Financial Liberalization and Trade Imbalances: A Quantitative Assessment

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Abstract

We develop a multi-country dynamic general equilibrium model to quantify the impacts of financial liberalization on global trade imbalances and welfare dynamics. Under financial liberalization, countries with comparative advantage in financial intermediation become international financial centers by attracting financial capital inflows, transforming them into physical capital, and conducting outward FDI. These capital flows lead to large and persist trade deficits in these countries. The model generates tractable gravity equations and capital accumulation process that characterize steady-states and transitional dynamics. Armed with these structural equations, we develop a new method to compute counterfactual transitional dynamics from the observed steady-states. By exploiting bilateral trade, FDI, and financial capital data over 1996-2006, we calibrate our model and find that the decline in the costs of trade, FDI, and international financial capital flow, respectively, can explain 41 percent, 31 percent, and 51 percent of the increase in global trade imbalances over this period.

Keywords: *Financial Liberalization; Financial Intermediation; Trade Imbalances; Growth.*

JEL classification: *F15; F21; F32; F41; F43.*

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1 Introduction

International financial liberalization has led to a dramatic increase in financial and physical capital flows across countries. These capital flows are regarded by an extensive literature as major factors shaping global trade imbalances.[1] They are also shown to have both short- and long-run effects on trade, production, and welfare. In particular, financial liberalization can change capital returns across countries, affecting capital accumulation and thereby income evolution. Yet, there is a lack of tractable frameworks that characterize the determinants of capital flows across many countries and quantify their impacts on the dynamics of trade imbalances and welfare, a gap this paper aims to fill.

In this paper, we quantify the impacts of financial liberalization on global imbalances and characterize the dynamic welfare effects of international capital flows. To achieve these, we develop a multi-country dynamic model with trade, FDI, international financial investment, and endogenous capital accumulation. We calibrate our model to data for 31 economies in 1996 and 2006. Our counterfactual exercises show that financial liberalization accounts for a substantial fraction of the increase in global trade imbalances over this period.

Our model combines a static multi-country general equilibrium model with a dynamic framework with endogenous saving and capital accumulation. Specifically, our static model incorporate international capital flows into a standard Eaton-Kortum model. The key assumption is that the physical capital, which can be used to produce final consumption goods, is transformed from financial capital via financial intermediation. Both final productivities and the efficiencies of financial intermediation differ across countries. Financial capital owners can transform their savings into physical capital by foreign financial intermediation, which creates financial capital flows. Similarly, producers can utilize foreign physical capital, which creates FDI. Both types of international capital flows are subject to standard iceberg frictions. Final goods are also tradable and subject to iceberg trade costs.

When financial liberalization, characterized by the decline in the costs of international capital flows, occurs, countries with comparative advantage in financial intermediation (such as the U.S.) become international financial centers by attracting financial capital from

[1] See Gourinchas and Rey (2014) for an extensive survey of the literature. The importance of portfolio investment is emphasized by Caballero et al. (2008), Mendoza et al. (2009), and Angeletos and Panousi (2011). The role of physical or industrial capital is discussed by Wang et al. (2017), Coeurdacier et al. (2015), and Ju and Wei (2010).

other countries, transforming them into physical capital, and conducting FDI globally. The inflows of FDI returns enable these countries to consume more goods than they produce and thus lead to trade deficits. In contrast, countries with comparative advantage in production (such as China) send their financial capital to foreign financial intermediation and utilize foreign physical capital by inward FDI. The outflows of FDI returns make them consume less than they produce and thus lead to trade surpluses. This way our model generates endogenous trade imbalances that depend on the frictions of international trade and capital flows.

The static specialization between production and financial intermediation further interacts with endogenous capital accumulation in the dynamic part of our model. We assume that financial capital is created by savings. Under financial liberalization, international financial centers have little incentive to save and accumulate financial capital themselves since they can always attract a large volume of financial capital from abroad. In contrast, countries with comparative advantage in production have to meet their demands of physical capital by saving more, sending their financial capital to foreign financial intermediation, and attracting inward FDI.

Our model is highly tractable and quantifiable in the data with many countries over multiple periods. The static part of our model delivers analytical gravity equations for international trade, FDI, and financial capital flows, which can be mapped to the observed bilateral flows in the data. Solving the saving problem for many countries is generally challenging since their saving decisions are interdependent in the global economy. However, our specification delivers closed-form solutions to the saving problem, in which for each country its next-period capital depends analytically on its current capital stock and real capital return.

Armed with these structural equations, we develop a new method to compute equilibrium in relative changes for both steady-states and transitional dynamics. Our method to compute steady-states in relative changes follows the "exact-hat algebra" developed by Dekle, Eaton, and Kortum (2008). To compute transitional dynamics in relative changes, we use the "exact-hat algebra" in each period, given the changes in capital stocks determined in the last period. The advantage of our method is that to characterize the dynamic effects of a certain policy, we do not need to calibrate or estimate the level of high-dimensional parameters such and trade and financial frictions and technologies of production and financial intermediation. Instead, we compute counterfactual dynamic changes based on the observed bilateral trade and financial flows and a very small set of calibrated parameters. Our algorithm converges fast: it takes less than 30 seconds in a personal computer to compute the transitional dynamics of 31 economies under a counterfactual financial liberalization.

In our quantification practice, we combine bilateral trade data from WIOD, bilateral FDI data from UNCTAD, and bilateral financial capital data from LBS and CPIS for 31 economies in 1996 and 2006. Through the lens of our model, we impute the changes in the frictions of trade, FDI, and financial capital from the data. We then insert the imputed trade and financial liberalizations into the observed steady-state in 1996 and compute the counterfactual steady-states. The results suggest that the decline in the costs of trade, FDI, and international financial capital flow, respectively, can explain 41 percent, 31 percent, and 51 percent of the increase in global trade imbalances between 1996 and 2006. This exercise highlights the importance of financial liberalization to the recent surge of trade imbalances.

