

The Global Trade Slowdown: Trade and growth, cause and effect

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Abstract

We study the trade and growth slowdown since the Great Recession in a dynamic quantitative two-country model in which trade responds gradually to changes in trade costs and trade policy changes are gradual. We capture the growth and trade factors driving the economy with movements in productivity, investment efficiency, and trade costs. Our model offers insights into how trade policy affects the economy and how productivity and investment efficiency can affect trade. We use Bayesian estimation to match the time series on trade integration and business cycles since 1980. We find that the trade slowdown since 2012 primarily reflects the completed transition to past reforms as well as a rise in current and future barriers. Absence these changes in trade barriers, growth factors should have led to a substantial increase in trade since 2012. The rise in current and future barriers though have temporarily boosted growth but makes us pessimistic about future trade flows.

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1. Introduction

Trade growth has slowed substantially since the Great Recession. For instance, the US real trade to GDP ratio has roughly held steady from 2012 to 2017 at 29 percent. In stark contrast, in the twenty years leading to the Great Recession, the trade to GDP ratio doubled from 13.5 to 27 percent. The slowdown in trade growth is even more severe as output growth has also fallen across these periods from about 3.0 percent per year to 1.7 percent. These dual slowdowns are common across many countries. In this paper, we use a two country dynamic stochastic general equilibrium model to identify the sources of these dual slowdowns.

Three main explanations for the seeming end of growing trade integration stand out. First, the transition from past trade reforms may be complete. That is, the run up to the Great Recession was characterized by many major trade deals such as CAFTA, NAFTA, and China's WTO ascension that took time to fully increase trade. Second, current and future trade barriers may have risen. This is another important possibility given the tendency for protectionist policies to be countercyclical, the rise in nationalistic politicians globally, the death spiral of prospective major trade agreements such as TTIP and TPP, and the backlash against NAFTA and the EU from Brexit. Indeed, the 2015 US Transportation Act lowered the allowable import content on federally funded investments by one-third over the next 5 years.¹ And third, the weakness in economic growth may discourage trade. This may operate through an effect of output growth on firm trade participation or through the well-known composition channel that trade is intensive in cyclically sensitive goods such as consumer durables or capital goods.

Quantifying the relative importance of these three sources of trade growth requires a dynamic general equilibrium model of trade integration and the business cycle with three features; 1) exogenous changes in current and future trade policy; 2) an endogenous grad-

¹The Fixing America's Surface Transportation (FAST) was passed in December of 2015. and phased-in an increase in domestic content requirements for transit rolling stock procurements from 60 percent to more than 70 percent by the year 2020.

ual response of trade to aggregate shocks; and 3) shocks that generate business cycles and changes in trend growth that are consistent with the cyclicity of trade. A dynamic general equilibrium model also allows us to examine the effect of changing trade policy on the slowdown in growth.

Trade barriers are modelled as following a very general stochastic process with asymmetries and trends. Specifically, inward and outward barriers are allowed to move together and apart to capture the unilateral and bilateral changes in trade barriers. Country-specific barriers fluctuate in response to persistent shocks to either the level or the change in trade barriers, what we call trend trade costs. Persistent shocks to the level follow an AR1 process and capture transitory and permanent changes in trade barriers and trade policies. The trend shocks capture the tendency for many trade agreements to include phase-in periods.² This general structure of trade barriers imposes some discipline on expectations of future trade policy. It also allows us to compare actual trade barriers against expected trade barriers at different points in times, including the end of our sample.

To capture the endogenous transition to a change in trade policy we build on the dynamic exporting model of Alessandria and Choi (2007). This model extends the international business cycle model of Backus, Kehoe, and Kydland (1994) to include heterogenous firms with a dynamic exporting decision from a large up-front sunk cost of exporting (Das, Roberts, and Tybout, 2009). It is consistent with the micro evidence on exporter characteristics and the dynamics of export participation in response to trade policy changes and aggregate fluctuations. To allow for even more gradual response to shocks we augment this model with input adjustment frictions.

Business cycles are assumed to arise from shocks to productivity and investment efficiency. To capture the growth slowdown, we allow for transitory and trend productivity shocks. To

²Baier and Bergstrand (2007) argue that the full impact of free trade agreements (FTA) can take up to fifteen years to be realized.

capture the cyclicity of trade, trade is modelled as being intensive in durable goods. Engel and Wang (2011) argue that about 70% of trade is in durable goods, and 40% is in capital goods. With this in mind, a change in the composition of demand can have different impacts on trade and output. Indeed, Eaton et al. (2016) show composition accounts for about two-thirds of the decline in trade in the Great Recession.

While our main focus is on the trade slowdown, our model includes a number of channels for trade to affect growth. First, there are the usual efficiency gains from lowering trade barriers operating through the lower costs of trade and shifting production to more efficient producers. Second, as trade is intensive in capital goods, a decline in trade barriers will lower the price of investment and lead to capital deepening. Third, the dynamics of trade barrier will affect the desire to invest and work. For instance, a decrease in future trade barriers is shown to be recessionary owing to the wealth effect as well as the expected future decline in the price of investment goods. Moreover, a temporary increase in trade barriers will also act much like a negative productivity shock and lead to a decline in output. These effects of trade barriers on investment and growth suggests that partial equilibrium analyses that attribute changes in the composition of final expenditures to growth factors will understate the importance of changes in trade barriers in the trade slowdown.

The model is estimated to match key features of the US and world economy from 1980 to 2016. In particular, the model is estimated to match US and ROW growth, US employment and investment rates, relative prices, trade integration, and net exports. Our estimation yields shocks and processes for these shocks. We then use our model decomposition to determine the source of fluctuations in the US trade to output ratio and US growth. We also use the model to provide a forecast of trade and output growth going forward.

We find that the trade slowdown largely reflects the completed transition to past reforms along with a sizeable increase in current and future barriers. In contrast to most analyses, we find that the shocks driving the recovery from the Great Recession should have boosted

trade significantly from 2012 to 2015. Only since 2015 have growth factors been a drag on trade.

Our dynamic model raises important concerns about trade (and growth) going forward with a sizeable reduction in trade forecast to occur over the next 10 years. This reduction arises because the model requires a slow transition to past reforms to capture the gradualness of trade integration leading up to the crisis. With this gradualness, the current trade stability of the past 5 years is estimated to reflect growth from past liberalization that is being undone by current and future barriers. As trade integration has yet to noticeably reverse, most of the stability reflects the chilling effects of an increase in future barriers. This likely reflects the chilling stance of the US towards NAFTA, TPP, and TTIP. We show that using a static model that abstracts from the exogenous and endogenous dynamic trade features of our model produces trade forecasts that are very stable going forward. Our model's pessimistic outlook on trade and trade barriers suggests much continued weakness in output growth as well.

There are several papers that examine the relative contributions of cyclical and structural factors on the trade slowdown. Constantinescu et al. (2015) argue that both cyclical and structural factors are important, and that the slowdown may represent convergence to a new trend for trade growth. They find that among the important structural factors are slowing of global value chains and lower investment in the composition of GDP. Empirical work by Boz et al. (2015) suggests that slightly over 50% of the slowdown is coming from cyclical factors. This number comes from estimating the import equation using a measure for demand that is adjusted for import intensity in each component. The predicted trade growth in the slowdown from this model is then interpreted as being the part of the slowdown from cyclical factors. It is likely that structural factors can also affect what is measured as demand in the data, so we take this number to be an upper bound. Freund (2009) argues that historically, the effects of a crisis on trade can last in the medium-run. Ollivaud and Schwellnus (2015) also claim that most of the slowdown is coming from cyclical factors. The results of these papers are all

based on empirical work. Very little has been done quantitatively. The second chapter of the October 2016 IMF World Economic Outlook was devoted to this question. The authors use a static version of the quantitative framework of Eaton et al. (2016) to claim that 60% of the slowdown in world trade growth relative to output growth is coming from changes in demand composition. To our knowledge, our paper is the first to use a dynamic quantitative model to assess the slowdown. Capturing dynamic responses to changes in structural variables is vital as these responses tend to be long lasting.

Our paper contributes to the literature on the delayed impacts of free trade agreements and globalization. Baier and Bergstrand (2007) argue that the full impact of free trade agreements on trade can take up to 10 to 15 years to be realized. Besedeš et al. (2015) argue that some of this is coming from gradual phase out of tariffs while Baier, Bergstrand, and Feng (2014) show that the extensive margin of trade response is more delayed than the intensive margin. In addition, there is a large literature in international economics which attempts to explain the empirical observation that trade responds more to changes in the terms of the trade in the long run than in the short run.³ The model we develop will capture both of these observations and will therefore allow for the impacts of a liberalization episode to become stronger over time.

In Section 2, we provide evidence of the slowdown both globally and in the United States. In Section 3, we discuss patterns of globalization in the precrisis period. In Section 4, we describe the model in detail. In Section 5, we describe our calibration of parameters as well as the estimation process and results. In Section 6, we discuss implications of the estimation about trade and output growth, and quantify the contributions of cyclical and structural factors to the trade slowdown in the U.S.

³See, for example, Alessandria et al. (2015), Ruhl et al. (2008), and Rabanal and Rubio-Ramirez (2015).

2. The Global Trade Slowdown

In this section, we show that post-recovery growth of global imports has been slow relative to both its historical growth and concurrent income growth. For the sake of completeness of the data, we will use only OECD countries although other authors have shown that the slowdown does in fact occur on a global scale. Constantinescu et al. (2015) show that the slowdown is more severe for advanced economies.

Using data for all OECD countries from the Quarterly National Accounts, we construct an OECD aggregate for import, export, and GDP growth. We weight a country's import growth by that country's share of total OECD import value. Export growth and GDP growth are similarly weighted. We define the precrisis period to be from 1990q1 to 2007q4 and the slowdown period to be from 2012q1 to 2016q3. We report the average annualized quarterly growth rates in Table 1. Figure 1 shows the growth rates of real imports and GDP since 1980.

