Trade Integration and the Trade Balance in China*

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Abstract
We study the large rise in Chinese gross and net trade flows, summarized by its large positive net foreign asset position, in a dynamic stochastic general equilibrium model of China and the Rest of the World with endogenous trade participation, pricing-to-market, aggregate fluctuations, and incomplete financial markets. The model features an endogenous time-varying trade elasticity from producer-level investments in export market access. We estimate the changes in technology, trade costs, and preferences accounting for the changes in China's gross and net trade flows, export participation, real gdp, and real exchange rate. We find that changes in trade barriers to be an important driver of the Chinese trade balance and the accumulation of foreign assets. We also find that the stagnation in trade growth since 2011 to primarily reflect the completed transition to past trade reforms rather than increase in trade barriers or reversal in the expected pace of future integration.
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1 Introduction

China's economic growth and integration with the world economy has been an important and defining economic event of the last twenty-five years. It has been characterized by a substantial rise in income, a large increase in international trade, the accumulation of substantial net foreign assets, and important swings in the real exchange rate.[1]

Studies of the role of Chinese trade integration have generally been undertaken in static trade models with exogenous imbalances, and analyses of Chinese imbalances have often abstracted from gross trade flows and relative prices. Our main interest is in studying the joint determination of trade integration and trade imbalances.

We focus on the role of trade integration in China's trade balance and asset accumulation for two main reason. First, this is clearly a period with substantial changes in policy and non-policy trade barriers. These changes in trade barriers have differed on exports and imports and over time, and have had substantial forward looking components, providing a rationale for intertemporal trade. Second, recent work by Alessandria, Choi and Ruhl (2014) and Alessandria and Choi (2015) has shown that trade policies can generate intertemporal trade. In particular, Alessandria and Choi (2015) show that a substantial share of the large expansion in the US trade deficit as a share of GDP in the 2000s can be attributed to changes in trade barriers.

China has been growing fast for decades and yet despite this, it has persistently run large current account surplus, accumulating a large stock of foreign assets. We study the sources of its growth, trade integration, and trade imbalances through the lens of a two-country dynamic stochastic general equilibrium model with incomplete asset markets, heterogeneous producers, and endogenous trade participation featuring a dynamic decision. We consider the role of persistent changes in trade barriers, technology, and preferences. The preference shock affects the discount factor and is designed to capture the often discussed Chinese

[1] Two striking features of China's economic growth over the last twenty years have been a sustained trade integration, with imports and exports expanding at roughly double the pace of economic activity, and large trade surpluses. For instance, China's share of US trade (exports and imports) has grown from 2.5 percent in 1992 to 10.6 percent in 2013. This growth has been unbalanced with Chinese exports to the US on average 3 times Chinese imports from the US. Indeed, China has grown from being a slight debtor to the rest of the world of about 5 percent of its GDP in 1992 to being creditor of about 21 percent of its GDP in 2011 (Lane and Milesi-Ferreti 2007).

"savings glut." We estimate the process for these shocks using data on gross and net trade flows, the real exchange rate and output in China and the rest of the world, and the dynamics of producer-level export participation. Then we study the contribution of these shocks on the Chinese and world economy.

In contrast to most analyses of Chinese trade integration, we focus on a model in which trade barriers make exporting an explicitly forward looking decision. The baseline model includes heterogenous producers facing trade costs that depend on their past export history as in Dixit (1989), Baldwin and Krugman (1988), Das, Roberts, and Tybout (2007), Alessandria and Choi (2007,14a,b) and Alessandria, Choi, and Ruhl (2014). These types of dynamic models have been shown to best explain producer level export participation as well as the dynamics of trade integration. The model allows for a different short-run and long-run trade elasticity and thus allows us to more accurately assess the sources of trade integration.

The model is calibrated to capture some salient features of producer involvement in international trade from the Chinese Census of Manufactures and US Exporter Profile. Particularly, we find that export participation among Chinese producers peaked in 2006 and has since fallen while export participation to China has steadily risen and only leveled off since 2011. The dynamics of export participation allow us to separately identify changes in variable versus fixed trade barriers.

We find trade integration shocks have had an important impact on the trade balance and the real exchange rate, consistent with the findings of Alessandria and Choi (2015) for the US. Trade integration shocks generate large swings in the trade balance through two mechanisms. First, transitory differences in bilateral trade barriers provide a motive for borrowing and lending by change the terms of trade in a predictable way. Second, changes in worldwide trade barriers can also have an effect on borrowing and lending. With more trade, the scale of borrowing and lending in response to changes in non-trade related shocks is expanded. Quite simply, a closed economy can not borrow and lend while and open economy can. Additionally, in an asymmetric world, common trade cost shocks have a larger effect on consumption in the smaller, more open country generating an additional motive for borrowing and lending following a persistent change in common trade costs. In total, we find that changes in trade barriers increased China's net foreign assets in 2014 by

40 percentage points of GDP.

Our model is also well-suited to evaluate the dynamics of trade intensity in China and the rest of the world. We use the model to account for the rise in trade intensity leading up to the Great Recession, the Great Trade Collapse and Rebound, and the Trade Slowdown since the Rebound. Specifically, we allow for both persistent shocks to common trade costs as well as persistent shocks to the growth rate of common trade costs. Shocks to the growth rate of trade costs are a parsimonious way to capture the tendency of trade pacts to have a phase-in period. We find that the growth in trade intensity in the 2000s reflected a persistent negative shock to the growth rate of worldwide trade barriers starting in 1999 and a series of reductions to Chinese and worldwide trade barriers. We find the Great Trade Collapse reflects a transitory rise in worldwide trade barriers but no persistent increase in the growth rate of trade barriers. We find that most of the slow-down in trade since the Great Trade Recovery reflects the waning influence of past trade agreements, and the lack of new innovations, rather than an outright reversal. Indeed, we find expectations for future trade barrier reductions in 2014 to be similar to expectations in 1999 prior to expansion.

The next section describes some related literature. Section 3 describes some salient features of Chinese integration. Section 4 builds a dynamic general equilibrium model. Section 5 describes the solution and estimation of the model. Section 6 describes the properties of the model. Section 7 summarizes the source of various changes in our estimated economy. Section 8 reports the sensitivity of our results to our modelling assumptions. Section 9 concludes.

2 Related Literature

A key contribution of this paper is to study Chinese trade integration and imbalances in a unified manner. Previous analyses of the role of Chinese imbalances have often abstracted from gross trade flows and relative prices. Some examples are Caballero, Farhi, and Gourinchas, (2008), Song, Storesletten and Zillibotti (2011), Buera and Shin (2009), Quadrini, Mendoza, and Rios-Rull (2009), Choi, Mark, and Sul (2008), Coeurdacier, Guibaud, and Jin (2015). Similarly, studies of Chinese integration have generally been undertaken in static trade models with exogenous imbalances (di Giovanni, Levchenko and Zhang, 2012 Tombe and Zhu 2013, Autor, Dorn and Hanson 2013, 2015).

Our approach to measuring changes in trade barriers is consistent with the larger Gravity literature (see a survey by Anderson 2011) which uses changes in bilateral trade flows and a model to infer changes in trade costs. Examples of recent work in this spirit that examines the role of changes in trade costs in aggregate fluctuations (Levchenko, Lewis, and Tesar, 2010, Jacks, Meissner, and Novy, 2011, Eaton, Kortum, Neiman and Romalis, 2014). Unlike this work, we use a two-country dynamic trade model to infer the changes in trade barriers as in Alessandria and Choi (2014b, 2015) and Alessandria, Kaboski and Midrigan, (2010, 2011, 2013). By using a dynamic model of trade, we are able to capture the well-known lagged effect of relative prices and trade barriers on trade flows[2] through the internal propagation of the model rather than an exogenous shock process.

3 Evidence

We begin by summarizing some salient features of China's integration into world markets. We focus on the period beginning in 1990 and ending in 2014. We move from the more aggregate features to disaggregate aspects. While most of the evidence we present is well-known, it serves as a useful foundation for the model and quantification.

Rapid catchup: Over the last twenty five years, China's real GDP increased by 900 percent, with an annual growth rate 9.6 percent, while the average annual growth rate was 2.4 percent for the US during this period. The sustained high economic growth makes China the world's second largest economy after the United States. Panel (a) of figure 1 shows the real GDP of China relative to the US, and relative to the rest of the world.

Rapid trade integration: Meanwhile, trade growth has been phenomenal. Average annual growth in China's real exports and imports has been about 14 percent (14.2 percent for real exports and 13.7 percent for real imports). As a result, China trade's volume are 30 times

[2] There is a long tradition of considering the dynamic response of aggegrate trade flows and relative prices (Magee, 1973, Junz and Rhomberg, 1973, Meade, 1988, Backus, Kehoe and Kydland, 1994). Examples of papers that estimate the dynamic response to relative prices include Hooper, Johnson and Marquez, 2000, and Gallaway, McDaniel, and Rivera, 2003.

higher than 25 years ago. Panel (b) of figure 1 shows total trade (measured as total real exports plus real imports) relative to real GDP. We see relatively stable trade integration from 1990 to 1996, a rapid integration between 1996 to 2007, followed by stable trade from 2007 to 2014. In the period of rapid integration, the trade share rose from 31 percent to 76 percent. Since 2007 it has held roughly steady around 75 percent.

Substantial trade surpluses and deficits: The growth of trade integration has been unbalanced, and China ran substantial trade surpluses during this period. Panel (c) of figure 1 shows the real trade balance as share of GDP (using the decomposition that $\frac{x-m}{y} = \frac{x-m}{x+m} \times \frac{x+m}{y} \approx 0.5 \times \ln(\frac{x}{m}) \times \frac{x+m}{y}$). China was running a small deficit in 1990s and the real trade surplus increased to 12 percent of GDP in 2008, then flattened during recent years. We decompose the movements in the trade balance to GDP ratio into the movements in the ratio of trade balance to trade ($\frac{x-m}{x+m}$) and trade to GDP ($\frac{x+m}{y}$), and Panel (d) of figure 1 shows the trade balance to GDP ratio and the counterfactual by holding the trade share constant at its level in 1996. We see that the surge in trade surpluses around 2004 primarily reflects an increase in openness rather than more unbalanced trade.

Important role for the extensive margin: China has been expanding its export in several dimensions. China exports much more varieties and to more destinations over time. Panel (a) of figure 2 shows that among the HS10 products the US import, China exports 45 percent of those product categories in 1992 and 80 percent in 2014. China's value share of US imports had grown from 5 percent in 1992 to 19 percent in 2014. Panel (b) of figure 2 shows the overall number of countries and HS 6 digit product pair in Chinese exports. It increased to 374324 in 2014 and is 4 times larger than in 1992.

Producer level export participation and intensity display similar dynamics. The Chinese Annual Survey of Enterprises 1998-2012 conducted by the Chinese National Bureau of Statistics includes all the manufacturing (and very few mining and service firms, we excluded them from the sample) State-Owned and non-SOEs firms with sales over 5 million RMB (about 600,000 US dollars), yielding 133,426 firms in 1998. This number rises to 381,739 in 2008 and drops to 320,391 in 2010.

The expanding of the sample could be due to firms' entry, or more firms have nominal value of sales higher than the survey threshold over time, or the survey has been expanding its coverage. To deal with the sampling problem, we run a linear probability model of firms export participation on firms size, controlling for industry and year fixed effects, then we calculate the unconditional export participation for year 1998-2010.

From the Chinese survey and data from the US Exporter Profile, we see a rapid expansion in export participation. For Chinese firms, panel (c) of figure 2 shows the dynamics of export participation for the period 1998 to 2010. Export participation grew consistently from 1998 to 2005 from 24.4 percent of firms to 32.7 percent. From 2005 to 2009 it contracted to 27.3 percent of firms and in 2010 it rose to 28.8 percent. To measure the increase in exporters selling to China we use data from the US. Here we see that only about 0.8 percent of US firms exported to China in 1992 and that this has grown to about 6 percent in 2014, with expansion leveling off since 2010 (panel (d) of figure 2).

