^{\dagger}$	0.08	0.20	0.20	0.46	0.20	0.25	0.24	0.19	0.19	0.09
X/M	slope	-0.39	$-0.39^{\dagger}$	-0.04	-0.39	0.08	-0.80	-0.21	-0.43	-0.47	-0.22	-0.18	-0.11
X/M	constant	0.50	$0.61^{\dagger}$	0.31	0.61	0.38	1.64	0.53	0.77	0.79	0.55	0.51	0.36
ΔRER	slope	-0.09	$-0.09^{\dagger}$	0.00	-0.09	-0.01	-0.02	-0.06	-0.06	-0.05	-0.07	-0.04	-0.06
ΔRER	constant	0.12	0.09	0.01	0.09	0.06	0.04	0.08	0.07	0.06	0.09	0.08	0.07
ΔTOT	slope	-0.13	$-0.04^{\dagger}$	0.01	-0.04	-0.01	0.00	-0.04	-0.04	-0.03	-0.03	-0.02	-0.03
ΔTOT	constant	0.10	0.08	0.01	0.08	0.06	0.03	0.09	0.06	0.05	0.08	0.07	0.06
Y	slope	-0.01	0.02	0.02	0.02	0.50	0.01	0.03	0.03	0.03	0.01	-0.03	0.02
Y	constant	1.17	$1.18^{\dagger}$	1.18	1.18	0.98	1.22	1.18	1.18	1.19	1.21	1.21	1.18
D/D^{*}	slope	-0.22	-0.11	-0.10	-0.11	0.50	-0.10	-0.14	-0.13	-0.14	-0.13	-0.15	-0.11
D/D^{*}	constant	1.33	1.18	1.18	1.18	0.92	1.17	1.19	1.19	1.18	1.22	1.21	1.18
Business Cycle Moments													
$\sigma(\Delta y)$, %		3.69	$5.38^{\dagger}$	5.24	5.38	5.37	5.84	5.41	5.84	5.71	5.42	5.36	5.31
$\sigma(\Delta c)/\sigma(\Delta y)$		1.06	$0.88^{\dagger}$	0.79	0.88	0.88	0.59	0.90	0.86	0.85	0.90	0.87	0.80
$\sigma(\Delta inv/\sigma(\Delta y)$		3.16	$3.21^{\dagger}$	2.47	3.22	3.28	2.53	3.66	4.42	4.21	3.47	3.07	3.12
$\rho(\Delta y_t, \Delta y_{t-1})$		0.39	0.29	0.30	0.29	0.29	0.23	0.29	0.26	0.18	0.28	0.29	0.29
$\rho(\Delta c_t, \Delta c_{t-1})$		0.37	0.24	0.26	0.24	0.24	0.36	0.24	0.24	0.14	0.23	0.26	0.24
$\sigma(TRY)$		0.15	$0.14^{\dagger}$	0.14	0.14	0.03	0.17	0.08	0.09	0.17	0.16	0.09	0.14
$\rho(TRY)$		0.98	$0.96^{\dagger}$	0.95	0.96	0.38	0.89	0.86	0.85	1.00	0.97	0.85	0.95
$\rho(TBY, \Delta y)$		-0.01	-0.18	-0.26	-0.18	-0.20	-0.08	-0.19	-0.04	-0.05	-0.18	-0.16	-0.22
$\rho(\Delta(c - c*), \Delta RER)$		-0.21	$0.04^{\dagger}$	0.36	0.04	-0.04	1.00	0.04	-0.24	-0.22	0.09	-0.06	0.13
$\rho(\Delta y, \Delta y^{*})$		0.21	$0.28^{\dagger}$	0.29	0.28	0.28	0.23	0.29	0.28	0.13	0.28	0.29	0.28
Trade Elasticity													
Short Run		0.22	$0.20^{\dagger}$	0.21	0.20	0.20	0.30	0.20	3.16	3.21	0.20	0.20	0.20
Long Run		3.22	$3.26^{\dagger}$	3.60	3.50	3.98	3.27	3.55	2.89	3.66	3.47	3.54	3.58
Distance		–	0.13	1.06	0.13	0.69	3.75	0.40	1.75	1.26	0.26	0.15	0.29

Notes: The superscript † denotes that the moment is targeted using the internally calibrated parameters. All of the moments except the slope for TBY are calculated using real values. For estimating the elasticity of TBY, both TBY and TRY are in nominal values and the constant is fixed to be zero. Business cycle moments are averages across countries.

Appendix

In this section we discuss four things. First, in appendix A we describe the data in our empirical analysis. Second, in appendix B we show that the positive relationship between the level of gross trade flows and dispersion of net trade flows is robust across many measures of net flows and country coverage. Third, in appendix C we discuss the sensitivity of our model to the persistence of the shocks to productivity. Fourth, in appendix D we show that the theoretical relationship from the model is robust to considering more countries.

A Data

In this section we describe our data sources, variables, and construction of variables. We focus on countries that are available in the Penn World Table (PWT) 10.0 at least since 1970, are covered in the broad basket of BIS Effective Exchange Rates, and have data on bilateral trade since 1970 in the Direction of Trade Statistics (DOTS). Among the 49 countries that satisfy these criteria, we exclude five entrepot countries,[12] resulting in the sample of 43 countries. Then we further exclude seven countries with measurement concerns in TBY.[13] This leaves us with 36 countries,[14] which we use as our baseline sample of countries for the period of 1970-2019.

Using PWT 10.0, we construct variables including trade to output ratio (TRY) and trade balance to output (TBY) as follows:

- TRY, real: Sum of export and import shares at current PPPs
- TRY, nominal: Sum of export and import shares at current PPPs, inflated by the price level of export relative to the price level of output
- TBY, nominal: Difference of export and import shares at current PPPs, inflated by the price levels

[12] Belgium, Luxembourg, Hong Kong, Singapore, and Malta

[13] Algeria, Bulgaria, Cyprus, Iceland, Ireland, Norway, Saudi Arabia, and the United Arab Emirates. For details, see Appendix B.

