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

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Abstract

This paper quantifies the effects of China's trade reform on its current account dynamics following WTO accession in 2001. We first present cross-country evidence to show that the adjustment of China's current account adjustment to WTO accession differs from the experience of other countries, exhibiting a distinct hump-shaped pattern. We then document some institutional facts and firm-level evidence and argue that asymmetric trade reform between the exporting and importing sectors in China may help to explain this hump-shaped pattern. Motivated by these facts, we develop a two-country dynamic Melitz model and apply it to the Chinese economy. We estimate that trade reform accounts for 47.6 percent of the accumulated trade surplus in 2001-2010 and contributes to the hump-shaped dynamics of China's trade balance and real exchange rate. Finally, we apply this model to estimate the welfare losses arising from the U.S.-China trade war since 2018.

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

JEL Codes: F15, F31, F32, F41

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1 Introduction

In the past twenty years, China's current account surplus has been a subject of international economic policy debate. It has been cited as a factor behind the recent trade war between the U.S. and China. An extensive literature seeks to explain China's current account imbalance from different angles. Among them, trade liberalization, including trade reform and reducing trade costs, is a major hypothesis. 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 a reduction in trade costs are as crucial as TFP changes in explaining China's accumulated current account surplus from 2000-2007. While these papers show that trade reform is essential in explaining China's current account surplus, they do not pay too much attention to the dynamics of the current account. According to the data, China's current account surplus was relatively small in the year before China joined the WTO and rose gradually until 2007, when it began to shrink. In other words, the response of China's current account to access WTO is hump-shaped. Understanding the dynamics of the current account is essential as it may provide a way to identify the contribution of different hypotheses, which is less explored in the literature. In this paper, we intend to fill this gap and quantitatively investigate the impact of China's access to WTO on the dynamics of its current account adjustment.

Before conducting a quantitative investigation, we look at some empirical facts. The first one is the cross-country evidence. How have the current accounts in other countries responded to WTO access? We regress current account balances across different countries on ten lagged dummy variables to pick up trade reform over the past decade, based on the data from the IMF and BIS [1]. Figure 1 documents the dynamics

[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.

of the current account after accession to the WTO. After grouping countries by their initial current account status (surplus or deficit), the effect of trade liberalization is statistically significant, especially in the early years of WTO accession. The magnitude is non-trivial. WTO accession increases the current account-to-GDP ratio by an estimated nine percentage points on average for the saving countries in the sample. The direction is different for saving and borrowing countries, which is consistent with the theoretical prediction of Obstfeld and Rogoff (2000) that the effect of trade costs on the current account relies on the initial status of the economy. According to theory and other countries' experiences, when a country integrates into the world economy, its current account is expected to rise immediately. However, this did not happen in the case of China after it entered the WTO. What could explain this difference? One possible explanation is that trade reform in China after WTO accession is more comprehensive than trade reforms that only work to reduce bilateral trade costs.

To consider this, we review trade reforms implemented by China in the first few years after WTO access. We document the following facts: (1) After accession to the WTO in 2001, China accelerated the removal of barriers faced by domestic exporters without hesitation, while import liberalization was implemented more cautiously. Export reforms potentially benefited new entrants, while import reforms tended to favor incumbent trade partners. (2) Trade reforms were often implemented alongside other economic reforms, such as domestic marketization and reducing frictions in the financial sector and labor market. These broader economic reforms directly or indirectly affect the external adjustment as well.

Motivated by these facts, we develop a two-country perfect foresight general equilibrium model with Melitz-type heterogenous firms entry. Our model is based on a stylized international macro model, including 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 effects caused by these shocks one by one. Based on disaggregated firm data from China, we apply this framework to China's post-WTO period since 2001. Our findings show that China's trade reforms have an essential impact on the country's external adjustments, accounting for 47.6 percent of the accumulated trade surplus and causing a hump-shaped dynamic in the trade balance. Additionally, lower trade costs explain an appreciation of the real exchange rate from 2001 to 2010. Furthermore, trade reform increases social welfare by 27.5 percent for China and 2.3 percent for foreign countries during the same period. Finally, we apply this model to estimate the welfare costs of the U.S.-China trade war since 2018.

Our paper is closely related to three strands of literature on global imbalances. 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 critical 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 toward 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 a symmetric decline in trade costs across countries.

The second related literature studies current account imbalances from a Chinese perspective. For example, Song et al. (2011) features financial sector imperfections in China in generating a current account surplus. The paper stresses the inability of productive domestic private sector firms to borrow from the formal financial sector as a key friction. Therefore, these firms need 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 reserves accumulation by China is 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 frictions, some argue that China's changing demographics also play an essential role in explaining its high saving rate. Wei and Zhang (2011) provide empirical evidence that suggests that the rising gender 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 a rise in the relative surplus of men in China may trigger the rise of the current account imbalance in China since 2002. However, the imbalance in the gender ratio can explain a high saving rate but not a high investment rate. Given the importance of trade cost in explaining global imbalances, Alessandria et al. (2017) study the effects of China's accession to the WTO on China's current account surplus in a calibrated macroeconomic model that embeds a Melitz-style heterogeneous firm model.

The third related strand of 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 estimate that real wages could fall by 0.32 percent for the United States and by 0.37 percent for China if both nations increased their bilateral import tariffs on each other to 45 percent while trade imbalances remained the same. Other studies including Amiti et al. (2019), Fajgelbaum et al. (2020), Flaaen et al. (2020) stress that the recent increase in trade protectionism in the U.S. has significantly raised domestic prices for intermediate and final goods and decreased import varieties, which has resulted in a decline in real incomes of the U.S. of $1.4 billion per month by the end of 2018. According to Benguria et al. (2022), the trade war has increased trade policy uncertainty (TPU) and 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 has resulted in a 2.3 percent decrease in firm investment and R&D spending and an 11.5 percent loss in profits.

