Asymmetric Trade Reforms and External Adjustment: Theory and Evidence from China

Qing Liu Kang Shi Junjie Tang Juanyi Xu*

September 2022

Abstract

This paper quantifies the effects of China's trade reforms on the current account in its post-WTO period since 2001. We first present cross-country evidence to show that the adjustment of the current account to WTO access in China differs from those in other countries, exhibiting a hump-shaped pattern. We then document some institutional facts and firm-level evidence and argue that asymmetric trade reforms between exporting and importing sectors in China may help to explain the pattern. Motivated by these facts, we develop a two-country dynamic Melitz model and applied it to the Chinese economy. Our quantification exercise shows that the trade reform not only accounts for 47.6 percent of the accumulated trade surplus in 2001-2010 but also contributes to the hump-shaped dynamics of the trade balance and the real exchange rate. Finally, we apply this model to estimate the welfare loss of the U.S.-China trade war.

Keywords: current account, global imbalance, trade reform, exchange rate

JEL Codes: F15, F31, F32, F41

*Liu: School of Economics and Management, Tsinghua University, Email: liuqing@sem.tsinghua.edu.cn; Shi: Department of Economics, The Chinese University of Hong Kong, Email:kangshi@cuhk.edu.hk; Tang: School of Management, Fudan University, Email: junjie.tang@link.cuhk.edu.hk; Xu: Department of Economics, The Hong Kong University of Science and Technology, Email:jennyxu@ust.hk. We thank Yan Bai, Dan Lyu, Vivian Yue, Jian Wang, and participants at various seminars and conferences.

1 Introduction

In the past twenty years, Chinas current-account surplus has been a subject of contentious international economic policy debate, which also leads to the recent trade war between the U.S. and China. There is a large literature that provides explanations of China's current account imbalances from different angles. Among them, trade liberalization including trade reform or reducing trade costs is one of the major and competitive hypotheses. For example, Reyes-heroles (2016) argues that 69 percent of the increase in world trade imbalances can be explained by decreases in trade costs across countries. Ju et al. (2021) studies the effects of trade liberalization on capital flows in a dynamic Heckscher-Ohlin model. Quantitatively, trade reforms such as tariff cuts and the reduction in trade costs are as important as TFP changes in explaining China's accumulated current account surplus from 2000-2007. While these papers show that trade reform is important in explaining China's current account surplus, they do not pay too much attention to the dynamics of the current account. To the data, China's current account surplus was very mild in the year before China joined the WTO, but started to rise gradually afterward until 2007 when it began to fall. In other words, the response of China's current account to access WTO is hump-shaped. Understanding the dynamics of the current account is also important as it may provide a potential dimension to identify the contributions of different hypotheses, however, it is less explored in the literature. In this paper, we intend to fill the gap and investigate quantitatively the impact of China's access to WTO on the dynamics of the current account.

Before conducting a quantitative investigation, we look at some empirical facts. The first one is the cross-country evidence. That is, how do the current accounts in other countries respond to the access to WTO? We regress the current account balance on ten lag dummy variables indicating whether the trade reform happened in the past decade, based on the data from the IMF and BIS [1]. Figure 1 documents the dynamics of

[1]Detailed specification can be found in the appendix. We also study the response of those countries who join a regional economic union, such as EU, ASEAN, Mercosur, and ALADI, and sign Free Trade agreements, such as NAFTA, Australia-U.S. FTA, ASEAN-Japan FTA, etc.

the current account after accession to the WTO. After grouping the countries by their initial current account status (surplus or deficit), the effect of trade liberalization becomes statistically significant, especially in the early years. And the magnitude seems non-trivial. For instance, the accession to the WTO would possibly increase the current account-to-GDP ratio by nine percentage points on average for the saving countries in the sample. The direction is different for the saving and borrowing countries, which is consistent with the theoretical prediction by Obstfeld and Rogoff (2000) that the effect of trade cost on the current account relies on the initial status of the economy. According to theory and other countries' experiences, when a country integrated with the world economy, its current account is expected to rise immediately. However, this does not happen in China after the entry of the WTO. What could explain this difference? One possible explanation is that trade reform in China after WTO access is more comprehensive than those reforms which simply reduce bilateral trade costs.

In view of this, we review trade reforms China has done in the first few years since the WTO access. We document the following facts; (1) After the accession to the WTO in 2001, China accelerated removing the barriers faced by domestic exporters without hesitation, while the import liberalization was implemented in a very cautious manner. Meanwhile, the export reform potentially benefits entrants, while the import reform favors incumbent trade partners. (2) Trade reforms are always being carried out along with other economic reforms, such as domestic marketization, the reduction of friction in financial sectors and the labor market, etc. They directly or indirectly affect the external adjustment as well.

Motivated by these facts, we develop a two-country perfect foresight general equilibrium model armed with Melitz-type heterogenous firms entry. Our model is based on a stylized international macro model and includes shocks to fixed and variable trade costs, the discount factor, investment, and Solow residuals. It is a variation of the dynamic stochastic general equilibrium model of Alessandria et al. (2017) and the dynamic trade model of Reyes-heroles (2016). We assume these shocks are not systematically correlated with each other. As such, the contribution to the dynamics of the

current account and exchange rate is decomposable by isolating the effect caused by these shocks one by one. Based on the disaggregated firm data from China, we apply this framework to China's post-WTO period since 2000. Our findings show that China's trade reforms have an important impact on the country's external adjustments, not only accounting for 47.6 percent of the accumulated trade surplus but also causing a hump-shaped dynamic in the trade balance. Meanwhile, lower trade costs explain an appreciation of the real exchange rate from 2001-2010. Furthermore, the trade reform increases social welfare by 27.5 percent for China and 2.3 percent for foreign countries during the same period. Finally, we also apply this model to estimate the welfare cost of the U.S.-China War.

Our paper is closely related to three strands of literature on the global imbalance. The first group takes the perspective of developed versus developing countries. One view that has received considerable attention is the global saving glut hypothesis of Bernanke (2005). Bernanke argues that financial crises cause capital flows to reverse, flowing from developing to industrialized countries. In particular, emerging market economies, especially in Asia, built up foreign exchange reserves to safeguard against potential future capital outflows and, to a lesser extent, as a result of promoting export-led growth. In doing so, governments in these nations channeled domestic savings into international capital markets. Another important view is the hypothesis of financial development emphasized by Caballero et al. (2008). They argue that a change in the perception of the ability of domestic financial markets to provide sound financial instruments for savings results in increased funds flowing abroad. [2] Recently, Jin (2012) and Ju et al. (2014) argue that due to differences in the factor intensity of tradeable sectors, trade openness leads capital to flow towards countries that become more specialized in capital-intensive industries. Based on Ricardian comparative advantage, Eaton et al. (2004) and Reyes-heroles (2016) extend the static to a dynamic setup. The former studies the trade collapse during the Great Recession where trade imbalances

[2]There is also a view provided by Dooley et al. (2004) who argues that developing countries have deliberately undervalued their exchange rates to promote growth in the traded-goods sector (and, for China, to absorb a large shift of rural workers to urban areas).

arise from the solution to a planner's problem, while the latter considers the role of trade costs on trade imbalances. Reyes-heroles (2016) calibrates the model and shows that 69% of the increase in world trade imbalances can be explained by the symmetric decline in trade costs across countries.

The second related literature studies the current account imbalance from the Chinese experience. For example, Song et al. (2011) features financial sector imperfections in China in generating a current account surplus. It stresses the inability of productive domestic private sector firms to borrow from the formal financial sector as key friction. These firms have to save to finance their investment. As the share of these firms grows in the economy, so does the country's current account surplus. Wen (2011) show that the massive foreign-reserve buildups by China are not necessarily the intended outcome of any government policies or an undervalued home currency, but instead a natural consequence of the country's rapid economic growth in conjunction with an inefficient financial system. In addition to financial friction, some argue that China's changing demographics also play an important role in explaining the high saving rate. Wei and Zhang (2011) provide empirical evidence that suggests that the rising sex ratio may explain about 50-60% of the increase in Chinese household savings from 1990 to 2007. Following them, Du and Wei (2010) concludes that the rise of the current account imbalance in China since 2002 may be triggered by the rise of the relative surplus of men in China. However, the imbalance in sex ratio can explain a high saving rate, but not a high investment rate. Given the importance of trade cost in explaining the global imbalance, Alessandria et al. (2017) study the effects of China's accession to WTO on China's current account surplus in a calibrated macroeconomic model that embeds a Melitz style heterogeneous firm model.

The third related literature investigates quantitatively the impact of the U.S.-China trade war on each country. Guo et al. (2018) forecast the change in trade flows and real wages caused by the trade war using Eaton and Kortum's multiple-sector, multiple-country general equilibrium model. They show that real wages would fall by 0.32 percent for the United States and 0.37 percent for China if both nations increased their

bilateral import tariffs on each other to 45 percent while the trade imbalance remained the same. Other studies including Amiti et al. (2019), Fajgelbaum et al. (2020), Flaaen et al. (2020) stress that the recent trade protectionism in the U.S. has significantly raised domestic prices for intermediate or final goods and decreased import varieties, which resulted in a decline in real income of the U.S. of $1.4 billion per month by the end of 2018. According to Benguria et al. (2022), after the start of the trade war, the trade policy uncertainty (TPU) increased significantly, which had a detrimental impact on Chinese listed companies, particularly smaller businesses. They show that a one-standard-deviation increase in TPU during the trade war resulted in a 2.3 percent decrease in firm investment and R&D spending and an 11.5 percent loss in profit.

We contribute to the existing literature, such as Reyes-heroles (2016) and Alessandria et al. (2017), in the following aspects. First, we show that China's current account adjustment to WTO access differs from other countries, exhibiting a hump-shaped pattern. Based on institutional facts and firm-level evidence we argue that this pattern may be due to asymmetric trade between exporting and importing sectors. Second, our unified framework is capable of carrying out an accounting exercise, which is to isolate the relevance of trade reforms and other frictions mentioned in the literature. Third, we explain the dynamics of current account and real exchange rate rather than the direction or second moment. The former usually contains more information and is helpful to identify the features of trade reforms.