[14] Argentina, Australia, Austria, Brazil, Canada, Chile, China, Colombia, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Peru, Philippines, Poland, Portugal, Republic of Korea, Romania, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, and United States.

- XM: Logged ratio of export and import shares at current PPPs
- RER: Logged rest-of-the-world price level of output relative to that of a country
- TOT: Logged ratio of the price level of exports to imports
- D^*/D: Logged rest-of-the-world real domestic absorption relative to that of a country
- $Y*/Y$: Logged Real relative expenditure-side GDP at current PPPs (inflated if nominal)

In the two-country analysis, rest-of-the-world output price level or domestic absorption is measured by the trade weighted average of non-US countries. Trade weights are from BIS and updated every 4 years during 1993-2016. For the period of 1970-1992, weights from 1993-1995 are used, while for the period of 2017-2019 weights from 2014-2016 are used.

B Empirical Robustness: Capital flows and trade

In this section we check the robustness of the findings in several aspects. First, we re-do the analysis using a different source of data. Second, we consider aggregating the countries into a few country groups or including more countries. Third, we compare the patterns in real and nominal terms. Finally, we use the current account and alternative measures of the trade balance that down-weights smaller countries.

First, we evaluate PWT in comparison to the System of National Accounts from United Nation Statistics Division (UN SNA). To construct trade to output ratio (TRY), trade balance to output (TBY), and export-import ratio (lnX/M) using UN SNA, we use GDP by expenditure at constant 2015 USD prices.

Comparing two different data sources, PWT and UN SNA, suggests potential concerns with using PWT data to study trade across countries over time, especially for entrepot and commodity exporting countries, as discussed in Johnson et al. (2013). For example, Norway's TBY of 1970 when measured with PWT exceeds -50%, while it is around 0% with UN SNA. In our sample, there are seven countries with a differences in real TBY larger than 20% at least once during the sample period, potentially attributing to the measurement errors and terms of trade effects when constructing real terms. In Figure B.1, we plot the real TBY of these countries over time, measured with PWT (solid line) and UN SNA (dashed line). For the baseline analysis, we exclude these seven countries and only consider 36 countries in our baseline sample.

However, such errors are not crucial for the observed relationship with cross-sectional TBY dispersion with the level of trade. In Table B.1 we compare the elasticity using data with 43 countries when we take a year as an unit of observation, measured with PWT (columns 1 and 3) to the one measured with UN SNA (columns 2 and 4). The the results from two sources are similar, suggesting that pattern we observe in the left panels of Figures 2 and 4 is robust to the source of data. On the other hand, when we take a country as an observation, these seven countries indeed are outliers, as shown in the lower panels of Figures 2 and 4. Accordingly, we exclude these seven countries in our baseline sample, resulting in 36 countries.

When using a country as a unit of account, we find the positive between net and gross trade flows relationship holds (Figure 2) when we look at alternative windows. To show this we further split the sample by considering 15-year windows for each country (Figure B.2). Similar to the earlier findings, there is a positive relationship between the trade balance dispersion and level of trade, and a negative relationship between the dispersion of the export-import ratio and trade.

We also highlight several countries with very high levels of trade and very volatile trade balances. In terms of high levels of trade, we see that key entrepots like Belgium, Hong Kong, and Singapore stand out. In terms of highly volatile trade balance, it is Norway and Saudi Arabia in the periods from 1970-85 that stand out. Obviously these outliers arise from very substantial asymmetric shocks related to oil discoveries and the price of oil.

Second, we aggregate the countries into a few groups and examine the pattern in the aggregated data. We consider eight group of countries consisting of North America, Mexico, other South America, Europe, China, Japan, other Asia, and rest of the world. Using bilateral trade from DOTS, we construct the trade variables including TBY, XM, and TRY for these groups. Figure B.3 shows that the relationship holds with the group of countries.

Our results on the comovement between trade integration and trade balance dispersion are robust to including more countries. Figure B.4 shows that dispersion in borrowing and lending is also rising when we consider a broader set of the 157 countries in the Penn World Table from 1950 onwards.

Third, we look at the sensitivity of the pattern measured in real terms. Figure B.5 shows the relationship we find using nominal terms also holds in real terms.

Finally, we confirm that when we use current account as a measure of net flows the positive correlation, we still find the positive correlation as we find in Figure 2. Figure B.6 shows the interquartile range of net trade flows over time, measured by the ratio of either trade balance or current account to GDP. Although there exists minor differences in these measures due to the differences between trade balance and current account – net income and net transfers – the two measures of dispersion move similarly over time, implying the positive relationship with the level of trade. We also run the reduced form analysis using the net financial flows, presented in Table B.2. Here we again find that gross trade flows plays a dominant role in explaining the net flows.

We also show the relationship between dispersion in net flows is a bit stronger if we measure the trade balance as a share of world average GDP (Figure B.7). This approach has the advantage of down-weighting small countries with large imbalances. In the upper panel of Figure B.7, we show the elasticity with a year as an observation, while the lower panel shows the results with a country as an observation. We again see the pattern is robust to the different measurement of trade. We find that, over the range of the changes in trade integration, the dispersion increases even more than in our main measure. Thus, our findings are robust to using an alternative weighting.

C Persistence of Productivity Shocks

In this section we analyze the results of the model when we vary the persistence of productivity shocks. In particular, we increase the persistence of common productivity shocks from $\rho_{z_c} = 0.96$ to 0.97, and the differential productivity shocks from $\rho_{z_d} = 0.98$ to 0.99. We adjust the volatility to keep the unconditional variance of the shock processes constant. The other parameters are kept the same as in the baseline. Table C.1 shows the results. The cases with higher persistence show almost same elasticity of dispersions to trade. For example, in both cases, dispersions in trade balance to output and export-import ratio change by around 0.20 and -0.39 as gross trade increases by 1 percentage point. When the differential productivity is more persistent and countries are subject to larger idiosyncratic shocks, the dispersion in output across countries becomes stronger while the dispersion in domestic absorption gets smaller. The business cycle moments are slightly differ even though the shock process itself has the same variance. However, all of these changes are quantitatively small.