We then characterize the welfare dynamics under trade and financial liberalization. The results suggest that the long-run welfare effects of these shocks can differ substantially from the short-run welfare effects that are obtained with fixed capital stocks. For example, China gains from FDI liberalization in the short run but loses in the long run. The key lies in the trade-off between labor income and capital return. In the short run, inward FDI increases the demand for Chinese labor and thus raises the labor income in China. However, the competition from foreign capital reduces the financial capital return in China, which leads to the decline in Chinese financial capital stock in the long run.

Our paper first relates to a large literature on global imbalances, asking why capital flows from developing to developed countries (see Gourinchas and Jeanne (2013) as the "allocation puzzle"). They mainly explain these imbalances by the asymmetric levels of financial development between North and South (see Caballero et al. (2008), Mendoza et al. (2009), Ju and Wei (2010), Song et al. (2011), Caballero et al. (2008), Mendoza et al. (2009), and Angeletos and Panousi (2011)). However, the bulk of the literature does not differentiate between FDI and financial flows (bank loans and portfolio investment). In reality, FDI mainly flows from North to South which is consistent with the predictions of the neoclassical growth model, while financial flows show the opposite pattern. Such two-way capital flow pattern has not been well studied in the literature. Ju and Wei (2010) first explains such a pattern using a simple two-country model highlighting inefficient financial system and poor corporate governance in the South. Recently, Wang et al. (2017) build a two-country dynamic model which features financial frictions on both the households' saving and the firms' borrowing in China. However, a two-country model leaves many important questions unanswered and cannot be quantified in a multi-country world. Our model allows two-way capital flows in a multi-country world, which is crucial for our quantification exercises.

Our paper is also related to the emerging literature combining intra-temporal trade with inter-temporal saving and capital accumulation. The static quantitative trade framework such as Eaton and Kortum (2002) does not allow endogenous trade imbalances. Anderson et al. (2015) introduces endogenous capital accumulation into a standard trade model. But without international capital flows and lending and borrowing, their framework cannot generate endogenous trade imbalances. Eaton et al. (2016) and Reyes-Heroles (2016), in contrast, consider international capital flows and lending and borrowing. Our paper is mostly related to Reyes-Heroles (2016). His paper highlights the contribution of trade cost reduction on global trade imbalance in a quantitative multi-country dynamic general equilibrium model. We depart from his work by differentiating between FDI and financial capital flows. The two-way capital flow phenomenon is at the center of this paper.

2 Model

2.1 Financial Capital Accumulation

Time is discrete and goes to infinity. There are N countries in the world. Each country i is inhabited by a unit mass of infinitely-lived entrepreneurs who make saving decisions. The entrepreneurs maximize

$$U_i = E_0 \sum_{t=0}^{\infty} \rho^t \log C_{it}, \tag{1}$$

subject to their budget constraint

$$P_{it} C_{it} + P_{it} \left[K_{it+1} - (1-\delta) K_{it} \right] = (1 - s_{it}) \, r_{it} K_{it} \tag{2}$$

where C_{it} is their consumption, K_{it} is the *financial capital* holding in period t, r_{it} is the rental rate of financial capital, and δ is the depreciation rate of financial capital. Notably, $s_{it} \in (0,1)$ is the income tax rate in country i. With this AK model setup, we have the following results:

Proposition 1 (Capital Accumulation) *The consumption of entrepreneurs in country* *i can be given by*

$$C_{it} = (1-\rho)\left[(1-s_{it})\frac{r_{it}}{P_{it}} + (1-\delta)\right]K_{it}. \tag{3}$$

Therefore, the capital in the next period is

$$K_{it+1} = \rho\left[(1-s_{it})\frac{r_{it}}{P_{it}} + (1-\delta)\right]K_{it}. \tag{4}$$

2.2 Final Production

The final good consists of a unit mass of varieties. The varieties are aggregated by a CES aggregator with the elasticity of substitution $\sigma > 1$. Each final variety can potentially be produced by a producer using labor and *physical capital* under perfect competition. The unit cost of final variety ν produced in country i is given by

$$c_{it}(\nu) = \frac{w_{it}^{\beta} q_{it}^{1-\beta}}{z_{it}(\nu)}, \quad \beta \in (0,1], \tag{5}$$

where q_{it} is the rental rent of physical capital and $z_{it}(\nu)$ is the productivity of producer ν. The final productivity $z_{it}(\nu)$ is drawn from a Frechet distribution

$$prob\left\{z_{it}(\nu) \leq z\right\} = \exp\left\{-T_{it}z^{-\theta}\right\}, \quad \theta > \max\left\{1, \sigma - 1\right\}. \tag{6}$$

Trade from country i to n incurs the standard iceberg trade cost $\tau_{in} \geq 1$.

2.3 International Capital Flows

Physical capital used for final production also consists of a unit mass of varieties which are aggregated by a CES function with the elasticity of substitution $\sigma^k > 1$. Each variety of physical capital can be produced by an investor under perfect competition using financial capital and intermediation labor. The unit cost of physical capital variety ω produced using financial capital in country i and intermediation labor in country ℓ to serve final producers in country n can be expressed as

$$\tilde{c}_{i\ell nt}(\omega) = \frac{\left(\mu_{i\ell t} r_{it}\right)^{\alpha}\left(\frac{w_{\ell t}}{H_{\ell t}^{\eta}}\right)^{1-\alpha}\gamma_{\ell nt}}{\phi_{\ell t}(\omega)}, \quad \eta \geq 0, \tag{7}$$

Table 1: Gravity Equations for FDI and Financial Capital

	Dependent variable	
	$\log(X_{\ell n}^{FDI})$	$\log(X_{i\ell}^{Finance})$
Log of distance	-.938***	-.908***
	(.086)	(.065)
Shared border	.133	-.261
	(.21)	(.17)
Common language	.200	.259*
	(.20)	(.15)
Legal origin	.652***	.463***
	(.13)	(.10)
Origin-Year FE	✓	✓
Destination-Year FE	✓	✓
R-squared	0.838	0.876
N. Obs.	629	1532

(Note: FDI stock data: UNCTAD. Financial capital stock data: LBS + CPIS.)

where $\mu_{i\ell t} \geq 1$ is the iceberg costs for transferring *financial capital* from country i to country ℓ, $H_{\ell t}$ is the aggregate intermediation labor in country ℓ, and $\gamma_{\ell n t}$ is the iceberg costs of transferring *physical capital* from country ℓ to country n. $\eta \geq 0$ characterizes the external economies of scale in financial intermediation. Moreover, $\phi_{\ell t}(\omega)$ characterizes the efficiency of financial intermediation for physical capital variety ω in country ℓ, which is drawn from a Frechet distribution

$$prob\,\{\phi_{\ell t}(\omega) \leq \phi\} = \exp\{-A_{\ell t} z^{-\epsilon}\}, \quad \epsilon > \max\{1, \sigma^k - 1\}, \tag{8}$$

where $A_{\ell t}$ depicts the average intermediation efficiency in country ℓ.