Finally, we turn to a brief discussion of changes in trade barriers. An important source of the rising integration between China and the Rest of the World has been a reduction in policy and non-policy barriers to trade. An example of the reduction on inward barriers is a gradual fall in tariffs on imports to China from 36.4 percent in 1990 to 4.2 percent in 2014 (Panel a of figure 3). Similarly, the US ad valorem tariff rate (weighted by trade) on Chinese goods decreased from 9.4 percent in 1990 to 2.8 percent in 2014 (Panel b). Moreover, the US granted Permanent Normal Trade Relations (PNTR) to China in October 2000, which became effective upon China joining the WTO at the end of 2001. Before that, even though Chinese goods were subject to the relative low NTR tariff rates since 1980s, they required renewals every year. Without successfully renewal, the import tariffs would jump to the higher non-NTR tariff rates. Figure 3 (c) shows the distributions of NTR rates and non-NTR rates for HS 8 digit products. Non-NTR rates are in general much higher, and on average 7 times higher than NTR rates. Pierce & Schott (2016) shows that PNTR removed the uncertainty and was associated with the increases in US imports from China and the number of Chinese exporters.

Of course, tariffs are only one barrier, and there are many others such as transportation costs, quantitative restrictions, ownership constraints, licensing, among others. many of these non-tariff barriers have been removed over time as well. In 1994, the Multifiber Agreement (MFA) was replaced by the Agreement on Textiles and Clothing (ATC), which implemented a gradual 10-year phase-out of the quota restrictions (see Brambilla, Khandelwal, and Schott, 2010). Figure 3 (d) shows the distribution of the fill rate (US import from China/Quota) of Chinese Textiles and Apparel products.[3] In 1999, most of the products have fill rate equal to 1, indicating the US imports from China were constrained by the quotas. The quotas increased over time, fewer Chinese Textiles and Apparel products were constrained by the quotas in 2004, and the MFA expired on Jan 2005. The end of the ATC lead to additional quotas and surge protection in the EU and US from mid 2005 to 2008. The Chinese government also made major reforms to its export license system. By 2000, private firms with registration capital less than 8.5 million Chinese Yuan were restricted to export. By 2003 this number decreased to 0.5 million and very few firms are restricted. There has also been numerous dumping cases both against China and by China (Bown, 2010). These features suggest substantial, but uneven and asymmetric declines, in trade barriers along with a substantial forward looking aspect to trade reform.

4 Model

We now develop a two country dynamic stochastic general equilibrium model with heterogenous producers entering and exiting the export market with aggregate shocks to productivity, trade costs, and the discount factor. The model combines features of the heterogenous producer trade models with features of standard international macro models. It is a variation of the equilibrium dynamic export participation model of Alessandria and Choi (2007, 2015) that includes shocks to trade costs and the discount factor, variable markups, and incomplete asset markets. We assume that trade cost shocks are exogenous rather than being the outcome of some trade agreement among nations. The process for these shocks is quite general allows for country-specific changes in barriers as well as changes to future trade barriers.

In each country, consumers consume a non-tradeable good made by combining a different mix of tradable intermediates, make a labor-leisure choice, and trade a non-contingent bond. Home and foreign prices are normalized to 1: $P_t = P_t^* = 1$, and the real exchange rate

[3] Only WTO members were included in the phase-out of under the ATC and so China's quotas remained quite constrained until 2001 when it joined the WTO, at which point it jumped to the new levels of quotas.

is defined as the relative price of a basket of foreign to home goods (a depreciation is an increase). The home country is China and the foreign country is the rest of the world.

Consumers: Consumers maximize the discounted sum of utility,

$$\max_{C_t, L_t, B_t} E_0 \sum_{t=0}^{\infty} \Theta_t U(C_t, L_t),$$

$$\text{subject to:} \qquad C_t + V_t \left(1 + \frac{\zeta_b}{2} \frac{Q_t B_t}{Y_t^N}\right) B_t = W_t L_t + B_{t-1} + \Pi_t + T_t,$$

where $U(C, L) = \left[C^\gamma (1-L)^{1-\gamma}\right]^{1-\sigma} / (1-\sigma)$, Π_t is the dividend payments from home firms and T_t is a lump-sum rebate of revenue from trade barriers and any portfolio holding cost, and V_t is the price of a noncontingent bond. There is also a small bond holding cost of $\frac{\zeta_b}{2} \frac{V_t}{Y_t^N} B_t$ for home with Y_t^N being nominal home GDP and $\frac{\zeta_b}{2} \frac{V_t B_t^*}{q_t Y_t^{N*}}$ for foreign. We also allow the home discount factor to vary over time

$$\ln(\Theta_{t+1}/\Theta_t) = \ln \beta_t = (1-\rho_b) \ln \overline{\beta} + \rho_b \ln \beta_{t-1} + \varepsilon_\beta,$$

where $\overline{\beta}$ is the steady state β and $\varepsilon_{\beta,t}$ is a shock. In a standard model $\Theta_t = \beta^t$. These types of shocks to the discount factor were introduced into international macro models by Stockman and Tesar (1995) and have been used extensively to explain the high savings rate of China (Kehoe, Ruhl and Steinberg, 2014) as well as crises episodes (Eggertson and Woodford, 2003, Christiano, et al. 2011).

Aggregation Technology or Consumption Index: In each country, a competitive retail sector combines a continuum of domestic goods with a set of available imported goods to produce the final good. We assume there is a unit mass of producers in each country. The aggregators are as follows:

$$D_t = \left(Y_{Ht}^{\frac{\rho-1}{\rho}} + a^{\frac{1}{\rho}} Y_{Ft}^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}, Y_{Ht} = \left(\int_0^1 Y_{hit}^{\frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}}, \text{ and } Y_{Ft} = \left(\int_{i \in \mathcal{E}_t^*} Y_{fit}^{\frac{\theta_t - 1}{\theta_t}} di\right)^{\frac{\theta_t}{\theta_t - 1}}.$$

The Armington elasticity is ρ and a is a measure of the taste for imported goods.[4] The elasticity of substitution for imported goods is allowed to be time varying, $\theta_t = \theta q_t^{\zeta_q} y_{r,t}^{\zeta_y}$ $\theta_t^* = \theta q_t^{-\zeta_q} y_{r,t}^{-\zeta_y}$ with q_t being the real exchange rate in terms of home aggregate (a rise in q means real depreciation of home) and $y_r = Y_H/Y_F$ is relative real income. The parameters (ζ_q, ζ_y) allow the markup on imported goods to vary systematically with the real exchange rate and relative income. An appreciation of the Chinese real exchange rate (q falls) will lead to a decline in the demand elasticity and rise in the markup on goods exported to China if $\zeta_q > 0$. Likewise as China gets richer so that y_r rises, markups on exports to China will rise if $\zeta_y < 0$. This is a parsimonious way of embedding pricing-to-market that allows for incomplete exchange rate pass-through and systematic deviations from the law of one price with income. It can be microfounded using search frictions as in Alessandria (2009), Alessandria and Kaboski (2011), or Drozd and Nosal (2013). The price indices for the aggregates are

$$P_{Ht} = \left(\int P_{hit}^{1-\theta} di\right)^{\frac{1}{1-\theta}}, P_{Ft} = \left(\int_{i \in \mathcal{E}_t^*} P_{fit}^{1-\theta_t} di\right)^{\frac{1}{1-\theta_t}}, \text{ and } P_t = \left(P_{Ht}^{1-\rho} + a P_{Ft}^{1-\rho}\right)^{\frac{1}{1-\rho}} = 1.$$

In equilibrium $D_t = C_t$.

Producers: We assume each country has a unit mass of producers each specialized in producing a differentiated variety using just labor. Producers are heterogenous and face idiosyncratic and aggregate shocks to productivity and trade costs. The production function of a producer i is given by

$$Y_{it} = e^{z_t + \eta_{it}} L_{it},$$

where z_t is the country-wide productivity and η_{it} is the producer-specific productivity. The country component of productivity follows an AR1 process which depends on a global and country-specific component.

To export a producer must incur both fixed and variable trade costs. To export in the current period, producers must hire some domestic labor. The amount of domestic labor

[4] The taste for the imported good, a, is a normalization. It is straightforward to increase the trade cost and lower the taste parameter without changing the properties of the model.

depends on a producer's export history. A new exporter will pay $W_t f_{0t}$ to start exporting while a continuing exporters will pay $W_t f_{1t}$. These costs are sunk and cannot be recovered in future periods. When an exporter stops exporting for a period to re-enter requires paying the cost $W_t f_{0t}$. Producers also face a (gross) marginal trade cost is given by ξ_t^* for China exporters, and $\xi_{,t}$ for ROW exporters. The fixed export costs is allowed to differ across countries and potentially change over time. The resource constraint for each good is

$$Y_{it} = Y_{hit} + m_{it}\xi_t^* Y_{hit}^*,$$

where m_{it} is the exporting decision of producer i in period t. The marginal trade cost is stochastic.

The dynamic programming problem of a firm is then

$$V_t(\eta, m) = \max_{m', p, p^*} pc_t(p) + m' p^* c_t(\xi^* p^*) - Wl - m' W f_{mt} + Q_t E V_{t+1}(\eta', m')$$

where $m = \{0, 1\}$ is an indicator that summarizes past export status and thus the current cost of exporting, f_{mt}.

It is well known that when $W_t f_{0t} > W_t f_{1t}$, the decision to export is forward looking. It is also well-known that there is a threshold technology for exporters to continue exporting (η_{1t}) and a second threshold technology for non-exporters to start exporting (η_{0t}). Producers will move in and out of the export market in response to idiosyncratic and aggregrate shocks. These thresholds satisfy the following equations

$$\begin{aligned} W_t f_{0t} - \pi_t^*(\eta_{0t}) &= Q_t E_t \Delta V_{t+1}(\eta' | \eta_{0t}) \\ W_t f_{1t} - \pi_t^*(\eta_{1t}) &= Q_t E_t \Delta V_{t+1}(\eta' | \eta_{1t}) \\ \Delta V_t(\eta) &= V_t(\eta, 1) - V_t(\eta, 0) \end{aligned}$$

The left hand side of the first two equations measures the net current cost of exporting and is equal to fixed export cost minus the current profit. The right hand side measures the discounted expected gain in producer value from starting the next period as an exporter rather than the non-exporter. The advantage of starting out as an exporter is related to savings by not having to pay the high entry export cost. When $W_t f_{0t} > W_t f_{1t}$,we have that $\eta_{0t} > \eta_{1t}$ so that new exporters are relatively productive compared to continuing exporters and there is what Baldwin and Krugman call exporter hysteresis in that exporter's enter when their costs are relatively low and remain in the market even when their costs are relatively high. When $W_t f_{0t} = W_t f_{1t}$ we have that $\eta_{0t} = \eta_{1t}$ and exporting is a static decision.

The measure of exporters and non-exporters over idiosyncratic productivity in each country is a state variable. It is potentially an infinitely dimensional object. To simplify the state space we follow Alessandria and Choi (2007) by assuming idiosyncratic productivity shocks are iid. This implies that we don't need to keep track of the distribution of productivity of last period's exporters and non-exporters, only the stock of past exporters. The stock of exporters evolves as

$$\begin{aligned} N_t &= N_{t-1}\Pr(\eta \geq \eta_{1t}) + (1 - N_{t-1})\Pr(\eta \geq \eta_{0t}) \\ N_t^* &= N_{t-1}^*\Pr(\eta \geq \eta_{1t}^*) + \left(1 - N_{t-1}^*\right)\Pr(\eta \geq \eta_{0t}^*) \end{aligned}$$

Aggregate Variables: To take the model to the data we need to define some aggregate variables. Nominal output (GDP) is given by

$$Y_t^N = \int \left(P_{hit} Y_{Hit} + \frac{P_{hit}^*}{q_t} Y_{Hit}^* \right) di.$$

Real GDP is given by

$$Y_t^R = \frac{Y_t^N}{P_{Ht}},$$

where we deflate nominal revenue by the domestic price of goods.