D Number of Countries

In this section we compare the results from our analysis based on varying the steady state level of trade to one that samples periods within simulations. Given that we are allowing the level of trade and trade costs to vary quite substantially we solve the model with a second order approximation. This level of approximation yields more accurate solutions than the linear approximation. However, a challenge with high-order approximations is that computational time increases quite substantially with the number of countries. Thus, for now we focus on estimating the effects by varying the number of countries in the model. We first simulate the model with 22 countries given the parameters we used in the baseline analysis. The findings show that the results are insensitive to adding the number of countries in the model.

To consider a larger set of countries, we let the additional countries to be of varying sizes so that the original dispersion in output is preserved. That is, we add countries the countries with the mean productivity $\bar{z}_m = 0.8693^m$ for $m \in \{2, 10, 14, 17\}$ to the baseline countries with $m \in \{0, 1, 2, \cdots, 17\}$. The rest of the parameters are set as in the baseline. We take the same approach as in the baseline analysis to simulate and derive the model predictions. Figure 13 shows the results and Table D.1 compares the moments with the baseline case with 18 countries. The result successfully captures the changes in the trade balance dispersion observed in data, growing by 0.19 as trade grows by 1 percentage points. Also, the relationship between TRY and X/M dispersion tend to be negative.

We then run the counterfactual exercises without financial or trade integration. The left panel of Table D.1 presents the results. When we shut off the financial shocks (yellow squares) the trade dispersion become is smaller and less elastic to gross trade. More importantly, without shocks to trade costs (green triangles) we cannot generate enough variations in gross trade, and there is an excess dispersion in net trade. The results show that the role of financial and trade integration for generating the increase in net and gross grades are robust to number of countries in the model.