The slowdown in trade is severe. Average annualized quarterly growth rates of real imports for the precrisis period is about 6.8%. For the slowdown period, average growth is about 3.2%.⁴ Real GDP growth has also slowed relative to the precrisis period, although the drop is not as pronounced. Real GDP went from an average growth rate of 2.7% in the precrisis period to 1.8% in the slowdown period. From 1990Q1 to 2007Q4, trade grew about 2.5 times as fast as output. Now it is growing less than twice as fast. This indicates that growth of trade is slower now both relative to its own growth in the precrisis period and concurrent output growth. These results are consistent with calculations done using different groups of countries performed by Constantinescu et al. (2015), Boz et al. (2015), ...

In this paper, we focus on pre- and post-crisis patterns for the United States. In the U.S., real total trade (exports plus imports) went from an average annual growth rate of 6.5%

⁴The fall in growth of nominal values for both imports and exports is even bigger, which comes from falling oil prices in recent years.

in the precrisis period to 2.5% after 2012. In comparison, the slowdown in real GDP was quite small, going from 3.0% to 2.1%. Similarly, the decline in the production of tradeable goods proxied by industrial production is about the same. In nominal terms, trade is actually growing slower than output and the trade to output ratio is declining rapidly starting in late 2014. This is likely coming from severe declines in the import price of oil.

3. Globalization Patterns

We now briefly discuss some aspects of changes in trade policy. We emphasize a decline in barriers with a substantial forward-looking component.

In the 1990s, the developed world saw substantial increases in globalization. The World Trade Organization (WTO) reports over 50 regional trade agreements that went into force between 1990 and 2000. To give some perspective, the 1970s and 1980s each witnessed about ten regional trade agreements reported by the WTO. The 1990s and 2000s also saw an increase in the number of multinational firms and supply chain integration. Lower import tariffs allowed firms to take advantage of lower production costs in foreign countries.

When free trade agreements enter into force, the tariff phase outs tend to be gradual. Kowalczyk and Davis (1998) explain that phase-out periods for tariffs were an area of some debate in early rounds of the General Agreement on Tariffs and Trade. Eventually, it was decided that preferential trade agreement tariff phase-outs for most goods would not exceed 10 years. Besedeš et al. (2015) look at NAFTA's scheduled phase-outs at the HS10 product level. Of the products they consider, 18% were already duty free at the commencement of NAFTA and an additional 42% were made duty free on impact. All other products took at least 5 years for tariff cuts to phase in, and about 7% of all products became duty free in 10 equal annual tariff cuts. Less than 1% of all products had a tariff phase in longer than 10 years. Trefler (2004) plots average tariffs for Canada and the U.S. against each other and average tariffs against the world in the wake of the Canada-U.S. Free Trade Agreement. The

bilateral tariffs show a clear gradual decrease.

Using HS8 tariff data from Feenstra et al. (2002), we construct a production weighted average tariff of the United States against Mexico, Canada, and the Most Favored Nation.⁵ We create a concordance between HS8 products and NAICS 6-digit codes.⁶ We take simple averages for HS8 products in a NAICS code to come up with an average tariff for the product. We then use production data from the NBER-CES Manufacturing Industry Database to weight each average tariff by its production relative to the production of the entire manufacturing sector.⁷ The weighted tariffs are plotted in Figure 2. Unfortunately, we only have tariff data back to 1989 and are therefore unable to see the change in tariffs imposed against Canada on impact from the Canada-U.S. Free Trade Agreement. However, we see that tariffs imposed against Canada drop quickly at first but then decrease more gradually as time goes on. A similar pattern emerges for Mexico. When NAFTA begins in 1994, we see a large decrease in tariffs against Mexico. After 1995, we see a more gradual decrease in the average tariff.

Figure 3 plots the simple averages of HS8 tariffs against the same three groups. The same patterns are clear for the simple average as well.

Now we turn to analyze Mexico's tariffs imposed against the U.S. In each year between 1991 and 2000, over 70% of Mexico's imports came from the U.S. and about 80% of its exports went to the U.S. Because of this, we can get a good idea of how tariffs against the U.S. moved with the commencement of NAFTA by simply looking at Mexico's aggregate tariff. We get tariff revenue and import value data from the OECD and compute an ad valorem tariff equivalent by dividing tariff revenue by the import value. Figure 4 plots the

⁵The most favored nation tariff is an upper bound on tariffs against all WTO members at the product level imposed by the WTO.

⁶See appendix for details.

⁷Many authors in the literature use the import value weighted tariffs. We do not use this method as the tariffs are endogenous to the import decision. In particular, the researcher cannot know if imports for a given product are low because the demand for that product is low or if tariffs dissuade people from buying that product from abroad.

resulting aggregate tariff. In addition to NAFTA, Mexico underwent a huge trade policy shift from 1992 to 1997, unilaterally cutting tariffs on thousands of products. Because of this, we see tariffs decreasing even before NAFTA began in 1994. However, after a couple years, we still see the same pattern. Namely, that the decrease in tariffs becomes more gradual.

In our model, we will allow for gradual changes in trade policy by specifying a stochastic process where shocks can have a gradual effect on trade costs. As trade policy takes many forms we follow the gravity literature and use the model to identify the changes in current and future trade barriers.

4. Model

We develop a two-country dynamic stochastic general equilibrium model with heterogeneous firms to study the short- and long-run effects of trade cost and productivity shocks on trade and output. We use the model of Alessandria and Choi (2007) and add adjustment costs on the import share, trade intensive in durable/capital goods, habit formation in consumption, labor augmenting balanced growth and shocks to investment efficiency and trade barriers.

There are two countries, Home and Foreign, each populated by a continuum of identical and infinitely lived consumers. Consumers make consumption and labor decisions and trade a non-contingent bond across countries. In each period t , the economy experiences an event s_t . The history of these events is denoted $s^t \equiv (s_0, \dots, s_t)$ where s_0 is given. The probability of a history s^t as $\pi(s^t, s_0)$.

Each country has a continuum (unit mass) of monopolistically competitive firms that produce differentiated intermediate goods. A firm is the unique producer of a single variety of a good. The firms are indexed by $i \in [0, 1]$. Intermediate goods producers use capital and labor to produce. Firm productivity has an aggregate component and an idiosyncratic component. The aggregate component Γ features balanced growth a la Aguiar and Gopinath

(2007) such that $\Gamma_t(s^t) = g_0(s_0)g_1(s^1)\dots g_t(s^t)$ where $g_t(s^t)$ is the growth rate of aggregate productivity at time t . Aggregate productivity across the two countries is assumed to be cointegrated of order C(1,1).

All firms produce their variety for the domestic market, but only some produce for the foreign market. In addition to an iceberg cost, firms that export must also pay a fixed cost which depends on their export status in the last period. New exporters must pay a higher fixed cost than continuing exporters, as is common in the literature. These fixed costs are denominated in units of labor.

Competitive final good producers in each country use intermediate goods produced in the domestic and foreign market to produce consumption and investment goods. Use of intermediates in production follows the familiar CES structure. To capture the empirical observation noted by Engel and Wang (2011) and others that trade is intensive in durable goods, we assume that the bias in production for home or foreign goods is different for consumption and investment goods. In addition, final goods producers face an adjustment cost in the ratio of domestic goods to foreign goods used in production as in Erceg et al. (2005) and Rabanal and Rubio-Ramirez (2015). This provides more flexibility for the model to capture the slow adjustment of trade to aggregate shocks observed in the data.

A. Consumers

Consumers are endowed with one unit of time which they can use for leisure or labor $L(s^t)$. Consumers choose labor, consumption, and a one-period bond to maximize utility subjective to a budget constraint. The representative consumer's objective function is

$$\max \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t | s_0) U(C(s^t) - \zeta \bar{C}(s^{t-1}), 1 - L(s^t))$$

where $\bar{C}(s^{t-1})$ denotes aggregate consumption of the previous period, $C(s^t)$ is today's consumption, and β is the discount factor. The budget constraint is

$$P_C(s^t)C(s^t) + Q(s^t)B(s^{t+1}) (1 + \Omega(B(s^{t+1}))) \leq P_C(s^t)W(s^t)L(s^t) + B(s^t) + \Pi(s^t)$$

where $P(s^t)$ is the price of consumption goods relative to the home currency, $W(s^t)$ is the real wage, $Q(s^t)$ is the price of a bond $B(s^{t+1})$ that pays one unit of the home currency in the next period, and $\Pi(s^t)$ denotes profits from home intermediate goods producers. There is also a portfolio adjustment cost determined by the function $\Omega(B)$. Notice that the budget constraint is written in terms of the home currency. Similarly, the foreign budget constraint is

$$P_C^*(s^t)C^*(s^t) + \frac{Q(s^t)}{e(s^t)}B^*(s^{t+1}) (1 + \Omega(B^*(s^{t+1}))) \leq P_C^*(s^t)W^*(s^t)L^*(s^t) + \frac{B^*(s^t)}{e(s^t)} + \Pi^*(s^t)$$

where asterisks denote prices and allocations in Foreign and $e(s^t)$ represents the nominal exchange rate.

From now on, we abstract from state dependence and write all variables with only time subscripts unless it is likely to be confusing. The first order conditions from the Home consumer's problem are:

$$(1) \quad -\frac{U_{L,t}}{U_{C,t}} = W_t$$

$$(2) \quad Q_t (1 + \Omega(B_{t+1}) + B_{t+1}\Omega'(B_{t+1})) = \beta\mathbb{E}_t \frac{U_{C,t+1}}{U_{C,t}} \frac{P_{C,t}}{P_{C,t+1}}$$

where U_I denotes the marginal utility with respect to $I \in (C, L)$. The Foreign Euler equation for bonds expresses the bond price as

$$(3) \quad Q_t (1 + \Omega(B_{t+1}^*) + B_{t+1}^*\Omega'_{t+1}^*)) = \beta\mathbb{E}_t \frac{U_{C^*,t+1}}{U_{C^*,t}} \frac{P_{C^*,t}}{P_{C^*,t+1}} \frac{e_t}{e_{t+1}}.$$

Using the two Euler equations, we also get an arbitrage condition.