We contribute to the existing literature, such as Reyes-heroles (2016) and Alessandria et al. (2017), in the following ways. 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 reform between the exporting and importing sectors. Second, our unified framework can be used to separately account for the relevance of trade reforms and other frictions mentioned in the literature. Third, we explain the dynamics of the current account and the real exchange rate rather than their direction or second moment. The dynamics usually contain more information and help identify the features of trade reforms.

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

2 Stylized Facts on Trade Reform

In this section, we first show the global experience of current account adjustment in response to various types of trade reforms based on a cross-country dataset. Trade reforms generate heterogeneous effects. They tend to have positive and lasting effects on saving countries' current account surpluses but a negative impact on borrowing countries, creating larger deficits. Like other saving countries, China's current account surplus increased after trade reforms, but its response was much slower than in other countries.

2.1 Global experience of external adjustments

Our empirical study is based on a dataset composed of 155 countries from 1960 to 2019. The dependent variables include the ratio of the current account balance to GDP and a currency's real effective exchange rate. These are sourced respectively from the International Financial Statistics (IFS) database of the International Monetary Fund (IMF) and the Bank for International Settlements (BIS) database. 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:

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

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 trade reform.

To capture the dynamic effect of 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 for this setting. External adjustment may last several years after reform due to intertemporal consumption smoothing and capital accumulation. Furthermore, as will be shown later, some countries like China

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

implement trade reform in stages rather than all at once. The time-variant shocks cause complex dynamics in the current account balance or real exchange rate adjustment. Our regression aims to explore the lasting effect of the trade reform over a ten-year timeframe.

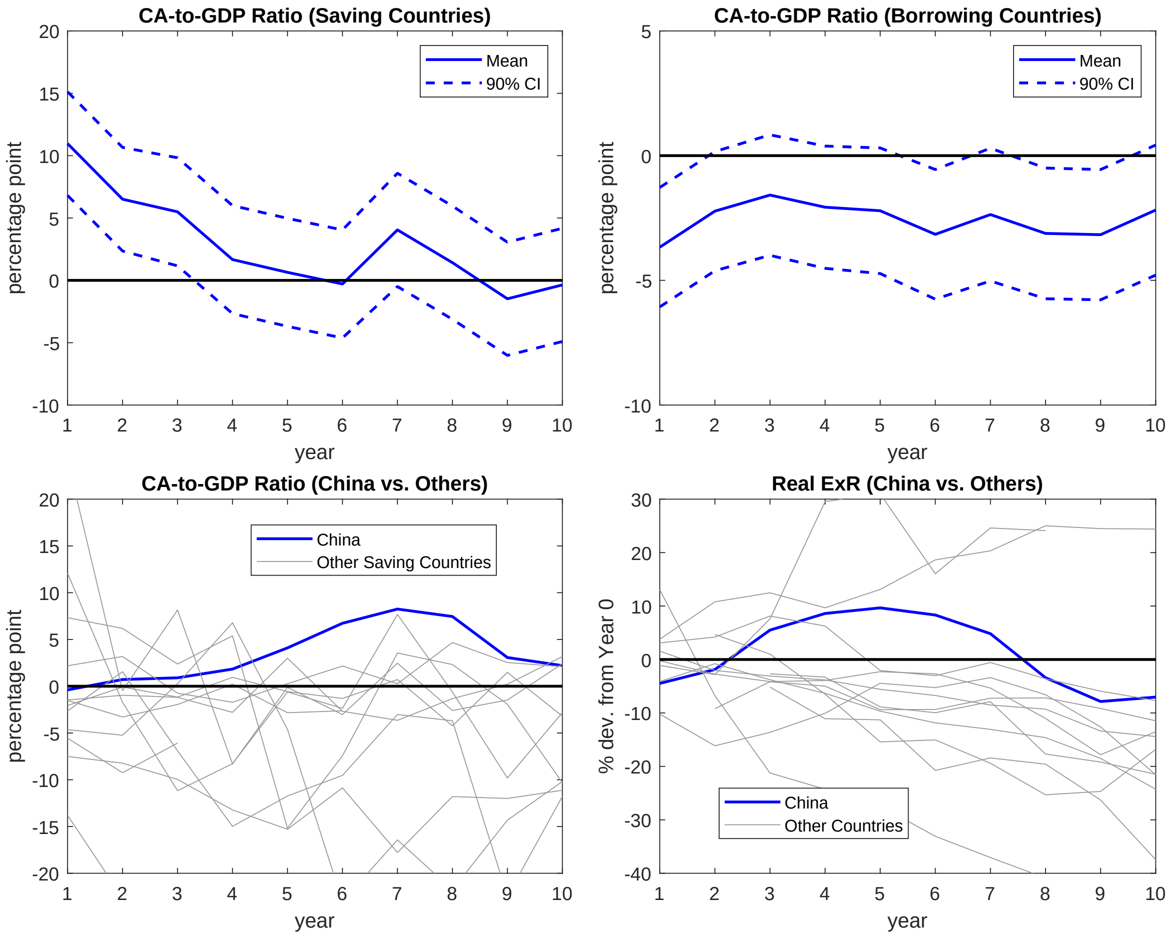
A dummy variable indicating each country's initial current account position (dum_c^p, $p \in \{s, b\}$) is included and interacts with the explanatory variable. Countries that had a current account surplus one year before the trade reform are regarded as saving countries, while those with a current account deficit are considered borrowing countries.[4] This setting examines the heterogeneous effect on saving and borrowing countries, following the idea of Obstfeld and Rogoff (2000), who argue that the effect of trade costs on an individual country's current account relies on its initial 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 implemented in saving countries. $\beta_i + \beta_i^b$ represents the same effect for borrowing countries. The results are graphically presented in the upper row of Figure 1. 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, trade reform raises borrowing countries' trade deficits. This is because lower trade costs reduce frictions in inter-temporal trade and narrow the real interest rate differential between international borrowers and savers.