The remainder of the paper is structured as follows: Section 2 summarizes worldwide trade reform experience as well as a background of China's trade-related reforms; Section 3 illustrates the theoretical model and all the exogenous shocks considered; Section 4 is about model calibration and the simulation method; Section 5 uses counterfactual experiments to assess the effect of the trade reform; Section 6 estimates the welfare consequences of the U.S.-China trade war under four different scenarios; Section 7 concludes the paper.

2 Stylized Facts on Trade Reform

In this section, we first show the global experience of current-account adjustment as a response to various types of trade reforms based on a cross-country dataset. It finds that the trade reform generates a heterogeneous effect on the current account balance. The reform has a positive and lasting effect on saving countries' current-account surpluses, but a negative impact on borrowing countries (larger deficits). Like other saving countries, China's current account surplus increased after the trade reform, but its response was much slower than other countries.

2.1 Global experience of external adjustments

The empirical study is based on a dataset composed of 155 countries over the period from 1960 to 2019. The dependent variables include the ratio of the current account balance to GDP and the currency's real effective exchange rate. The source is the international financial statistics (IFS) database of the International Monetary Fund (IMF) and the real exchange rate database of Bank for International Settlements (BIS). In the benchmark model, we use the event of WTO accession as a proxy for each country's trade reform.[3] The model specification is as follows:

$$y_{c,t} = \sum_{i=1}^{10} \left(\beta_i \cdot TR_{c,t-i} + \beta_i^p \cdot TR_{c,t-i} \times dum_c^p \right) + \alpha_c + \alpha_t + \varepsilon_{s,t}, \tag{2.1}$$

where c and t denote country and time, respectively. $p \in \{s, b\}$ indicates whether the country runs a current account surplus (s) or deficit (b) prior to the trade reform.

To capture the dynamic effect of the trade reform, we regress the dependent variable ($y_{c,t}$) on ten lagged dummy variables indicating whether the trade reform happens in period $t-i$ ($TR_{c,t-i}$). There are two reasons behind this setting. The external adjustment may last for several years after the reform due to intertemporal consumption smoothing and the presence of capital accumulation. Furthermore, as will be shown

[3] In Appendix A.1, alternative events are explored, such as joining regional economic unions and signing Free Trade Agreement, as the robustness check. The results are preserved.

in the subsequent part, some countries like China implement trade reform in stages rather than all at once. The time-variant shocks cause a complex dynamic of the current account balance or real exchange rate. The regression aims to explore the lasting effect of the trade reform over a ten-year timeframe.

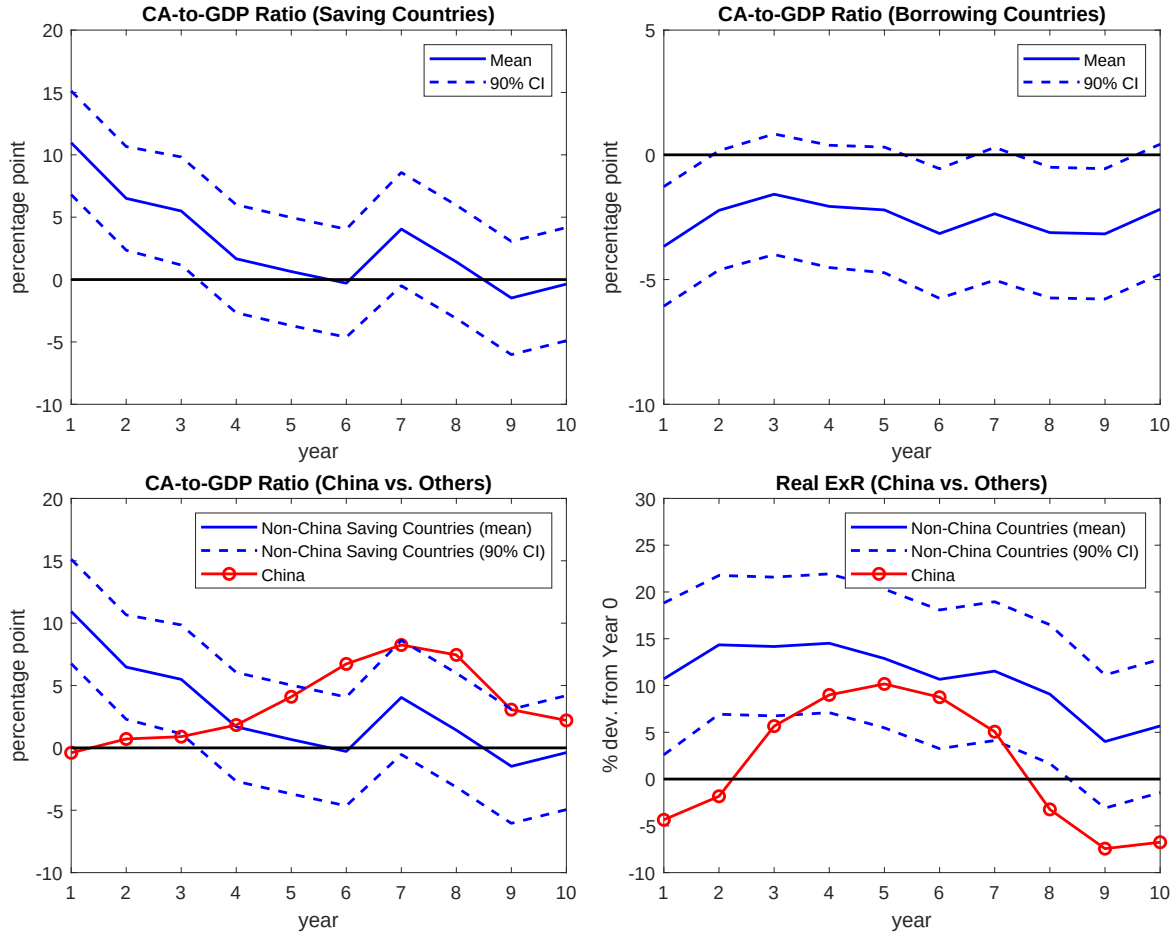
In addition, a dummy variable indicating each country's initial current account position (dum_c^p, $p \in \{s, b\}$) is included and interacts with the explanatory variable. Countries that had a current account surplus one year before the trade reform are regarded as saving countries, while those with a current account deficit are considered borrowing countries.[4] This is to examine the heterogeneous effect on saving and borrowing countries, following the idea of Obstfeld and Rogoff (2000), who argue the effect of trade cost on current account relies on the country's trade balance position. A country fixed effect (α_c) and a year fixed effect (α_t) are included to control for other factors affecting the dependent variable.

Based on this specification, $\beta_i + \beta_i^s$ represents the average effect on the dependent variable i years after the trade reform is carried out in the saving countries. $\beta_i + \beta_i^b$ represents the same effect for the borrowing countries. The results are graphically presented in the upper row of Figure 1. The trade reform increases the current-account surplus to GDP ratio by 11.0 percentage points in the first year for the saving countries, and the effect lasts for three years. As expected, the trade reform raises borrowing countries' trade deficits. This is because lower trade costs reduce friction in inter-temporal trade and narrow the real interest rate differential between international borrowers and savers.

The global experience shows when a saving country integrates with the world economy, its current account surplus will rise immediately. The current account dynamic follows a downward sloping curve. China, like other saving countries, has a positive response to the trade reform in terms of current account surplus, but it lags behind the

[4]When identifying saving or borrowing countries in the regression, we use a stricter criterion: countries with a current account surplus of more than 1.8 percent of GDP (25th percentile) are regarded as saving countries, whereas those with a current account deficit of more than 3.1 percent of GDP (25th percentile) as borrowing countries. In this way, we can limit the impact of outliers.

Figure 1: The Effect of the Trade Reform on the Ratio of the Current Account Surplus to GDP and the Real Exchange Rate



sample mean. As shown in the bottom left panel of Figure 1, China's current account surplus remains small in the first three years before rapidly increasing from the fourth year, having a hump-shaped pattern between 2004 and 2010. There is also a difference in real exchange rate dynamics between the global and Chinese experiences (see the bottom right panel).

These findings motivate a revisit of the effect of the trade reform in two aspects. To begin, how different trade reform processes affect not only the changing direction or accumulative amount of capital flows but also the dynamic of the current account balance.[5] Second, can the shape of dynamics be used to distinguish the impact of trade reform from the impact of other economic forces such as financial friction, productivity shock, and so on? These are regarded as alternative explanations for the current account response in the literature.

Before the model illustration, we first review several key features of China's trade reforms during the WTO accession in the next part.

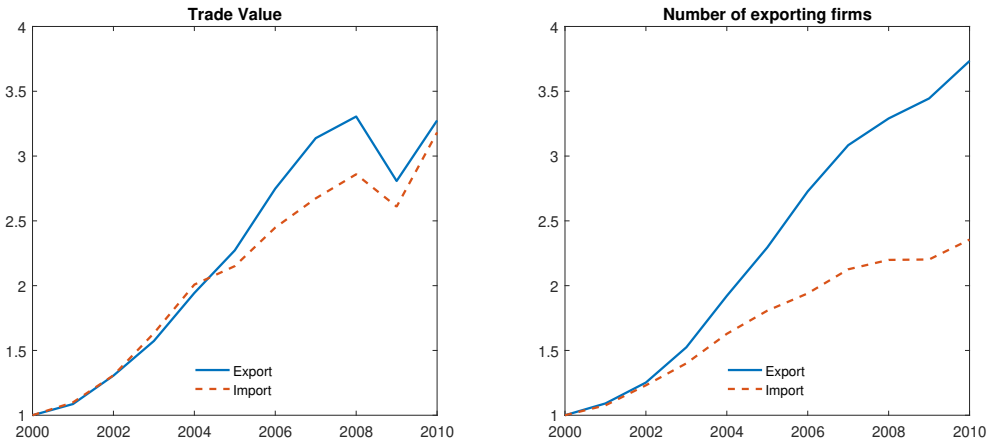
2.2 Institutional facts on China's trade-related reforms

In the decade following China's WTO accession (2001-2010), China launched a vast economic reform program, gradually removing various trade barriers and economic friction for both exports and imports. On exports, a growing number of private and small state-owned enterprises were permitted to reach the global market. The Chinese government committed to giving trading rights to all types of domestic firms, lowering the requirement on minimum registered capital, and increasing export quotas. Meanwhile, the import reform is relatively intensive-margin oriented. The major purpose is to increase access to foreign intermediate goods while protecting domestic industries of final products. The import reform included a significant tariff reduction in input imports, although there was still a stringent requirement on foreign trading partners and other non-tariff barriers.