B. Final Goods Producers

In each country, there are many final goods producers that engage in perfect competition. Home final goods producers use both Home- and Foreign-produced intermediate goods as inputs to create consumption and investment goods according to the following CES production technologies⁸

$$(4) \quad C^p(s^t) = \left[\int_0^1 y_h^C(i, s^t)^\theta di^{\frac{\rho}{\theta}} + \omega_C^{1-\rho} \left(\phi(TR^C(s^t), TR^C(s^{t-1})) \int_0^1 y_f^C(i, s^t)^\theta di^{\frac{1}{\theta}} \right)^\rho \right]^{\frac{1}{\rho}}$$

$$(5) \quad I^p(s^t) = \left[\int_0^1 y_h^I(i, s^t)^\theta di^{\frac{\rho}{\theta}} + \omega_I^{1-\rho} \left(\phi(TR^I(s^t), TR^I(s^{t-1})) \int_0^1 y_f^I(i, s^t)^\theta di^{\frac{1}{\theta}} \right)^\rho \right]^{\frac{1}{\rho}}$$

where $y_n^X(i, s^t)$ is the quantity of intermediate goods produced by firm i in country n used in the production of good X . Parameter θ determines the elasticity of substitution between within country varieties while ρ determines the elasticity of substitution between Home- and Foreign-produced goods. ω_C and ω_I capture home bias in production of consumption and investment, respectively. We allow these to be different, and in particular we impose $\omega_I > \omega_C$ to capture the empirical observation that trade is intensive in durable goods. Define the consumption and investment trade ratios as

$$TR^C(s^t) = \frac{Y_f^C(s^t)}{Y_h^C(s^t)} \quad \text{and} \quad TR^I(s^t) = \frac{Y_f^I(s^t)}{Y_h^I(s^t)}.$$

where

$$Y_j^C(s^t) = \int_0^1 y_j^C(i, s^t)^\theta di^{\frac{1}{\theta}} \quad \text{and} \quad Y_j^I(s^t) = \int_0^1 y_j^I(i, s^t)^\theta di^{\frac{1}{\theta}}.$$

Then the adjustment cost $\phi(\cdot, \cdot)$ takes the form

$$(6) \quad \phi(TR(s^t), TR(s^{t-1})) = \left[1 - \frac{\iota}{2} \left(\frac{TR(s^t)}{TR(s^{t-1})} - 1 \right)^2 \right].$$

⁸Foreign final goods producers also use intermediates from both economies and have analogous production technologies, holding constant elasticities of substitution and home bias parameters.

This adjustment cost has been used by Rabanal and Rubio-Ramirez (2015) and Erceg et al. (2005). It causes firms to optimize by adjusting the trade ratio gradually, thereby capturing a low short-run and high long-run trade elasticity.

The adjustment cost on the import share makes the decision regarding today's purchases of intermediates dynamic. This will be particularly important when we consider shocks that change future trade costs in a predictable way. In order to minimize movements in the import share, firms will gradually make changes to their purchases of foreign intermediates.

Final goods producers produce consumption goods and investment goods separately and maximize profits over each type of final good. That is, they choose intermediates to maximize two profit functions

$$(7) \quad \sum_{t=0}^{\infty} \sum_{s^t} Q(s^{t+1}|s^t) P(s^t) C(s^t) - \int_0^1 p_h(i, s^t) y_h^C(i, s^t) di - \int_0^1 p_f(i, s^t) y_f^C(i, s^t) di$$

$$(8) \quad \sum_{t=0}^{\infty} \sum_{s^t} Q(s^t|s^{t-1}) P_I(s^t) I(s^t) - \int_0^1 p_h(i, s^t) y_h^I(i, s^t) di - \int_0^1 p_f(i, s^t) y_f^I(i, s^t) di$$

with (7) subject to equations 4 and 6; (8) subject to equations 5 and 6. The firm treats these as distinct problems. Notice that while final goods producers buy intermediates for the production of consumption and investment goods separately, the intermediate goods producers only produce one type of intermediate and charge the same price for it, regardless of its final use.

Demand for aggregates of foreign $Y_f^X(s^t)$ and home intermediates $Y_h^X(s^t)$ are determined implicitly from the first order conditions

$$(9) \quad P_h(s^t) = \frac{\partial X(s^t)}{\partial Y_h^X(s^t)} + \frac{\partial X(s^{t+1})}{\partial Y_h^X(s^t)}$$

$$(10) \quad P_f(s^t) = \frac{\partial X(s^t)}{\partial Y_f^X(s^t)} + \frac{\partial X(s^{t+1})}{\partial Y_f^X(s^t)}$$

where $P_h(s^t)$ and $P_f(s^t)$ are the aggregate home price levels for home and foreign intermedi-

ates, respectively, and can be expressed as

$$P_h(s^t) = \left(\int_0^1 p_h(i, s^t)^{\frac{\rho}{\rho-1}} di \right)^{\frac{\rho-1}{\rho}}$$

$$P_f(s^t) = \left(\int_0^1 p_f(i, s^t)^{\frac{\rho}{\rho-1}} di \right)^{\frac{\rho-1}{\rho}}$$

which is the usual Dixit-Stiglitz price index.

Given demand for $Y_h^X(s^t)$, the demand faced by an individual Home firm i in the Home market is

$$(11) \quad y_h^{X,d}(i, s^t) = \left(\frac{p_h(i, s^t)}{P_h} \right)^{\frac{1}{\theta-1}} Y_h^X$$

and the demand faced by an individual Foreign firm i in the Home market is Home firm i in the Home market is

$$(12) \quad y_f^{X,d}(i, s^t) = \left(\frac{p_f(i, s^t)}{P_f} \right)^{\frac{1}{\theta-1}} Y_f^X$$

Prices for consumption and investment goods are determined through the zero profit conditions. In particular, P_X is pinned down by $P_X(s^t)X(s^t) = P_h(s^t)Y_h^X(s^t) + P_f(s^t)Y_f^X(s^t)$ for $X \in \{C, I\}$. Since trade is intensive in investment goods, P_I will be more responsive to changes in foreign prices.

C. Intermediate Goods Producers

Each country has a continuum of intermediate goods producers of measure unity. These firms each produce a unique variety of a good and engage in monopolistic competition. Intermediate goods producers use capital and labor to produce their good. Firm productivity has an aggregate component that is the same for everyone, and an idiosyncratic component.

The production technology of the firm is

$$(13) \quad \sum_{X \in \{C, I\}} y_h^X(i, s^t) + \xi^*(s^t) y_h^{*X}(i, s^t) = e^{z(s^t)} k(i, s^{t-1})^\alpha (A(i, s^t) l(i, s^t))^{1-\alpha}$$

where $y_h^X(i, s^t)$ and $y_h^{*X}(i, s^t)$ represent domestic and foreign sales of intermediates for the production of final good X , $k(i, s^t)$, $l(i, s^t)$, and $e^{z(s^t)}A(i, s^t)^{1-\alpha}$ represent firm specific capital stock, labor, and productivity, respectively, and ξ^* represents a stochastic iceberg cost of exporting to the Foreign market. Firm productivity $e^{z(s^t)}A(i, s^t)^{1-\alpha}$ has two aggregate components and one idiosyncratic component. In particular, $z(s^t)$ is at the aggregate level and

$$\ln A(i, s^t) = \ln \Gamma(s^t) + \eta(i, s^t).$$

The aggregate component $\Gamma(s^t)$ grows at rate g_t in every period with $\Gamma(s_{-1}) = 1$ so that $\Gamma(s^t) = g_0(s_0) \dots g_t(s^t)$. We follow Rabanal et al. (2011) in specifying the stochastic process for growth rates to make productivity across countries cointegrated of order $C(1,1)$. We also include some persistence in the process. Thus, we have

$$\begin{aligned} \ln g(s^t) &= c + \kappa(\ln \Gamma_{t-1} - \ln \Gamma_{t-1}^*) + \rho_g \ln g(s^{t-1}) + \varepsilon_g^c + \frac{1}{2}\varepsilon_g^d \\ \ln g^*(s^t) &= c^* - \kappa(\ln \Gamma_{t-1} - \ln \Gamma_{t-1}^*) + \rho_g \ln g^*(s^{t-1}) + \varepsilon_g^c - \frac{1}{2}\varepsilon_g^d \end{aligned}$$

where $\varepsilon_g^c \sim N(0, \sigma_g^{c2})$ and $\varepsilon_g^d \sim N(0, \sigma_g^{d2})$. Notice that shocks to growth rates are either common or differential shocks and affect the growth rates of both economies. The process for $z(s^t)$ is

$$\begin{aligned} z_t &= \rho_z z_{t-1} + \varepsilon_z^c + \frac{1}{2}\varepsilon_z^d \\ z_t^* &= \rho_z z_{t-1}^* + \varepsilon_z^c - \frac{1}{2}\varepsilon_z^d \end{aligned}$$

The idiosyncratic component of firm productivity, $\eta(i, s^t)$ is iid both across firms and across time with $\eta(i, s^t) \sim N(0, \sigma_\eta^2)$.