Equation (7) suggests that bilateral FDI and international financial flows should be depicted by gravity equations. The regression results in Table 1 show that the gravity equation holds for FDI and financial capital flows.

2.4 International Lending and Borrowing

So far our model allows for trade imbalances but not current account imbalances. In this section, we introduce lending and borrowing of the workers'. Each country i is also inhabited a unit mass of workers. Each worker can live for two periods, young and old.

Each young worker in country i at period t is endowed with L_{it} units of labor. We make the following assumption of financial capital tax revenues:

Assumption 2 (Pension System) *The government of country i collects income tax revenue $s_{it}r_{it}K_{it}$ at period t and sends it as a lump-sum transfer to old workers at period $t+1$.*

The worker solves the following problem:

$$\begin{aligned} \max_{C_{it}^{w1}, C_{it+1}^{w2}} & \log\left(C_{it}^{w1}\right) + \rho \log\left(C_{it+1}^{w2}\right), \\ \text{s.t. } & P_{it}C_{it}^{w1} + B_{it} = (1 - s_{it})\, w_{it}L_{it}, \\ & P_{it+1}C_{it+1}^{w2} = R_{t+1}B_{it} + s_{it}\left(r_{it}K_{it} + w_{it}L_{it}\right), \end{aligned} \tag{9}$$

where C_{it}^{w1} is the consumption of young workers in country i at period t and C_{it+1}^{w2} is the consumption of old workers in country i at period $t+1$. B_t is a global bond with the gross nominal return R_{t+1} in period $t+1$. w_{it} is the nominal wage and P_{it} is the price for final goods.

Proposition 3 (International Borrowing and Lending) *The first order condition of the workers' problem delivers*

$$\begin{aligned} R_{t+1} &= \frac{1}{\rho} \frac{\sum_{i=1}^{N} s_{it}\left(r_{it}K_{it} + w_{it}L_{it}\right)}{\sum_{i=1}^{N} (1 - s_{it})\, w_{it}L_{it}}, \\ B_{it} &= \frac{\rho}{1+\rho}(1 - s_{it})\, w_{it}L_{it} - \frac{1}{(1+\rho)R_{t+1}} s_{it}\left(r_{it}K_{it} + w_{it}L_{it}\right). \end{aligned} \tag{10}$$

This simple OLG framework is not only highly tractable but also empirically relevant. It predicts that, ceteris paribus, countries with higher capital-to-labor ratio tend to have larger current account deficits. The regression results in Table 2 suggest that this prediction is consistent with the data. For 179 countries over 1960-2014, one percentage point increase in capital-to-labor ratio decreases current account balance as a share of GDP by about 3 percentage points.

Our OLG framework is also qualitatively close to the standard neoclassical growth model in Reyes-Heroles (2016). In our model, under a positive productivity shock, the increase in wage income exceeds the increase in capital return in the short run, which leads to current account surpluses in this country.

Table 2: CA Balance and Capital-Labor-Ratio

	CA surplus as % of GDP
$\log(K/L)$	-2.929***
	(1.13)
Log of GDP per worker	2.060**
	(1.03)
TFP	10.54***
	(3.25)
Country FE and Year FE	✓
R-squared	0.427
N. of Obs.	3697

(Note: CA balance: World Bank. Capital and labor: Penn World Table.)

2.5 Aggregation and Dynamic Equilibrium

In this subsection, we express aggregate international trade and capital flows in terms of technologies and frictions, taking advantage of the properties of Frechet distribution. First, the expenditure share of physical capital in country n produced by intermediation in country ℓ using financial capital from country i can be given by

$$\lambda_{i\ell nt} := \frac{\kappa_{i\ell nt}}{\sum_{i',\ell'} \kappa_{i'\ell' nt}} = \frac{A_{\ell t}\left[(\mu_{i\ell t} r_{it})^{\alpha}\left(w_{\ell t} H_{\ell t}^{-\eta}\right)^{1-\alpha}\gamma_{\ell nt}\right]^{-\epsilon}}{\sum_{i',\ell'} A_{\ell' t}\left[(\mu_{i'\ell' t} r_{i't})^{\alpha}\left(w_{\ell' t} H_{\ell' t}^{-\eta}\right)^{1-\alpha}\gamma_{\ell' nt}\right]^{-\epsilon}}, \tag{11}$$

where $\kappa_{i\ell nt}$ is the expenditure of country n on physical capital produced by intermediation in country ℓ using financial capital from country i, and $\sum_{i',\ell'} \kappa_{i'\ell' nt}$, by definition, is country n's total expenditure on physical capital, or namely, nominal physical capital holding. For tractability, we assume full depreciation for physical capital.

The rental rate of physical capital in country n is thereby

$$q_{nt} = \tilde{\gamma}_1 \left[\sum_{i',\ell'} A_{\ell' t}\left[(\mu_{i'\ell' t} r_{i't})^{\alpha}\left(w_{\ell' t} H_{\ell' t}^{-\eta}\right)^{1-\alpha}\gamma_{\ell' nt}\right]^{-\epsilon}\right]^{-\frac{1}{\epsilon}}, \tag{12}$$

where $\tilde{\gamma}_1$ is a constant.