[5]The accumulative amount of capital flows during a certain period equals the sum of the current account balance over the same period.

Margins of trade. Although China's exports and imports both grew at a comparable rate between 2000 and 2010, the extensive margin accounts for a larger share of the growth of Chinese exports than for imports. Figure 2 compares the annual value of Chinese exports and imports to the number of Chinese exporters and importers over the period 2000-2010 (with the base year of 2000 normalized to 1). The data is from China's Custom Database. It shows that the number of exporters grew by 3.7 times throughout the period, faster than the rise of annual export or import values or the number of importers.

Figure 2: Chinese Exports and Imports: Value and Number of Traders (2000=1)



We also employ the margin decomposition exercise used by Bernard et al. (2009) and Fernandes et al. (2019) to explore empirically how each margin contributes to the change in exports and imports. The dataset is China's Customs Database from 2000 to 2010. A time-series decomposition shows that net firm entrance and product variety account for 51 and 16 percent of China's export growth during the period, higher than the 26 and 6 percent contributions to import growth.

Alternatively, we regress the unique number of firms counted from each country-product-year trade flow on the total value of each country-product-year trade flow. The coefficient is the extensive-margin elasticity, which represents the contribution of firm entry and exit to the change in trade flows. As shown by Table 1, the extensive margin elasticity for exports is 29 percentage points higher than that for imports in the

baseline regression (Column 1, HS-2). We also use HS-4 and HS-6 level data as well as different types of fixed effects, to address the measurement error problem. The result remains robust.

Table 1: Estimation of extensive margin elasticity, China 2000-2010

		(1)	(2)	(3)
HS-2	Export	0.62	0.38	0.30
	Import	0.33	0.30	0.19
	Difference	0.29	0.08	0.11
HS-4	Export	0.59	0.39	0.34
	Import	0.32	0.32	0.23
	Difference	0.27	0.08	0.12
HS-6	Export	0.55	0.40	0.36
	Import	0.34	0.32	0.25
	Difference	0.21	0.07	0.10
	Country-Product FE	Yes	Yes	Yes
	Year FE		Yes	
	Country-Year FE			Yes

Export-favoring measures. China promoted various policies to support export growth after China's WTO accession in 2001, many of which were especially beneficial to new entrant firms. Before 2001, export trading rights were restricted to large-scale trading and manufacturing state-owned enterprises with a narrow scope of business. During the Pre-WTO negotiation, the Chinese government promised to grant trading rights to more Chinese firms, subject to a minimum registered capital requirement. This requirement was gradually lowered from US$ 1 million in 2000 to zero in 2004 (see Table 2). This policy opened the door of the export market to a wide range of Chinese firms.

Table 2: Requirement on minimum registered capital

Year	2000	2001	2002	2003	2004 and thereafter
Rmb Million	8.5	5	3	1	0

Source: 2004 and 2005 Report to Congress on China's WTO Compliance, United States Trade Representative.

The second policy is to increase textile export quotas. Under the Agreement on Tex-

tiles and Clothing (ATC) effective from 1994, Chinese textile exports were constrained by a quota system. Before 2001, the Chinese government gave limited quotas to state-owned enterprises only. According to Alessandria et al. (2017), most textile products had a fill rate of 1 in 1999, which means the quota for all sub-categories had been used up. Between 2002 and 2006, the number of quotas increased gradually, with 30 percent of them becoming open for public bidding. With more quotas available in 2006, an increasing number of Chinese apparel firms were able to enter the export market by purchasing export quotas.

The expenditure on export quota accounted for a non-trivial share of total costs paid by domestic exporters, which is evidenced in a news report in 2005: Jiayu Apparel Fashion Ltd., a local apparel manufacturer in Zhejiang Province, spent around US$ 2 million on quota purchasing each year, compared to its total annual export value of US$ 7 million[6]. It is also evident in the data of the black-market pricing for sock export quota in Table 3. In 2003, the quota price was equal to 140 percent of the production cost. Thanks to the export reform, the ratio declined to only 14 percent in August 2006.

Table 3: Black-market price for sock export quota (US$ per dozen pair)

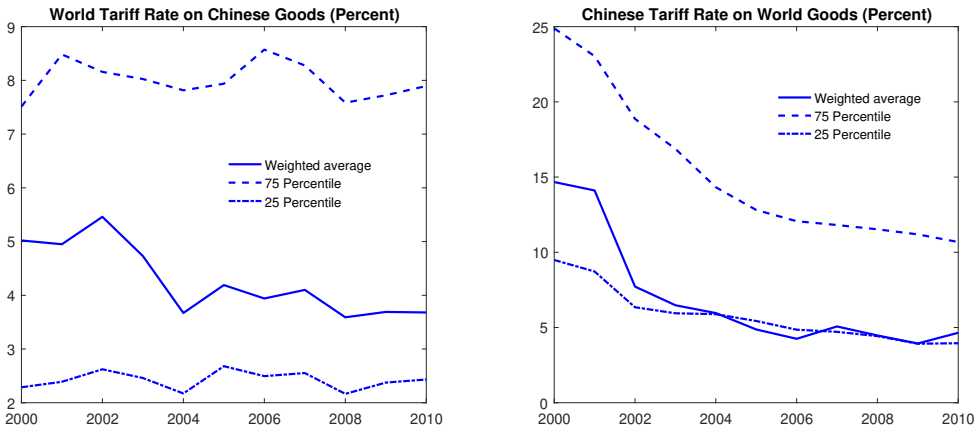
Date	Production Cost	Quota Price	Quota Price/Prod. Cost
Dec. 2003	2.5	3.50	1.40
Jan. 2006		1.80	0.72
Mar. 2006		1.36	0.54
May 2006		1.08	0.43
Aug. 2006		0.34	0.14

Note: The data is from "Probable Effect of Proposed Definitions for Certain Baby Socks", United States International Trade Commission Investigate No. 332-474, August 2006.

Import tariff reduction. The import reform is characterized by a significant reduction in the average tariff rate, possibly in favor of incumbent firms. Figure 3 documents the tariff rates imposed on Chinese imports to those imposed on Chinese exports. The weighted average tariff rate (effectively applied) declined from 14.7 percent in 2000 to 4.7 percent in 2010.

[6]The source is Sina News on 18 September 2005.
URL: http://finance.sina.com.cn/g/20050918/10131976708.shtml

Figure 3: Tariff Rates on Chinese Exports and Imports



Source: World Integrated Trade Solution (WITS).

But the tariff reduction is uneven among different product categories. The tariff cut on intermediate goods is greater than that on final goods, as shown by Table 4. The cheaper input goods enable Chinese manufacturers to keep their costs down. They may be protected from foreign competitors by a higher barrier to imported final products.

Table 4: Chinese tariff rates imposed on world goods

	SITC Category	2000	2005	2010
Intermediate Goods	**Weighted average of intermediate goods**	**16.0**	**4.4**	**2.4**
	Crude materials, inedible, except fuels	21.7	3.4	1.7
	Mineral fuels, lubricants and related materials	8.2	1.6	0.8
	Animal and vegetable oils and fats	39.7	12.3	7.6
	Chemicals	13.1	7.3	5.0
Final Goods	**Weighted average of final goods**	**13.6**	**4.9**	**6.0**
	Manufact goods classified chiefly by material	14.5	6.3	4.6
	Machinery and transport equipment	12.3	3.7	3.8
	Miscellaneous manufactured articles	19.0	8.6	18.2
	Commod. & transacts.	6.6	4.8	5.4

Source: World Integrated Trade Solution (WITS).

The removal of non-tariff barriers is relatively slower. The administrative barriers for foreign-invested trading firms include a more stringent requirement on both the minimum registered capital (US$6.3 million) and past revenue (average annual US$30

million tradings with China in the preceding three years) for foreign trading firms. These numbers are higher than those for export firms. A higher entry threshold would possibly favor incumbent firms over new entrants.

In addition, U.S. firms complained about the uplift in dutiable values by Chinese customs to offset the tariff cut, discrimination against retailers who do not manufacture goods in China, and a lack of transparency in the tariff-rate quota system.[7] Furthermore, the Chinese government frequently used Anti-Dumping measures against its trading partners in 2003-2007.[8]

Asymmetric trade reform. Based on the institutional facts stated above, China's trade reforms feature an asymmetry in the rate of liberalization for exports and imports. Non-tariff barriers and implicit administrative distortions have an important impact on China's trade balance in addition to the tariff reduction. As will be shown in Section 4, the change in trade costs recovered by the theoretical model is consistent with the feature of China's trade reforms.

3 A Two-country Model

In this section, we build a two-country perfect foresight general equilibrium model equipped with a Melitz-type heterogeneous firms entry. The model is based on a stylized international macro model and includes various shocks to fixed and variable trade costs, the discount factor, investment, and Solow residuals. It is a variation of the dynamic stochastic general equilibrium model of Alessandria et al. (2017) and the dynamic trade model of Reyes-heroles (2016). These shocks, we assume, are not systematically correlated with each other. As such, the shock's effect on the current account and real exchange rate dynamics is decomposable.