Nominal exports are given by

$$EX_t^N = \int q_t P_{hit}^* Y_{hit}^* di = \frac{a}{q_t} P_{Ht}^{*1-\rho} D_t^*.$$

The export price index is given by

$$P_{Xt} = \frac{P_{Ht}^*}{q_t \xi_t^*}.$$

Real exports are given by

$$EX_t^R = \frac{EX_t^N}{P_{Xt}} = a\xi_t^{*1-\rho} q_t^{-\rho} P_{Xt}^{-\rho} D_t^*.$$

The nominal import is given by

$$IM_t^N = \int P_{fit} Y_{fit} di = a P_{Ft}^{1-\rho} D_t.$$

The nominal trade balance to nominal GDP ratio is given by

$$NXY_t = \frac{EX_t^N - IM_t^N}{Y_t^N}.$$

The import price index is given by

$$P_{Mt} = \frac{P_{Ft}}{\xi_t}.$$

Real imports are given by

$$IM_t^R = \frac{IM_t^N}{P_{Mt}} = a\xi_t^{1-\rho} P_{Mt}^{-\rho} D_t.$$

5 Solution and Estimation

We solve the model by linearizing it around the steady state. Given that we are dealing with a large model, we fix several parameters to conventional values and estimate the rest using Bayesian techniques. Table 1 reports calibrated and estimated parameters.

The time period is a year and so we set $\beta = 0.96$. The weight on leisure is set so that hours worked in the rest of the world is equal to 1/4. The bond adjustment cost is set to 0.0001 to ensure stationarity but otherwise not affect our results. The elasticity of substitution across varieties, ($\theta = 5$), is chosen to yield a 20 percent markup.

The fixed trade costs (f_0, f_1, f_0^*, f_1^*), standard deviation of idiosyncratic productivity shocks $\left(\sigma_\eta, \sigma_\eta^*\right)$, variable trade costs, weight in the aggregator (a), and Armington aggregator (ρ) determine trade flows. We assume steady state fixed costs are the same in China and the ROW. Of course, given that fixed costs are based in units of local labor there will be large differences across countries in the cost of exporting related to the differences in wages. The standard deviation of idiosyncratic shocks is assumed to be the same across countries and constant.

To determine the parameters related to trade and heterogeneity we proceed in two steps. First, we choose the trade costs parameters so that in a symmetric version of our model with no iceberg costs we would have the following characteristics of trade and producers involved in trade:

1. 15 percent of producers export,
2. 12.5 percent trade share of gdp,
3. 2 percent annual exit rate,
4. Exporters that are 2.5 times larger than non-exporters.

This yields an export entry cost that is almost 9 times the cost of staying in the market and a standard deviation of shocks of 23.5 percent. We use these estimates as our prior in our estimation in the second stage. To clarify the rest of the parameters we estimate, we now describe the shocks.

We assume productivity, trade cost, and discount factor shocks are independent. There is a global and China-specific productivity shock. The global productivity follows an AR1 process,

$$\ln z_{ct} = \rho_z^c \ln z_{ft-1} + \varepsilon_{zt}^c,\ \ \varepsilon_{zt}^c \overset{iid}{\sim} N\left(0, \sigma_z^c\right)$$

while productivity in China depends on the global component and its country-specific component,

$$\begin{aligned}
\ln z_{ht} &= z_{ft} + z_{d,t} - \bar{z} \\
\ln z_{dt} &= \rho_z^d \ln z_{dt-1} + \varepsilon_{zt}^d,\ \varepsilon_{zt}^d \overset{iid}{\sim} N\left(0, \sigma_z^d\right)
\end{aligned}$$

where $\bar{z}$ is the productivity disadvantage of China relative to the rest of the world.

We have 6 trade costs split between two variable costs and four fixed costs. We allow the variable trade costs and China's fixed costs to vary. For the iceberg trade costs, we rewrite the country iceberg cost shocks to include a common shock and country specific shock,

$$\begin{aligned}
\ln \xi_t &= \ln \xi_{ct} + \frac{1}{2} \ln \xi_{dt}, \\
\ln \xi_t^* &= \ln \xi_{ct} - \frac{1}{2} \ln \xi_{dt}.
\end{aligned}$$

To capture the effect of phasing in of trade barrier reductions the common iceberg trade costs is assumed to have both a transitory and more persistent growth rate component, ξ_{gt-1}. It is assumed that the shock to the growth of the common iceberg trade cost is known 1 year in advance of implementation while the transitory common shock occurs contemporaneously. The process for the differential trade cost is also assumed to be persistent,

$$\begin{aligned}
\ln \xi_{ct} &= \left(1 - \rho_{\xi_c}\right) \ln \bar{\xi}_c + \rho_{\xi_c} \ln \xi_{ct-1} + \ln \xi_{gt-1} + \varepsilon_{\xi_c t}, \\
\ln \xi_{gt} &= \rho_{\xi_g} \ln \xi_{gt-1} + \varepsilon_{\xi_g t}, \\
\ln \xi_{dt} &= \left(1 - \rho_{\xi_d}\right) \ln \bar{\xi}_d + \rho_{\xi_d} \ln \xi_{dt-1} + \varepsilon_{\xi_d t}.
\end{aligned}$$

Shocks to variable trade costs are assumed to be independent and have standard deviations $(\sigma_{\xi c}, \sigma_{\xi d}, \sigma_{\xi g})$. We also allow for persistent shocks to China's fixed costs,

$$\begin{aligned}
\ln f_{0t} &= \left(1 - \rho_{f0}\right) \ln f_0 + \rho_{f0} \ln f_{0t-1} + \varepsilon_{f0,t}, \\
\ln f_{1t} &= \left(1 - \rho_{f1}\right) \ln f_1 + \rho_{f1} \ln f_{1t-1} + \varepsilon_{f1,t}.
\end{aligned}$$

In total, there are eight shocks $\left(\varepsilon_{zt}^f, \varepsilon_{zt}^d, \varepsilon_{\xi_c}, \varepsilon_{\xi_g}, \varepsilon_{\xi_d}, \varepsilon_{f0}, \varepsilon_{f1}, \varepsilon_b\right)$. The persistence and standard deviation of these shocks are assumed to be independent. The persistence of the fixed export costs are constrained to be the same $\left(\rho_{f0} = \rho_{f1} = \rho_f\right)$. We also estimate the level of variable trade costs and the productivity gap between countries $\left(\bar{\xi}_c, \bar{\xi}_d, \bar{z}\right)$, the pricing-to-market parameters $\left(\zeta_q, \zeta_y\right)$, and the Armington elasticity and risk aversion parameters (ρ, σ). These parameters are estimated using the following six time series from China and the rest of the world for the period 1990 to 2014:

1. China's relative size measured using constant 2005$,
2. A weighted average of ROW GDP with a linear trend removed,
3. The real exchange rate (OECD),
4. The ratio of nominal exports to nominal imports,
5. The share of trade in real gdp (X+M)/GDP,
6. The share of Chinese exporters to the rest of the world (1998 to 2010).

For these parameters we have relatively flat priors (table 1). Figure 4 depicts the series used to estimate the model and the results from the estimation. Even though we have missing data on Chinese export participation in the 1990s and since 2010, the estimation yields quite reasonable movements in export participation. In particular, it suggests gradual expansion prior to 1998 with some reasonable swings. It also predicts a robust expansion since 2010. Figure 5 depicts the estimated innovations to productivity, tastes, and trade costs.

Table 1 reports some moments related to our estimated parameters. We discuss the posterior mode of estimated parameters. The Armington elasticity is estimated to be 1.82 and the risk aversion parameter is 4.42 which are consistent with values commonly used in the literature on international business cycles (see Chari, Kehoe and McGrattan, 2002), but the Armington elasticity is a good bit lower than commonly employed in trade integration studies, where the tendency is to set $\theta = \rho$. We also find that the cost of starting to export is about 9 times the cost of continuing in the export market which again is consistent with the literature (see for example Das, Roberts, and Tybout, 2007, or Alessandria and Choi, 2014). We estimate that the dispersion in idiosyncratic shocks is 0.185. These three parameters govern the characteristic of exporters as well as the strength of the extensive margin response. We also estimate that there is about two times the pricing-to-market with the real exchange rate (0.053) as with relative income (-0.028).

The shocks are estimated to be quite persistent with annual autocorrelations that range between 0.73 and 0.999. The least persistent shock is the detrended global productivity shock with an autocorrelation of about 0.738 while China's productivity is very close to a unit root (0.999). The discount factor shock is quite persistent with an autocorrelation of nearly 0.974. Differential trade costs are also quite persistent at over 0.987. The transitory common trade cost has an autocorrelation of 0.962 while the persistence of the growth shock is 0.975. Shocks to export fixed costs are also persistent with an autocorrelation of 0.75. We also find that the transitory common and differential trade costs are roughly equally volatile and about 10 times as volatile as the trend trade cost shocks.

Figure 6 plots productivity, discount factor, and trade costs as deviations from the steady state. China productivity grows quite substantially while ROW productivity fluctuates around zero and there is a substantial decline with the Great Recession. The Chinese discount factor shows some substantial fluctuations over this period with relatively high patience at the beginning of the sample, in the late 90s around the time of the Asian Crisis, and in the period prior to the Great Recession. The relatively high initial patience provides an important reason that China is accumulating assets at the start of the sample.

Trade costs from China fall substantially more than trade costs to China but there are some interesting variations. In particular, in the early period trade costs to China are falling while trade costs from China are rising. These two trade costs start falling in sync in the mid-to-late 1990s and then the trade cost from China starts falling quite quickly in the early 2000s until the Great Recession. Since the Great Recession trade costs from China have continue to fall while trade cost to China have actually risen. This may perhaps reflect the stimulus programs in China favoring expenditures on domestic goods. Panel (e) shows that at the beginning of the sample trade costs were expected to fall almost 3 percent year. The expected pace of liberalization accelerated through 2004, peaking at about 7 percent, since then expectations have reverted to about 5.5 percent.

We find that the fixed entry costs to be stable throughout the period while the continuation cost fell and then rose temporarily around 2005. These costs have mean reverted by 2014, although one should be cautious in interpreting these since we lack evidence on Chinese export participation from 2011 onwards, although some of our variety based measures show an extensive margin expansion in this period (Figure 2).

6 Model Properties

To illustrate the mechanics of our model and shed some light on the identification in our estimation, we consider the impulse response from the steady state to each shock. Specifically, we consider the impact of a one standard deviation increase in each of our shocks in the model on the variables used in the estimation (we abstract from fixed cost shocks as the impacts are primarily on export participation) evaluated using our estimated parameters. Figure 7 summarizes the dynamics of some key macro variables while figure 8 depicts changes in export participation in China and the ROW.

Panels (a) and (b) of figure 7 shows the response of China and ROW real GDP respectively to each shock. Productivity shocks are the main drivers of real gdp. China's real gdp rises almost permanently with China's productivity. China and ROW real GDP rise transitorily with a global productivity shock. An increase in China's patience has a small positive effect on real GDP in China and negative effect on the ROW. Obviously, these shocks have larger effects on the smaller country.

Panel (c) shows that the nominal export-import ratio responds more to a larger range of shocks. Increases in patience (β), future trade costs $\left(\xi_g\right)$, differential trade costs (ξ_d), and China's productivity lead to surpluses. A rise in the transitory common trade costs leads to a deficit. A transitory increase in the relative costs of getting goods into China relative to the ROW raises the price of Chinese consumption leading it to save and thus run a surplus. The effect of changes on the export-import ratio from changes in global trade barriers is a result of having an asymmetric model with China consumption more reliant on trade. A transitory increase in global trade costs has a larger effect on the more open economy leading it to borrow to smooth consumption. A future increase in trade barriers leads China to run a surplus today to bring more consumption into those periods where consumption is lower.

The real exchange rate (panel d) depreciates (rises) with an increase in Chinese productivity and patience. It appreciates substantially with an increase in the differential trade cost. Transitory and persistent growth changes in global trade costs have relatively mild effects on the real exchange and work in opposite directions.