Second, given the rental rate of physical capital, q_{nt}, the expenditure share in country

m on final goods produced by country n can be expressed as

$$\pi_{nmt} := \frac{X_{nmt}}{X_{mt}} = \frac{T_{nt}\left(w_{nt}^{\beta} q_{nt}^{1-\beta} \tau_{nmt}\right)^{-\theta}}{\sum_{n'} T_{n't}\left(w_{n't}^{\beta} q_{n't}^{1-\beta} \tau_{n'mt}\right)^{-\theta}}. \tag{13}$$

The price index of final goods in country m is thereby

$$P_{mt} = \tilde{\gamma}_2 \left[\sum_{n'} T_{n't}\left(w_{n't}^{\beta} q_{n't}^{1-\beta} \tau_{n'mt}\right)^{-\theta}\right]^{-\frac{1}{\theta}}, \tag{14}$$

where $\tilde{\gamma}_2$ is a constant.

Labor wage income is the sum of wage incomes of production and financial intermediation workers:

$$w_{it} L_{it} = \beta \sum_{m} \pi_{imt} X_{mt} + w_{it} H_{it}, \tag{15}$$

where the wage income of financial intermediation workers is given by

$$w_{it} H_{it} = (1-\alpha) \sum_{k,n} \lambda_{kint} \left[(1-\beta) \sum_{m} \pi_{nmt} X_{mt}\right]. \tag{16}$$

Financial capital returns come from global portfolio returns net intermediation costs:

$$r_{it} K_{it} = \alpha \sum_{\ell,n} \lambda_{i\ell nt} \left[(1-\beta) \sum_{m} \pi_{nmt} X_{mt}\right]. \tag{17}$$

Finally, the expenditure on final goods equates the sum of final consumption and the investment in financial capital:

$$X_{it} = (1-s_{it})\left(r_{it} K_{it} + w_{it} L_{it}\right) - B_{it} + s_{it-1}\left(r_{it-1} K_{it-1} + w_{it-1} L_{it-1}\right) + R_t B_{it-1}. \tag{18}$$

Now we can define our equilibrium:

Definition 4 (Dynamic Equilibrium) *Given the initial financial capital and bond $\{K_{i0}, B_{i0}\}_i$ and labor endowment sequences $\{L_{it}\}_{i,t}$, an equilibrium consists of sequences of prices $\{w_{it}, q_{it}, P_{it}, r_{it}, R_{t+1}\}_{i,t}$ and allocations $\{K_{it+1}, B_{it}, H_{it}, X_{it}\}_{i,t}$ such that*

(i) Wage is determined by labor market clearing as Equation (15).

(ii) The financial intermediation labor, (H_{it}), satisfies Equation (16).

(iii) Given (K_{it}), the capital returns satisfy Equation (17).

(iv) Total expenditure satisfies goods market clearing in Equation (18).

(v) The final good price index is given by Equation (14) and the physical capital price index is given by Equation (12).

(vi) The evolution of financial capital is characterized by the entrepreneurs' saving decision in Equation (4).

(vii) Bond $\{B_{it}\}$ and its return R_{t+1} are given by the workers' decision in Equation (10).

2.6 Steady-State

In this subsection, we consider the steady-state equilibrium. Suppose that in the steady-state all exogenous variables are constant over time. From Equation (4), we derive the steady-state real capital return:

$$\frac{r_i}{P_i} = \frac{1}{1-s_i}\left[\frac{1}{\rho} - (1-\delta)\right]. \tag{19}$$

Then the steady-state capital stock can be derived from Equation (17):

$$K_i = \frac{\alpha(1-s_i)}{\frac{1}{\rho} - (1-\delta)} \frac{1}{P_i} \sum_{\ell,n} \lambda_{i\ell n}\left[(1-\beta)\sum_m \pi_{nm} X_m\right]. \tag{20}$$

Given (r_i, K_i), the steady-state $(w_i, H_i, X_i, P_i, q_i, B_i, R)$ satisfy Equation (15), (16), (18)[2], (14), (12), and (10).

Now we consider the response of steady-state equilibrium to exogenous shocks. Let y' be the value of any variable y after change and $\hat{y} = y'/y$. Then steady-state equilibrium in relative changes can be characterized as follows:

Proposition 5 (Steady-State Equilibrium in Relative Changes) *Given data on $(\lambda_{i\ell n}, \pi_{nm}, X_m)$ and parameters $(\alpha, \beta, \eta, \epsilon, \theta, s_i)$, the steady-state equilibrium in relative changes consists of $\left(\hat{w}_i, \hat{K}_i, \hat{H}_i, \hat{X}_i, \hat{P}_i, \hat{q}_i, \hat{r}_i, \hat{B}_i, \hat{R}\right)$ such that:*

[2] The expenditure in the steady-state can be simplified into $X_i = r_i K_i + w_i L_i + (R-1)B_i$.

(i) Capital market clearing:

$$\hat{r}_i \hat{K}_i r_i K_i = \alpha \sum_{\ell,n} \hat{\lambda}_{i\ell n} \lambda_{i\ell n} \left[(1-\beta) \sum_m \hat{\pi}_{nm} \pi_{nm} \hat{X}_m X_m \right], \tag{21}$$

where

$$\hat{\lambda}_{i\ell n} = \frac{\hat{A}_\ell \left[(\hat{\mu}_{i\ell} \hat{r}_i)^\alpha \left(\hat{w}_\ell \hat{H}_\ell^{-\eta} \right)^{1-\alpha} \hat{\gamma}_{\ell n} \right]^{-\epsilon}}{\sum_{i',\ell'} \lambda_{i'\ell' n} \hat{A}_{\ell'} \left[(\hat{\mu}_{i'\ell'} \hat{r}_{i'})^\alpha \left(\hat{w}_{\ell'} \hat{H}_{\ell'}^{-\eta} \right)^{1-\alpha} \hat{\gamma}_{\ell' n} \right]^{-\epsilon}}, \tag{22}$$

and

$$\hat{\pi}_{nm} = \frac{\hat{T}_n \left(\hat{w}_n^\beta \hat{q}_n^{1-\beta} \hat{\tau}_{nm} \right)^{-\theta}}{\sum_{n'} \pi_{n'm} \hat{T}_{n'} \left(\hat{w}_{n'}^\beta \hat{q}_{n'}^{1-\beta} \hat{\tau}_{n'm} \right)^{-\theta}}. \tag{23}$$