In each country, a unit mass of monopolistic producers manufacture tradable in-

[7]See more details in "2004 and 2005 U.S. trade representative's Report to the U.S. Congress on China's WTO Compliance"

[8]See details in "China's WTO Entry: Antidumping, Safeguards, and Dispute Settlement" by Chad P. Bown, China's Growing Role in World Trade, March 2010.

termediate goods and sell them to both domestic and foreign final-good producers. Intermediate producers are heterogeneous in productivity. The final-good producers serve local households in a perfectly competitive market. Final goods are used for consumption or investment. The representative household spends incomes on consumption, investment, and holding foreign assets. The home country represents China and the foreign is the rest of the world. Only the expressions for the home country are presented below, while corresponding foreign-country expressions are analogous.

3.1 Household problem

Households in the home country h maximize the lifetime utility subject to a budget constraint as below:

$$\begin{aligned} \max_{c_{h,t},b_{h,t+1}} \quad & \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_{h,t} U(c_{h,t}), \quad U(c_{h,t}) = c_{h,t}^{1-\sigma}/(1-\sigma), \quad c_{h,t} = C_{h,t}/L_{h,t} \\ \text{s.t.} \quad & P_{h,t}C_{h,t} + P_{h,t}\mathrm{I}_{h,t} + V_t B_{h,t+1} = w_{h,t}L_{h,t} + r_{h,t}K_{h,t} + B_{h,t} + \Pi_{h,t} + T_{h,t}. \end{aligned} \tag{3.2}$$

$\xi_{h,t}$ is intertemporal preference shifter or demand shock at period t. $C_{h,t}$ and $c_{h,t}$ are the aggregate and per-capita consumption, respectively. Both consumption $C_{h,t}$ and investment $\mathrm{I}_{h,t}$ are measured by home final goods. V_t is the face value for a non-state contingent bond $B_{h,t+1}$. $\Pi_{h,t}$ is the lump-sum rebate of firm profits to households. $T_{h,t}$ is the government tax. The law of motion for capital is given below, in which δ is the depreciation rate.

$$K_{h,t+1} = (1-\delta)K_{h,t} + \mathrm{I}_{h,t}, \tag{3.3}$$

Investment shock. Capital accumulation is affected by an exogenous shock of domestic investment. As shown by Song et al. (2011), due to financial imperfections in China, private investment was constrained by limited collateral held by newly established private firms. During the early stages of the reform, the investment by state-

owned enterprises heavily depended on the government's economic plan and was less sensitive to market-based interest rates. The investment's deviation from a social optimal growth path would affect China's current account surplus.

Preference shifter. The Euler equation is derived from the first-order conditions of the household problem, in which $\hat{\xi}_{h,t+1}$ represents the change in intertemporal preference. It is a wedge in the inter-temporal consumption decision, affecting the expected real interest rate. The preference shifter absorbs exogenous demand shocks and excessive saving motives. As shown by Buera and Shin (2017), Chinese private entrepreneurs have to save as much as possible to increase collateral in order to overcome the borrowing constraint. Additionally, the preference shifter absorbs the temporary impatience caused by the 2008-2009 financial crisis, which reduces savings. These underlying forces that change the preference shock affect saving decisions and current account balance.

$$U'(c_{h,t}) = \frac{\beta}{V_t}\mathbb{E}_t\left[\frac{P_{h,t}}{P_{h,t+1}}\hat{\xi}_{h,t+1}U'(c_{h,t+1})\right], \quad \hat{\xi}_{h,t+1} = \xi_{h,t+1}/\xi_{h,t} \tag{3.4}$$

3.2 Final-good producers

The final-good market is perfectly competitive. The producers use both a basket of intermediate goods made in the home country $Y_{hh,t}$ and a basket of intermediated goods imported from foreign $Y_{fh,t}$ to manufacture final goods. $a_h^{1/\rho}$ is a time-invariant home-bias. ρ is the substitution rate between the home and foreign goods.

$$D_{h,t} = \left(Y_{hh,t}^{\frac{\rho-1}{\rho}} + a_h^{\frac{1}{\rho}} Y_{fh,t}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}, \tag{3.5}$$

Intermediate goods are produced by a unit mass of monopolistic firms in each country. Each bundle of intermediate goods is aggregated by each firm's products with constant elasticity of substitution (CES). θ is the inter-firm substitution rate. $\Sigma_{f,t}$ is the set of exporters in foreign.

$$Y_{hh,t} = N_{h,t}\left(\int_0^{\infty} y_{hh,t}(\phi)^{\frac{\theta-1}{\theta}}\Omega_h(d\phi)\right)^{\frac{\theta}{\theta-1}}, \tag{3.6}$$

$$Y_{fh,t} = N_{f,t}\left(\int_{\Sigma_{f,t}} y_{fh,t}(\phi)^{\frac{\theta-1}{\theta}}\Omega_f(d\phi)\right)^{\frac{\theta}{\theta-1}}. \tag{3.7}$$

Domestic firm entry. $N_{h,t}$ are the total numbers of firms in the home country, which increases exogenously over time. We refrain from endogenizing domestic firm entry, as it is primarily affected by the pace of domestic marketization starting in the early 1980s, which allows the establishment of private firms. While being regarded uncorrelated with the post-2001 trade reform, it is an alternative explanation for the increase in the number of Chinese exporters and the change in the trade balance.

3.3 Intermediate-good producer

Intermediate-good producers adopt a Cobb-Douglas production function and use both labor and capital inputs. Firms are heterogeneous in productivity ϕ, which follows a constant distribution $\Omega_h = 1 - \phi^{-\alpha_h}$ in home. Firms observe their productivity levels ϕ before making decisions on production and market entry.

Technology shock. $z_{h,t}$ is an exogenous country-specific technology shock. It captures technological improvement and a reduction of labor-market frictions in China. Xu et al. (2015) shows that more free labor mobility dampens the increase in labor costs and causes currency depreciation in the early 2000s. The technology shock affects the relative competitiveness of a country's exports and the expected future income, both of which have an impact on the trade balance and the real exchange rate.

$$y_{h,t} = z_{h,t}\phi k_{h,t}^{\gamma}\ell_{h,t}^{1-\gamma}, \tag{3.8}$$

With the monopolistic status, intermediate-good producers optimally set prices equal to the marginal cost multiplied by a constant markup $\theta/(\theta-1)$ subject to the demand functions below.

$$y_{hh,t} = \left[\frac{p_{hh,t}(\phi)}{P_{hh,t}}\right]^{-\theta} \frac{Y_{hh,t}}{N_{h,t}}, \qquad y_{hf,t} = \left[\frac{p_{hf,t}(\phi)}{P_{hf,t}}\right]^{-\theta} \frac{Y_{hf,t}}{N_{h,t}}, \tag{3.9}$$

$$MC_{h,t} = \frac{\gamma^{-\gamma}(1-\gamma)^{\gamma-1}}{z_{h,t}\phi} r_{h,t}^{\gamma} w_{h,t}^{1-\gamma} \tag{3.10}$$

$$p_{hh,t}(\phi) = \frac{\theta}{\theta-1} MC_{h,t}, \quad p_{hf,t}(\phi) = \frac{\theta}{\theta-1} MC_{h,t} \cdot \frac{\tau_{h,t}}{q_{h,t}}. \tag{3.11}$$

Icerberg trade cost. For the export price, firms face an iceberg trade cost $\tau_{h,t} > 1$. It includes the tariff rate, transportation cost, and other non-tariff trade barriers. $q_{h,t}$ is the real exchange rate defined as the relative price of foreign goods relative to home goods. Due to the constant markup, the gross profit is proportional to revenue.

$$\pi_{hh,t}(\phi) = \frac{1}{\theta} x_{hh,t} = \frac{1}{\theta} p_{hh,t}(\phi)^{1-\theta} P_{hh,t}^{\theta-\rho} P_{h,t}^{\rho} D_{h,t}/N_{h,t}, \tag{3.12}$$

$$\pi_{hf,t}(\phi) = \frac{1}{\theta} x_{hf,t} = \frac{1}{\theta} a_h \cdot p_{hf,t}(\phi)^{1-\theta} P_{hf,t}^{\theta-\rho} P_{f,t}^{\rho} D_{f,t}/N_{h,t}. \tag{3.13}$$

Fixed trade cost. Each intermediate-good firm has to pay a fixed operating cost $f_{x,t}^{h}$ to enter the export market. The zero-profit condition pins down the productivity cutoff ϕ_{hf}^{*} for home exporters and the share of home exporters in total firms.

$$\pi_{hf,t}(\phi_{hf,t}^{*}, z_{h,t}) = f_{x,t}^{h} w_{h,t}/q_{h,t}, \tag{3.14}$$

$$n_{h,t} = Pr(\phi \geq \phi_{hf,t}^{*}) = (\phi_{hf,t}^{*})^{-\alpha_h}. \tag{3.15}$$

How does a change in trade cost affect a country's saving decision and trade balance in a general equilibrium model? Firstly, as shown by Obstfeld and Rogoff (2000) and Reyes-heroles (2016), the trade cost is friction for inter-temporal trade, resulting in a real interest rate differential between international borrowers and lenders. A trade-cost reduction increases international borrowing by lowering the real interest rate for

borrowing countries but raising the rate for lending (saving) countries.

Meanwhile, an expected decline in trade costs has a future wealth effect. Expecting a richer future, no one wants to lend now. Lending countries reduce the current-account surplus in the early period. This coincides with a mitigated borrowing demand, which is due to a rise in the equilibrium real interest rate. With both effects, an expected gradual reduction in trade costs increases the current-account surplus of saving countries in a long run but dampens the surplus in the short term.

In addition, the trade cost affects the real exchange rate by changing the relative price between two countries through both term-of-trade and sectoral relocation effects.

3.4 Price indices and market clearing

The sectoral and country-level price indices are summarized as follows. The real exchange rate is defined as the relative price of foreign final goods relative to home goods.

$$P_{h,t} = (P_{hh,t}^{1-\rho} + a_h P_{fh,t}^{1-\rho})^{\frac{1}{1-\rho}}, \tag{3.16}$$

$$P_{hh,t} = \left[\int_1^{\infty} p_{hh,t}(\phi)^{1-\theta}\Omega_h(d\phi)\right]^{\frac{1}{1-\theta}}, \quad P_{fh,t} = \left[\int_{\phi_{fh,t}^*}^{\infty} p_{fh}(\phi)^{1-\theta}\Omega_f(d\phi)\right]^{\frac{1}{1-\theta}}. \tag{3.17}$$

$$q_{h,t} = \frac{P_{f,t}}{P_{h,t}}. \tag{3.18}$$

The model is closed by several market-clearing conditions.