Panel (e) show the impact of the shocks on real trade as a share of GDP. Trade declines most in response to increases in current and future trade barriers. The impact of the transitory shock is immediate and persistent, while the changes in future trade barriers only has a gradual impact. The two shocks have the same impact after 12 years. Increases in China's productivity lowers its trade share as it becomes a larger share of world output. The increase in patience has a small transitory negative effect on trade.

Finally, we consider the impact of each shock (including fixed export costs) on Chinese and ROW export participation. Given the relative size of the countries the shocks have a larger effect on China's export participation. China's export participation increases in response to more patience and decreases with global trade costs (transitory and growth), differential trade costs, and China's fixed export costs. The dynamics of export participation are hump shape in response to transitory shocks because of the need to build export capacity through the dynamic export decision. Not surprisingly, increases in global trade costs (transitory or growth shocks) lead to a decline in export participation in both countries. Increases in patience, differential trade costs, and China's productivity move export participation in China and the ROW in opposite directions. A transitory rise in global productivity increases export participation slightly as this is the only accumulable asset that can be used to smooth consumption. Finally, an increase in China's fixed export costs leads to a decline in export participation in both countries as this effectively raises the cost of accumulating exporters and leads world economy to sacrifice these investments to smooth consumption.

7 Results

We now use the estimated model to answer a range of question which essentially amount to evaluating the contribution of different shocks to the changes in some key variables. Tables 2 and 3 report a conditional (over the sample) and unconditional variance decomposition of a number of series. Figure 9 plots a shock decomposition of some key aggregate variables. Figure 10 plots the change in China's trade balance and net foreign assets as a share of GDP and the contribution of different shocks allowing for the interaction effects of different shocks. Figure 11 plots a shock decomposition of trade related variables.

What accounts for the movements in the Chinese trade surplus? Here we focus on the ratio of nominal exports to imports since this removes the effect of changes the trade share of GDP. Figure 9 (a) shows that China has maintained a surplus for most years except 1994. It also shows peak surpluses of about 20 percent in 1998 and 1999 and again in 2007 and 2008. Our shock decomposition suggests that initial conditions account for the early surpluses but die out by 2005. Preference shocks are important high frequency contributors that explain the surpluses of the late 1990s but have been a drag since the Great Recession. Differential and common trade costs seem to be the main source of surpluses since the mid 2002. Our conditional variance decomposition suggests that shocks to the Chinese discount factor are the most important driver at 81.7 percent, while the unconditional variance decomposition suggests China's productivity growth should account for 47 percent. Shocks to differential trade costs account for 6.0 (conditional) to 18 percent (unconditional). However, we see that the shocks to trade costs and productivity have very low frequency movements that do not seem to be accounted for well in the conditional variance decompositions.

What explains the dynamics of the trade balance as a share of gdp? It is more common to study the trade balance as a share of GDP. Measured this way, the Chinese trade surplus as a share of GDP (in nominal terms) fluctuates substantially over the period of interest, with surpluses of almost 5 percent of GDP in 1997 and 8 percent in 2007. We have argued that the a substantial portion of the larger surpluses in 2007 relates to trade being a large share of nominal GDP so that aggregate shocks in the latter period will end up leading to larger imbalances. To capture this interaction effect in our decomposition we note that the trade balance is well approximated by

$$\frac{TB}{GDP} \approx 0.5 \ln \left(EX_N / M_N \right) \times \frac{EX_N + M_N}{Y_N}.$$

We then use the behavior of each of these variables in our model to construct the trade balance as a share of GDP. Given that we have important interaction effects and many shocks, we present the effects by summarizing over three groups of variables: Initial, Productivity and Preferences (Z_c, Z_d, β), and Trade $(\xi_c, \xi_d, \xi_g, f_0, f_1)$. We call them I, P, and T respectively. We report 9 cases, *Data*, *All*, I, P, T, $(I \times P = IP - I - P)$, $(I \times T = IT - I - T)$, $(P \times T = PT - P - T)$, $(I \times P \times T = All - I - P - T - I \times P - I \times T - P \times T)$. From figure 10 (a) we clearly see that changes in trade barriers have been the main contributing factor in the expansion in the trade surplus from 2004 to 2007. We also see that the reversal of the surplus from 2007 to 2011 can be attributed to the aggregate shocks and the interaction of the aggregate shocks with the change in trade barriers.

What explains the large increase in Chinese net foreign assets as a share of GDP? Figure 10 (b) plots the change in China's net foreign assets as a share of gdp in the model and data (from the World Development Indicators[5]). Over the period, China increases its foreign assets by 36.2 percent of GDP. To construct the model equivalent, we follow the same approach as we did for the trade balance. Specifically, we use the model's initial assets to GDP $(V_{1990}B_{1990}/Y_{1990})$ and then update V_tB_t/Y_t using the law of motion

$$\frac{V_tB_t}{Y_{Nt}} = \left(\frac{V_{t-1}B_{t-1}}{Y_{Nt-1}}\right)\left(\frac{1}{V_{t-1}}\right)\left(\frac{Y_{Nt-1}}{Y_{Nt}}\right) + \frac{0.5\ln\left(X_{Nt}/M_{Nt}\right)}{Y_{Nt}},$$

and our measure of each variable from the model. As our model captures both the nominal trade balance and real trade share of gdp, the main difference between our measure and the data is most likely due to differences in returns on foreign and domestic assets and real and nominal gdp. Overall, the model does quite well in capturing the dynamics of net foreign assets. As before we consider the impact of three different groups of shocks. Table 4 summarizes the contribution of these shocks to the change in NFA from 1990 to 2014 (measured as percentage points of GDP). We see that initial conditions (40.2 percent), Trade costs (28.3 percent), and the interaction of Trade costs and initial conditions (25.3 percent) are the main reasons China accumulated assets while the interaction of Productivity-Preference shocks with Initial conditions (-28.4 percent) and with all shocks were forces for reduced asset accumulation (-13.9 percent). By themselves, the Productivity-Preference

[5] We focus on this measure rather than the Lane-Milesi-Ferretti (2007) measure since this measure makes fewer adjustments for valuation effects.

shocks only increased net foreign assets by 3.5 percent of gdp. The bottom three lines of Table 4 report the contribution of pairwise combinations of the shocks and intital conditions. We find that with just the preference and producttivity shocks plus the initial conditions, China would have accumulated assets of 15.2 percent of GDP, thus changes in trade barriers accounted for about a 40 percentage point increase in Chinese net foreign assets.

How much of the growth in output and consumption in China was from a decline in trade barriers? For output, the decline in trade barriers has almost no impact in China relative to the rest of the world (less than 1 percent) or relative to the world trend (less than 0.5 percent). China's output growth is mostly driven by productivity improvements. This echoes the result in Waugh (2010) about differences in trade costs having a minimal impact on differences in income per capita. We find a more important impact of changes in trade costs on real consumption though, with productivity accounting for about 84 percent of China's consumption fluctuations and trade integration shocks about 14.0 percent.

How have shocks in China affected consumption and output in the rest of the world? We find that shocks to Chinese savings account for 1.4 percent of the conditional variance of rest of the world real output and 0.8 percent of consumption. Uneven trade integration shocks account for slightly less than 0.01 percent of real gdp fluctuations and less than 1.1 percent of real consumption. Surprisingly, only 56.9 percent of the fluctuations in ROW consumption are explained by the global productivity shock and 37 percent are explained by changes in trade costs. Trade costs have an insignificant effect on real output with 98 percent of real output fluctuations in the ROW from the global productivity shocks.

What explains the growth in trade in China and the ROW? From the top panel of Table 5, the main source of the 47.9 percentage point rise in China's trade share of GDP (measured in real terms) was the decline in worldwide trade barriers. The gradual reduction of trade costs accounted for 43 percent of the rise while the common shocks accounted for 55 percent. Changes in fixed export costs had a minimal effect on the change in trade. The 22.1 percentage point rise rest of the world trade (measured in nominal terms) is roughly equally split between common (27.8 percent) and growth rate shocks (21.4 percent), China productivity growth (18 percent), and the differential trade cost shocks (12.6 percent). The waning effect of initial conditions contributed to about 1/3 of the growth in trade in China and 1/5 of the growth in ROW trade.

What explains the weak trade growth since 2011? The bottom panel of Table 5 reports the average annual contribution of shocks to trade growth in China and the ROW in the period 2011 to 2014 relative to the expansion period from 1997 to 2007. Overall, we see that trade relative to GDP has grown 0.8 percentage points slower in the ROW and 4.6 percentage points slower in China. The common trade cost is the main source of the slow-down accounting for a reduction in the growth of trade to gdp in the ROW of 124 percent and 80 percent in China. This primarily reflects the large negative innovations in the earlier period and a lack of any additional negative innovations and mean reversion in the latter period. The trend shocks have also contributed to the slow-down in the pace of trade integration in the ROW. While future reductions in trade barriers are expected from the trend shock (figure 12 plots the dynamics of the trend shock to trade costs), we can see clearly the trend accelerated from 1998 to 2004 but has since retrenched.

How did changes in preferences that encouraged Chinese savings affect Chinese trade integration? Changes in preferences have almost no impact on trade integration as they primarily lead to substitution between imports and exports. Indeed it is an important driver of export participation but works in opposite directions at home and abroad. Overall, we find that changes in the discount factor accounted for only 2.5 percent of the increase in trade real trade in China and less than 1 percent in the ROW.

What explains the dynamics of the Chinese real exchange rate. The real exchange rate in 2014 is roughly equal to its level in 1990. Over the period though, there are some substantial swings. In particular there is a 60 percent depreciation from 1990 to 1994 that is partially reversed by 1998. The real exchange rate then appreciates by about 20 percent through 2005 and then depreciated by about 30 percent. The model primarily attributes the movements in the real exchange rate to the differential trade cost and differential productivity. Indeed, we see that the appreciation since 2004 is primarily a result of relatively higher trade barriers on Chinese imports rising faster than Chinese productivity falls.

8 Sensitivity

We now consider the sensitivity of our decompositions to our modelling assumptions. Specifically, we compare the results in our benchmark model with pricing-to-market to an alternative model without pricing-to-market, and another model without pricing-to-market and a static export decision. We first estimate a version of our benchmark model with no pricing-to-market $\zeta_q = \zeta_y = 0$, denoted *No PTM*, and then a version of this model with a static export decision ($f_0 = f_1$), denoted *Static*. In general, these alternative models generate qualitively similar results about the important of changes in trade integration for the dynamics of the Chinese trade balance.

Table 6 compares the posterior mode of each of the estimated parameters in each of the models. For the most part, the parameters are quite similar. The main differences come in our estimated parameters related to producer heterogeneity. In the *Static* model, only the most productive producers export and so there must be much less producer heterogeneity to generate the same amount of trade as in the benchmark model (4 percent compared to 18 percent in the benchmark). The process for aggregate shocks is also similar across models with shocks generally slightly more persistent and larger in the static exporting model. The biggest difference comes in the process for the shock to fixed export costs. In the static model, the export cost shock has an autocorrelation of 0.986 compared to 0.75 in the benchmark model.

Table 4 reports the contribution of each shock in these alternative models to the change in net foreign assets to GDP from 1990 to 2014 in China. The models generate slightly different increases in assets even though they each generate the same dynamics of nominal-export import ratio and real GDP because of some differences in initial asset positions and the movemens in nominal and real GDP. Specifically, eliminating pricing-to-market from our benchmark model, leads to a larger accumulation of foreign assets in China between 1990 and 2014 (66.6 percent vs 54.9 percent). Without changes in trade barriers, the model would have generated an increase in assets of 24.1 percentage points, thus trade shocks increase asset accumulation by 42.5 percentage points compared to 39.7 percentage points in the benchmark. With just the static exporting decision, the model predicts an even larger rise in foreign assets from 1990 to 2014 of 71.6 percentage points. Without changes in trade barriers, the model would have generated an increase in assets of 33.3 percentage points, thus trade shocks increase asset accumulation by 38.3 percentage points.