Global experience demonstrates that when a saving country integrates with the world economy, its current account surplus exhibits an immediate upsurge. However, this effect diminishes over time, often turning negative in the fifth year following the reform. Despite its inherent volatility, the current account's trajectory roughly follows a descending trend. Notably, China, like other saving-oriented nations, responds

[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



positively to trade reforms, resulting in an expansion of its current account surplus. However, this positive impact lags behind that observed in other saving countries. As illustrated in Figure 1's lower-left panel, the increase in China's current account surplus remains relatively modest during the initial three years, experiencing a noteworthy increase from the fourth year onward, thus forming a distinct hump-shaped pattern between 2004 and 2010. The dynamics of the Renminbi's real exchange rate following trade reform also diverge from the global norm. While other currencies tend to exhibit a unidirectional trend (either appreciating or depreciating), the Renminbi's real exchange rate demonstrates a hump-shaped trajectory between 2001 and 2010, as depicted in the lower-right panel of Figure 1.

These findings motivate us to revisit the effect of trade reform in two aspects. First, it is important to ask how different trade reform processes could affect the changing direction or accumulative amount of capital flows and the dynamics of the current account balance.[5] Second, consider if the shape of dynamics could be used to distinguish the impact of trade reform from other shocks, such as reductions in financial frictions and productivity shocks. These are regarded as alternative explanations for the current account response in the literature.

Before the model illustration, we review several key features of China's trade reform following WTO accession.

2.2 Institutional facts on China's trade-related reforms

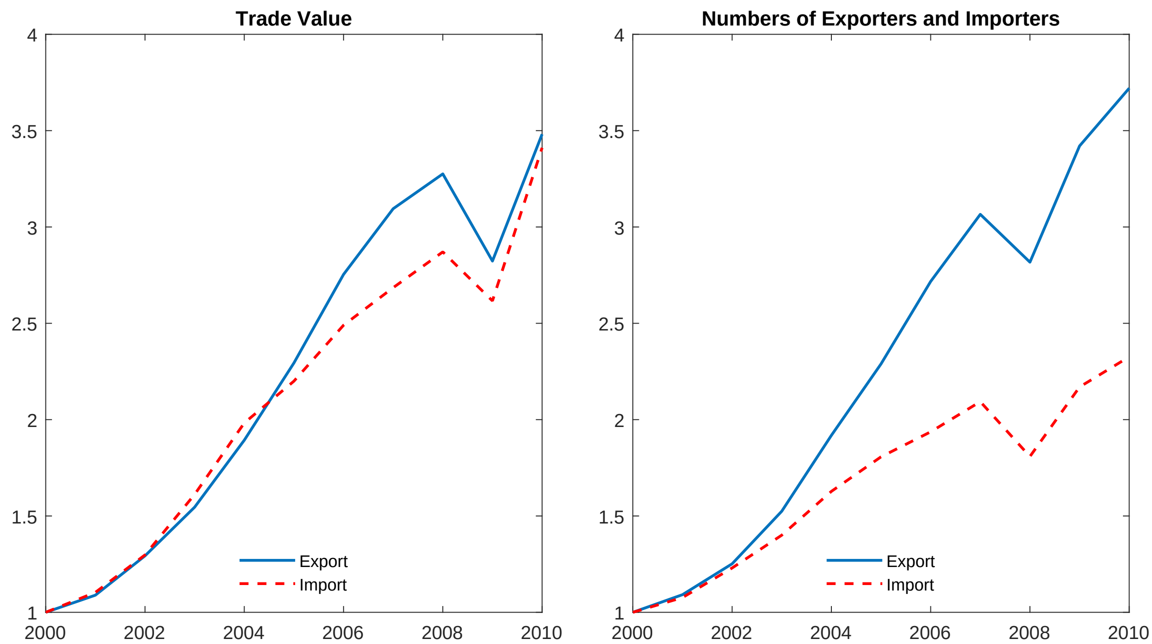
In the decade following China's WTO accession (2001-2010), China launched a vast economic reform program, gradually removing various trade barriers and economic frictions to exports and imports. On exports, many private and small state-owned enterprises were permitted to trade in global markets. The Chinese government committed to giving trading rights to all types of domestic firms, lowering the requirement on minimum registered capital, and increasing export quotas. Import reform was rela-

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

tively intensive-margin oriented to increase access to foreign intermediate goods. The reform for final goods imports is limited to protect domestic industries. 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.

Margins of trade. Although China's exports and imports 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 employ the margin decomposition exercise used by Bernard et al. (2009) 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 entry and product variety account for 51 and 16 percent of

China's export growth during the period, higher than their contribution of 26 and 6 percent to import growth.

We further validate this result by following Fernandes et al. (2023) and 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, representing 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 and different types of fixed effects to address the measurement error problem. The result is 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 operated within a narrow scope of business. During WTO negotiations, 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 export markets to a wide range of Chinese firms.