(1) Domestic demand for final goods:

$$D_{h,t} = C_{h,t} + \mathrm{I}_{h,t};$$

(2) Intermediate-goods market clearing:

$$y_{h,t} = y_{hh,t} + m_{h,t} \cdot \tau_{h,t} \cdot y_{hf,t},$$

where $m_{h,t}$ is the export status for home country:

$$m_{h,t}(\phi) = \begin{cases} 0, & \text{if } \phi < \phi^*_{hf,t}; \\ 1, & \text{if } \phi \geq \phi^*_{hf,t}. \end{cases} \tag{3.19}$$

(3) Labor market clearing. Aggregate population growth is exogenously determined.

$$L_{h,t} = N_{h,t} \cdot \int_0^\infty \ell_{h,t}(\phi)\Omega_h(d\phi); \tag{3.20}$$

(4) Capital market clearing:

$$K_{h,t} = N_{h,t} \cdot \int_0^\infty k_{h,t}(\phi)\Omega_h(d\phi); \tag{3.21}$$

$$B_{h,t} + B_{f,t} = 0. \tag{3.22}$$

4 Bring the Model to Data

In this section, we calibrate the parameters used in this model and recover the time-variant shocks from the datasets of China and the rest of the world. The dataset used in the calibration covers 2000 to 2019. The long period enables us not only to explore the effect of trade reforms in 2000-2010 in Section 5 but also to estimate the welfare loss from the U.S.-China trade war since 2019 in Section 6. We stop by 2019 to rule out the complicated effect of the Covid-19 pandemic.

4.1 Time-invariant parameters

First, we set the annual subjective discount factor $\beta = 0.95$ and the intertemporal substitution rate $1/\sigma = 0.35$ following Havránek (2015). The inter-sector substitution rate ρ equals 1.8 and inter-firm substitution rate θ is 5, following Alessandria et al. (2017). The capital-income share γ is set at 0.4 and the annual depreciation rate is 0.05, which are the average levels for China between 2000 and 2019. The data source is Penn World Table 9.1.

The Pareto index in the firm distribution function is estimated to be 6 for France by Chaney (2008) and Eaton et al. (2011), which corresponds to the foreign country in the study. For China, we employ the method proposed by Helpman et al. (2004) and estimate the home Pareto index α_h to be 4.5, using Chinese Industrial Enterprise Database.

We choose the values for home bias parameters a_h and a_f under two assumptions. To begin, most non-tariff barriers to Chinese exports were efficiently removed in 2016. Therefore, we set the iceberg cost for home exports in 2016 ($\tau_{h,2016}$) to be the 2016 average tariff rate imposed on Chinese exports plus 10 percentage points (estimated transportation cost and insurance). We choose the year 2016 because the latest available tariff data is up to 2016 according to World Integrated Trade Solution (WITS). Second, the home country has no home bias: $a_h = 1$. The parameter values are summarized in the table below.

Table 5: Parameter values

Parameter	Name	Value	Sources
β	Subjective discount factor	0.95	Standard for annual data
σ	Risk averse	1/0.35	Havranek (2015)
γ	Share of cap. income	0.4	Penn World Table V9.0
ρ	Inter-sector substitution rate	1.8	Alessandria et al. (2017)
θ	Inter-firm substitution rate	5	Alessandria et al. (2017)
δ	Depreciation rate	0.05	Penn World Table 9.1
α_h	Home Pareto Index	4.4551	Chinese Industrial Enterprise database
α_f	Foreign Pareto Index	6	Channey(2008), Eaton, Kortum and Kramarz (2007)
a_h	Home bias for the home country	1	
a_f	Home bias for the foreign country	0.176	Match trade iceberg costs for 2016

4.2 Time-variant exogenous shocks

Next, we use the data on employment and capital stock for China and the rest of the world from 2000-2019 to represent the aggregate labor and capital supply in home and foreign countries, respectively. The rest 12 time-variant shocks are recovered from the data.

Firstly, we recover the iceberg trade cost ($\tau_{h,t}$) from comparing the sectoral price indices for domestic ($p_{hh,t}$) and exporting goods ($p_{hf,t}$). The price difference comes from two sources: 1) at the firm level, exporting products face an additional iceberg cost compared with domestic products; 2) at the sector level, the set of operating firms is different due to the presence of fixed trade costs: the productivity threshold for exporting firms is higher.

Following this idea, we use the data on the real output and the share of export and import from Penn World Table[9] and the real exchange rate data from BIS to recover both the nominal and real output in domestic and export sectors, and corresponding sectoral prices.[10] In addition, the share of exporting firms among all firms directly gives the productivity threshold of entering the global market due to the Pareto distribution of firm productivity. The difference that cannot be explained by the productivity cutoffs is attributed to the iceberg trade cost.

Secondly, the preference shock ($\hat{\xi}_{h,t+1}$) and the bond interest rate (V_t) affect the intertemporal consumption smoothing, as shown in the Euler equation. Without loss of generality, we normalize the preference shock in the foreign country to be one. The relative marginal utility of consumption in the foreign country equals the world interest rate. The discrepancy between the world interest rate and the relative marginal utility of consumption in the home country is caused by the preference shock.

Thirdly, the fixed trade cost ($f_{x,t}^h$) is the ratio of average exporting profit to wage, according to the zero-profit condition. Since the exporting price of each firm and the

[9]The data from 2000 to 2017 is from Penn World Table 9.1. The data for 2018 and 2019 is estimated using annual growth rates reported by Chinas National Bureau of Statistics, World Bank, and IMF.

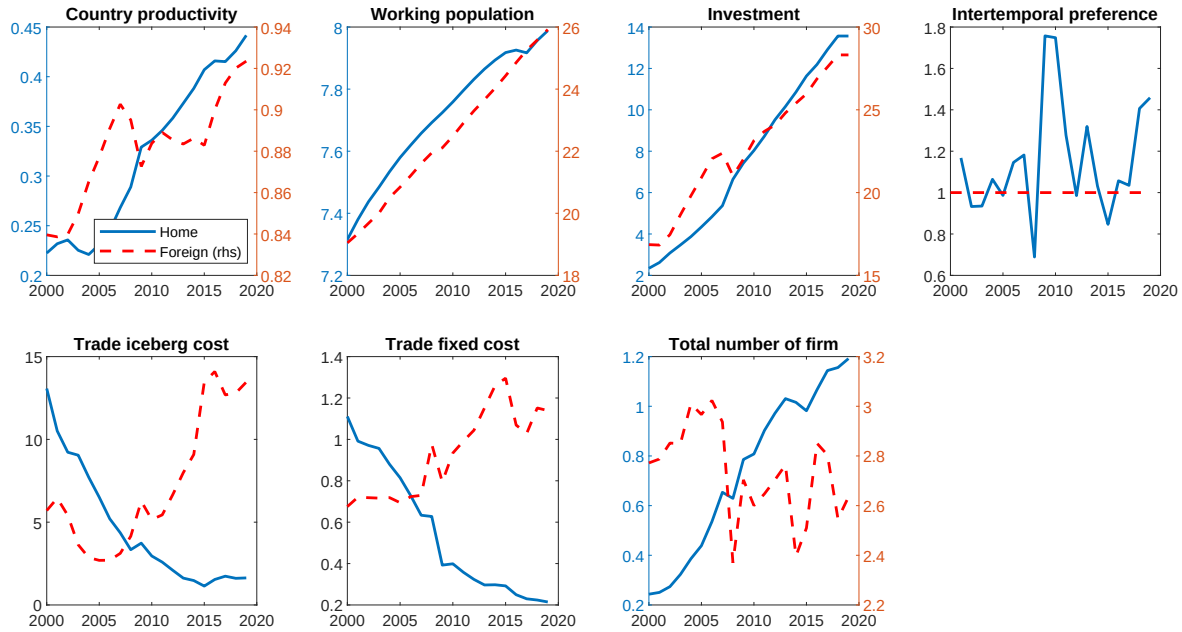
[10]The foreign aggregate price level is normalized to one, which means the aggregate price level in the home country is the reciprocal of the real exchange rate.

set of exporting firms have been recovered in the previous steps, we can pin down the fixed trade costs.

Fourthly, the country-level productivity shock ($z_{h,t}$) is reflected in the price of the domestic products ($p_{hh,t}$) together with wage and capital rent. The Cobb-Douglas production function guarantees constant labor and capital income shares. It is easy to compute the series of wages and rent in each country with the data on labor and capital supply and GDP. With the goods and input prices, we recover the country's productivity.

Finally, the investment shocks ($I_{h,t}$) are recovered from the series of the capital stock and a depreciate rate. We compute the domestic firm entry ($N_{h,t}$) with the number of exporting firms and their share in the total number of firms. The time-variant shocks for the foreign country are recovered analogously. The results are presented in Figure 4.

Figure 4: Time-Variant Shocks Recovered from Data (2000-2019)



Economic reforms If we look at the reform period from 2000 to 2010, the pattern of trade costs recovered from the data is in line with the institutional realities regarding China's trade reforms documented in Section 2. The export iceberg cost declines

sharply from 2000 to 2010. Likewise, the import iceberg cost drops fast between 2000 and 2005, mainly driven by a significant reduction in tariff rates. But the import cost remains higher than the export cost after 2006, probably because of a rise in tariffs on final-good imports and other non-tariff barriers. The rising import cost after 2010 is probably related to the country's national security strategy, which gradually replaces imported technical devices with domestically produced ones.

Meanwhile, the decline of the export fixed cost is remarkable between 2000 and 2010 compared with a mild rise in the import fixed cost. This is also consistent with the observation that the export reform favors extensive margin growth. The export-favoring policies also contribute to the fast growth of the number of exporting firms.