We next consider how the source of trade integration depends on the structure of our model. Table 7 reports the contribution of each shock to the growth in the nominal trade share in the ROW and China in our three models. The top panel reports changes for the whole sample while the bottom panel focuses on the difference in the annualized growth rate from 2011 to 2014 compared to 1997 to 2007.

In terms of the growth in the trade share of nominal GDP over the whole sample, we find that eliminating pricing-to-market from the benchmark model primarily makes growth shocks less important (35.0 vs 43.0 percent in the benchmark). The reduced importance of the trend shock makes the common (59.5 vs 55.5 percent) and differential costs more important (14.2 percent vs 2.7 percent) and initial conditions less important (36.9 percent vs 43.9 percent). Eliminating the dynamic export decision along with PTM yields more similar results as with our benchmark model. The main difference is that changes from fixed costs provide a small drag on integration in the ROW and China in our benchmark models, but are a small positive contributor in the Static model.

For the trade slowdown in the ROW, all three models primarily point to the common shocks, but the static model attributes relatively more (88.0 percent vs 79.9 percent in the benchmark for China trade). The static model suggests that the shocks to trend trade cost growth have actually been a slight positive compared to the small drag we find in the benchmark model. Figure 12 compares the dynamics of the trend trade growth across three models. Expectations of trade costs declines are much lower in the benchmark model than the static model, although expectations for future integration remain at levels similar to those in the late 1990s in all three models. The benchmark model also suggests a much larger slow-down in the pace of future global trade cost declines than our alternative models. The much larger reversal in expectations in the dynamic exporting model arises because of the gradualness of trade in this model implies that trade will continue to grow absent changes in trade costs.

9 Conclusion

China's economic growth and integration with the world economy has been an important and defining economic event of the last twenty-five years. We study the source of this growth and integration through the lens of a two-country dynamic stochastic general equilibrium model with incomplete asset markets, heterogeneous producers, and endogenous trade participation featuring a dynamic decision and persistent changes in trade barriers, technology, and tastes. We use the model to account for the contribution of these shocks on China and the Rest of the World.

Our dynamic model of trade integration and growth allows for trade integration to influence the dynamics of the trade balance and lead to changes in foreign assets. A key finding is that trade integration has been an important driver of fluctuations in China's trade balance and accumulation of foreign assets. Trade integration operates through two main channels. First, differences in the timing of opening, captured by transitory changes in trade barriers, create a motives for intertemporal trade. Indeed, we find these types of shocks have contributed greatly to the accumulation of China's foreign assets. Second, transitory changes in the global or common trade costs affect the accumulation of assets by changing the scale of borrowing and lending and because we have considered asymmetric economies. Quantitatively, we find that without these changes in trade integration, China would have accumulated 40 percent fewer assets (as a share of GDP) through 2014.

We also use our model to account for the dynamics of trade integration between China and the Rest of the World. By allowing for both a persistent shock to common trade costs as well as a persistent shock to the future growth rate of common trade costs, we can distinguish between the lagged effects of past trade agreements, current shocks, and future shocks. We find that the growth in trade to GDP from the late 90s to the Great Recession reflected a combination of shocks with reductions in common and differential trade barriers and a persistent decline in rate of trade cost reductions. We find the Great Trade Collapse reflects a transitory rise in worldwide trade barriers but no persistent increase in the growth rate of trade barriers. Indeed, we find that most of the slow-down in trade since the Great Trade Recovery reflects the waning influence of past trade agreements rather a substantial retrenchment in the pace of future trade agreements. It is the period from the 90s to the Great Recession that is unusual and not the period since the Great Recession. This suggests the need for new trade agreements to set the world economy off on a new wave of trade integration.

Finally, we have remained agnostic about the source of different trade cost movements following much of the Gravity literature in measuring these as a residual. Having found these may have had important aggregate consequences, a useful next step would be to relate these to actual policy or technological changes.

10 Data

- Time period 1990 to 2014.
- China's relative size is measured using constant 2005$, World Development Indicators - WDI
- The real exchange rate (OECD)
- The ratio of nominal exports to nominal imports (China Statistical Bureau)
- The share of trade in real gdp (X+M)/GDP.(China Statistical Bureau)
- Chinese manufacturing export participation from Chinese Annual Survey of Enterprises (China Statistical Bureau)
- China's net foreign assets - 1990 - 2014 (World Development Indicators)
- US Export Participation to China - US Exporters from US Exporter Profile (1992, 1996 to 2014) scaled by US firms with 20+ employees from Small Business Administration (1988 - 2011). Share of exporters interpolated for 1993 to 1995 period. Number of firms from 2012-2014 is assumed to grow at a constant rate.
- China's Import Tariffs - World Development Indicators, Mean, manufactured products (%) and Weighted mean, manufactured products (%).

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Table 1: Parameters

Fixed Parameters

β	ζ_b	γ	a_1	θ
0.96	0.0001	0.30	0.16	5

Estimated Parameters

	prior mean	posterior mean	posterior mode	90% HPD Interval		prior	prior std.dev.
ρ_{z_d}	0.975	0.9977	0.9993	0.995	0.9999	unif	0.0144
ρ_{z_c}	0.75	0.7807	0.7379	0.6058	0.9559	unif	0.1443
ρ_{ξ_c}	0.5	0.9312	0.9617	0.8617	0.9996	unif	0.2886
ρ_{ξ_d}	0.5	0.9846	0.9871	0.9684	0.9999	unif	0.2886
ρ_b	0.5	0.9341	0.9739	0.8452	0.9986	unif	0.2886
ρ_{ξ_g}	0.5	0.8417	0.9745	0.6373	0.9975	unif	0.2886
ρ_f	0.5	0.7895	0.7547	0.5925	0.9939	unif	0.2886
σ_{z_d}	0.07	0.0692	0.0664	0.052	0.086	invg	0.025
σ_{z_c}	0.033	0.0361	0.0332	0.0279	0.0432	invg	0.025
σ_{ξ_c}	0.2	0.1568	0.1567	0.1218	0.1895	invg	0.05
σ_{ξ_d}	0.124	0.1399	0.1326	0.1051	0.1742	invg	0.05
σ_{ξ_g}	0.016	0.0418	0.0113	0.0055	0.0912	invg	0.02
σ_{f_0}	0.01	0.0076	0.0047	0.0025	0.0136	invg	0.05
σ_{f_1}	0.22	0.2208	0.2188	0.205	0.2376	invg	0.01
σ_b	0.005	0.0057	0.0033	0.0019	0.0109	invg	0.01
$\bar{q}$	-1	-1.0459	-1.0518	-1.3639	-0.6777	norm	0.25
$\bar{Y}_w$	-1.335	-1.3198	-1.3273	-1.3958	-1.2479	norm	0.2
ρ	2	1.7975	1.8167	1.5194	2.0776	invg	1
σ	5	4.7777	4.4192	3.3591	5.9876	invg	1
$\bar{z}$	2.42	2.338	2.3449	2.1749	2.4864	norm	0.1
$\bar{\xi}_c$	0.5	0.5031	0.5045	0.4251	0.5742	norm	0.05
$\bar{\xi}_d$	0.1	0.1132	0.1001	-0.0379	0.2631	norm	0.1
ς_q	0	0.0364	0.0526	-0.1515	0.2441	norm	0.15
ς_y	0	-0.0203	-0.0275	-0.113	0.0888	norm	0.15
f_0	0.37	0.3786	0.3681	0.2969	0.4545	invg	0.05
f_1	0.04	0.0422	0.0428	0.0348	0.0498	invg	0.005
σ_η	0.235	0.199	0.186	0.1508	0.2434	invg	0.05

Notes: Based on annual data from 1990 to 2014.

Table 2: Variance Decomposition (in percent)

	Z_c	Z_d	ξ_c	ξ_d	β	ξ_g	f_1
ξ_c	0	0	23.99	0	0	76.01	0
ξ_h, ξ_f	0	0	15.94	33.56	0	50.5	0
β	0	0	0	0	100	0	0
Y_n/Y_f	0	88.51	0.17	3.42	7.72	0.18	0
C_h/C_f	0	91.83	0.25	2.22	5.11	0.59	0
Export-Import Ratio	0	34.84	0.94	19.44	43.73	1.04	0.02
China Trade Share (real)	0	13.7	8.84	15.44	32.79	29.19	0.04
RER	0	20.63	1.01	43.34	33.01	1.98	0.02
Y_f	9.52	31.09	0.86	17.66	39.87	0.98	0.02
Y_h	0.1	93.19	0.1	2	4.5	0.11	0
C_h	0.07	93.8	0.36	1.44	3.32	1.02	0
C_f	9.55	20.15	3.87	16.76	38.55	11.1	0.03
N_h	0	34.14	2.44	18.02	36.67	7.96	0.77
N_f	0	37.75	2.29	17.42	35.35	7.17	0.02
$TradeShare$	0	14.76	18.39	4.16	0.52	62.15	0.01
$TradeShare_f$	0	31.55	12.42	7.47	7.59	40.93	0.03
$TradeShare_{World}$	0	18.02	16.71	4.34	5.4	55.5	0.03

Table 3: Conditional Variance Decomposition (in percent, 25 periods)

	Z_c	Z_d	ξ_c	ξ_d	β	ξ_g	f_1
ξ_c	0	0	56.85	0	0	43.15	0
ξ_c, ξ_d	0	0	34.16	39.92	0	25.92	0
β	0	0	0	0	100	0	0
Y_n/Y_f	0	99.25	0.01	0.11	0.59	0.03	0.01
C_h/C_f	0	89.78	3.93	2.33	0.58	3.38	0
Export-Import Ratio	0	0.18	3.5	11.32	80.29	3.95	0.76
China Trade Share (real)	0	4.13	50.74	0.47	0.64	43.83	0.19
RER	0	11.28	2.54	82.75	1.27	2.11	0.05
Y_f	97.94	0.01	0.17	0.26	1.45	0.15	0.02
Y_h	2.16	97.4	0.01	0.06	0.34	0.02	0
C_h	2.08	83.49	7.04	1.23	0.31	5.84	0
C_f	62.52	0.85	18.34	3.36	0.83	14.01	0.09
N_h	0.02	0.26	36.9	5	2.21	37.29	18.33
N_f	0.01	1.36	42.07	7.43	1.88	47.18	0.06
$TradeShare$	0	1.41	51.33	5.7	0.03	41.48	0.04
$TradeShare_f$	0	2.33	50.28	6.63	0.12	40.51	0.13
$TradeShare_{World}$	0	0.88	53.55	2.23	0.05	43.17	0.11

Table 4: Source of Change in China's Assets-GDP (%)

	Benchmark	No PTM	Static
Data	36.2	36.2	36.2
All	54.9	66.7	71.6
Initial (I)	40.2	1.0	1.4
Productivity-Preferences (P)	3.5	0.8	1.7
Trade (T)	28.3	37.4	17.6
IxP	-28.4	22.3	30.2
IxT	25.3	33.6	40.9
PxT	0	-8.4	3.1
IxPxT	-13.9	-20.1	-23.4
IP	15.2	24.1	33.3
IT	93.8	72.0	59.8
PT	31.7	29.9	22.4

Data is based on WDI. P denotes shocks to (Z_c, Z_d, β),
and T denotes shocks to $(\xi_c, \xi_d, \xi_g, \tau_0, \tau_1)$. Cross (x) denotes interaction effects while IP, IT, PT denotes impact of two determinants together

Table 5: Source of Change in Trade-GDP (1990 to 2014)

	China Real	China Nominal	ROW Nominal
Productivity-Global	0.1%	0.0%	0.0%
Productivity-China	-46.3%	-32.9%	17.6%
Discount Factor	2.5%	-0.5%	0.5%
Trade Cost			
Common	55.5%	66.6%	27.8%
Difference	2.7%	-29.3%	12.6%
Trend	43.0%	51.5%	21.4%
Fixed-enter	0.0%	0.0%	0.0%
Fixed-continue	-1.3%	-0.7%	-0.5%
Initial	43.9%	45.4%	20.8%
Total	47.9%	30.2%	22.1%

Each entry measures the share of the change in trade from 1990 to 2014 from that shock alone.