Firms own the capital and choose investment $x(i, s^t)$ every period. The law of motion for capital is

$$(14) \quad k(i, s^t) = (1 - \delta)k(i, s^{t-1}) + \psi(s^t)x(i, s^t).$$

where $\psi(s^t)$ is investment specific technology (IST). The stochastic process for IST is

$$\begin{aligned}\ln \psi_t &= \rho_\psi \psi_{t-1} + \varepsilon_\psi^c + \frac{1}{2} \varepsilon_\psi^d \\ \ln \psi_t^* &= \rho_\psi \psi_{t-1}^* + \varepsilon_\psi^c - \frac{1}{2} \varepsilon_\psi^d\end{aligned}$$

where $\varepsilon_\psi^c \sim N(0, \sigma_\psi^c)$ and $\varepsilon_\psi^d \sim N(0, \sigma_\psi^d)$.

At the beginning of a period, a firm is identified by its idiosyncratic productivity $\eta(i, s^t)$, undepreciated capital stock $k(i, s^{t-1})$ from the last period, and last period's export status $m(i, s^{t-1})$. The firm then chooses investment $x(i, s^t)$, labor $l(i, s^t)$, current export status $m(i, s^t)$, and prices $p_h(i, s^t)$ and $p_h^*(i, s^t)$ to maximize the present discount value of profits. The problem for an individual firm i can be expressed recursively as⁹

$$\begin{aligned}(15) \quad V(\eta, k, m, s^t) &= \max_{x, l, m', p_h, p_h^*} \pi(i) + m'^*(i) \\ &+ \sum_{s_{t+1}|s^t} \int Q(s^{t+1}|s^t) V(\eta', k', m'^{t+1}) dF(\eta')\end{aligned}$$

where

$$(16) \quad \pi(i) = \sum_{X \in \{C, I\}} p_h y_h^X(i) - P_C W l - P_I x$$

$$(17) \quad \pi^*(i) = e \left[\sum_{X \in \{C, I\}} p_h^* y_h^{*X}(i) - P_C W (m \tau_1 + (1 - m) \tau_0) \right]$$

subject to the production technology (13), the law of motion for capital (14), and the downward sloping demand curves (11 and the Foreign analogue of 12). $F(\eta)$ is the cumulative distribution function of the normal distribution with variance σ_η^2 .

Let $V_1(\eta, k, m, s^t)$ be the value of a firm that chooses $m' = 1$. I.e. the firm chooses to export in the current period. Similarly, let $V_0(\eta, k, m, s^t)$ be the value of a firm that chooses

⁹Dependence on the state s^t is not shown explicitly in the following exposition for convenience.

$m' = 0$. Then we can rewrite the value of a firm as

$$V(\eta, k, m, s^t) = \max\{V_1(\eta, k, m, s^t), V_0(\eta, k, m, s^t)\}.$$

Clearly, V_1 and V_0 are both increasing functions of η . Also V_1 only crosses V_0 once for given (k, m, s^t) . Thus, there exists a cutoff productivity level at which the firm is indifferent between exporting and not exporting. Above that level, the firm exports and below that level, they produce goods only for the domestic market. Because the fixed cost of exporting depends on the firm's export status in the last period, the cutoff also depends on the exporters previous export status. Let η_0 be the cutoff productivity level for firms that did not export in the last period and η_1 be the cutoff productivity for firms that did export. Then η_0 and η_1 satisfy

$$(18) \quad V_1(\eta_0, k, 0, s^t) = V_0(\eta_0, k, 0, s^t)$$

$$(19) \quad V_1(\eta_1, k, 1, s^t) = V_0(\eta_1, k, 1, s^t).$$

Since $\tau_0 > \tau_1$, we know that $\eta_0 > \eta_1$. That is, beginning to export requires a higher productivity shock than continuing to export.

Because the idiosyncratic productivity shocks are iid over time, we know that all firms have the same expectations over their productivity in the next period. Then the only thing that determines a firms choice of capital for the next period is their export status in the current period. The distribution of capital is then determined by two mass points, weighted by the number of exporters and nonexporters.

The percentage of nonexporters that begin exporting in state s^t is just $1 - F(\eta_0(s^t))$. Similarly, the percentage of exporters that continue exporting is $1 - F(\eta_1(s^t))$. Let $N(s^t)$ be the measure of exporters in state s^t . Then we have

$$(20) \quad N(s^t) = (1 - N(s^{t-1}))[1 - F(\eta_0(s^t))] + N(s^{t-1})[1 - F(\eta_1(s^t))].$$

Let $\Phi(s^t)$ ($\Phi^*(s^t)$) represent the set of Home (Foreign) firms that export. Then the measure of $\Phi(s^t)$ is $N(s^t)$, the number of exporters. The labor hired in Home for the purpose of paying the fixed cost L_{fc} is

$$(21) \quad L_{fc}(s^t) = \int_{i \in \Phi(s^t)} \tau_1 m(i, s^{t-1}) + \tau_0 (1 - m(i, s^{t-1})) di.$$

D. Variable Trade Costs

The iceberg costs ξ^* and ξ faced by Home and Foreign intermediate goods producers, respectively, are stochastic. Each cost has a trend component and a transitory component. The trend component is meant to capture bilateral globalization between countries, which is expected to decrease trade costs both on impact and in the future. Because we use a linearization to solve the model, we choose a stochastic process for trade costs such that a trend shock to trade costs will still eventually return the steady state, but it will take a long time. The transitory component captures other deviations in the trade costs such as short term protection measures. The process for these trade costs is

$$\begin{aligned} \xi(s^t) &= \xi_c(s^t) + \frac{1}{2} \xi_d(s^t) \\ \xi^*(s^t) &= \xi_c^*(s^t) - \frac{1}{2} \xi_d(s^t) \end{aligned}$$

where

$$\begin{aligned} \xi_d(s^t) &= \rho_{\xi_d} \xi_d(s^{t-1}) + \varepsilon_{\xi}^d \\ \xi_c(s^t) &= (1 - \rho_{\xi_c}) \bar{\xi} + \rho_{\xi_c} \xi_c(s^{t-1}) + \Delta + \varepsilon_{\xi}^c \\ \xi_c^*(s^t) &= (1 - \rho_{\xi_c}) \bar{\xi} + \rho_{\xi_c} \xi_c^*(s^{t-1}) + \Delta^* + \varepsilon_{\xi}^c \\ \Delta(s^t) &= \rho_{\Delta} \Delta(s^{t-1}) + \varepsilon_{\Delta}^c + \frac{1}{2} \varepsilon_{\Delta}^d \\ \Delta^*(s^t) &= \rho_{\Delta} \Delta^*(s^{t-1}) + \varepsilon_{\Delta}^c - \frac{1}{2} \varepsilon_{\Delta}^d \end{aligned}$$

and $\varepsilon_a^b \sim N(0, \sigma_a^{b2})$ for all $a \in \{\xi, \Delta\}$ and $b \in \{c, d\}$. We use common and differential shocks instead of country specific shocks so that no assumptions about correlation of trade cost movements across countries need to be made. In addition, with this setup the responses to common shocks can be interpreted as responses to global movements in trade costs, such as those expected in times of rapid globalization.

E. Equilibrium

In equilibrium, there are several market clearing conditions that must be met. We must have $C^{(*)p}(s^t) = C^{(*)}(s^t)$ and $I^{(*)p}(s^t) = \int_0^1 x^{(*)}(i, s^t)$. All intermediate goods producers must set supply equal to demand from domestic final goods producers. Exporters must also meet the demand from foreign final goods producers. The market clearing conditions for labor are $L(s^t) = \int_0^1 l(i, s^t) + L_{fc}$ and $L^*(s^t) = \int_0^1 l^*(i, s^t) + L_{fc}^*$. All profits from intermediate goods producers are given to the representative agent. The market clearing condition for international bonds is $B(s^t) + B^*(s^t) = 0$, bonds are in zero net supply. Because budget constraints are written in terms of the domestic currency for each country, we can normalize one price in each country. Here, we choose $P_C(s^t) = P_C^*(s^t) = 1$ for all s^t .

We center our attention on stationary equilibrium so that all allocations and prices are functions of the state s^t . In this model, the state can be summarized by the distribution of (η, k, m) and (η^*, k^*, m^*) , aggregate productivity Γ and Γ^* , and variable trade costs ξ and ξ^* . The assumption that idiosyncratic firm productivity is iid over time makes tracking the distribution of individual firm variables much simpler. All firms have the same expectations over their idiosyncratic productivity tomorrow. Thus, export status in the previous period is the only determinant of a firm's capital stock. Firms that did not export in the last period will have a lower capital stock than firms that did. Let $K_0^{(*)}$ be the stock of capital carried by Home (Foreign) firms that did not export in the previous period and $K_1^{(*)}$ the stock of the firms that did. Then the state of the economy can be characterized by $K_0, K_0^*, K_1, K_1^*, N,$

Γ , Γ^* , ξ , and ξ^* .

5. Calibration and Estimation

In this section we describe the functional forms chosen and parameters calibrated in the model. For many parameters, we begin by calibrating reasonable values and then use Bayesian estimation to choose parameters that can match time series from the data.

The per period utility function is given by

$$U(C(s^t) - \zeta \bar{C}(s^{t-1}), 1 - L(s^t)) = \frac{\left[(C(s^t) - \zeta \bar{C}(s^{t-1}))^\gamma (1 - L(s^t))^{1-\gamma} \right]^{1-\sigma}}{1 - \sigma}.$$

The intertemporal elasticity of substitution is $1/\sigma$ and γ gives the share of net consumption in the composite good.

For the portfolio adjustment cost, we choose a functional form that is consistent with a balanced growth path. In this case, the adjustment cost is a function of the ratio of expenditures on new debt to nominal output. In particular, portfolio adjustment costs are convex such that

$$\Omega \left(\frac{QB}{Y^N} \right) = \frac{\omega_b QB}{2 Y^N}.$$

We set ω_b small enough that it induces stationarity but does not affect any equilibrium dynamics of the model.