The remaining exogenous variables reflect other economic reforms and international demand shocks for China between 2000 and 2010. For instance, the rapid growth of productivity growth, investment, and the total number of firms are consistent with various reforms in China over the same period such as domestic marketization, financial-market liberalization, and labor-market liberalization. The intertemporal preference shift becomes very volatile in 2008 and 2009 due to the impact of the global financial crisis.

5 Effect of Trade Reform (2000-2010)

In this section, we conduct various counterfactual analyses to isolate the effect of the trade reform on the trade balance and the real exchange rate between 2001 and 2010. China's trade reforms have an important impact on the country's external adjustments, not only accounting for 47.6 percent of the accumulated trade surplus but also causing a hump-shaped dynamic in the trade balance. Meanwhile, lower trade costs explain an appreciation of the Renminbi exchange rate from 2001-2010. Finally, the trade reform increases social welfare by 27.5 percent for the home country and 2.3 percent for the foreign country during the same period.

The economic results of different scenarios in this section are simulated using a

backward iteration method as in Reyes-heroles (2016). We assume that all exogenous shocks remain constant after 2019 and that the economy will reach a steady state in the distant future in 2040.[11] The goal of computation is to search for a steady state which ensures the initial value of foreign asset holdings equals the value of China's foreign exchange reserves in 2000. In all scenarios, the economy starts from the same initial steady state.[12]

5.1 Trade balance and the real exchange rate

To quantify the trade reform's contribution to the trade balance and the currency's real exchange rate, we first keep the time-variant shocks to trade iceberg and fixed costs while assuming all the other exogenous shocks remain at the 2000 levels and simulate economic outcomes solely resulting from the trade reform (TR).[13] The second counterfactual scenario simulates a world without trade reform by turning off the trade-cost shocks and resuming all other shocks (OS). We estimate the interaction effect by subtracting the pure effects of the trade costs and other shocks from the total effect, i.e. TR x OS = Total Effect − TR − OS. The simulated sequences of trade balance and the real exchange rate are compared to the actual data.

The simulation results are presented in Figure 5. The trade reform since 2001 generates a strong positive effect on the home country's trade balance in the period 2004-2010 but a dampening effect before 2004. This is consistent with expectations in Section 3.3. By contrast, the other shocks cause a large trade surplus early in 2001 and 2002. This is due to a combined effect of both faster-growing productivity and financial imperfections as shown by the literature, such as Song et al. (2011) and Buera and Shin (2017). As a result, the dampening effect of the trade reform offsets the positive effect of other shocks, causing small trade surpluses between 2001 and 2004.

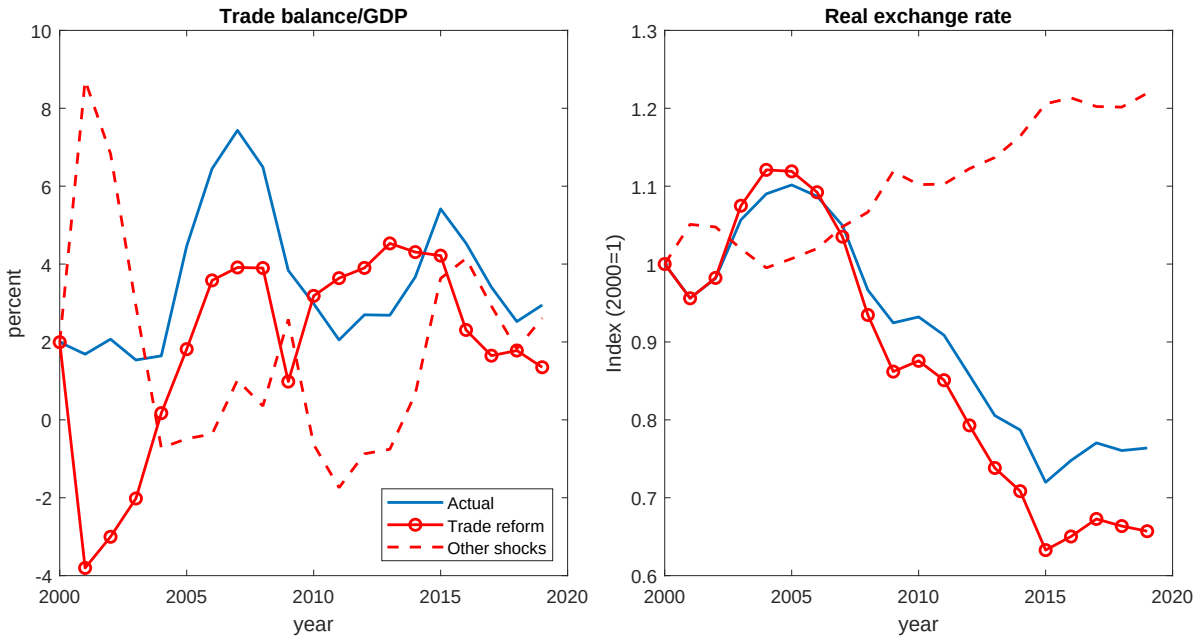
To quantify the trade reform's contribution to China's trade balance dynamics, we

[11] We allow a sufficiently long period of convergence to reduce the impact of the post-2019 shock assumption on the dynamics of variables between 2000 and 2019.

[12] See details in Appendix A.2.

[13] For preference shifter, we use the average level between 2000 and 2005 to avoid noise in one year.

Figure 5: Comparison of Actual and Simulated Dynamics of Selected Variables in Different Scenarios



first measure the total amount of trade surplus caused by trade-cost changes, as is done in Reyes-heroles (2016) and Alessandria et al. (2017). As reported in Table 6, the trade reform accounts for 22.6 percent of the accumulated trade surplus between 2001 and 2010. The contribution is especially high in 2006-2008. 53-60 percent of China's trade surplus comes from the trade reform. If we include the interaction effect, the trade reform's contribution rises to 47.6 percent from 2001-2010. This result is comparable to various estimates in the literature. For instance, Alessandria et al. (2017) show that 70 percent of the increase in China's net foreign assets from 1990-2014 is due to trade-cost changes; Ju et al. (2021) find that the trade reforms are as important as TFP changes in explaining China's accumulated current account surplus from 2000-2007; Reyes-heroles (2016) estimates an over one-hundred percent contribution from the trade-cost reduction between 1970 and 2007.[14]

In addition, the comparison of lines in Figure 5 shows that the trade reform has

[14]Reyes-heroles (2016) shows that China would have had a severe trade deficit in 2007, accounting for 0.27 percent of world GDP, if the trade costs remained at their 1970 levels. By contrast, China's trade surplus equals 0.72 percent of world GDP in 2007.

Table 6: Contributions of different hypotheses to the ratio of trade balance to GDP for China (2001-2010)

(Unit: percent)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Accumu. 2001-2010
Trade balance/GDP											
Total effect	1.7	2.1	1.5	1.6	4.5	6.5	7.4	6.5	3.8	3.0	38.6
Trade reform	-3.8	-3.0	-2.0	0.2	1.8	3.6	3.9	3.9	1.0	3.2	8.7
Other shocks	8.7	6.8	2.9	-0.7	-0.5	-0.4	1.0	0.4	2.6	-0.6	20.2
TR x OS	-3.2	-1.8	0.6	2.2	3.1	3.2	2.5	2.2	0.3	0.4	9.6
TR with interaction	-7.0	-4.8	-1.4	2.4	4.9	6.8	6.4	6.1	1.3	3.6	18.4
Contribution											
Trade reform	-225.6	-144.9	-131.4	10.5	40.7	55.5	52.6	60.1	25.6	106.8	22.6
Other shocks	517.1	330.0	190.7	-43.9	-10.8	-5.7	13.7	5.5	67.2	-21.2	52.4
TR x OS	-191.5	-85.0	40.8	133.4	70.2	50.1	33.6	34.5	7.2	14.5	25.0
TR with interaction	-417.1	-230.0	-90.7	143.9	110.8	105.7	86.3	94.5	32.8	121.2	47.6

an important effect on the construction of a hump-shaped dynamic of China's trade balance from 2001 to 2010. To quantify the contribution to this feature, we calculate the correlation coefficients between the simulated trade balance sequences and the actual data. For the trade reform, the correlation is 0.83, while it is -0.48 for the other shocks (see Table 7). This demonstrates the importance of trade reform.

Table 7: Comparison of the simulated trade balance and real exchange rate dynamics with the actual data (2001-2010): correlation coefficient

	Trade Balance/GDP	Renminbi's Real Exchange Rate
Total Effect	1.00	1.00
Trade Reform	0.83	0.98
Other Shocks	-0.48	-0.91
Trade Reform with Interation Effect	0.80	0.99

Without the trade reform, the Renminbi's real exchange rate would have depreciated by 12.2 percent from 2001-2010. In reality, the currency appreciates by 6.8 percent mostly due to the effect of the trade reform. The trade reform's non-trivial contribution to the real exchange rate is also confirmed by the correlation analysis. The simulated sequence of the real exchange rate in the trade reform case features a hump shape in 2001-2010, similar to what is observed in reality. The correlation is 0.98 (see Table 7).

5.2 Gains from the trade reform

Based on this quantitative model, we estimate the two countries' welfare gains from China's trade reform, using a consumption-equivalent method in a dynamic setting. The welfare gain is measured by a percentage change in total consumption on average from a no-trade-reform case to a real-world case. $c_{i,t}^{Acutal}$ and $c_{i,t}^{NR}$ represent the consumption amount in the real world and the no-trade-reform counterfactual case for country i, respectively. x_d measures the percentage of consumption compensation that assures households maintain their utility level when the trade reform is absent.

$$\sum_{t=2000}^{2010} \beta^{t-2000} \xi_{i,t} U(c_{i,t}^{Actual}) = \sum_{t=2000}^{2010} \beta^{t-2000} \xi_{i,t} U[c_{i,t}^{NR}(1+x_d)], \quad i = h, f. \tag{5.23}$$

The results show that China's trade reforms increase social welfare by 27.5 percent for China and 2.3 percent for the rest of the world from 2001-2010.