Change in the Source of the Change in Trade-GDP (2011-2014 vs 1997 to 2007)

	China Real	China Nominal	ROW Nominal
Productivity-Global	0.7%	0.2%	0.0%
Productivity-China	10.5%	5.1%	-12.7%
Discount Factor	5.9%	-2.8%	6.3%
Trade Cost			
Common	79.9%	74.1%	124.1%
Difference	-5.3%	15.5%	-29.1%
Trend	6.1%	3.9%	7.6%
Fixed-enter	0.0%	0.0%	0.0%
Fixed-continue	-6.6%	-2.8%	-8.9%
Initial	9.0%	6.7%	11.4%
Total	-4.6%	-4.3%	-0.8%

Each entry measures the share of the change in trade growth accounted for by each shock.

Table 6: Posterior Mode of Parameters - Alternative Models

	Benchmark	No PTM	Static
ρ_{z_d}	0.9993	0.9995	0.9994
ρ_{z_c}	0.7379	0.7349	0.7289
ρ_{ξ_c}	0.9617	0.9581	0.9763
ρ_{ξ_d}	0.9871	0.9869	0.9883
ρ_b	0.9739	0.9556	0.9731
ρ_{ξ_g}	0.9745	0.9696	0.979
ρ_f	0.7547	0.8494	0.9836
σ_{z_d}	0.0664	0.0662	0.0664
σ_{z_c}	0.0332	0.0332	0.0333
σ_{ξ_c}	0.1567	0.1628	0.1695
σ_{ξ_d}	0.1326	0.1559	0.1437
σ_{ξ_g}	0.0113	0.0107	0.0115
σ_{f_0}	0.0047	0.0047	-
σ_{f_1}	0.2188	0.2194	0.2184
σ_b	0.0033	0.0038	0.003
$\bar{q}$	-1.0518	-1.0045	-0.9968
$\bar{Y}_w$	-1.3273	-1.3287	-1.3899
ρ	1.8167	1.8536	1.7564
σ	4.4192	4.4147	4.5284
$\bar{z}$	2.3449	2.3431	2.3482
$\bar{\xi}_c$	0.5045	0.5023	0.5019
$\bar{\xi}_d$	0.1001	0.1	0.1177
ς_q	0.0526	-	-
ς_y	-0.0275	-	-
f_0	0.3681	0.3706	-
f_1	0.0428	0.0439	0.0848
σ_η	0.186	0.1838	0.0398
Log Data Density	220.813958	219.542045	219.29049

Table 7: Source of Change in Trade-GDP (1990 to 2014)

	China Real Trade share			ROW Nominal Trade Share		
	Benchmark	No PTM	Static	Benchmark	No PTM	Static
Productivity-Global	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Productivity-China	-46.3%	-45.8%	-44.1%	17.6%	18.0%	15.0%
Discount Factor	2.5%	3.4%	2.9%	0.5%	0.6%	0.5%
Trade Cost						
Common	55.5%	59.5%	53.8%	27.8%	31.7%	29.3%
Difference	2.7%	14.2%	5.0%	12.6%	13.9%	10.8%
Trend	43.0%	35.0%	39.3%	21.4%	18.7%	21.3%
Fixed-enter	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fixed-continue	-1.3%	-3.3%	3.1%	-0.5%	-1.4%	1.3%
Initial	43.9%	36.9%	40.1%	20.8%	18.5%	21.7%
Total	47.9%	47.9%	47.9%	22.1%	20.7%	21.9%

Each entry measures the share of the change in trade from 1990 to 2014 from that shock alone.

Change in the Source of the Change in Trade-GDP
(2011-2014 vs 1997 to 2007)

	China Real Trade share			ROW Nominal Trade Share		
	Benchmark	No PTM	Static	Benchmark	No PTM	Static
Productivity-Global	0.7%	0.7%	0.0%	0.0%	0.0%	0.0%
Productivity-China	10.5%	10.9%	11.4%	-12.7%	-10.7%	-10.4%
Discount Factor	5.9%	8.8%	7.4%	6.3%	4.8%	3.9%
Trade Cost						
Common	79.9%	88.0%	88.0%	124.1%	127.4%	132.5%
Difference	-5.3%	-14.4%	-5.7%	-29.1%	-28.6%	-23.4%
Trend	6.1%	5.5%	-0.2%	7.6%	6.0%	-2.6%
Fixed-enter	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fixed-continue	-6.6%	-7.4%	-7.7%	-8.9%	-8.3%	-9.1%
Initial	9.0%	8.1%	6.8%	11.4%	9.5%	10.4%
Total	-4.6%	-4.6%	-4.6%	-0.79%	-0.84%	-0.77%

Each entry measures the share of the change in trade growth accounted for by each shock.