Appendix - Figures and Tables

Figure B.1: Countries with Large Differences in Real TBY

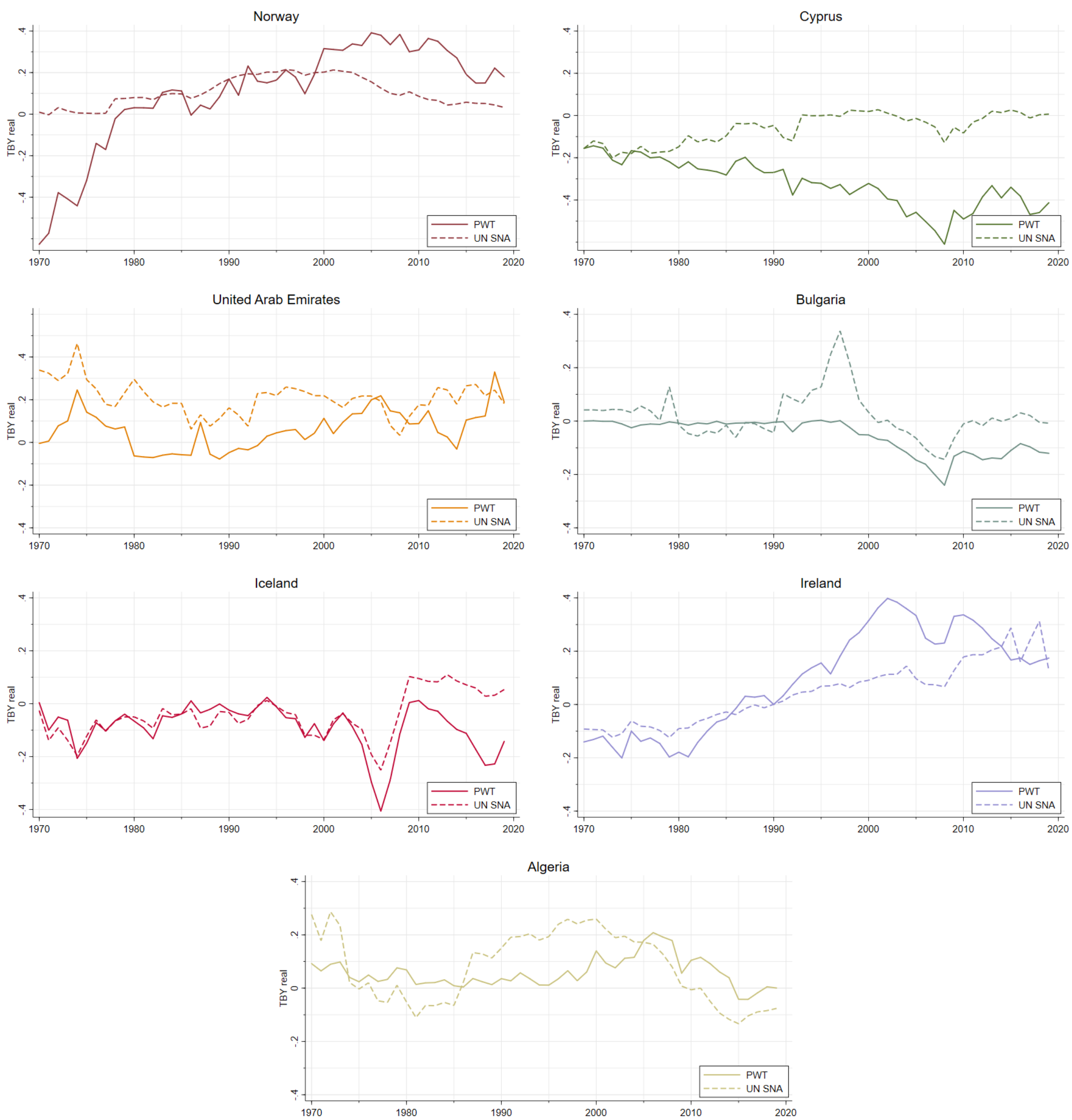
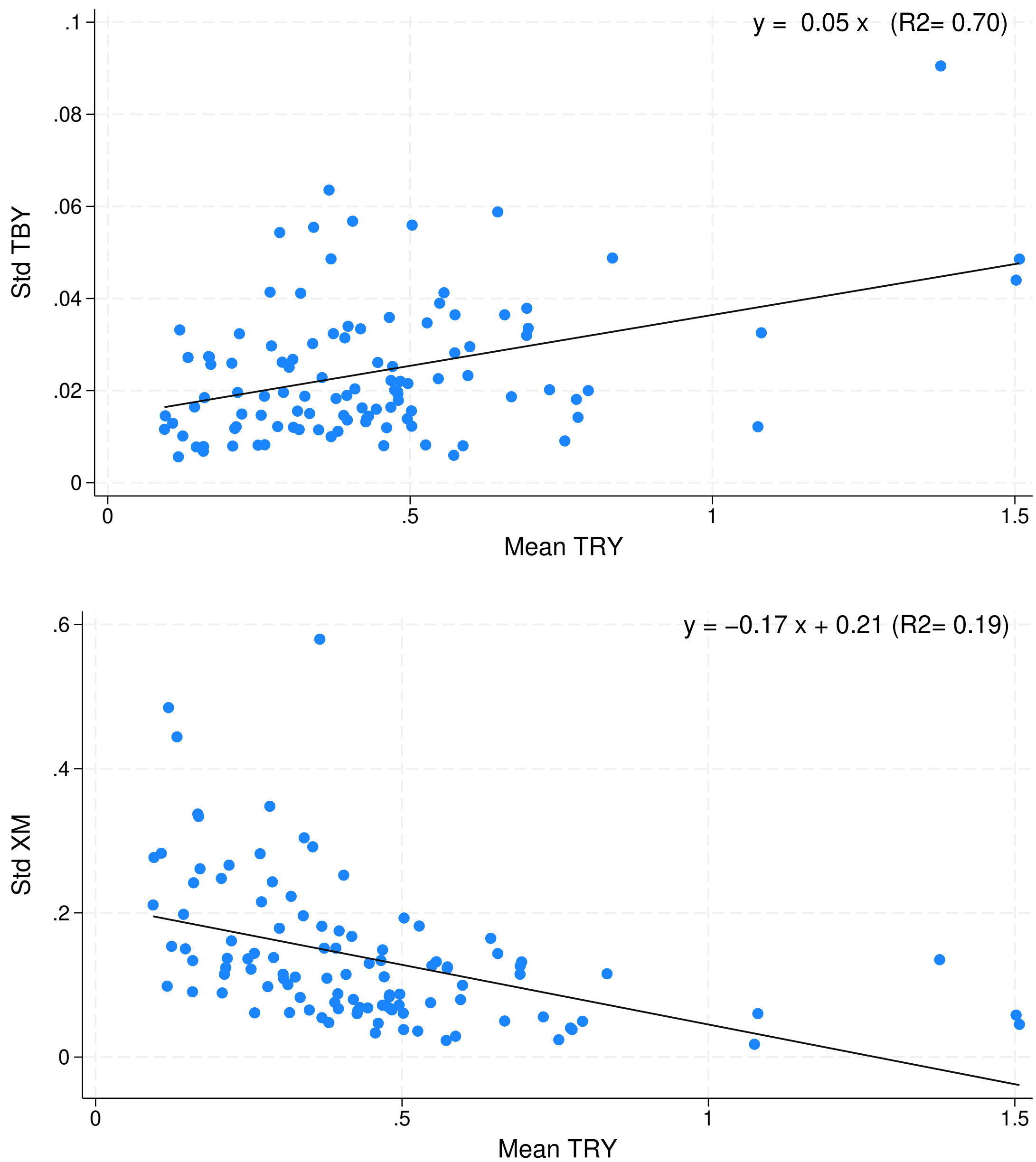


Figure B.2: Relationship by Country Across Time Periods



Notes: Each observation is dispersion measured across countries in 1970-1984, 1985-1999, or 2000-2019.