Table 2 shows the initial calibration for all parameters. A period is one quarter. We set $\beta=0.99$ to match a steady state real interest rate of 4%. The parameter ζ which determines habit persistence for consumers, is set to 0.3, within the bounds of the literature. We choose the share of net consumption γ in the utility function to match a Frisch elasticity of about 2, which is close to values in the literature. The intertemporal elasticity of substitution σ is set to 1/6. We set $\alpha=0.36$ as is common in the literature to match the share of revenue that goes to labor. We set $\delta=0.05$ to increase the investment share to 0.2 in steady state.

The elasticity of substitution between varieties within a country is determined by θ . It also determines markups of intermediate firms. Here we set $\theta=2/3$ which implies a markup of 50%. This is within the estimates in the literature which are summarized by Schmitt-Grohé (1997). The elasticity of substitution between home and foreign goods is determined by ρ . Here we choose an elasticity of 1.5 ($\rho=1/3$) as in Backus et al. (1994). To capture the intensiveness of trade in durable goods, we set ω_I and ω_C to match an import share of 13.3% where 65% of imported goods are for the purpose of producing the investment good. Engel and Wang (2011) claim that around 70% of trade is in durable goods. Using their same method, we find that the average share of imports in durable goods from 1980-2014 is about 65%. The parameter on the adjustment cost of the trade share ι is set to 400. The response of the equilibrium dynamics in this model to changes in ι is nonlinear. Changing ι from 0 to 10 dramatically changes dynamics while moving from an ι of 200 to 300 makes very little change. We choose 400 for the benchmark case since preliminary estimations of this parameter indicate that it takes on a high value.¹⁰

We set κ , which determines how quickly country productivities converge after a shock, to 0.002. This is below the value of 0.007 in Rabanal et al. (2011). Since we are considering an economy with symmetric countries, we are allowing productivities across countries to converge at a slower pace. In this paper, we allow for persistence in the growth rates of productivity and assume countries are symmetric so that $c = c^*$. We $\rho_g = 0.3$, which is close to estimates in Aguiar and Gopinath (2007) for developed economies. To match the steady state growth rate of .0035 from Rabanal et al. (2011) implies $c = .0025$. For Hicks-neutral productivity shocks, we choose a persistence ρ_z of 0.9. The volatility of idiosyncratic shocks to firms' productivity σ_η is set to 0.3. This implies that exporters are 16% more productive

¹⁰Testing for identification using the approach of ? confirms that ι is identified in estimation, although it is not strongly identified, possibly because of these nonlinearities. Because of this weak identification, we choose to use a more moderate value of $\iota=400$ and note that the dynamics of the model will be quite similar for parameter values above 300.

than nonexporters, within the range documented empirically by Bernard and Jensen (1999).

We set the steady state iceberg cost $\bar{\xi} = 1$. We want trade costs to be stationary but very persistent. We need stationarity because we are using a linearization to solve the model. We want high persistence because changes in trade costs are often permanent in nature. We set $\rho_{\xi}^d = 0.95$ and $\rho_{\xi}^c = 0.998$. We set $\rho_{\Delta} = 0.9$ so that the model generates the same average trade barrier over the next 10 years as with a 10 year linear phase-in.¹¹ This matches our empirical observations about free trade agreements. The fixed costs of exporting ensure that 3% of exporters stop exporting every period and 20% of all firms export.

The standard deviation for all shocks apart from ε_{η} is set to 0.01. We use Bayesian estimation to determine these parameters and set the standard deviation of our prior to infinity.

The estimation results as well as the prior distributions are listed in Table 3. We estimate all shock volatilities, the persistence parameters in each stochastic process, and several other variables from the model. We estimate the model to match eight series from the data: U.S. real GDP growth, nominal investment share, real trade share, real exports over imports, the terms of trade, hours of labor, the relative price of investment to consumption, and a measure of rest of world real GDP growth. U.S. data on nominal and real GDP, investment, consumption, exports, and imports were obtained from the BEA's National Income and Product Accounts tables for the period from 1980Q1 to 2016Q2. We define investment in the model to be gross private domestic investment plus the consumption of durables. With this data, we have real GDP growth, the nominal investment share, and the two trade series that we consider. The terms of trade comes from the BEA. Since our model lacks pricing to market, we cannot match both series. The measure for the rest of world real GDP comes from the Federal Reserve Bank of Dallas' Database of Global Economic Indicators. Our final set of eight series contains data from 1980Q2 to 2016Q2. The model is able to match all eight

¹¹With our geometric trade costs this leads to a slightly higher trade barrier over a ten year window..

series almost exactly, as shown in Figure 5.

6. Results

In this section, we examine the source of fluctuations in growth- and trade-related variables. To highlight the model's identification we first consider the response of key variables to innovations to productivity, investment costs, and trade costs. We then discuss the dynamics of trade and growth factors and their contribution to trade and output fluctuations. We then examine the model's forecasts for trade and growth. To close, we contrast the results in our dynamic trade model with those from a static trade model with no forward looking trade decisions or variables.

A. Impulse Responses

As our model has a number of novel features we discuss each shock in detail. Given that we have many shocks and country-specific shocks are often discussed in the literature, we focus on global shocks only. We first consider the effect of shocks that are emphasized as being the source of business cycles and then consider trade shocks.

Figure 11 shows that a shock to the trend in global productivity leads to a gradual decline in global productivity. The effect is largest on impact but productivity continues to fall for the next four quarters. On impact, this shock is expansionary as consumers work harder in advance of the impending deteriorating times. Investment also rises to smooth out the shock. Given the capital-intensity of trade this leads to a relatively sharp temporary increase in the trade-output ratio. After the initial boost in output, real output gradually falls as the country reduces its capital stock. This leads the trade-output ratio to remain relatively low along the transition.

Figure 12 shows that a transitory increase in productivity boosts output temporarily for the usual reasons. Hours and investment rise temporarily and the trade share rises with the higher investment rate.

A persistent fall in the price of investment boosts output and the investment rate (Figure 13). The higher investment rate leads to a persistent increase in the trade share. Investment and the trade share mean revert faster than the shock and with time the trade-output ratio is lower than initially.

We next consider the impact of changes in trade costs. Figure 14 plots a decline in the trend of trade costs. This gradually lowers trade costs. Perhaps surprisingly, it also generates a temporary recession on impact. The expected decline in trade costs makes consumers richer and also lowers the future price of investment. Both effects lead to a sharp contraction in hours, investment, and trade.

Figure 15 plots the impact of a persistent shock to the common trade cost. As this shock is close to a unit root, a decrease in trade costs leads to a small but persistent boom. On impact the investment rate rises and trade share rise. These remain elevated throughout with the trade share gradually growing owing to the accumulation of more exporters and changing input mix. We find the trade elasticity starts at about 0.75 and then very gradually rises to close to 1 over the next 10 years.

Figure 16 shows the response to a persistent decrease in the common trade costs with a very small adjustment cost. Here, the trade to output ratio rises on impact and then continues to rise over the next eight quarters before mean-reverting with the shock. The eight quarter impact is about 60% more than the impact effect. Thus the response of trade is much faster than with our input adjustment costs.

B. Trade and Growth Slowdown

Figure 7 shows estimated aggregate productivity movements for the U.S. and the rest of the world. US productivity fell in the 1980s with the recession but recovered quickly. The ROW is a trade weighted aggregate of US trading partners. Thus, the drop in productivity for the ROW in the 1990s is probably coming from the bad economic situation in Mexico, a

large trading partner of the US. The ensuing sharp increase in productivity may be coming from an increasing trade weight on China starting in the early 2000s. We see that in the slowdown period, US productivity decreases dramatically and does not seem to be recovering quickly. This indicates that movements in productivity are also important for explaining the slowdown.

Figure 6 shows the estimated movements in the log of trade costs from the model. For foreign firms exporting to the United States, we see that trade costs were decreasing consistently prior to the crisis. Exporters in the U.S. face increasing trade costs in the 1980s, stagnant trade costs in the 1990s and then see a large drop in trade costs. During the slowdown period, both trade costs seem to be increasing. This is suggestive that recent changes in trade policy or attitudes towards trade are partially responsible for the slowdown.

Figure 9 plots the estimated path of common trade costs along with expectations of the path in trade costs for the subsequent 10 years at various points. The actual paths of trade barriers are generally quite different than expectations. For instance, in 1980 trade costs were forecast to fall but rose instead. At the time of Nafta in 1995 trade costs moved about as expected. While the anticipated rise in trade costs at the start of the Great Recession never materialized. On the other hand, neither did the decline in trade costs at the start of the trade slowdown. Indeed, the current outlook calls for quite a stark increase in trade costs. Figure 10 shows how the trend trade cost has changed over time and clearly shows that the outlook for trade barriers worsened at the end of 2015.

Figure 17 plots the trade to output ratio and counterfactuals with only trade cost shocks (Trade) and productivity and investment cost shocks (Growth). The 80 log point rise in trade from 1980 to 2016 is clearly attributed almost entirely to a change in trade barriers. This is perhaps not surprising since the investment rate is essentially unchanged compared to 1980.

Trade integration though was a quite uneven process. The contribution of trade factors picks up in the late 80s and rapidly expands trade through the early 2000s. Interestingly,

growth factors became a substantial drag on trade integration at the time of the 2001 Recession and remained so until the recovery from the Great Recession.

Zooming into the period following the Great Trade Collapse we find that trade factors were a substantial drag on trade until the end of 2015. The drag from trade barriers was nearly completely offset by a boost from growth factors. Since the end of 2015, trade factors have boosted trade while growth factors have been a big drag on trade.