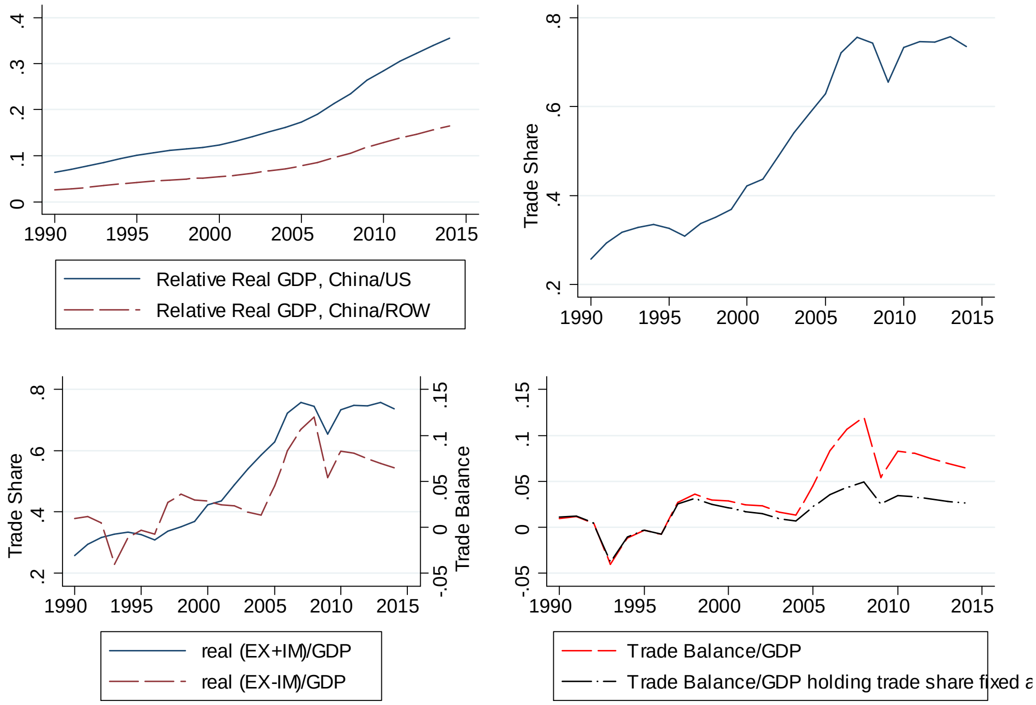


Figure 1: Aggregate Dynamics in China

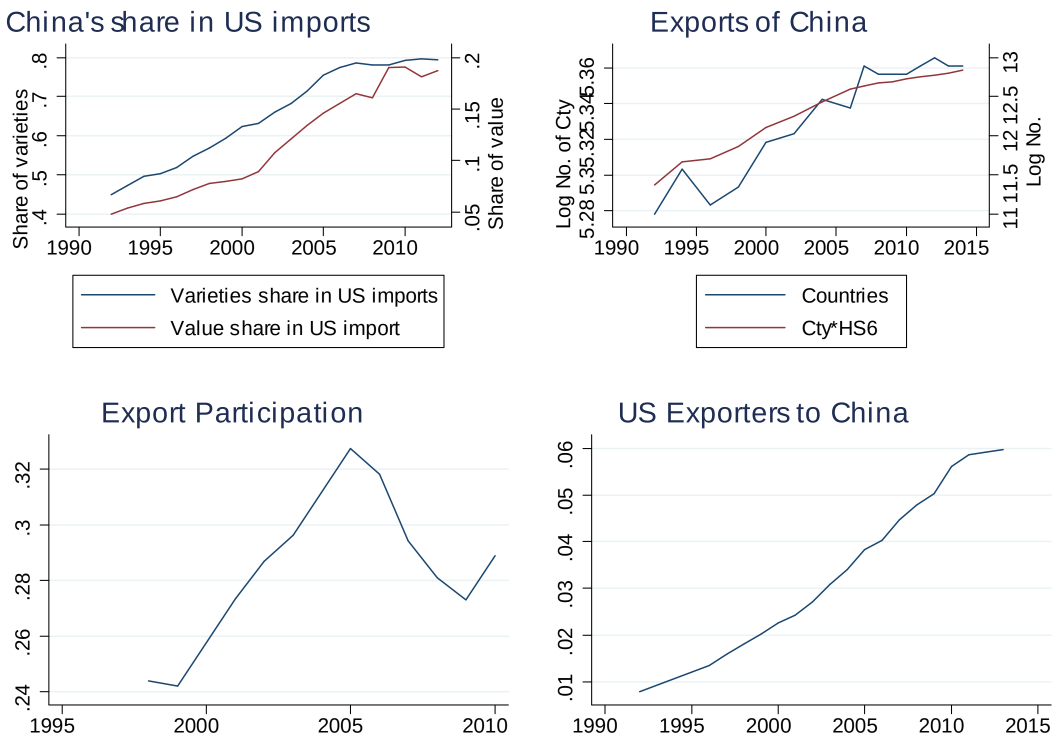


Figure 2: Disaggregate Trade Dynamics in China

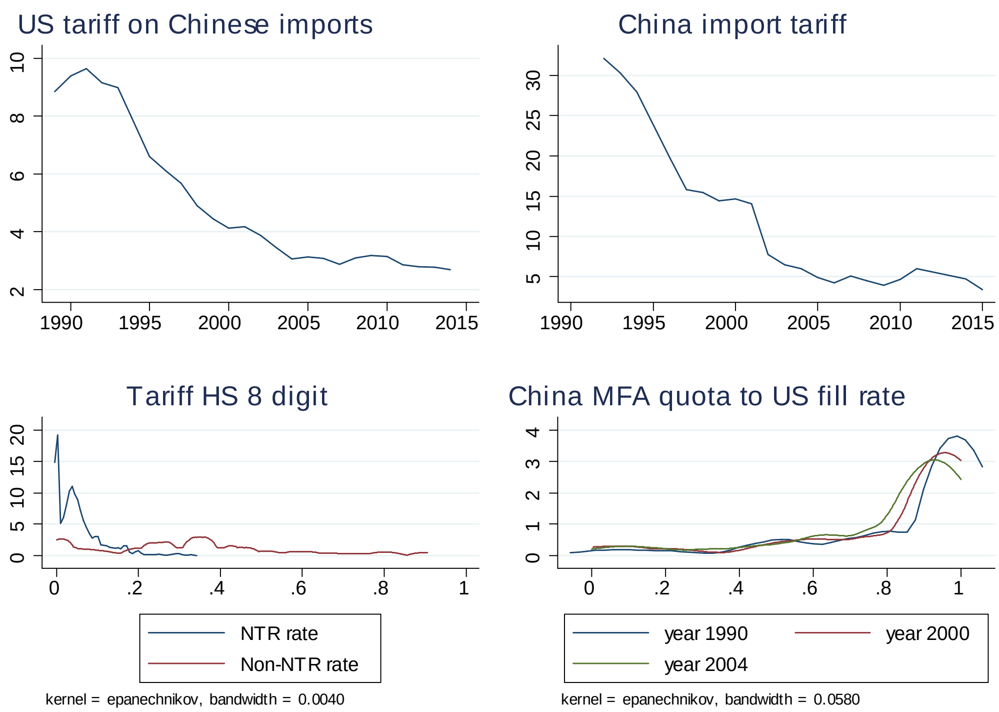


Figure 3: Trade Barriers: China and US

Figure 4: Historical and Smoothed Series

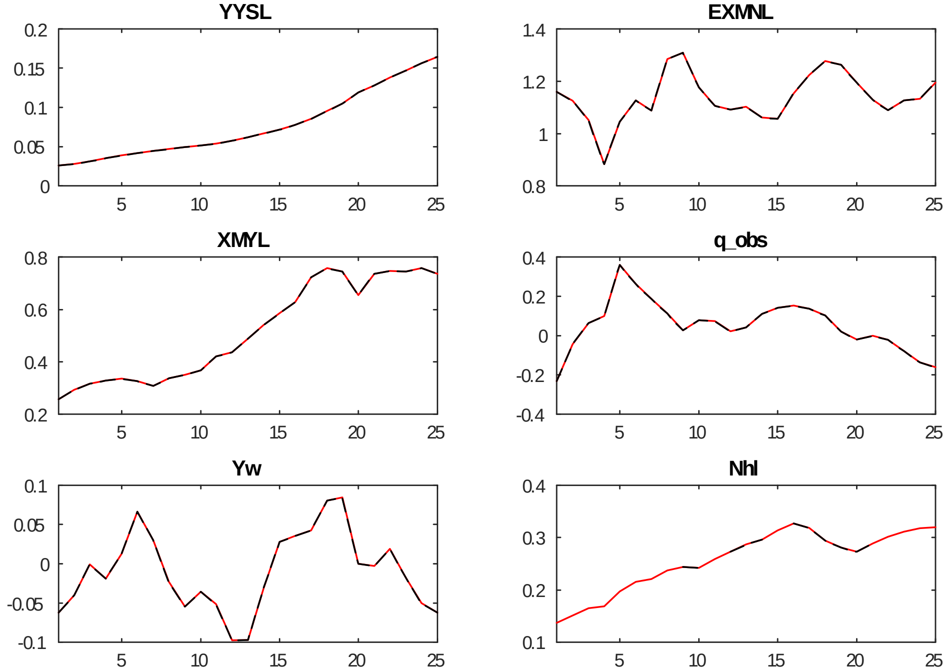


Figure 5: Estimated Shocks

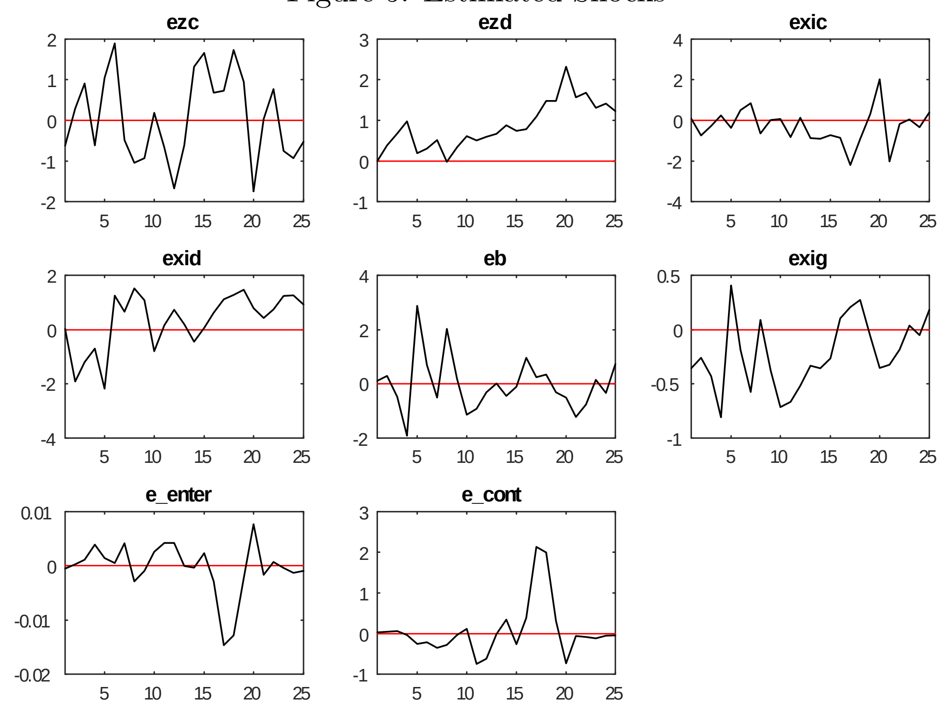
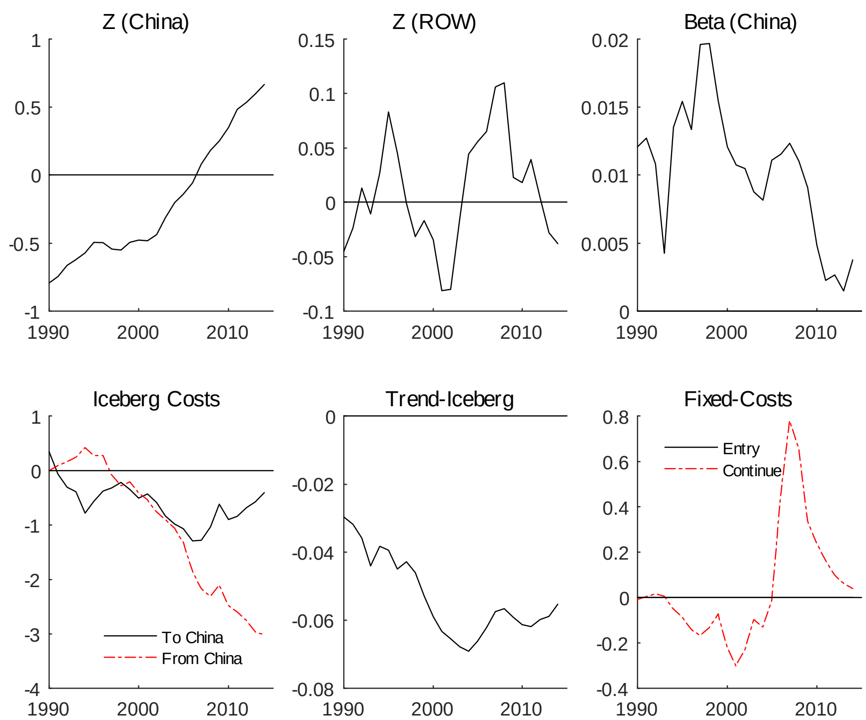