Table 2: Requirement on minimum registered capital

Year	2000	2001	2002	2003	2004 and thereafter
US$ Thousand	1,026	604	362	121	0

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

The second policy was to increase textile export quotas. Under the Agreement on Textiles and Clothing (ATC), which became effective in 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 was entirely used up. Between 2002 and 2006, the number of quotas increased gradually, with 30 percent opening for public bidding. With more quotas available in 2006, more Chinese apparel firms could enter the export market by purchasing export quotas.

The expenditure on export quotas 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]. There is also evidence in the data of black-market pricing of sock export quotas (see Table 3). In 2003, the quota price was equal to 140 percent of production costs. The ratio declined to 14 percent in August 2006 thanks to export reforms.

Import tariff reduction. Import reform is characterized by a significant reduction in the average tariff rate, possibly favoring incumbent firms. Figure 3 documents the tariff rates imposed on Chinese imports compared with 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. As a comparison, the tariff reduction on Chinese exports was mild during the same period. Export-side reforms concentrated more on removing

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

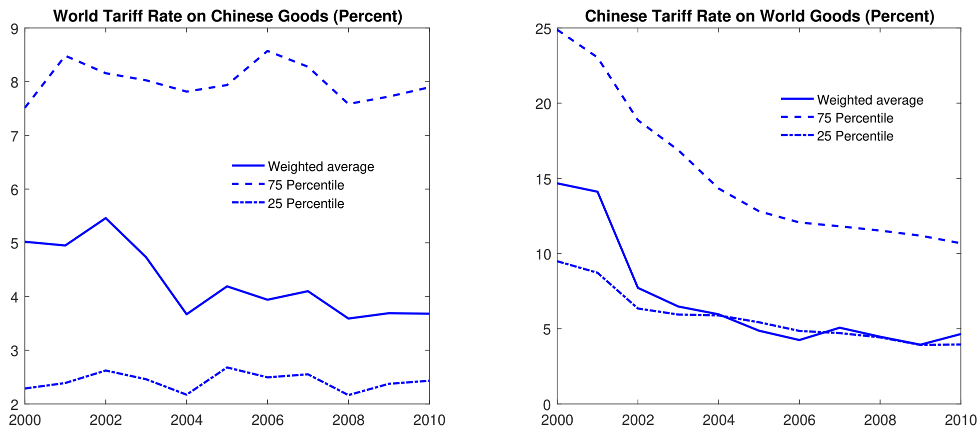
Table 3: Black-market price for sock export quota (US$ per dozen pair)

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.

non-tariff barriers and entry costs, while import reforms primarily focused on tariff reductions.

Figure 3: Tariff Rates on Chinese Exports and Imports



Source: World Integrated Trade Solution (WITS).

However, the tariff reduction is uneven among different product categories. The tariff cut on intermediate goods is more significant than on final goods, as shown by Table 4. Cheaper input goods allowed Chinese manufacturers to keep their costs down. A higher barrier to imported final products protected them from foreign competitors.

The removal of non-tariff barriers was relatively slower. The administrative barriers for foreign-invested trading firms included a more stringent requirement on the minimum registered capital (US$6.3 million) and past revenue (average annual US$30 million tradings with China in the preceding three years) of foreign trading firms. These

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).

numbers are higher than those for export firms. A higher entry threshold would possibly favor incumbent firms over new entrants.

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 above, China's trade reform features an asymmetry in the liberalization rate for exports and imports. Non-tariff barriers and implicit administrative distortions have an essential impact on China's trade balance, in addition to tariff reductions. As shown in Section 4, the change in trade costs recovered by our theoretical model is consistent with this feature of China's trade reforms.

[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: Anti-dumping, Safeguards, and Dispute Settlement" by Chad P. Bown, China's Growing Role in World Trade, March 2010.

3 A Two-country Model

In this section, we build a two-country perfect foresight general equilibrium model equipped with 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 intermediate goods and sell them to domestic and foreign final-good producers. Intermediate producers are heterogeneous in productivity. The final goods producers serve local households in a perfectly competitive market. Final goods are used for consumption or investment. The representative household spends income on consumption, investment, and holding foreign assets. The home country represents China, and the foreign country represents the rest of the world. Only the expressions for the home country are presented below, and 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 nonstate 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 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. In the early 2000s, investment by state-owned enterprises was heavily dependent on the government's economic plan and, therefore, less sensitive to market-based interest rates. The deviation of investment from a socially optimal growth path affects 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 preferences. 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 borrowing constraints. 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 the 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 goods market is perfectly competitive. Producers use 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 a constant elasticity of substitution (CES). θ is the inter-firm substitution rate. $\Sigma_{f,t}$ is the set of exporters in the foreign country.

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

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

Domestic firm entry. $N_{h,t}$ is the total number 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 this is regarded as uncorrelated with the post-2001 trade reform, it is an alternative explanation for the increase in 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 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 deciding production and market entry.

Technology shock. $z_{h,t}$ is an exogenous country-specific technology shock. It captures technological improvements and reductions in labor-market frictions in China. Xu et al. (2015) shows that an increase in labor mobility dampens increases in labor costs and causes currency depreciation in the early 2000s. The technology shock affects the relative competitiveness of a country's exports and expected future income, both of which impact 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 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 tariff rates, transportation costs, 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 a constant markup, gross profits are proportional to revenues.

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

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

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.

$$\pi_{hf,t}(\phi^*_{hf,t}, z_{h,t}) = f^h_{x,t} w_{h,t}/q_{h,t}, \tag{3.14}$$

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

How does a change in trade costs 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), trade costs are 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 it 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 their current account surplus in the early period. This coincides with a mitigated borrowing demand due to a rise in the equilibrium real interest rate. Combining these effects, an expected gradual reduction in trade costs increases the current account surplus of saving countries in the long run but dampens the surplus in the short term.