Turning to an accounting for US growth, we find a strong negative relationship between trade and growth factors (Figure 18). In terms of an unconditional variance decomposition, Table 5 shows the variance decomposition of HP-filtered variables. We find that trade shocks account for between 7 and 10 percent of the fluctuations in investment and output at typical business cycle frequencies. Figure 18 suggests that trade boosted growth in the lead up to the Great Recession, was a substantial drag in the Great Recession, and has been the sole source of growth in the dual slowdown period.¹²

C. Trade and Growth Forecasts

Our dynamic theory can also be used for forecasting. Here we consider the dynamics of the trade-output ratio as well as GDP growth. Recall, trade will evolve in response to pass and future trade cost changes as well as the aggregate shocks. Figure 19 plots the point forecast for real trade-output with a two standard deviation confidence interval. Our theory predicts that trade will fall consistently through 2019. The net effect is a near halving of the US trade share. There is considerable uncertainty about this forecast particularly further out. The near term weakness in trade integration actually has a positive impact on output growth through 2018 (figure 20) before output is expected to retrench substantially.

¹²The strong negative relationship between trade and growth factors in accounting for real gdp growth is perhaps exaggerated by the model since it abstracts from some features that have been shown to be important such as inventories (see Alessandria, Kaboski, and Midrigan, 2013).

D. Sensitivity

To clarify the effect of modelling trade as arising from a dynamic trade model we consider an alternative model without these features. In particular, we eliminate trend trade cost changes and instead assume all shocks to trade costs are nearly permanent. We also eliminate the sunk export cost and the input adjustment frictions. The model is estimated using the same data. Table 4 summarizes the estimated parameters.

A key finding is that the static model's fit is considerably worse with a marginal likelihood of compared to 2520 to 2200. Additionally, the model generates a very stable forecast for the trade share and real output going forward.

7. Conclusion

This paper is a first attempt to study US trade integration and business cycles in a unified framework. Our model allows for aggregate shocks to productivity and investment costs to influence trade flows and for shocks to trade costs to affect business cycles. Importantly, we allow trade to respond gradually to aggregate shocks to productivity or trade policy and explicitly model the changing trends in trade and growth with trend shocks to trade costs and productivity. We show that these changing trends and lagged effects are important to capture the growth and trade slowdowns following the Great Recession.

A key advantage of our dynamic theory is that we can use the model to discipline expectations on future growth and trade barriers. As many changes in trade policy can be anticipated, and are currently being discussed, this is a necessary feature of any quantitative analysis. This is particularly important as with trade intensive in durables and capital goods, trend shocks to productivity and trade barriers are shown to lead to substantial fluctuations in the investment rate and trade share. Indeed, we find that an expected increase in future trade barriers will stimulate investment and trade.

Our preliminary accounting attributes the trade slowdown to the waning influence of past

reforms and an increase in current and future barriers. The rise in future barriers suggests a relatively large reversal of trade integration. Static theories of trade are much less pessimistic about the future but also fit the data much worse. We also find that trade has actually had a positive effect on growth during the slowdown period and is expected to do so in the near term.

Finally, our results should be viewed with some caution as we find a very strong negative relationship between growth and trade factors for trade fluctuations. This likely arises from cyclical fluctuations in trade primarily being driven by composition and because of the sharp identification of future trade barriers through the investment rate. An interesting extension would be to allow for trade fluctuations because trade is inventory-intensive as emphasized by Alessandria, Kaboski, and Midrigan (2013).

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Appendix

- A1. Tables
- A2. Figures

Data	Precrisis	Slowdown	Percent change
OECD Real Imports	6.8%	3.2%	-53%
OECD Real Exports	6.8%	3.7%	-46%
US Real Trade	6.5%	2.6%	-60%
OECD Real GDP	2.7%	1.8%	-33%
US Real GDP	3.0%	2.0%	-33%
ROW Real IP	3.3%	2.2%	-33%
US Real IP	2.8%	2.0%	-29%

Table 1: Precrisis and slowdown average annualized quarterly growth rates.

Preferences	$\beta=0.99, \zeta=0.3, \gamma=0.18, \sigma=6$
Production	$\theta=2/3, \rho=1/3, \iota=400, \omega_C=0.076, \omega_I=0.895, \delta=0.05, \alpha=0.36$ $c=c^*=0.0025, \kappa=0.002, \rho_g = 0.3, \sigma_\eta = 0.3, \sigma_g^d=\sigma_g^c=0.01$
Trade Costs	$\bar{\zeta}=1, \rho_\xi^c=0.998, \rho_\xi^d=0.95, \rho_\Delta=0.9, \tau_1=0.039, \tau_0=0.077,$ $\sigma_\xi^c = \sigma_\xi^d = \sigma_\Delta^c = \sigma_\Delta^d=0.01$

Table 2: Initial calibration for model parameters. Estimated parameters include persistence and volatility of all shocks. We also estimate $c, \omega_C, \omega_I, \rho, \theta,$ and $\bar{\psi}$.

Param	Prior Dist	Pr Mean	Pr Std Dev	Lower Bd	Upper Bd	Post Mean
c	Normal	0.0025	0.002			0.001
ω_C	Beta	0.078	0.05	0	1	0.003
ω_I	Beta	0.895	0.05	0	1	0.9
ρ	Beta	0.33	0.15	0	0.99	0.15
$\theta - \rho$	Inverse Gamma	0.34	0.15			0.6
$\bar{\psi}$	Normal	0	0.01			0.01
ρ_ξ^d	Beta	0.95	0.05	-1	0.999	0.97
ρ_g	Beta	0.3	0.2	0	1	0.42
ρ_z	Beta	0.9	0.05	-1	1	0.91
ρ_ψ	Beta	0.9	0.05	-1	1	0.97
σ_ψ^c	Inverse Gamma	0.01	∞			0.069
σ_ψ^d	Inverse Gamma	0.01	∞			0.1
σ_z^c	Inverse Gamma	0.01	∞			0.003
σ_z^d	Inverse Gamma	0.01	∞			0.016
σ_g^c	Inverse Gamma	0.01	∞			0.006
σ_g^d	Inverse Gamma	0.01	∞			0.007
σ_ξ^c	Inverse Gamma	0.01	∞			0.118
σ_ξ^d	Inverse Gamma	0.01	∞			0.051
σ_Δ^c	Inverse Gamma	0.01	∞			0.024
$\text{corr}(\varepsilon_\xi^c, \varepsilon_\Delta)$	Normal	0	0.2			0.39

Table 3: Prior distributions and posterior means.

Param	Prior Dist	Pr Mean	Pr Std Dev	Lower Bd	Upper Bd	Post Mean
c	Normal	0.0025	0.002			0.002
ω_C	Beta	0.078	0.05	0	1	0.0004
ω_I	Beta	0.895	0.05	0	1	0.876
ρ	Beta	0.33	0.15	0	0.99	0.212
$\theta - \rho$	Inverse Gamma	0.34	0.15			0.6
$\bar{\psi}$	Normal	0	0.01			-0.07
ρ_g	Beta	0.3	0.2	0	1	0.54
ρ_z	Beta	0.9	0.05	-1	1	0.93
ρ_ψ	Beta	0.9	0.05	-1	1	0.997
σ_ψ^c	Inverse Gamma	0.01	∞			0.105
σ_ψ^d	Inverse Gamma	0.01	∞			0.206
σ_z^c	Inverse Gamma	0.01	∞			0.014
σ_z^d	Inverse Gamma	0.01	∞			0.017
σ_g^c	Inverse Gamma	0.01	∞			0.009
σ_g^d	Inverse Gamma	0.01	∞			0.015
σ_ξ^c	Inverse Gamma	0.01	∞			0.04
σ_ξ^d	Inverse Gamma	0.01	∞			0.064

Table 4: Estimation priors and results for a static model with no input adjustment costs ($\iota=0$), no sunk cost of exporting ($\tau_0 = \tau_1$), and no gradual phase-ins ($\sigma_\Delta = 0$).

Variable	Growth	Trade	ε_g^c	ε_g^d	ε_ψ^c	ε_ψ^d	ε_z^c	ε_z^d	ε_Δ^c	ε_ξ^c	ε_ξ^d
RER	94.11	5.89	0.00	32.04	0.00	59.68	0.00	2.40	0.02	0.01	5.86
Real Trade	19.82	80.18	0.74	0.10	18.56	0.00	0.42	0.00	56.19	23.99	0.00
Real Output	89.90	10.10	0.16	31.69	1.91	55.14	0.15	0.85	3.85	0.77	5.48
Trade/Output	34.01	65.99	0.98	6.18	14.67	11.79	0.21	0.18	44.90	19.91	1.17
Inv/Output	92.44	7.56	0.07	34.15	0.94	57.05	0.01	0.22	1.85	0.19	5.52
Labor	35.55	64.45	2.04	3.80	22.06	6.45	0.27	0.93	59.81	3.06	1.57

Table 5: Variance decomposition of HP-filtered variables. The first column is the percent of variance coming from growth, productivity, and investment specific technology shocks. The second column is the percent of variance from shocks to trade costs. Columns 3-11 show the contribution to the variance for each type of shock separately.