6 The U.S.-China Trade War in 2019

The Trump presidency changed the U.S. trade policy toward China in 2018 by dramatically raising tariffs and other trade barriers on Chinese goods. According to the estimates by Peterson Institute for International Economics (PIIE), the average U.S. tariff on Chinese exports climbed from 3.1 percent in January 2018 to 19.3 percent in June 2022.[15] The tariff hike covers 66.4 percent of Chinese exports to the U.S. In response to U.S. trade protection measures, the Chinese government imposed retaliatory tariffs on U.S. imports in the same year. Based on the same estimates, the Chinese average tariff on U.S. exports rose from 8.0 percent in January 2018 to 21.2 percent in June 2022. Although the two countries reached a Phase One trade agreement in 2020 to limit the risk, the exporters from each country continue to suffer from high trade costs as of

[15]See Chad P. Bown. 2021. US-China Trade War Tariffs: An Up-to-Date Chart, available at https://www.piie.com/research/piie-charts/us-china-trade-war-tariffs-date-chart.

writing.

One of the reasons behind these practices, as stated by the Trump administration, is to reduce the U.S.-China trade deficits.[16] However, whether this policy goal will be achieved remains questionable. This is because world trade after 2019 is seriously affected by the Covid-19 pandemic. It becomes challenging to isolate the trade war's long-run effect based on an empirical study directly, but a theoretical framework, as in our study, can serve the quantification purpose.

To do so, we consider four counterfactual cases to simulate the ongoing trade war. We assume the trade-war shock occurs in 2019. Prior to that, no one anticipates the shock, but it is rationally expected by everyone since 2019. As such, economic activities before 2019 are unchanged from the previous baseline case. The bond holding at the end-2018 $B_{h,2018}$ becomes the initial state in the computation of the transition path in different counterfactual scenarios.[17]

First, we assume the trade war only affects each country's iceberg trade costs in our model temporarily and ends in five years. In 2019-2023, each country's export iceberg cost increases by the same percentage as the tariffs: in particular $\tau_{h,t}$ and $\tau_{f,t}$ increase by 1.9 and 1.1 times, respectively.[18] In this scenario, the trade imbalance can be reduced. Our simulation results show that China's share of trade surplus in GDP falls by one percentage point on average in 2019-2023 (see Figure 6). In response to the trade disadvantage, the home currency depreciates by 2.8 percent during the same period.

However, this comes at a heavy economic cost. Both countries' output will be dragged down if there are no other remedy policies. The drop in consumption is more

[16] See "Findings of the Investigation into China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974", Office of the U.S. Trade Representative, March 22, 2018.

[17] Like the computation algorithm described in Section 5, the computation goal is to search for a steady state that ensures equalization of the initial value of foreign asset holdings in 2018.

[18] According to PIIE's estimates, the average U.S. tariff on Chinese exports increases by 6.24 times. Considering the U.S. share in Chinese exports is 16.75 percent in 2017, the average trade cost faced by Chinese exports increases by 6.24 x 0.1675 x $\bar{\tau}_h$ +(1−0.1675) x $\bar{\tau}_h$ = 1.88 $\bar{\tau}_h$. Likewise, the average Chinese tariff on U.S. exports rises by 2.65 times and the U.S. share in Chinese imports is 5.96 percent in 2017. Based on the same method, the trade cost faced by the foreign country increases by 1.1 times.

severe for the foreign country in 2019-2023 (-2.3 percent) than that for the home country (-1.2 percent). The higher trade costs imposed by the U.S. inevitably push up import prices and the domestic inflation rate. Social welfare decreases by 0.7 and 0.8 percent for the home and foreign countries, respectively.[19] This result is comparable to the estimates in the literature, which are derived from a static trade model. For instance, Guo et al. (2018) estimates the real wage decreases by 0.37 percent for China and 0.32 percent for the U.S. owing to the trade war.

Figure 6: Effect of the U.S.-China Trade War: Temporary and Permanent Shocks to Trade Iceberg Costs

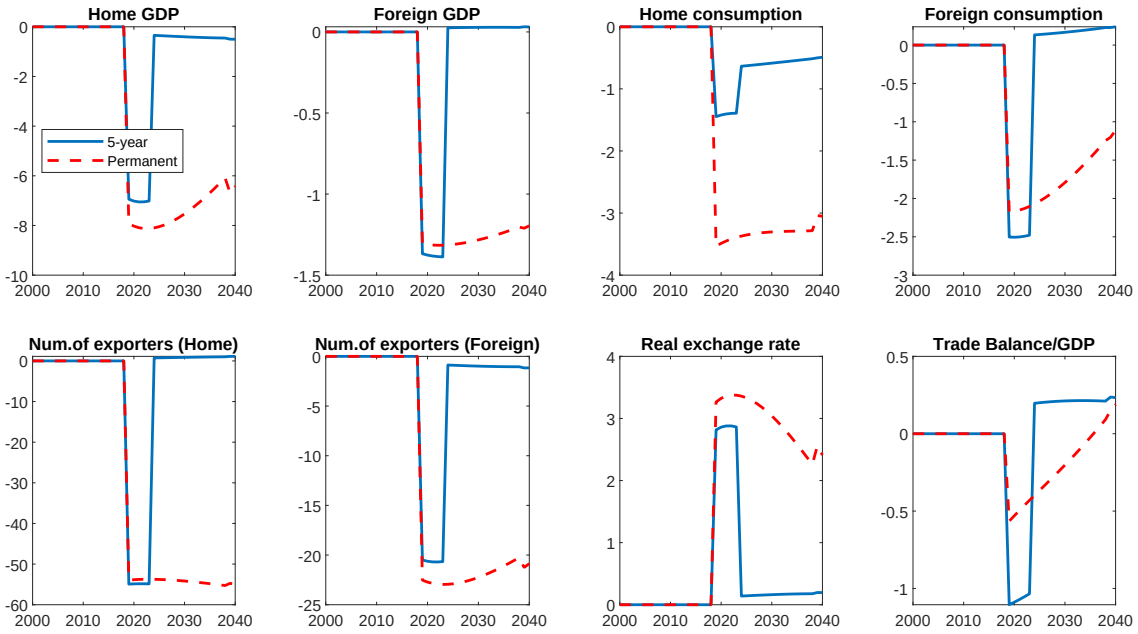
Secondly, we consider a worse scenario in which the iceberg costs stay at elevated levels permanently (until the economy reaches the steady state). In this case, China's trade balance to GDP ratio would decline by 0.5 percentage points in 2019, but the negative effect would last for a longer time (see Figure 6). In a dynamic setting, the rising trade costs not only hinder intra-temporal trade but also prevent intertemporal consumption smoothing in each country by raising the real interest rate. This results in a greater economic loss by reducing the future income for the home country and

[19]The welfare loss from the trade war is estimated by the same consumption-equivalent method as described in Section 5

increasing the repayment burden for the foreign country. The simulation results show that the home country's welfare falls by 3.1 percent in 2019-2040. The foreign country experiences a high welfare loss of 1.8 percent.

Besides the tariff hike, the escalation of the trade war may have induced other non-tariff trade barriers such as restrictions on the local market entry of foreign firms. It is therefore reasonable to consider a rise in trade fixed cost in the third and fourth scenarios. We assume the trade iceberg and fixed costs both rise by the same percentage in a 5-year period and a permanent case, respectively. The results indicate that, in addition to a more severe economic recession in both countries, the rising fixed cost causes many exporters to exit the global market. The number of exporters decreases by over 50 percent for the home country and 20 percent for the foreign country throughout the trade war (see Figure 7). The welfare loss increases to 3.4 percent for the home country and 1.9 percent for the foreign country if the trade war continues for a long time.

Figure 7: Effect of the U.S.-China Trade War: Temporary and Permanent Shocks to Trade Iceberg and Fixed Costs



7 Conclusion

This study revisits China's early 2000s trade reforms and their long-lasting effect on the country's current account and the real exchange rate between 2001 and 2010. We perform a decomposition analysis using a dynamic two-country Melitz model with a variety of economic frictions. The results show that the trade reform plays an important role in the formation of China's hump-shaped current account dynamics between 2001 and 2010, accounting for 47.6 percent of the accumulated trade surplus. The estimated welfare gain from China's trade reforms is 27.5 percent for China and 2.3 percent for the rest of the world from 2001-2010. We also apply this model to the U.S.-China trade war since 2019 and estimate the long-run effect under four different scenarios. Overall, our paper emphasizes two things: First, the current account dynamics are important in identifying the contribution of different hypotheses. Secondly, asymmetric trade reforms between exporting and importing sectors after WTO access in China may help to explain China's unique current account dynamics.

References

Alessandria, George, Horag Choi, and Dan Lu, "Trade Integration and the Trade Balance in China," *IMF Economic Review*, 2017, *65* (3), 633–674.

Amiti, Mary, Stephen J Redding, and David E Weinstein, "The impact of the 2018 tariffs on prices and welfare," *Journal of Economic Perspectives*, 2019, *33* (4), 187–210.

Benguria, Felipe, Jaerim Choi, Deborah L Swenson, and Mingzhi Jimmy Xu, "Anxiety or pain? The impact of tariffs and uncertainty on Chinese firms in the trade war," *Journal of International Economics*, 2022, *137*, 103608.

Bernanke, BS, "The global saving glut and the US current account deficit," 2005.

Bernard, Andrew B, J Bradford Jensen, Stephen J Redding, and Peter K Schott, "The margins of US trade," *American Economic Review*, 2009, *99* (2), 487–93.

Buera, Francisco J. and Yongseok Shin, "Productivity growth and capital flows: The dynamics of reforms," *American Economic Journal: Macroeconomics*, 2017, *9* (3), 147–185.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas, "An Equilibrium Model of and Low Interest Rates," *American Economic Review*, 2008, *98* (1), 358–393.

Chaney, Thomas, "Distorted gravity: The intensive and extensive margins of international trade," *American Economic Review*, 2008, *98* (4), 1707–21.