(ii) Capital price:

$$\hat{q}_n = \left[\sum_{i',\ell'} \lambda_{i'\ell' n} \hat{A}_{\ell'} \left[(\hat{\mu}_{i'\ell'} \hat{r}_{i'})^\alpha \left(\hat{w}_{\ell'} \hat{H}_{\ell'}^{-\eta} \right)^{1-\alpha} \hat{\gamma}_{\ell' n} \right]^{-\epsilon} \right]^{-\frac{1}{\epsilon}}. \tag{24}$$

(iii) Final price:

$$\hat{P}_m = \left[\sum_{n'} \pi_{n'm} \hat{T}_{n'} \left(\hat{w}_{n'}^\beta \hat{q}_{n'}^{1-\beta} \hat{\tau}_{n'm} \right)^{-\theta} \right]^{-\frac{1}{\theta}}. \tag{25}$$

(iv) Good market clearing:

$$\hat{X}_i X_i = \hat{r}_i \hat{K}_i r_i K_i + \hat{w}_i \hat{L}_i w_i L_i + (\hat{R} R - 1) \hat{B}_i B_i. \tag{26}$$

(v) Labor market clearing implies that

$$\hat{w}_i \hat{L}_i w_i L_i = \beta \sum_m \hat{\pi}_{im} \hat{X}_m \pi_{im} X_m + \hat{w}_i \hat{H}_i w_i H_i, \tag{27}$$

where

$$\hat{w}_i \hat{H}_i w_i H_i = (1-\alpha) \sum_{k,n} \hat{\lambda}_{kin} \lambda_{kin} \left[(1-\beta) \sum_m \hat{\pi}_{nm} \hat{X}_m \pi_{nm} X_m \right]. \tag{28}$$

(vi) Capital return:

$$\hat{r}_i = \hat{P}_i. \tag{29}$$

(vii) Global bond interest rate:

$$\hat{R}R = \frac{1}{\rho} \frac{\sum_{i=1}^{N} s_i \left(\hat{r}_i \hat{K}_i r_i K_i + \hat{w}_i \hat{L}_i w_i L_i \right)}{\sum_{i=1}^{N} (1 - s_i)\, \hat{w}_i \hat{L}_i w_i L_i}. \tag{30}$$

(viii) Bond holdings:

$$\hat{B}_i B_i = \frac{\rho}{1+\rho}(1 - s_i)\hat{w}_i \hat{L}_i w_i L_i - \frac{1}{(1+\rho)\hat{R}R} s_i \left(\hat{r}_i \hat{K}_i r_i K_i + \hat{w}_i \hat{L}_i w_i L_i \right). \tag{31}$$

2.7 Transitional Dynamics

In this subsection, we derive the transitional dynamics starting from steady-state capital allocation $(K_{it})_{i=1}^{N}$ at period t. The analytical solution of the saving problem enables us to solve the changes in transitional dynamics with respect to exogenous shocks.

Algorithm 6 (Transitional dynamics in relative changes) *Suppose that initially the economy stays in its steady state at period t and $t-1$. Given data on the steady state $(\lambda_{i\ell n}, \pi_{nm}, X_m)$, parameters $(\alpha, \beta, \eta, \epsilon, \theta, s_i)$, and permanent exogenous shocks occurring in period t, the transitional dynamics in relative changes, $\left(\hat{w}_{it+k}, \hat{H}_{it+k}, \hat{X}_{it+k}, \hat{P}_{it+k}, \hat{q}_{it+k}, \hat{B}_{it+k}, \hat{R}_{t+k+1}\right)$ and $\left(\hat{r}_{it+k}, \hat{K}_{it+k+1}\right)$ for $k = 0, 1, 2\ldots$, satisfy:*

(i) Given steady-state capital stock (K_i), changes in capital returns at period $t+k$ are given by

$$\hat{r}_{it+k} = \frac{1}{r_i K_i \hat{K}_{it+k}} \alpha \sum_{\ell,n} \hat{\lambda}_{i\ell nt+k} \lambda_{i\ell n} \left[(1-\beta) \sum_{m} \hat{\pi}_{nmt+k} \pi_{nm} \hat{X}_{mt+k} X_m \right], \tag{32}$$

where $(\hat{\lambda}_{i\ell nt+k})$ is given by Equation (22) and $(\hat{\pi}_{nmt+k})$ is given by Equation (23).

(ii) Equilibrium changes in X_{it+k} can be expressed by

$$\begin{aligned} \hat{X}_{it+k} X_i &= (1 - s_i) \left(\hat{r}_{it+k} \hat{K}_{it+k} r_i K_i + \hat{w}_{it+k} \hat{L}_{it+k} w_i L_i \right) - \hat{B}_{it+k} B_i \\ &+ s_i \left(\hat{r}_{it+k-1} \hat{K}_{it+k-1} r_i K_i + \hat{w}_{it+k-1} \hat{L}_{it+k-1} w_i L_i \right) + \hat{R}_{t+k} \hat{B}_{it+k-1} R B_i. \end{aligned} \tag{33}$$

(iii) Capital accumulation:

$$\hat{K}_{it+k+1} = \left[\frac{(1-s_i)\frac{r_i}{P_i}}{(1-s_i)\frac{r_i}{P_i} + (1-\delta)} \frac{\hat{r}_{it+k}}{\hat{P}_{it+k}} + \frac{(1-\delta)}{(1-s_i)\frac{r_i}{P_i} + (1-\delta)} \right] \hat{K}_{it+k}, \tag{34}$$

where, be definition, $\hat{K}_{it+k+1}$ denotes the relative change from steady-state to K'_{it+k+1} and the steady-state $(1-s_i)\frac{r_i}{P_i} = \frac{1}{\rho} - (1-\delta)$.