In addition, trade costs affect the real exchange rate by changing the relative price between two countries through terms-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.

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

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

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

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 of our 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 sample enables us to explore the effect of trade reforms in the 2000-2010 period in Section 5 and also to estimate the welfare loss from the U.S.-China trade war since 2019 in Section 6. We end in 2019 to rule out the 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 average levels for China between 2000 and 2019. The data source is the 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), corresponding 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 the Chinese Industrial Enterprise Database.

We choose the values for the home bias parameters a_h and a_f under two assumptions. First, 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 ten 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 is assumed to have 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 the home and foreign countries, respectively. The rest 12 time-variant shocks are recovered from the data.

Firstly, we recover the iceberg trade cost ($\tau_{h,t}$) by 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 real output and the share of exports and imports from the Penn World Table[9] and the data on the real exchange rate from BIS to recover both nominal and real output in the domestic and export sector, 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 cutoff 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 in-

[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 China's 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.

tertemporal 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 profits to wages, according to the zero-profit condition. Since the exporting price of each firm and the set of exporting firms have been recovered in the previous steps, we can pin down fixed trade costs.

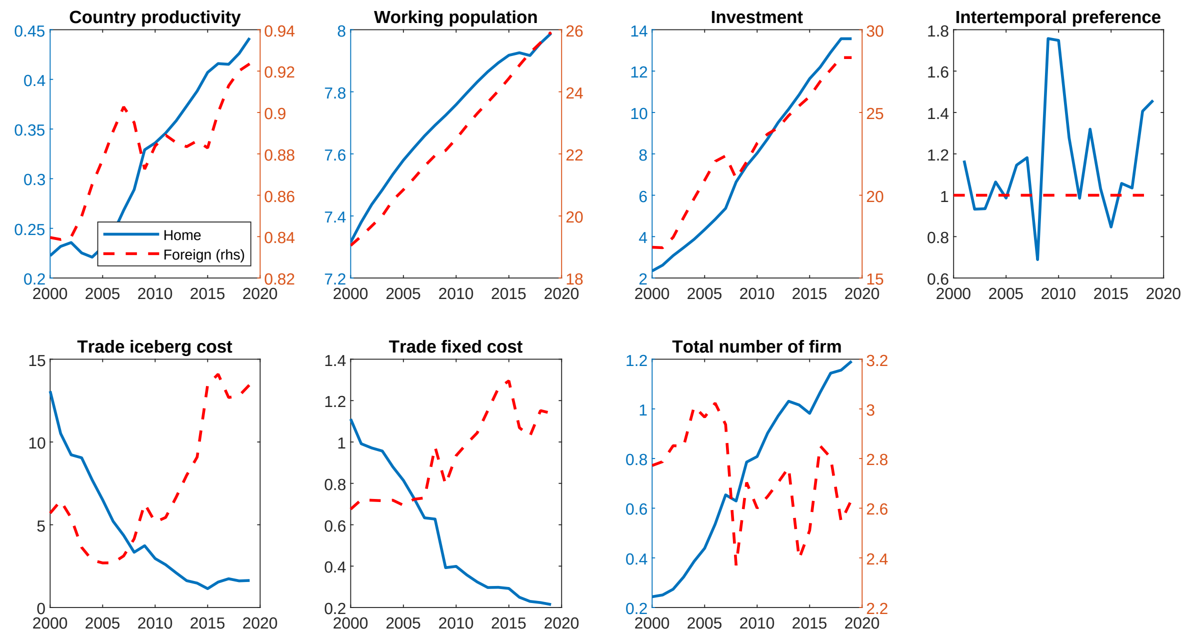
Fourthly, the country-level productivity shock ($z_{h,t}$) is reflected in the price of the domestic products ($p_{hh,t}$) together with wage and capital rent. The Cobb-Douglas production function guarantees constant labor and capital income shares. It is easy to compute a series of wages and rent for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

Finally, investment shocks ($\mathrm{I}_{h,t}$) are recovered from data on capital stock and depreciate rates. We compute 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.

Economic reforms If we look at the reform period from 2000 to 2010, the pattern of trade costs recovered from the data aligns 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. However, 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 trend is consistent with

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



the observation that export reform favored extensive margin growth. These policies contribute to the fast growth of the number of exporting firms.

The remaining exogenous variables reflect other economic reforms and international demand shocks to China between 2000 and 2010. For instance, the rapid growth of productivity, investment, and the total number of firms is 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 trade reform on the trade balance and the real exchange rate between 2001 and 2010. China's trade reform impacts the country's external adjustments, accounting for 47.6 percent of the accumulated trade surplus and 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, trade reform increases social welfare by 27.5 percent for the home country and 2.3 percent for the foreign country over 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 that 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 contribution of trade reform to the trade balance and the currency's real exchange rate, we 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 trade reform (TR).[13] The second counterfactual scenario simulates a world without trade reform by turning off 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. 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 the expectations discussed 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 faster-growing productivity and financial imperfections, as shown by the literature, such as Song et al. (2011) and Buera and Shin