Dooley, Michael P., David Folkerts-Landau, and Peter Garber, "The revived Bretton Woods system," *International Journal of Finance and Economics*, oct 2004, *9* (4), 307–313.

Du, Qingyuan and Shang-Jin Wei, "A Sexually Unbalanced Model of Current Account Imbalances," *NBER Working Paper*, 2010, *No. w1600.*

Eaton, Jonathan, Samuel Kortum, and Francis Kramarz, "Dissecting trade: Firms, industries, and export destinations," *American Economic Review*, 2004, *94* (2), 150–154.

_ , _ , and _ , "An Anatomy of International Trade: Evidence From French Firms," *Econometrica*, sep 2011, *79* (5), 1453–1498.

Fajgelbaum, Pablo D, Pinelopi K Goldberg, Patrick J Kennedy, and Amit K Khandelwal, "The return to protectionism," *The Quarterly Journal of Economics*, 2020, *135* (1), 1–55.

Fernandes, Ana, Peter Klenow, Sergii Meleshchuk, Andres Rodriguez-Clare, and Martha Denisse Pierola, "The Intensive Margin in Trade," *NBER Working Paper*, 2019, *No. w25195.*

Flaaen, Aaron, Ali Hortaçsu, and Felix Tintelnot, "The production relocation and price effects of US trade policy: the case of washing machines," *American Economic Review*, 2020, *110* (7), 2103–27.

Guo, Meixin, Lin Lu, Liugang Sheng, and Miaojie Yu, "The day after tomorrow: Evaluating the burden of Trump's trade war," *Asian Economic Papers*, 2018, *17* (1), 101–120.

Havránek, Tomáš, "Measuring intertemporal substitution: The importance of method choices and selective reporting," *Journal of the European Economic Association*, 2015, *13* (6), 1180–1204.

Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple, "Export versus FDI with heterogeneous firms," *American Economic Review*, 2004, *94* (1), 300–316.

Jin, Keyu, "Industrial structure and capital flows," *American Economic Review*, 2012, *102* (5), 2111–2146.

Ju, Jiandong, Kang Shi, and Shang-Jin Wei, "On the connections between intratemporal and intertemporal trades," *Journal of International Economics*, 2014, *92*, S36–S51.

_ , _ , and _ , "Trade reforms and current account imbalances," *Journal of International Economics*, 2021, *131*, 103451.

Obstfeld, Maurice and Kenneth Rogoff, "The six major puzzles in international macroeconomics: Is there a common cause?," *NBER Macroeconomics Annual*, 2000.

Reyes-heroles, Ricardo, "The Role of Trade Costs in the Surge of Trade Imbalances," Working paper November 2016.

Song, Zheng Michael, Kjetil Storesletten, and Fabrizio Zilibotti, "Growing Like China," *American Economic Review*, 2011, *1* (25), 196–233.

Wei, Shang-Jin and Xiaobo Zhang, "The competitive saving motive: Evidence from rising sex ratios and savings rates in China," *Journal of Political Economy*, jun 2011, *119* (3), 511–564.

Wen, Yi, "Making Sense of China's Excessive Foreign Reserves Making Sense of China's Excessive Foreign Reserves," Technical Report 2011.

Xu, Juanyi, Xiaodong Zhu, and Yong Wang, "Structural Change and the Dynamics of China-US Real Exchange Rate," *Working Paper*, 2015.

A Technical Appendix

A.1 Alternative Trade Reforms

In this appendix, we describe the construction of the dataset used in the empirical study and report the results of the robustness check.

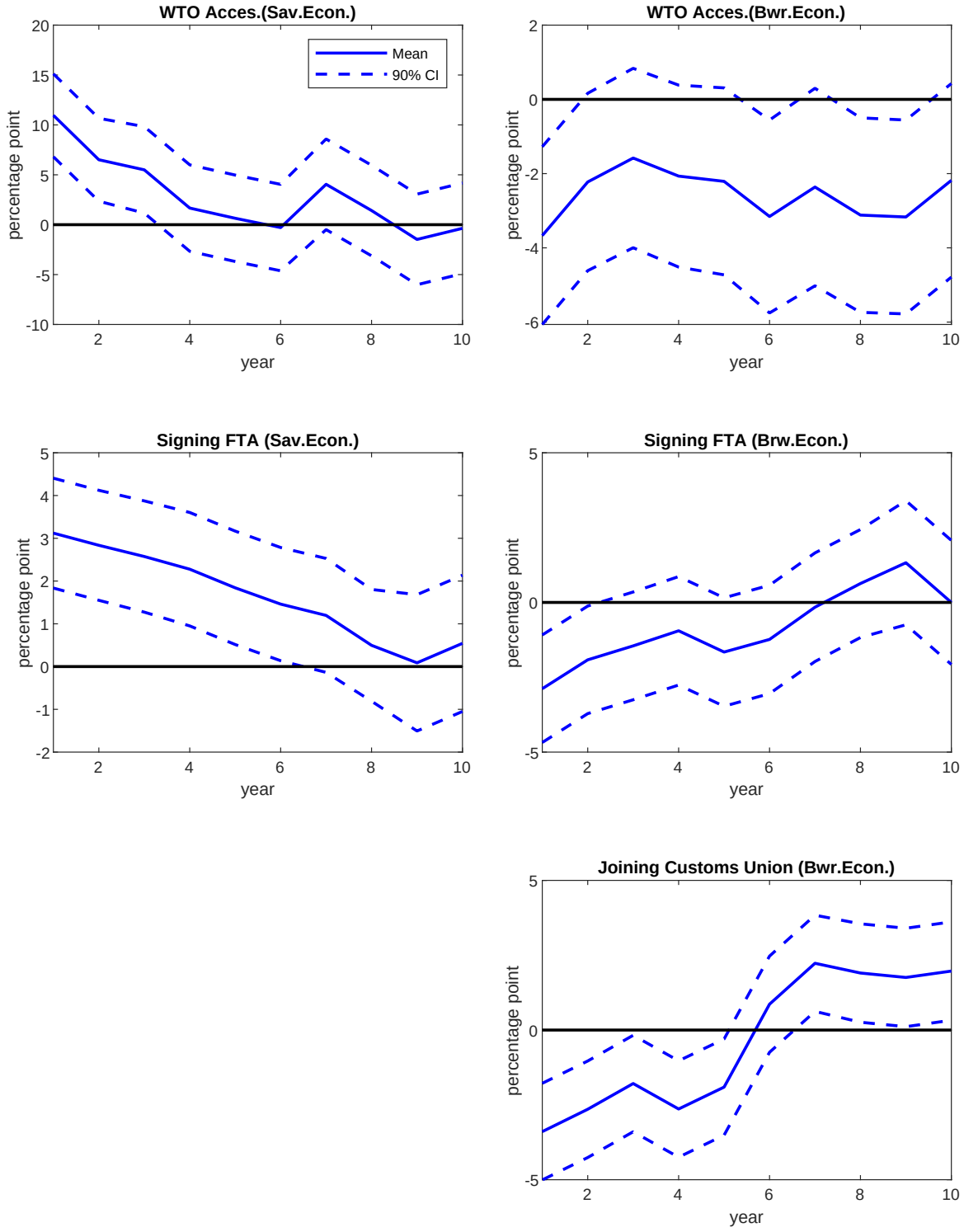
We construct the dataset by combining the data on the current account balance as a percentage of GDP from the international financial statistics (IFS) database and the data of the real effective exchange rate (REER) database from the Bank of International Settlement (BIS). In addition, the year of WTO accession, signing of Free Trade Agreements (FTA), and joining custom unions for each country are collected from the official websites of WTO, European Union, ASEAN, ALADI, and Mercosur, and news reports.

In the context of this paper, we used the event of WTO accession to proxy the trade reform as the explanatory variable. As the robustness check, we consider the events of signing free trade agreements (including NAFTA, Australia-US FTA, and ASEAN-Japan FTA), as well as joining custom unions (including European Union, ASEAN, Mercosur, and ALADI) as an alternative proxy for the trade reform. The same model specification is adopted as in Section 2 to estimate the effect of the trade reform on the current account balance. The estimation results are presented graphically in Figure 8. For the case of joining custom unions, only the results for borrowing countries are reported, as there are not enough observations of saving countries for this case. The main results presented in Section 2 are preserved when considering different trade reforms. The trade reform increases the current-account surplus for saving countries and widens the deficit for borrowing countries.

A.2 Simulation Method

A backward iteration method is used to simulate the economic outcomes of different scenarios using the theoretical model. We assume all exogenous shocks remain constant after 2019 and the economy will reach a steady state in 2040. The goal of computation

Figure 8: The Effect of the Trade Reform on the Ratio of Current Account Surplus to GDP



is to search for a steady state which ensures the initial value of foreign asset holdings match the data.

In particular, we use the value of foreign exchange reserves of China in 2000 as a proxy for the country's foreign asset holdings in the initial state, which is denoted as FX_{2000}. Below is the computation algorithm:

1. Guess the foreign asset position of China in the steady state B_h^*, which pins down all the variables in the steady state;

2. Iterate back as follows:

   (a) Consider period t, given $C_{h,t+1}, C_{f,t+1}, P_{h,t+1}, P_{f,t+1}, B_{h,t+1}$, all the variables in period t can be computed backwardly. So we know $C_{h,t}, C_{f,t}, P_{h,t}, P_{f,t}, B_{h,t}$;

   (b) Repeat Step (a), we can further compute $C_{h,s}, C_{f,s}, P_{h,s}, P_{f,s}, B_{h,s}$, where $s = t-1$. And go on until $s = 0$;

3. Compute $d = (B_{h,0} - B_{h,0}^{data})^2$;

4. If d is larger than an arbitrary criterion, re-guess the value of B_h^* and go back to Step 2-4 until d is small enough;

5. Finally, we obtain the initial state ($t = 0$), which can be used for further counterfactual exercise.

This method is applied to all the counterfactual exercises in the following section and the economy always starts from the same initial state value in different scenarios.