(iv) Equilibrium changes $(\hat{q}_{nt+k}, \hat{P}_{mt+k}, \hat{w}_{it+k}, \hat{H}_{it+k}, \hat{B}_{it+k}, \hat{R}_{t+k+1})$ satisfy Equation (24), (25), (27), (28), (31), and (30).

Notice that $\hat{K}_{it} = \hat{K}_{it-1} = 1$ and $\hat{B}_{it-1} = 1$. Therefore, the full path of transitional dynamics for $k = 0, 1, 2 \ldots$ can be computed by forward iteration using the equation system above.

3 Calibration

In our quantification practice, we consider 31 economies (30 economies[3] + rest of the world) in 1996 and 2006, a period with rapid expansion of trade imbalances. We first calibrate few parameters from the literature. Then we impute capital shares that are needed for counterfactual analysis from the observed FDI and financial capital flows. Finally, we impute trade and financial liberalization between 1996 and 2006 from the data.

3.1 Parameters from Literature

To conduct counterfactual analysis, we calibrate key model parameters from the literature. The calibration sources and results are presented in Table 3:

3.2 Imputing $(\lambda_{i\ell nt}, \pi_{nmt})$

Our counterfactual analysis requires the data on international trade share π_{nmt} and capital share $\lambda_{i\ell nt}$. While the former is straightforward from

$$\pi_{nmt} = \frac{X^{\text{Trade}}_{nmt}}{X_{mt}}, \quad X_{mt} = \sum_{n=1}^{N} X^{\text{Trade}}_{nmt}, \tag{35}$$

[3] These economies include Australia, Austria, Belgium, Brazil, Canada, China, Czech, Germany, Denmark, Spain, Finland, France, the United Kingdom, Hungary, Indonesia, India, Japan, Korea, Luxembourg, Mexico, the Netherlands, Poland, Portugal, Romania, Sweden, Turkey, Taiwan, and the United States.

Table 3: Calibration of $(\alpha, \beta, \eta, \epsilon, \theta, \delta, \rho)$

Parameter	Source
$1-\alpha = 0.1$	Income share of financial intermediation
$\beta = 0.6$	Labor income share
$\eta = 0.3$	External economies of scale in financial intermediation
$\epsilon = 7.26$	Capital flow elasticity. Wang (2017)
$\theta = 4$	Trade elasticity. Arkolakis et al. (2017)
$\delta = 0.2$	Capital depreciation rate
$\rho = 0.9$	Time discounting rate
s_{it}	Observed current account imbalances

the latter is not directly observed. Through the lens of our model, we impute $\lambda_{i\ell nt}$ from bilateral FDI and financial capital stocks, $(X_{\ell nt}^{\text{FDI}})$ and $(X_{i\ell t}^{\text{FIN}})$:

$$\lambda_{i\ell nt} = \frac{X_{i\ell t}^{\text{FIN}}}{\sum_{i'=1}^{N} X_{i'\ell t}^{\text{FIN}}} \frac{X_{\ell nt}^{\text{FDI}}}{\sum_{\ell'=1}^{N} X_{\ell' nt}^{\text{FDI}}}. \tag{36}$$

Bilateral trade flows across 31 countries come from WIOD. Bilateral FDI stocks are from UNCTAD data. And bilateral financial holdings come from LBS and CPIS. The details of these data bases are presented in the appendix.

3.3 Imputing Trade and Financial Liberalization

Quantifying the impacts of actual trade and financial liberalizations require their sizes. Following the spirit of Head and Ries (2014), we assume that the changes in these bilateral frictions are symmetric. Here we let "hat" denote the relative changes from 1996 to 2006. Then the changes in trade costs can be expressed as

$$\hat{\tau}_{nm} = \left(\frac{\hat{X}_{nm}^{\text{Trade}} \hat{X}_{mn}^{\text{Trade}}}{\hat{X}_{nn}^{\text{Trade}} \hat{X}_{nm}^{\text{Trade}}} \right)^{-\frac{1}{2\theta}}. \tag{37}$$

Similarly, the changes in FDI costs are

$$\hat{\gamma}_{\ell n} = \left(\frac{\hat{X}_{\ell n}^{\text{FDI}} \hat{X}_{n\ell}^{\text{FDI}}}{\hat{X}_{\ell\ell}^{\text{FDI}} \hat{X}_{nn}^{\text{FDI}}} \right)^{-\frac{1}{2\epsilon}}. \tag{38}$$

And the changes in the costs of financial capital flows are

$$\hat{\mu}_{i\ell} = \left(\frac{\hat{X}^{\text{FIN}}_{i\ell} \hat{X}^{\text{FIN}}_{\ell i}}{\hat{X}^{\text{FIN}}_{ii} \hat{X}^{\text{FIN}}_{\ell\ell}} \right)^{-\frac{1}{2\epsilon}}. \tag{39}$$

4 Counterfactuals

4.1 Trade Imbalances in the Steady-State

Our first counterfactual exercise explores how the imputed trade and financial liberalizations between 1996 and 2006 contribute to the increase in the size of global trade imbalances. The data suggests that the sum of absolute values of net exports across 31 countries in our sample as a share of world absorption increased from 0.8% in 1996 to 1.51% in 2006. We assume that the observed worlds in 1996 and 2006 are in the steady-states. Starting from the world in 1996, we compute changes in steady-state trade imbalances under our imputed trade liberalization. This isolates the role of trade liberalization on global trade imbalances. Similarly, we quantify the impacts of our imputed decline in FDI and financial capital flow costs on steady-state trade imbalances.

Table 4: Counterfactual Global Trade Imbalances

Scenario	Trade Imbalances (%)	% Contribution in changes
Data in 1996	0.8	-
Data in 2006	1.51	-
Trade liberalization	1.09	41
FDI liberalization	1.02	31
Financial capital liberalization	1.16	51
FDI + Financial capital	1.34	76

The results suggest that the observed decline in trade costs increases global trade imbalance as a share of world absorption in the steady-state to 1.09%, while the decline in FDI and financial capital flow costs, respectively, increases global trade imbalances to 1.02% and 1.16%. Therefore, the decline in the costs of trade, FDI, and international financial capital flow, respectively, can explain 41 percent, 31 percent, and 51 percent of the increase in trade imbalances over this period.