Figure B.3: Relationship with Aggregated Group of Countries

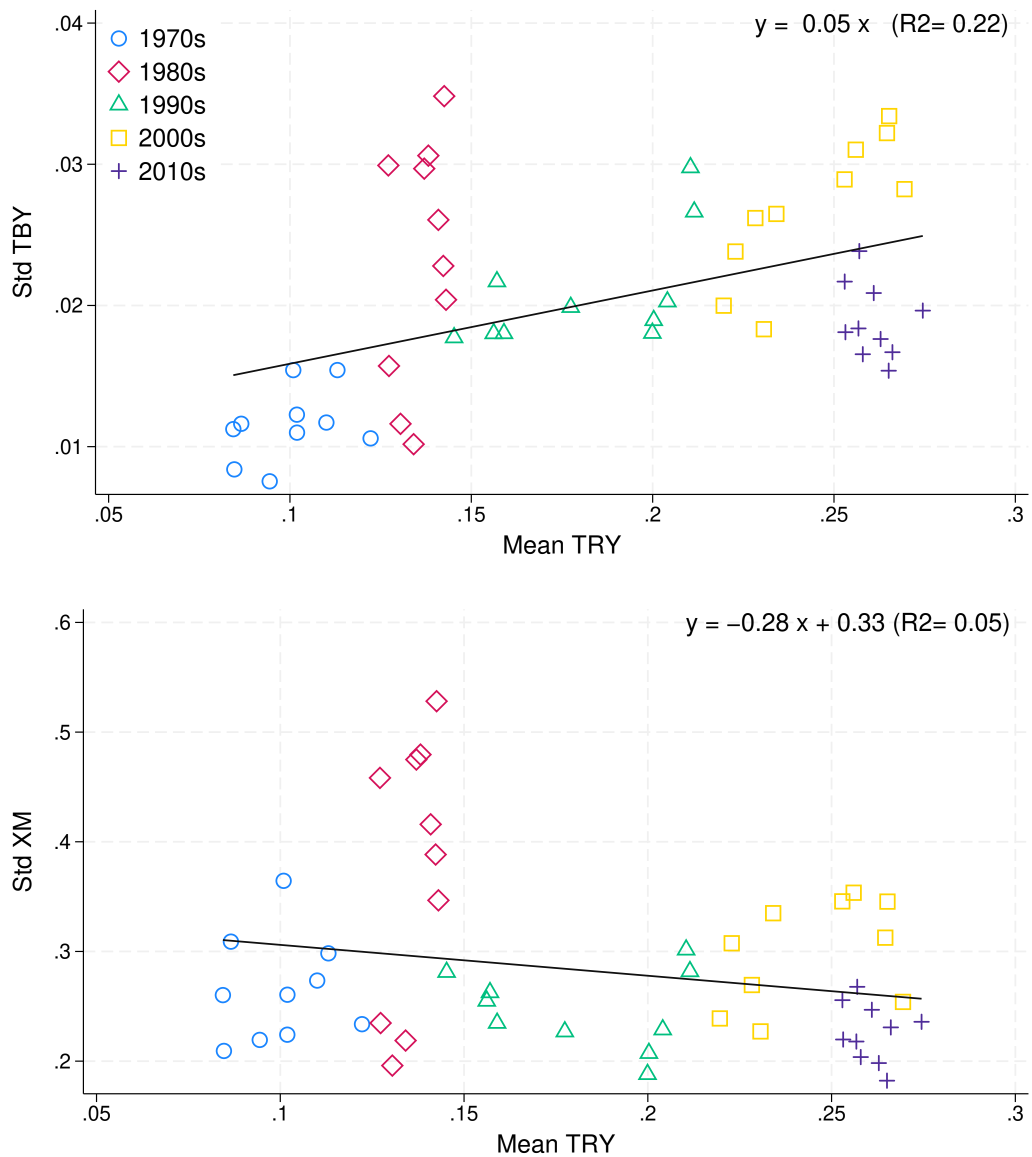
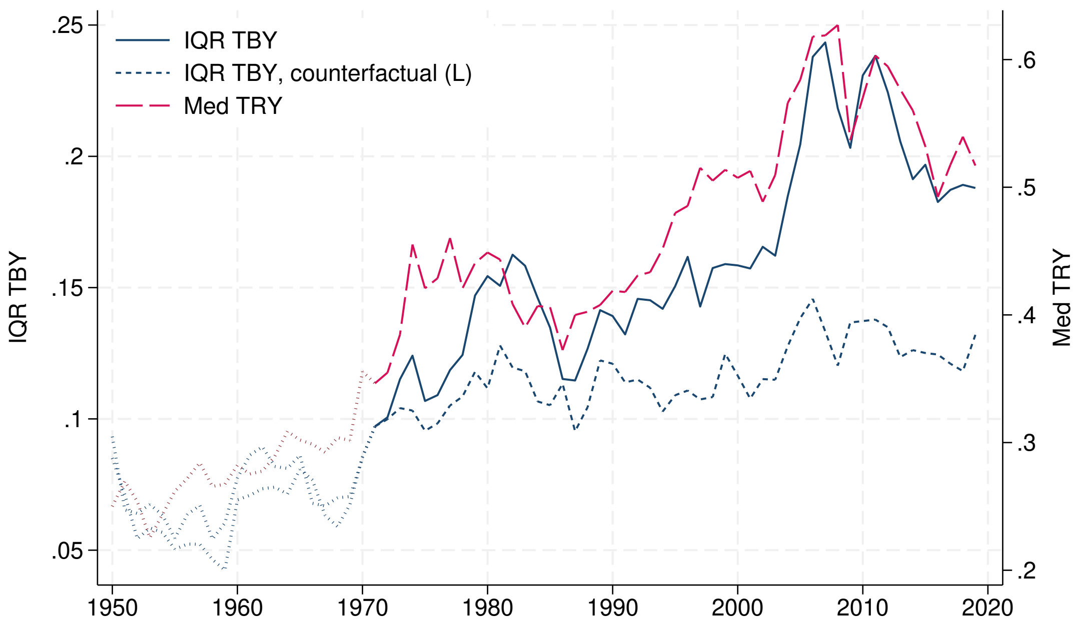
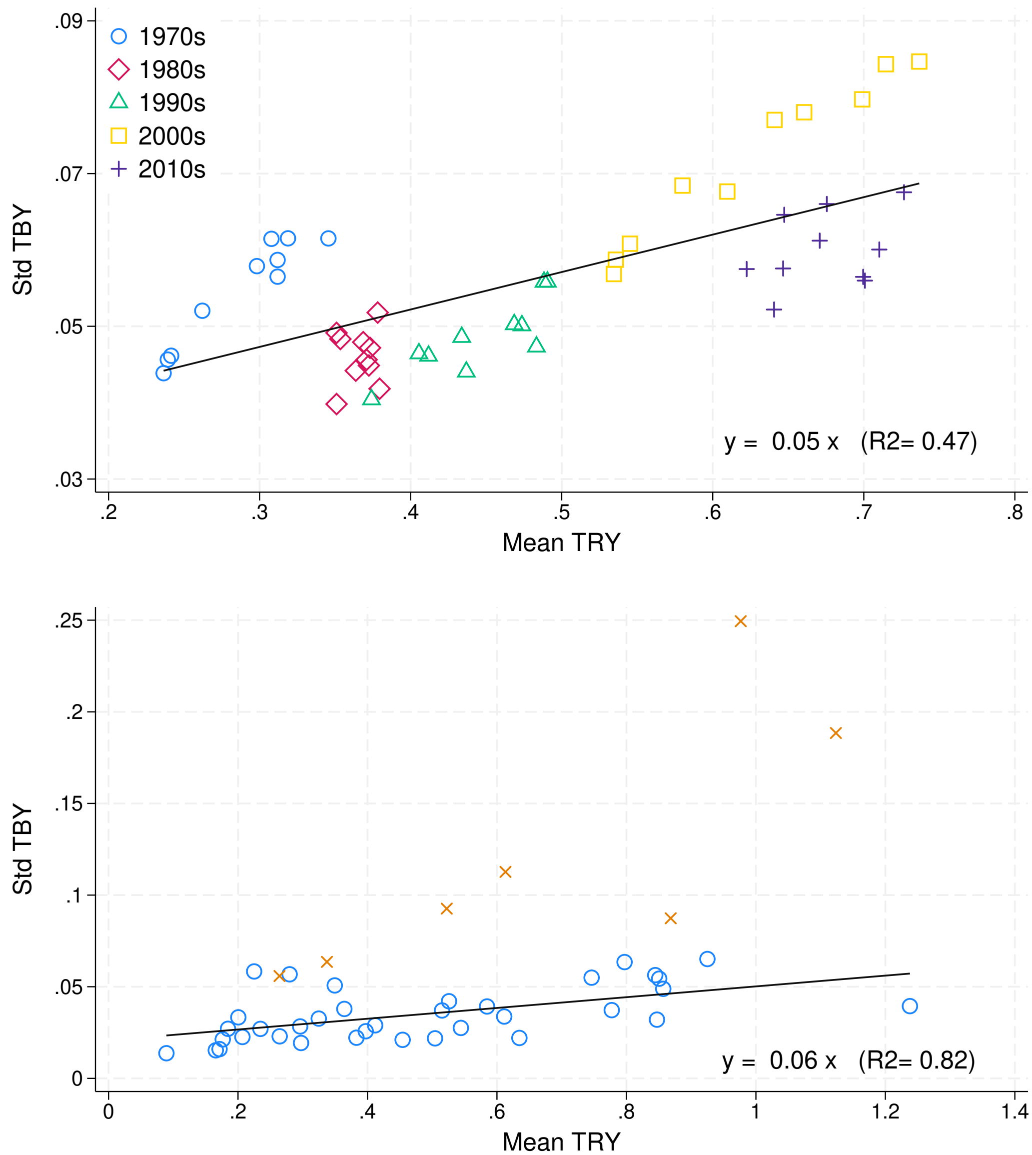