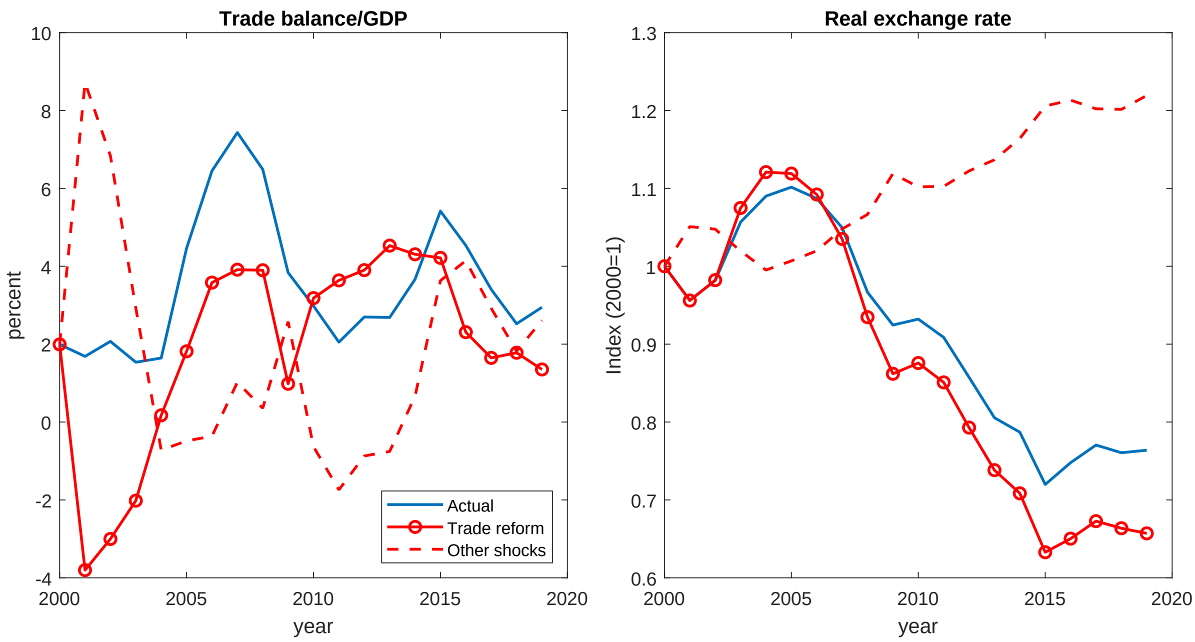
[11]We allow a sufficiently long period of convergence to reduce the impact of the post-2019 shock assumption on the dynamics of variables between 2000 and 2019.

[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.

(2017). As a result, the dampening effect of trade reform offsets the positive effect of other shocks, causing small trade surpluses between 2001 and 2004.

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



To quantify the contribution of trade reform to China's trade balance dynamics, we 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, trade reform accounts for 22.6 percent of the accumulated trade surplus between 2001 and 2010. The contribution is especially high in 2006-2008 and 53 to 60 percent of China's trade surplus comes from trade reform. If we include the interaction effect, trade reform's contribution rises to 47.6 percent in 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 trade cost reductions between 1970 and 2007.[14]

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

A comparison of lines in Figure 5 shows that trade reform has an essential influence on the hump-shaped dynamics of China's trade balance from 2001 to 2010. To quantify this, we calculate the correlation coefficients between the simulated trade balance sequences and the actual data. For 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 trade reform, the Renminbi's real exchange rate would have depreciated by 12.2 percent in 2001-2010. In reality, the currency appreciated by 6.8 percent, primarily due to the effects of trade reform. The non-trivial contribution of trade reform to the real exchange rate is also confirmed by 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 the actual data. The correlation is 0.98 (see Table 7).

[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.

5.2 Gains from 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 the average percentage change in total consumption from a no-trade-reform case to a real-world one. $c_{i,t}^{Acutal}$ 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 ensures that households maintain their utility level in the no-trade-reform case.

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

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

6 The U.S.-China Trade War

Analyzing China's trade reform in the early 2000s has significant policy implications for the ongoing U.S.-China trade war. This is because the trade war, marked by heightened cross-border trade costs, essentially represents a reversal of effects arising from trade reform following China's WTO accession in 2001. An in-depth understanding of the diverse effects of trade reform can be helpful in understanding the potential impacts of a trade war. The Trump presidency changed U.S. trade policy toward China in 2018 by dramatically raising tariffs and other trade barriers on Chinese goods. According to the Peterson Institute for International Economics (PIIE) estimates, 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

[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.

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 average tariff on U.S. exports to China 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, exporters from each country continue to suffer from high trade costs at the time of writing.

As stated by the Trump administration, one of the reasons behind these practices is to reduce the U.S.-China trade deficit.[16] However, whether this policy goal will be achieved remains questionable. World trade was seriously affected by the COVID-19 pandemic, and so it is challenging to isolate the trade war's long-run effect based on the data alone. The theoretical framework used in our study can help quantify this.

To do so, we consider four counterfactual cases to simulate the ongoing trade war. We assume the trade war shock occurred in 2019.[17] Prior to that, no one anticipated the shock, but it has been 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.[18]

First, we assume the trade war only temporarily affects each country's iceberg trade costs in our model 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.[19] In this scenario, the trade imbalance can be re-

[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] Although the trade conflict between the U.S. and China started in July 2018, the announced tariff rate hikes were initially moderate and there was still a lot of uncertainty in the second half of 2018 about whether the countries were in a trade war. Coming into 2019, the implemented rate hikes became substantial and the event was widely recognized by global markets.