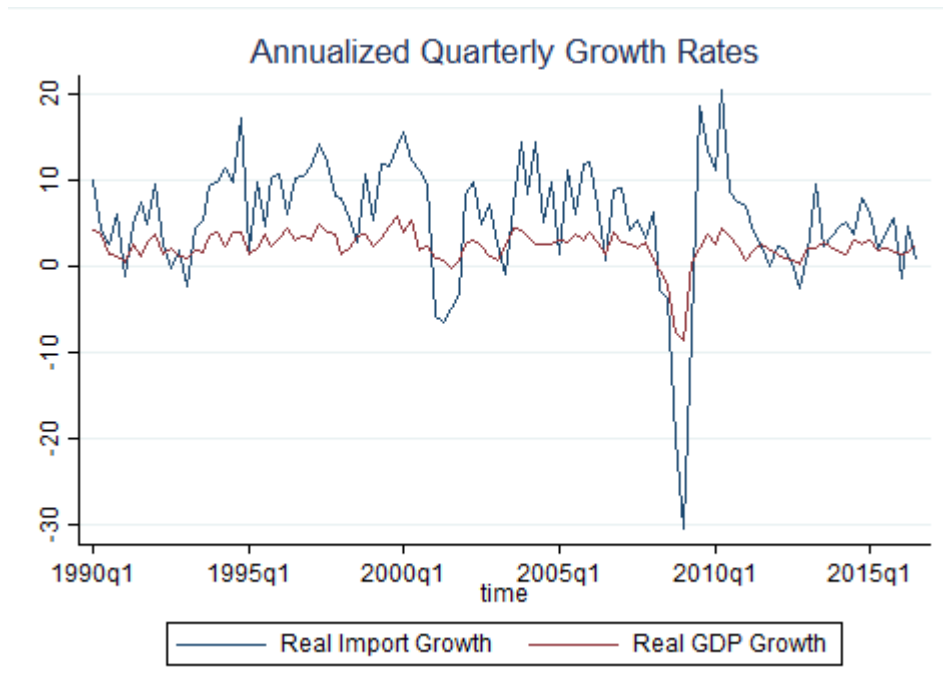


Figure 1: Weighted growth for OECD aggregate.

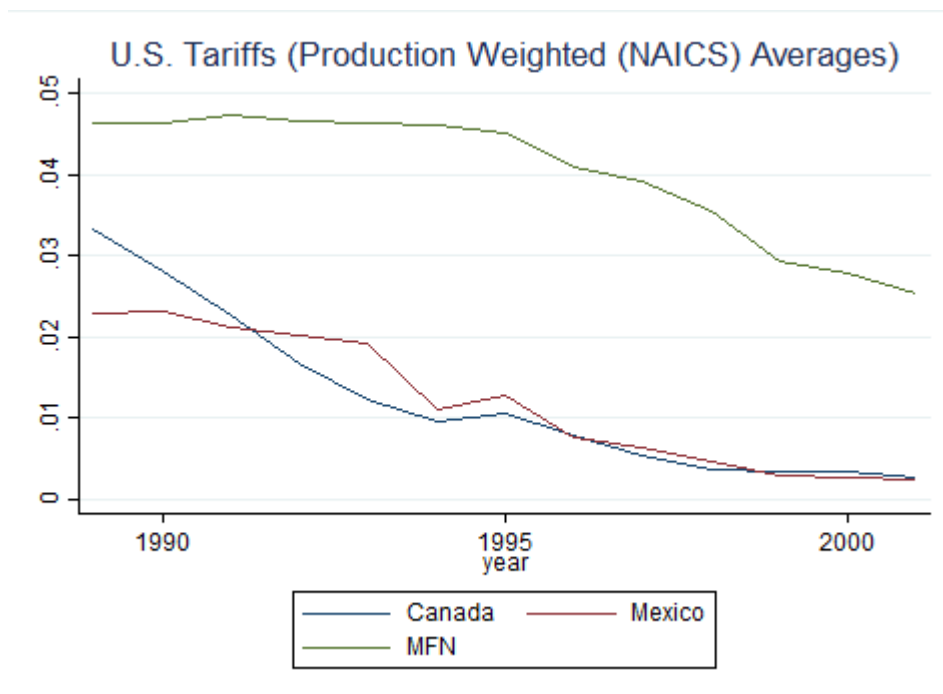


Figure 2: Production weighted average tariffs imposed by the U.S. against Canada and Mexico. Also, the production weighted average most favored nation tariff.

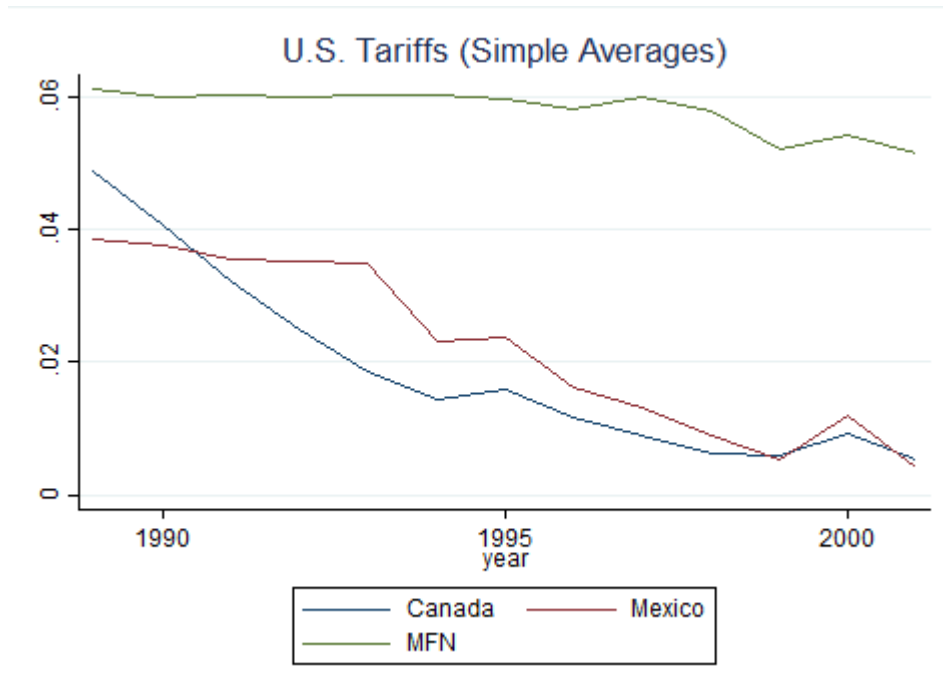


Figure 3: Simple average tariffs across all products at the HS8 level.

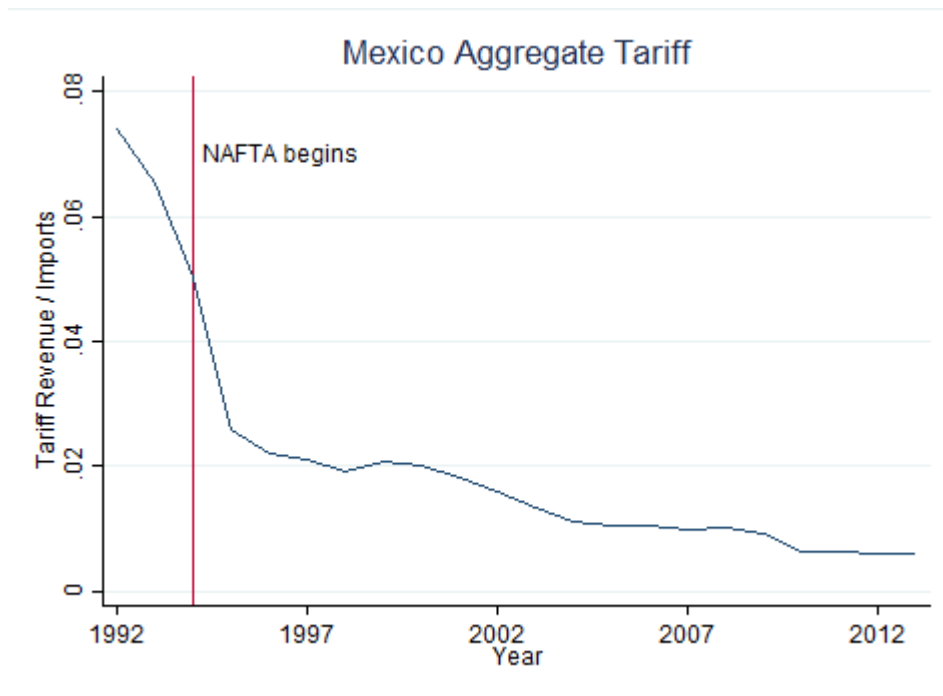


Figure 4: Mexico's aggregate ad valorem equivalent tariff.

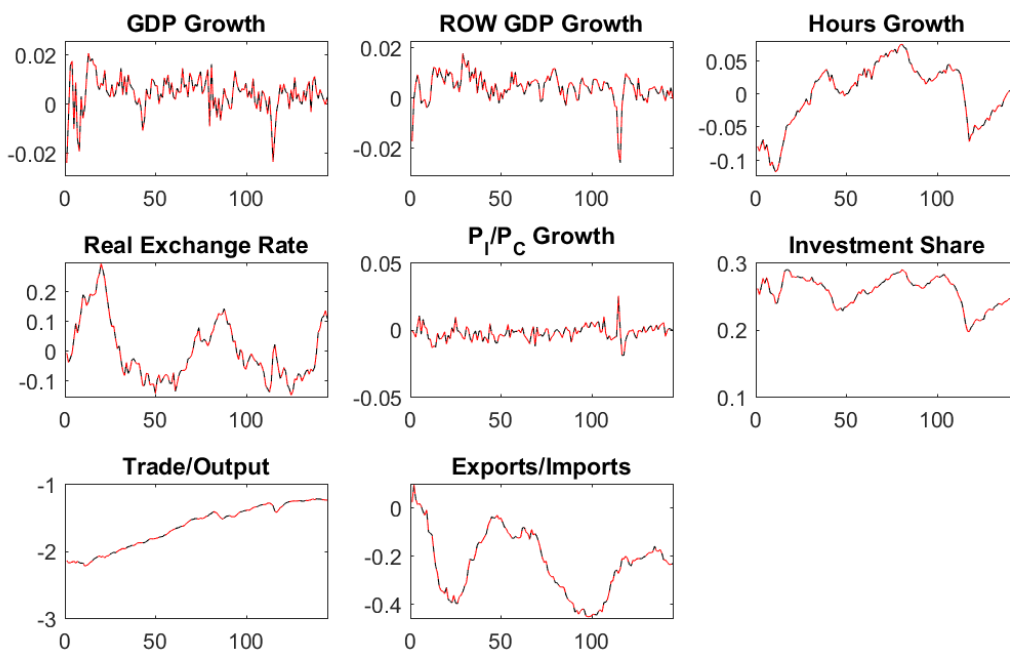


Figure 5: This figure shows the historical data (black) and the estimated series (red).