Figure B.4: Relationship in Larger Sample of Countries



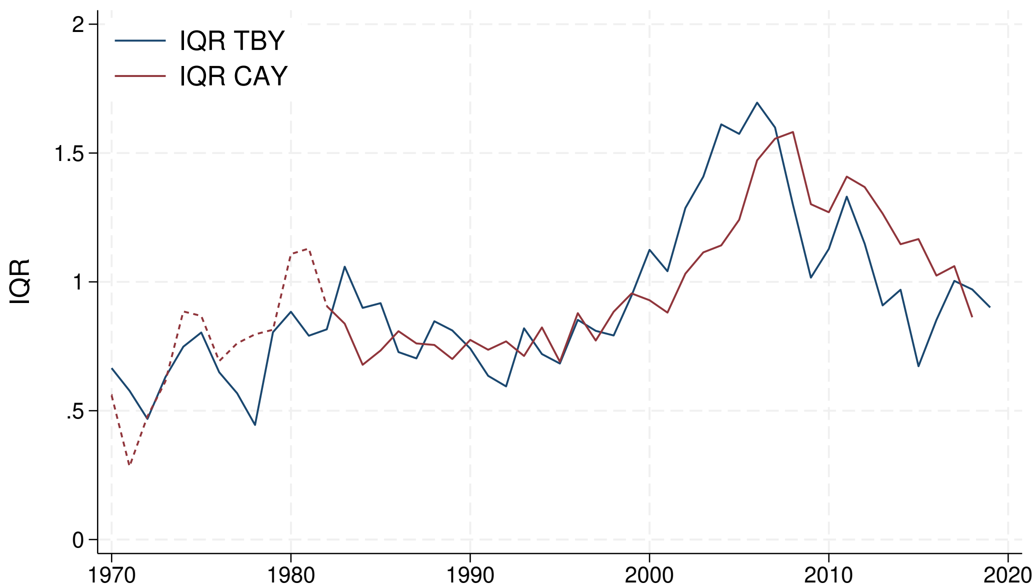
Notes: The figure shows the interquartile range of TBY and median of TRY for the full sample of 157 countries in PWT 10.0. Prior to 1970, there are countries with missing values resulting in an unbalanced panel and we plot them with dotted lines.