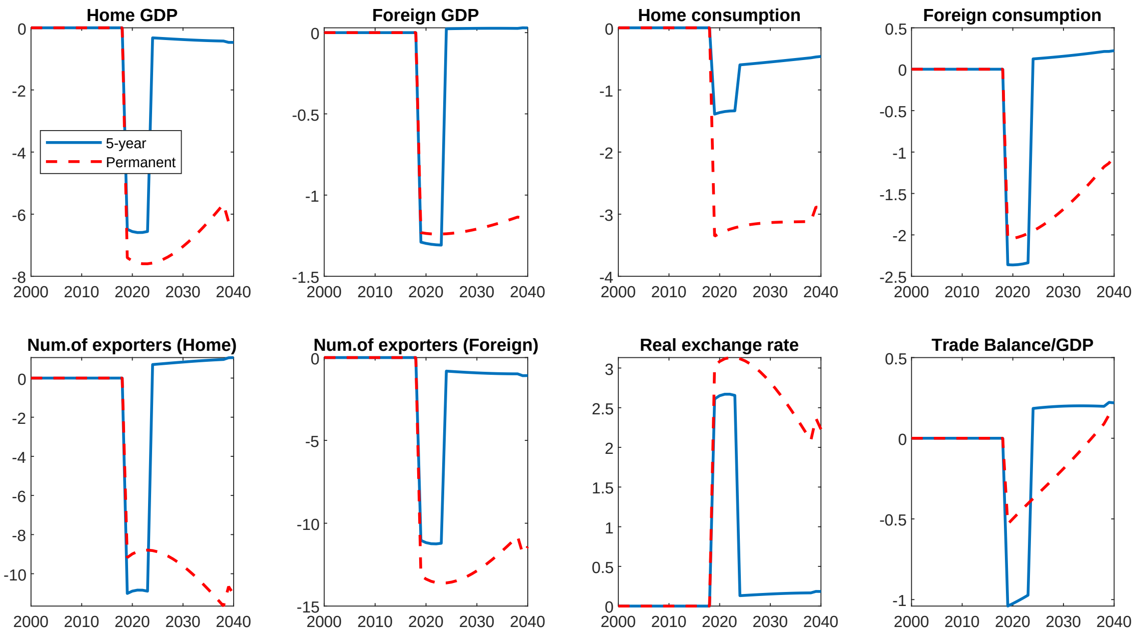
[18] Like the computation algorithm described in Section 5, the computation goal is to search for a steady state that ensures equalization of the initial value of foreign asset holdings in 2018.

[19] 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.

duced. 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 reduced if there are no mitigating policies. The drop in consumption is more severe for the foreign country in 2019-2023 (-2.3 percent) than for the home country (-1.2 percent). The higher trade costs imposed by the U.S. inevitably push up import prices and domestic inflation rates. Social welfare decreases by 0.7 and 0.8 percent for the home and foreign countries, respectively.[20] This result is comparable to estimates in the literature 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 a steady state). In this case, China's

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

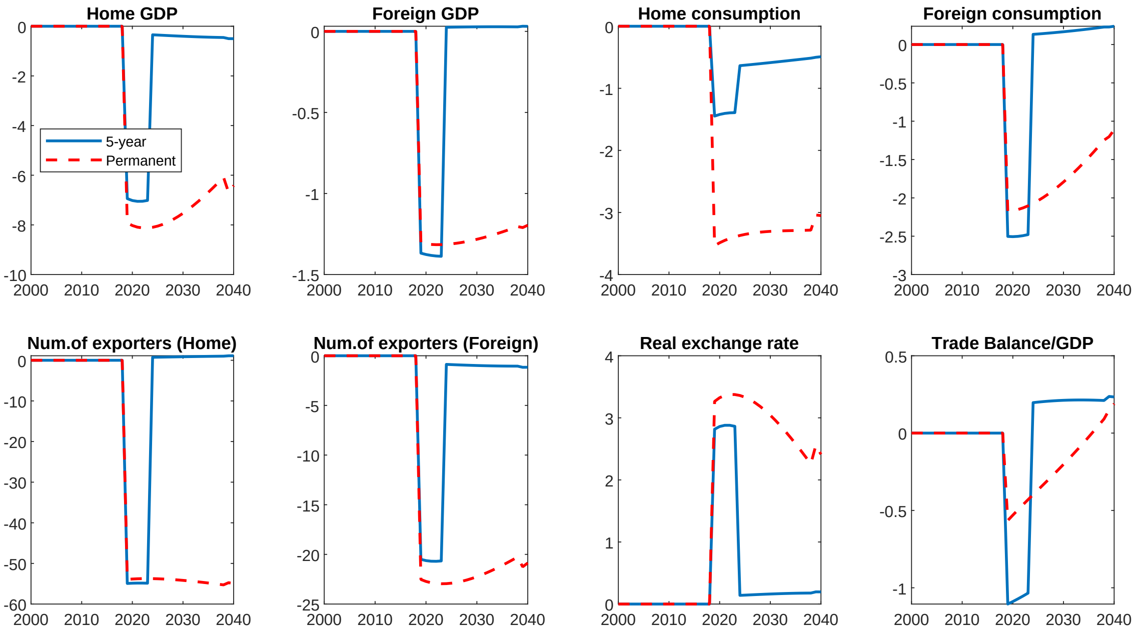
trade balance to GDP ratio would decline by 0.5 percentage points in 2019, but the negative effect would last longer (see Figure 6). In a dynamic setting, rising trade costs hinder intra-temporal trade and prevent intertemporal consumption smoothing in each country by raising the real interest rate. This results in a greater economic loss by reducing the future income for the home country and 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 also 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 fixed trade costs in the third and fourth scenarios. We assume the trade iceberg and fixed costs rise by the same percentage in 5 years and a permanent case, respectively. The results indicate that, in addition to a severe economic recession in both countries, rising fixed costs cause many exporters to exit the global market. The number of exporting firms 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.