Figure 6: Deviations from Steady State of Exogenous State Variables



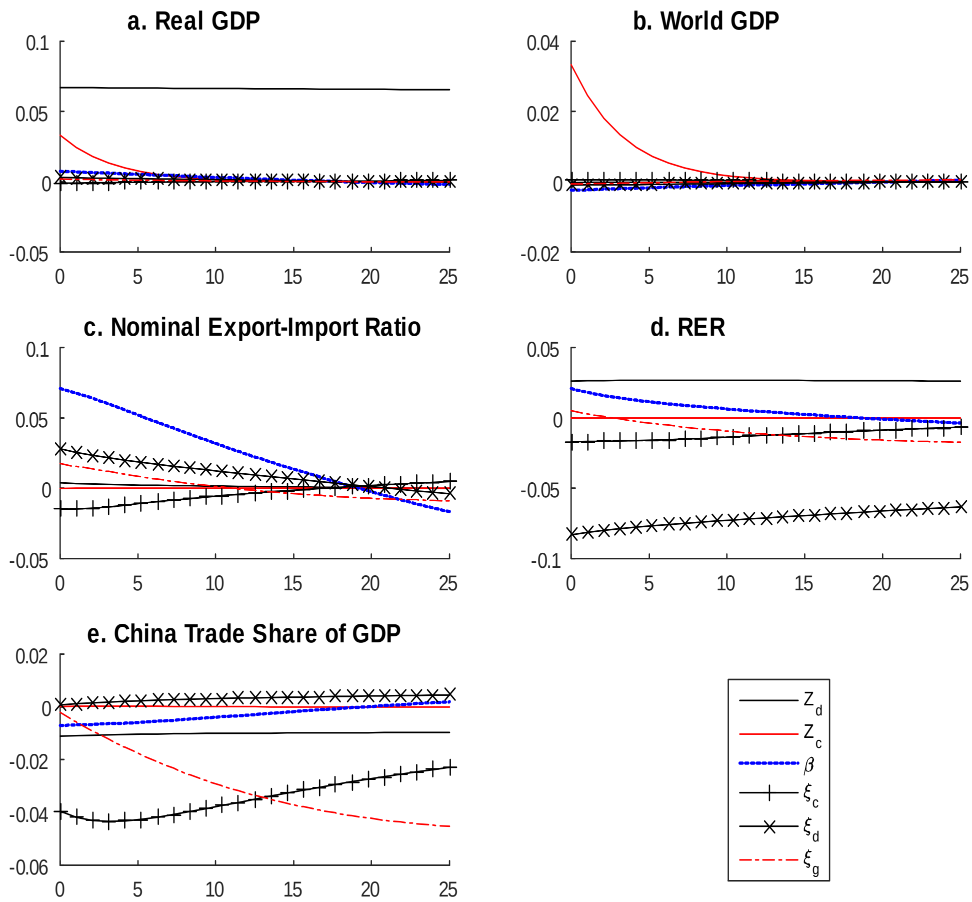


Figure 7: Impulse Response Benchmark

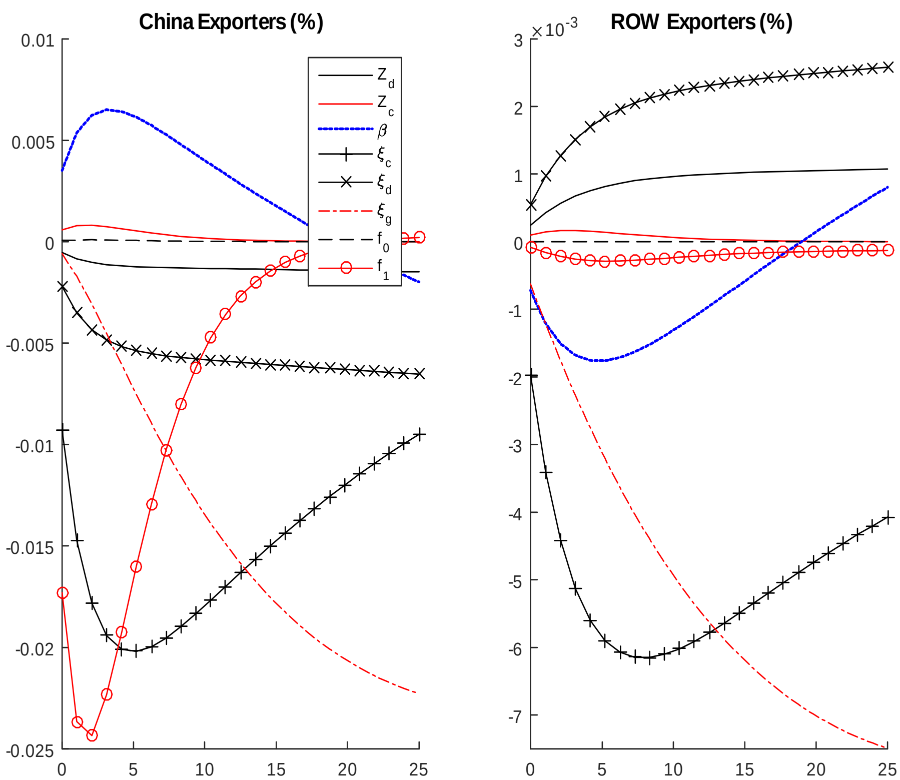


Figure 8: Exporter Dynamics: Impulse Response

Figure 9: Decomposition of Aggregate Dynamics

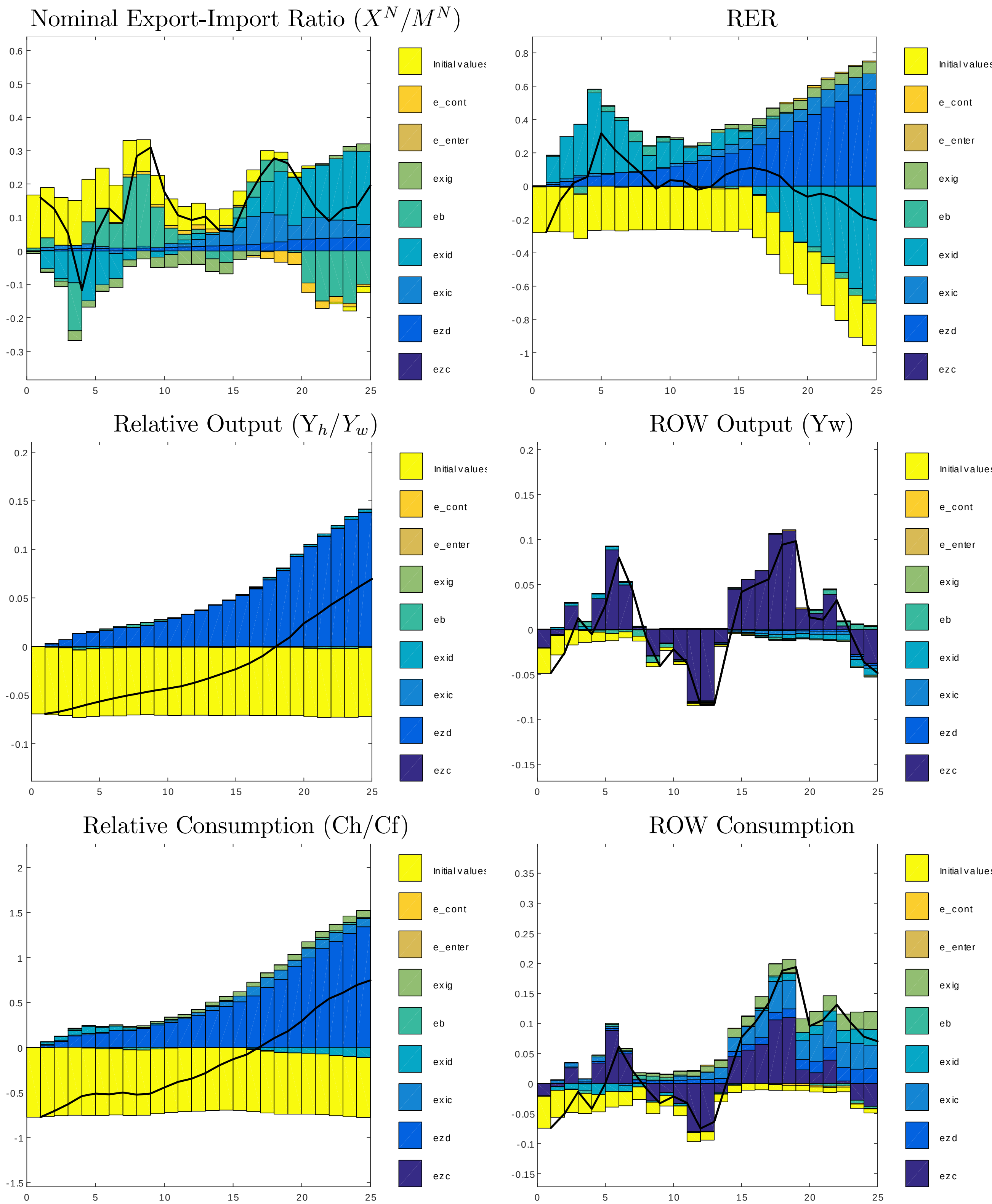
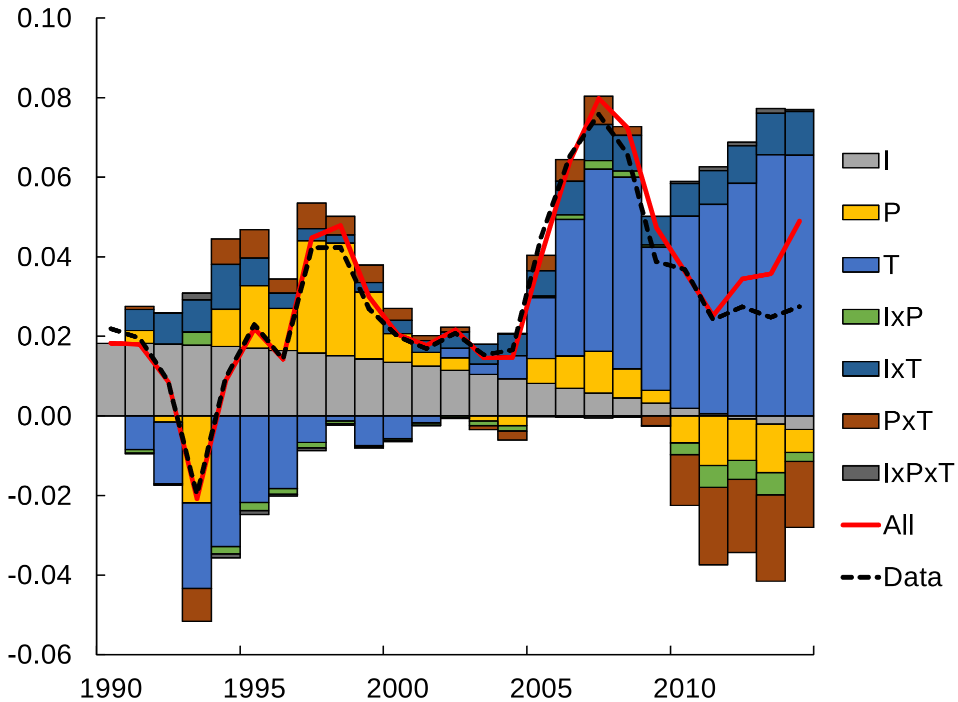


Figure 10: Decomposition of TB/Y and Net Foreign Assets

a. TB/Y (Nominal)



b. Net Foreign Assets/GDP

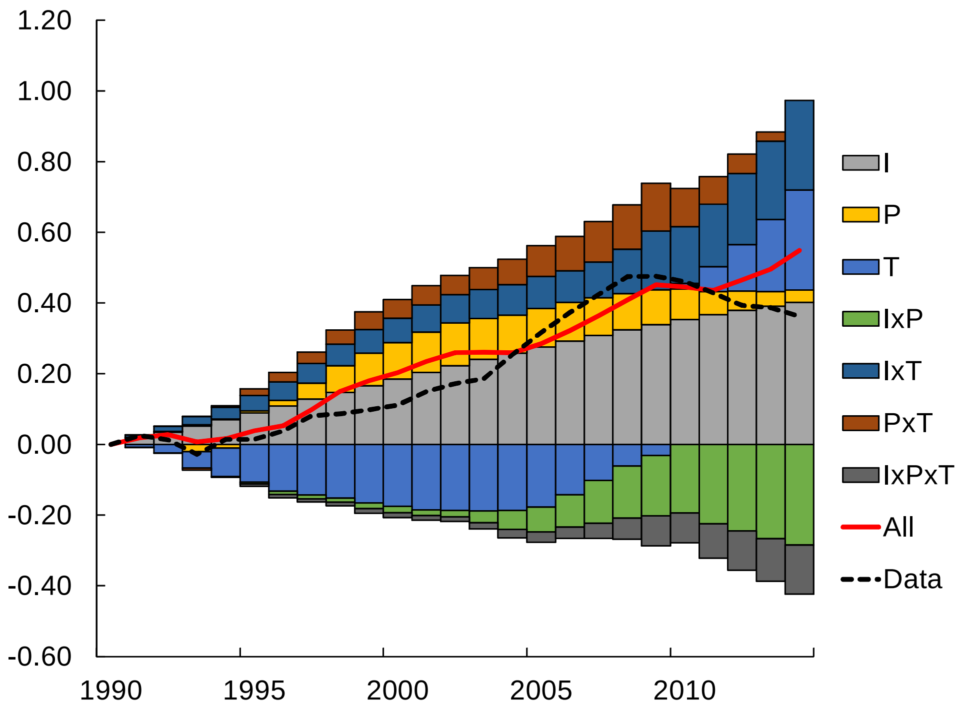


Figure 11: Decomposition of Trade Dynamics

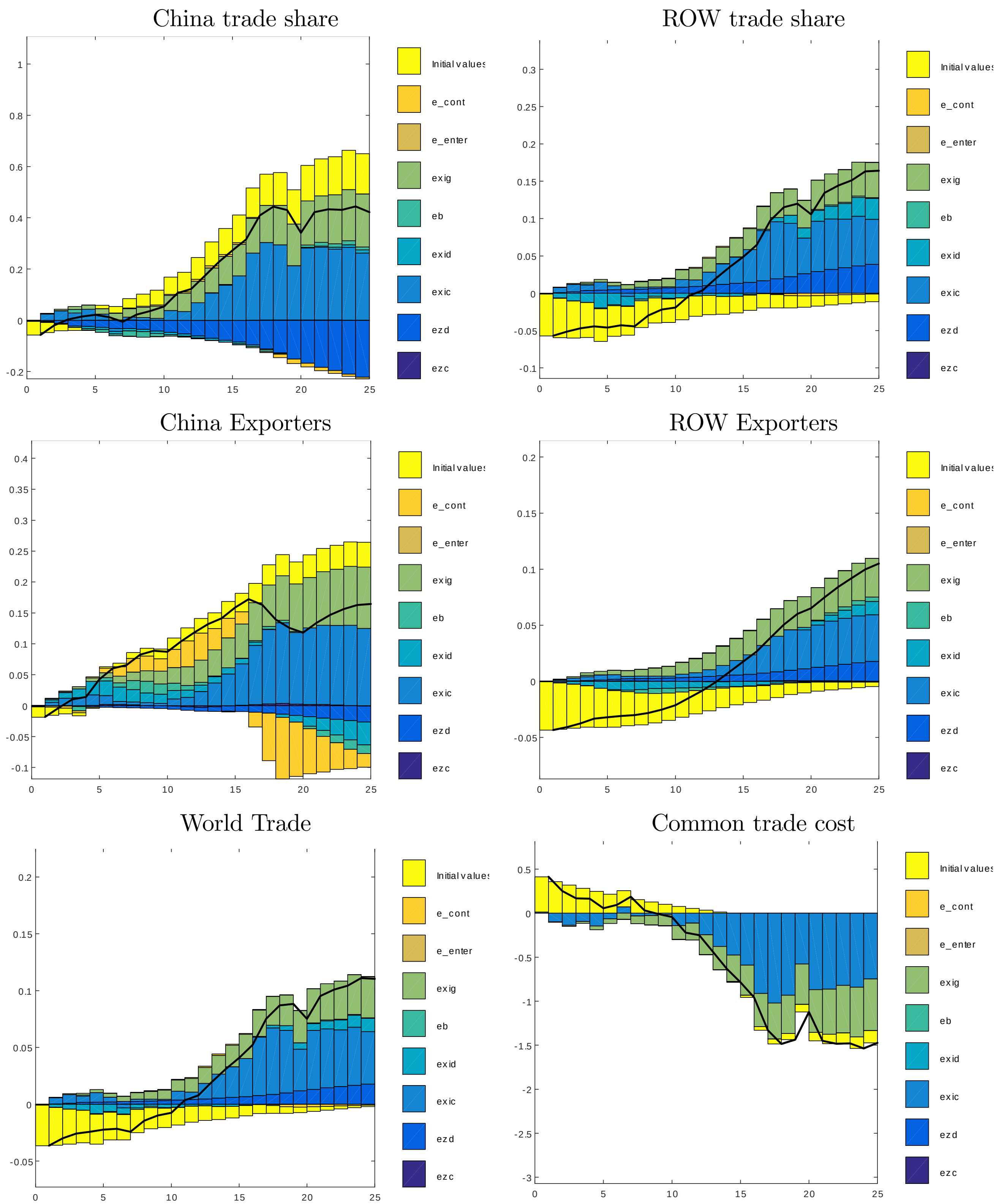


Figure 12. Trend Trade Cost