Figure B.5: Relationship in Real Terms



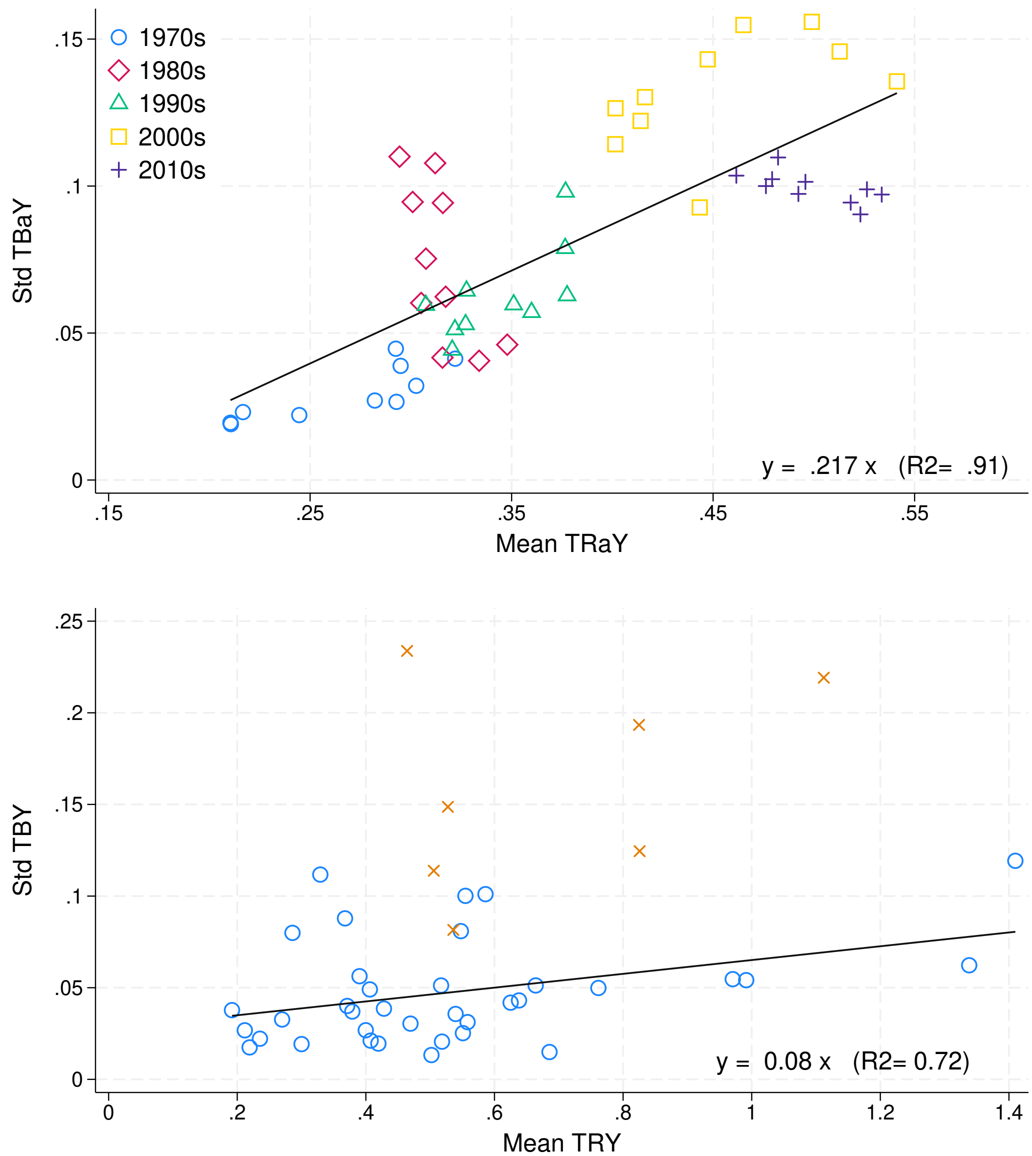
Notes: The upper panel plots cross-country moments for each year, with decades presented in different colors. The lower panel shows the time series moments for each country. The x-markers in the lower panel represent entrepot countries that are not included in our baseline sample and are not taken into account for the regression. Both TBY and TRY are measured in real terms.

Figure B.6: Relationship Measured by Current Account



Notes: The figure shows the interquartile range of TBY and CAY, where CAY is current account as a share of GDP, calculated using our baseline sample of 36 countries. Current account is from WDI. Prior to 1983, some countries in the baseline sample are missing values for the current account.

Figure B.7: Relationship in Share of World Average Output



Notes: The figure shows the relationship the net and gross flows as a share of world average output. In the upper panel the cross-country moments are calculated for each year, while in the lower panel takes each country as an observation and time series moments are calculated. The x-markers in the lower panel represent entrepot countries that are not included in our baseline sample and are not taken into account for the regression.

Table B.1: Comparison of Data Sources

	(1) Disp TBY	(2) Disp TBY	(3) Disp lnX/M	(4) Disp lnX/M
TRY mean	0.15***	0.10***	-0.12	-0.43***
	(0.00)	(0.00)	(0.09)	(0.03)
Constant			0.41***	0.50***
			(0.04)	(0.02)
Observations	50	50	50	50
R-squared	0.97	0.95	0.04	0.83
Data source	PWT	UN SNA	PWT	UN SNA

Notes: The table shows the regression result using 43 countries. Dispersion is measured by the standard deviation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table B.2: Cross-sectional Regressions for Net Financial Flow

VARIABLES	(1) Disp (A-L)/Y	(2) Disp (A-L)/Y	(3) Disp (A-L)/Y	(4) Disp (A-L)/Y	(5) Disp (A-L)/Y	(6) Disp (A-L)/Y	(7) Disp (A-L)/Y	(8) Disp (A-L)/Y	(9) Disp (A-L)/Y	(10) Disp (A-L)/Y	(11) Disp (A-L)/Y
TRY med	0.403***	0.400***	0.393***	0.354***	0.252*	0.317***	0.165				-0.909***
	(0.104)	(0.101)	(0.108)	(0.095)	(0.135)	(0.092)	(0.150)				(0.135)
d ln Y med		-0.176				0.038	0.040	0.075	0.033		
		(0.384)				(0.302)	(0.310)	(0.370)	(0.315)		
d ln Y med (-1)		-0.310				-0.140	0.104	-0.080	0.260		
		(0.389)				(0.365)	(0.403)	(0.403)	(0.362)		
ln Oil price			0.008			0.029	0.041*	0.067**	0.057**		
			(0.022)			(0.022)	(0.021)	(0.027)	(0.023)		
Disp d ln Y				-1.955**	-1.599*	-1.929*	-1.513	-2.462**	-1.386		
				(0.966)	(0.937)	(0.955)	(0.920)	(1.187)	(1.002)		
Disp d ln Y (-1)				-2.082**	-2.237**	-2.294**	-2.646***	-2.663**	-2.913***		
				(0.931)	(0.967)	(0.903)	(0.902)	(1.028)	(0.806)		
Disp d ln RER					-0.657		-0.836		-1.247**		
					(0.506)		(0.607)		(0.526)		
Disp d ln RER (-1)					-0.325		-0.479		-0.831*		
					(0.421)		(0.516)		(0.441)		
(A+L)/Y med										0.098***	0.246***
										(0.014)	(0.023)
Observations	48	48	48	48	48	48	48	48	48	48	48
R-squared	0.296	0.313	0.298	0.469	0.492	0.485	0.518	0.336	0.499	0.572	0.769