7 Conclusion

This study investigates China's post-2000 trade reform and its long-lasting effects on the country's current account and real exchange rate dynamics between 2001 and 2010. We perform a decomposition analysis using a dynamic two-country Melitz model with various economic frictions. The results show that trade reform plays an essential role in forming 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 reform 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

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



2018 and estimate long-run effects under four different scenarios. Overall, our paper emphasizes two things: First, the dynamics of current account adjustment are essential in identifying the contribution of different hypotheses to explain China's current account surplus in the literature. Secondly, asymmetric trade reform between exporting and importing sectors after China's WTO accession in 2001 may help to explain China's unique hump-shaped current account dynamics in response to this.

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A Technical Appendix

A.1 Alternative Trade Reforms

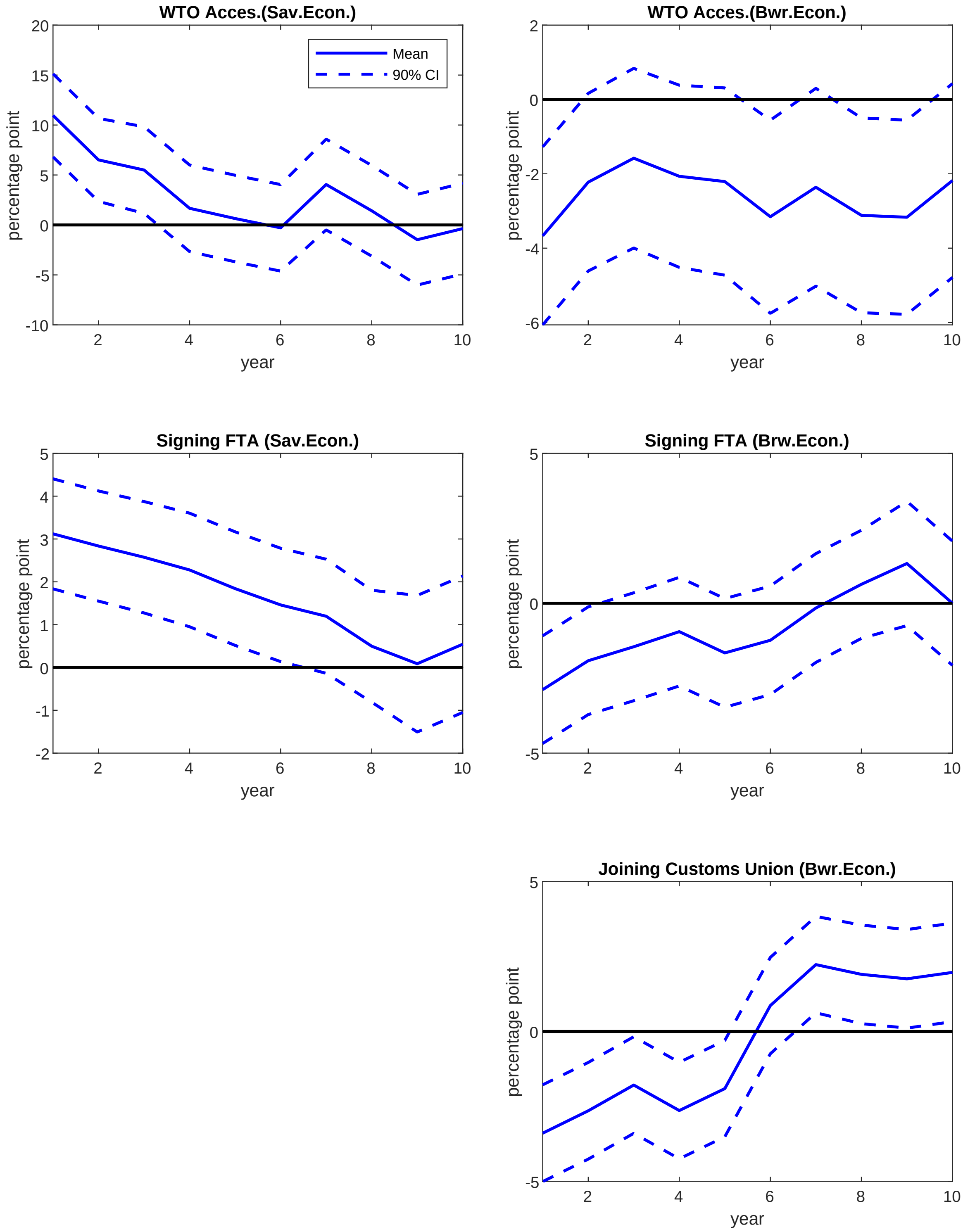
In this appendix, we describe the construction of the dataset used in our empirical study and report the results of the robustness check.

We construct our dataset by combining data on the current account balances as a percentage of GDP from the International Financial Statistics (IFS) database and data on the real effective exchange rate (REER) database from the Bank of International Settlement (BIS). In addition, information on the year of WTO accession, the signing of the Free Trade Agreements (FTA), and entering customs unions for each country are collected from the official websites of the 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 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 trade reform. The same model specification is adopted as in Section 2 to estimate the effect of trade reform on the current account balance. The estimation results are presented graphically in Figure 8. For the effect of joining customs unions, only the results for borrowing countries are reported, as there are not enough observations on saving countries. The main results presented in Section 2 are preserved when considering different trade reforms. Trade reform increases the current account surplus of saving countries and widens the deficit of 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

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



computation is to search for a steady state that ensures the initial value of foreign asset holdings matches the data.

In particular, we use the value of the 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.