4.2 The Dynamics of Trade Imbalances

Our model can also be used to quantify the impacts of trade and financial liberalization on the dynamics of trade imbalances. To achieve this, we impute the annual changes in trade, FDI, and financial capital costs over 1996-2006. We then insert the imputed changes into our model and compute the counterfactual trade imbalances in each year.

Figure 1: Global Trade Imbalances over 1996-2006

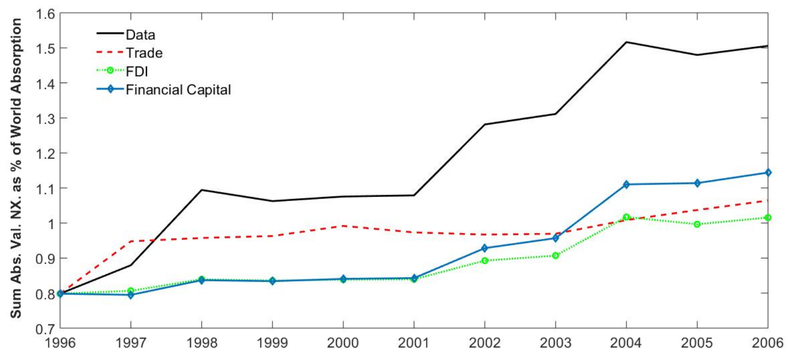


Figure 1 shows the dynamics of global trade imbalances, measured by the sum of absolute values of net exports as a share of world absorption. It suggests that the decline in the costs of financial capital flows is quantitatively important to understanding the surge of global imbalances. The trade and FDI liberalizations are also quantitatively significant.

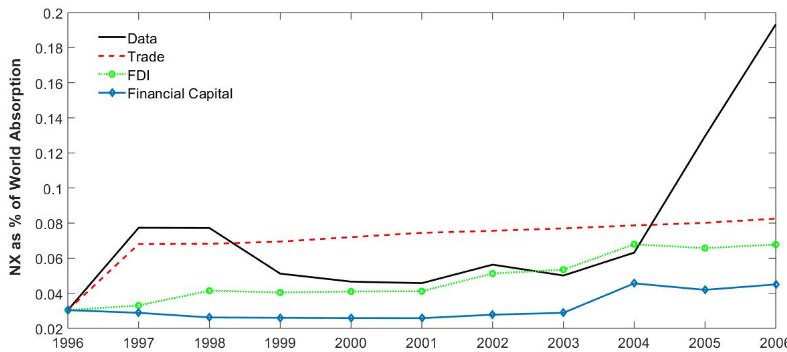
Figure 2 shows that changes in net exports for China and the U.S. Trade and financial liberalizations make the U.S. specialize more in financial intermediation and China more in production. The expansion of two-way capital flows increases trade imbalances in the U.S. and China. Moreover, financial liberalization increases the U.S. financial capital stock, which enables the U.S. to borrow more.

4.3 Welfare Dynamics

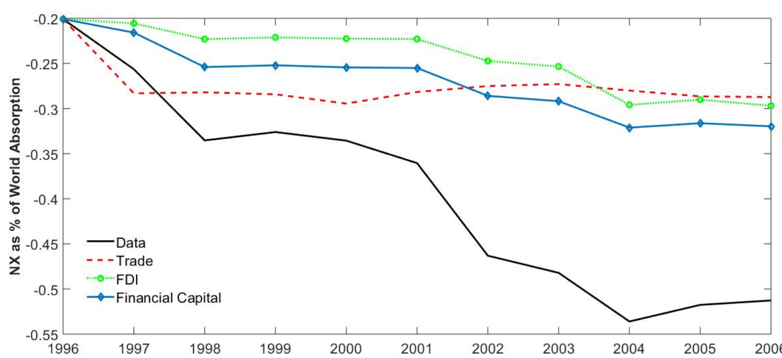
In this subsection, we characterize the dynamic welfare consequences of trade and financial liberalization. We consider a simple exercise in which all trade costs are permanently decreased by 10%. FDI and financial capital liberalization are conducted similarly. Figure 3 shows the welfare dynamics under these shocks. It highlights the differences between short- and long-run welfare consequences and emphasizes the importance of endogenous capital accumulation. For example, China gains from FDI liberalization in the short-run

Figure 2: Net Exports in China and the U.S.

(a) China

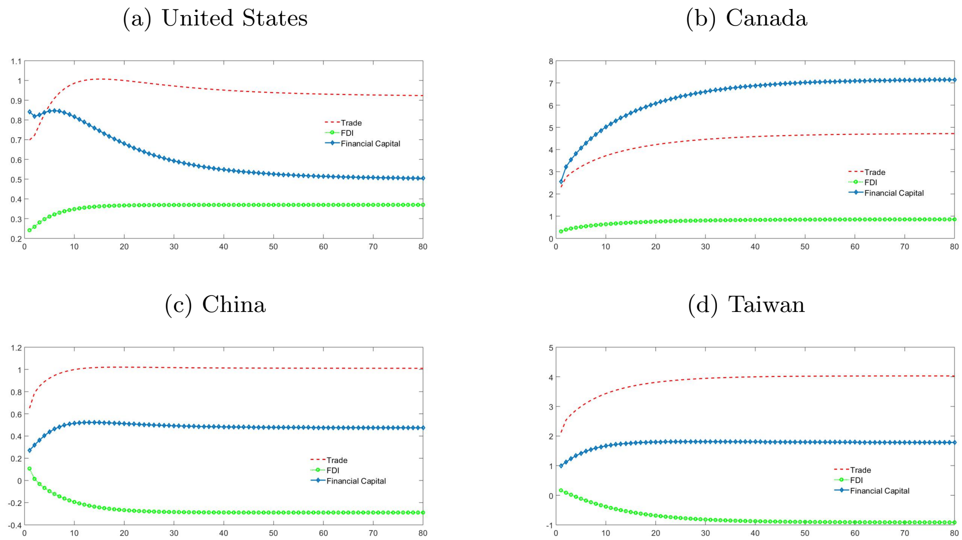


(b) United States



with fixed financial capital stocks. The gain comes from the increase in Chinese wage income caused by the surge of inward FDI. However, in the long run, China will decrease its financial capital due to the competition from foreign capital. This will lead to sizable welfare losses in the long run.