Notes: Data from Penn World Table 10.0 and External Wealth of Nations, 1970-2019 with 36 countries. Disp denotes dispersion and is measured by the interquartile range. Oil price is an annual average of imported crude oil price ($/barrel, real) (US EIA). Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table C.1: Persistence of Productivity Shocks

		Data	Baseline	$\rho_{zc} = 0.97$	$\rho_{zd} = 0.99$
Integration and Cross-country Dispersion					
TBY	slope (nominal)	0.11	$0.20^{\dagger}$	0.20	0.20
X/M	slope	-0.39	$-0.39^{\dagger}$	-0.39	-0.38
X/M	constant	0.50	$0.61^{\dagger}$	0.61	0.61
ΔRER	slope	-0.09	$-0.09^{\dagger}$	-0.09	-0.08
ΔRER	constant	0.12	0.09	0.09	0.09
ΔTOT	slope	-0.13	$-0.04^{\dagger}$	-0.04	-0.04
ΔTOT	constant	0.10	0.08	0.08	0.08
Y	slope	-0.01	0.02	0.02	0.07
Y	constant	1.17	$1.18^{\dagger}$	1.18	1.19
D/D^*	slope	-0.22	-0.11	-0.11	-0.06
D/D^*	constant	1.33	1.18	1.18	1.18
Business Cycle Moments					
$\sigma(\Delta y)$, %		3.69	$5.38^{\dagger}$	5.17	5.11
$\sigma(\Delta c)/\sigma(\Delta y)$		1.06	$0.88^{\dagger}$	0.89	0.90
$\sigma(\Delta inv)/\sigma(\Delta y)$		3.16	$3.21^{\dagger}$	3.25	3.25
$\rho(\Delta y_t, \Delta y_{t-1})$		0.39	0.29	0.23	0.36
$\rho(\Delta c_t, \Delta c_{t-1})$		0.37	0.24	0.19	0.34
$\sigma(TRY)$		0.15	$0.14^{\dagger}$	0.14	0.14
$\rho(TRY)$		0.98	$0.96^{\dagger}$	0.96	0.95
$\rho(TBY, \Delta y)$		-0.01	-0.18	-0.18	-0.16
$\rho(\Delta(c - c*), \Delta RER)$		-0.21	$0.04^{\dagger}$	0.04	0.00
$\rho(\Delta y, \Delta y^*)$		0.21	$0.28^{\dagger}$	0.23	0.42
Trade Elasticity					
Short Run		0.22	$0.20^{\dagger}$	0.20	0.20
Long Run		3.22	$3.26^{\dagger}$	3.50	3.51
Distance		–	0.13	0.13	0.15

Notes: All of the moments except the slope for TBY are calculated using real values. Business cycle moments are averages across countries.

Table D.1: Model Results – Number of Countries

			18 Countries			22 Countries		
		Data	All	No financial integration	No trade integration	All	No financial integration	No trade integration
Integration and Cross-country Dispersion								
TBY	slope (nominal)	0.11	0.20†	0.08	0.20	0.19	0.08	0.19
X/M	slope	-0.39	-0.39†	-0.04	0.08	-0.22	-0.02	0.22
X/M	constant	0.50	0.61†	0.31	0.38	0.55	0.31	0.29
ΔRER	slope	-0.09	-0.09†	0.00	-0.01	-0.07	0.00	0.00
ΔRER	constant	0.12	0.09	0.01	0.06	0.09	0.01	0.05
ΔTOT	slope	-0.13	-0.04†	0.01	-0.01	-0.03	0.01	0.00
ΔTOT	constant	0.10	0.08	0.01	0.06	0.08	0.01	0.06
Y	slope	-0.01	0.02	0.02	0.50	0.01	-0.01	0.66
Y	constant	1.17	1.18†	1.18	0.98	1.21	1.22	0.88
D/D^{*}	slope	-0.22	-0.11	-0.10	0.50	-0.13	-0.13	0.63
D/D^{*}	constant	1.33	1.18	1.18	0.92	1.22	1.22	0.83
Business Cycle Moments								
$\sigma(\Delta y)$, %		3.69	5.38†	5.24	5.37	5.42	5.24	5.40
$\sigma(\Delta c)/\sigma(\Delta y)$		1.06	0.88†	0.79	0.88	0.90	0.79	0.90
$\sigma(\Delta inv/\sigma(\Delta y)$		3.16	3.21†	2.47	3.28	3.47	2.54	3.54
$\rho(\Delta y_t, \Delta y_{t-1})$		0.39	0.29	0.30	0.29	0.28	0.30	0.29
$\rho(\Delta c_t, \Delta c_{t-1})$		0.37	0.24	0.26	0.24	0.23	0.26	0.24
$\sigma(TRY)$		0.15	0.14†	0.14	0.03	0.16	0.17	0.03
$\rho(TRY)$		0.98	0.96†	0.95	0.38	0.97	0.96	0.47
$\rho(TBY, \Delta y)$		-0.01	-0.18	-0.26	-0.20	-0.18	-0.26	-0.21
$\rho(\Delta(c - c*), \Delta RER)$		-0.21	0.04†	0.36	-0.04	0.09	0.37	-0.02
$\rho(\Delta y, \Delta y^{*})$		0.21	0.28†	0.29	0.28	0.28	0.29	0.29
Trade Elasticity								
Short Run		0.22	0.20†	0.21	0.20	0.20	0.20	0.20
Long Run		3.22	3.26†	3.60	3.98	3.47	3.56	4.06
Distance		–	0.13	1.06	0.69	0.26	1.00	0.91

Notes: All of the moments except the slope for TBY are calculated using real values. Business cycle moments are averages across countries.