Figure 3: Welfare Dynamics under Permanent Shocks



(a) United States

(b) Canada

(c) China

(d) Taiwan

5 Conclusion

International financial liberalization/integration has long been regarded as an important driving force behind the surge of global trade imbalances. Yet no quantification has been provided to this issue. This paper builds a multi-country dynamic model that does not only rationalize international trade and capital flows in a standard gravity framework but also allows for endogenous trade and current account imbalances. This paper is the first attempt to integrate those important concerns and quantify their roles in determining global imbalances. The model is highly tractable and can be used in other dynamic quantitative analysis.

The main results show that trade, FDI, and financial capital liberalizations are quantitatively important to the increase in global trade imbalances over 1996-2006. These liberalizations make countries further specialize in financial intermediation and production.

The resulting expansion of capital flows and international lending and borrowing increases the trade deficits in countries specialized in financial intermediation and increases the trade surpluses in countries specialized in production.

Lastly, this paper also develops a new algorithm computing the counterfactual changes in transitional dynamics. The algorithm is efficient for computing the dynamics of many countries and can be used in solving other dynamic problems.

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Appendix A Theoretical Results

A.1 The Solution to the Saving Problem

The representative entrepreneur in Country i maximizes

$$U_i = E_0 \sum_{t=0}^{\infty} \rho^t \log C_{it}, \tag{40}$$

subject to their budget constraint

$$C_{it} + K_{it+1} = R_{it} K_{it} \tag{41}$$

in which $R_{it} = \frac{r_{it}}{P_{it}} + (1 - \delta)$ is the real return to capital and is taken as given by individual entrepreneurs. The F.O.C. to K_{it+1} is

$$\frac{1}{C_{it}} = \rho E_t \left[\frac{R_{it+1}}{C_{it+1}} \right]$$

With this AK-type model setup, we can show the consumption/saving decisions of the representative entrepreneur is linear in her total wealth $R_{it}K_{it}$. To show this we adopt a guess-and-verify method. Assuming the policy function of K_{it+1} takes the following form $K_{it+1} = sR_{it}K_{it}$, and $C_{it} = (1 - s) R_{it}K_{it}$, in which s is a constant. Inserting this conjecture into the Euler equation above, we have

$$\begin{aligned} \frac{1}{(1-s) R_{it}K_{it}} &= \rho E_t \left[\frac{R_{it+1}}{(1-s) R_{it+1}K_{it+1}} \right] \\ \frac{1}{(1-s) R_{it}K_{it}} &= \rho E_t \left[\frac{R_{it+1}}{(1-s) R_{it+1} s R_{it} K_{it}} \right] \end{aligned}$$

by which we get $s = \rho$ and our conjecture is verified. We have the following policy functions:

$$C_{it} = (1 - \rho) \left[\frac{r_{it}}{P_{it}} + (1 - \delta) \right] K_{it} \tag{42}$$

$$K_{it+1} = \rho \left[\frac{r_{it}}{P_{it}} + (1 - \delta) \right] K_{it}. \tag{43}$$

Appendix B Data appendix

B.1 Trade Data

The bilateral trade flow data comes from the World Input-Output Database (WIOD). The data covers sectoral bilateral trade value across 41 major economies over 1995-2014. It also contains sectoral domestic sales. We consider aggregate bilateral trade flows across 31 economies (30 economies + rest of the world) in 1996 and 2006, a period with rapid expansion of trade imbalances. These economies include Australia, Austria, Belgium, Brazil, Canada, China, Czech, Germany, Denmark, Spain, Finland, France, the United Kingdom, Hungary, Indonesia, India, Japan, Korea, Luxembourg, Mexico, the Netherlands, Poland, Portugal, Romania, Sweden, Turkey, Taiwan, and the United States. To avoid temporary shocks, we take simple average of trade flows over 1995-1997 and 2005-2007.

We also utilize the aggregate import and export values for each economy from the World Bank Database (WBD). To combine two data sets, we multiply the bilateral trade flows, X_{nm}^{TR} where $n \neq m$, by an exporter-specific shifter ι_n^{TR} so that $\frac{\sum_{m \neq n} \iota_n^{TR} X_{nm}^{TR}}{\sum_{i \neq n} \iota_i^{TR} X_{in}^{TR}}$ is equal to the corresponding ratio in the WBD.

B.2 FDI Data

(TBD)

B.3 Capital Stock Data

The stocks of foreign assets and liabilities data are based on two sources, the BIS Locational Banking Statistics (LBS) and the IMF Coordinated Portfolio Investment Survey (CPIS). They contain both bilateral (between a pair of countries) and aggregate (between a country and the rest of the world) holdings.

The LBS provides international banking transactions information. The BIS collects outstanding claims and liabilities from all banks located in 47 reporting countries on their holdings in more than 200 counterparty countries. The reporting banks takes up around 80% of the estimated cross-border claims of all banks world-wide in 2007. The stocks are valued at current prices and exchange rates. The data is available quarterly over 1977-2017.

CPIS covers the holdings of portfolio investment securities, including equity and investment fund shares and long-term and short-term debt securities, by major investing countries. Annual data is available from 2001 to 2012.

LBS provides bank lending information. CPIS covers portfolio debt and equity flow but generally no loans are included. Capital stocks in this paper are constructed by summing up the outstanding claims in LBS and total investment assets in CPIS.

We take the year 1996 and 2006 to study the two periods of interest. Data from earliest available year is used as proxies for 1996 if collection of such data type only started at a later time.