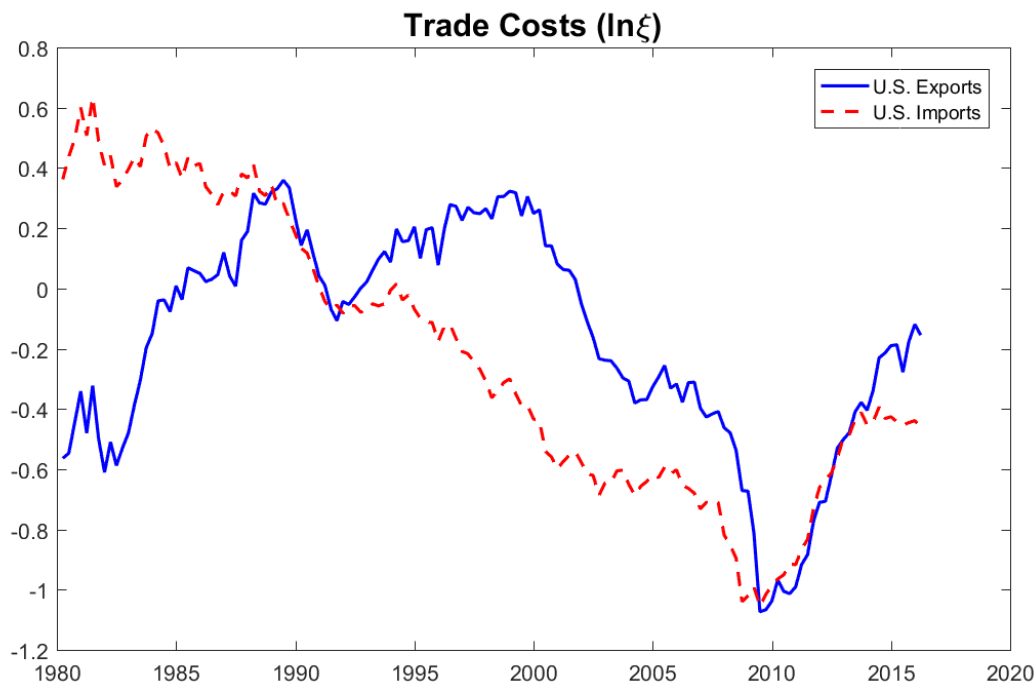


Figure 6: Estimated trade costs from 1980 to 2016.

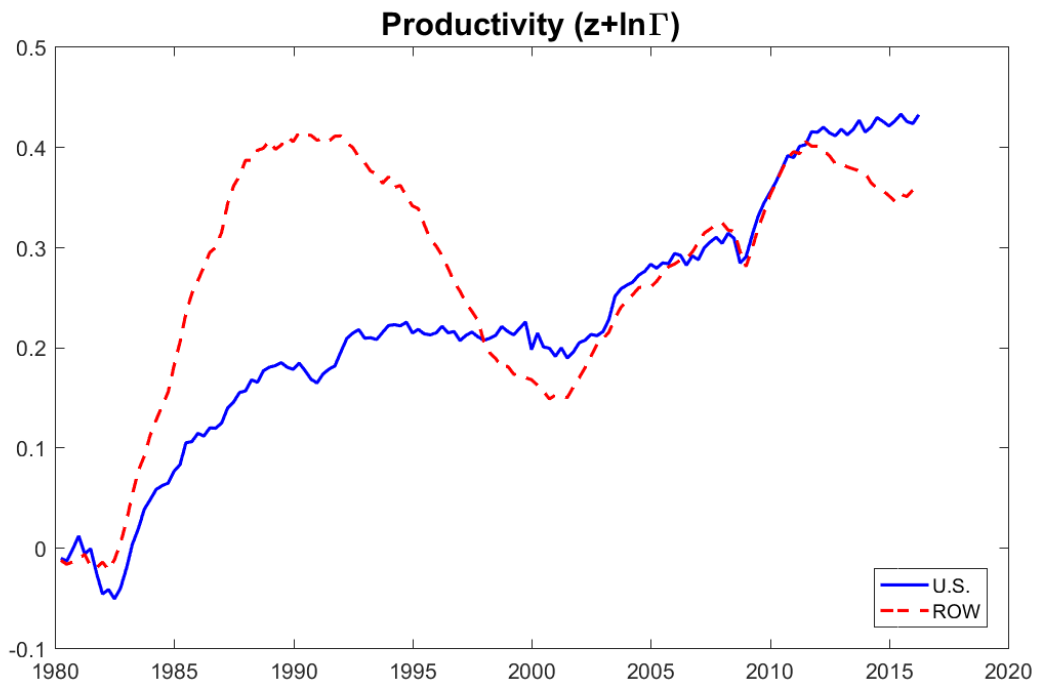


Figure 7: Estimated productivity for U.S. and the ROW from 1980 to 2016.

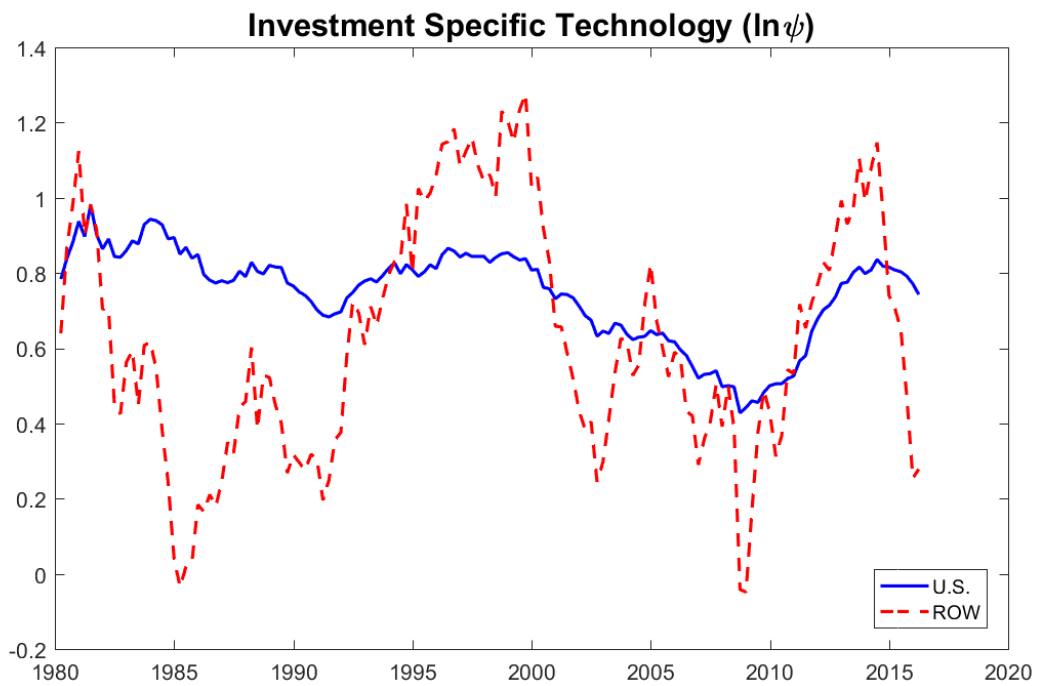


Figure 8: Estimated investment specific technology for U.S. and the ROW from 1980 to 2016.

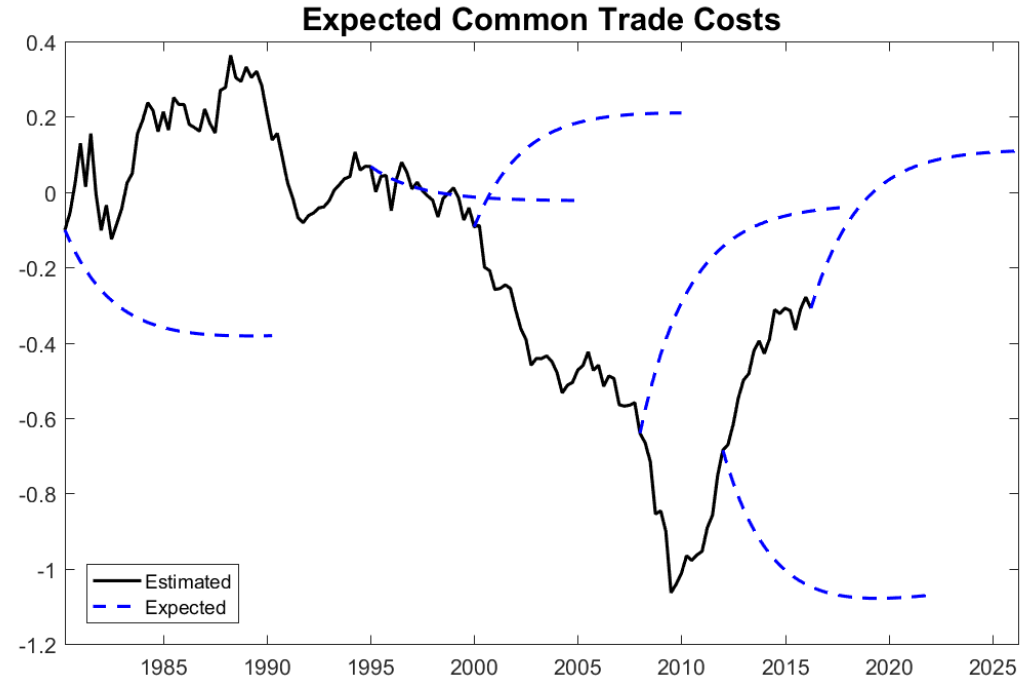


Figure 9: Common trade cost faced by exporters. Blue lines show agents predictions for future trade costs at different horizons.

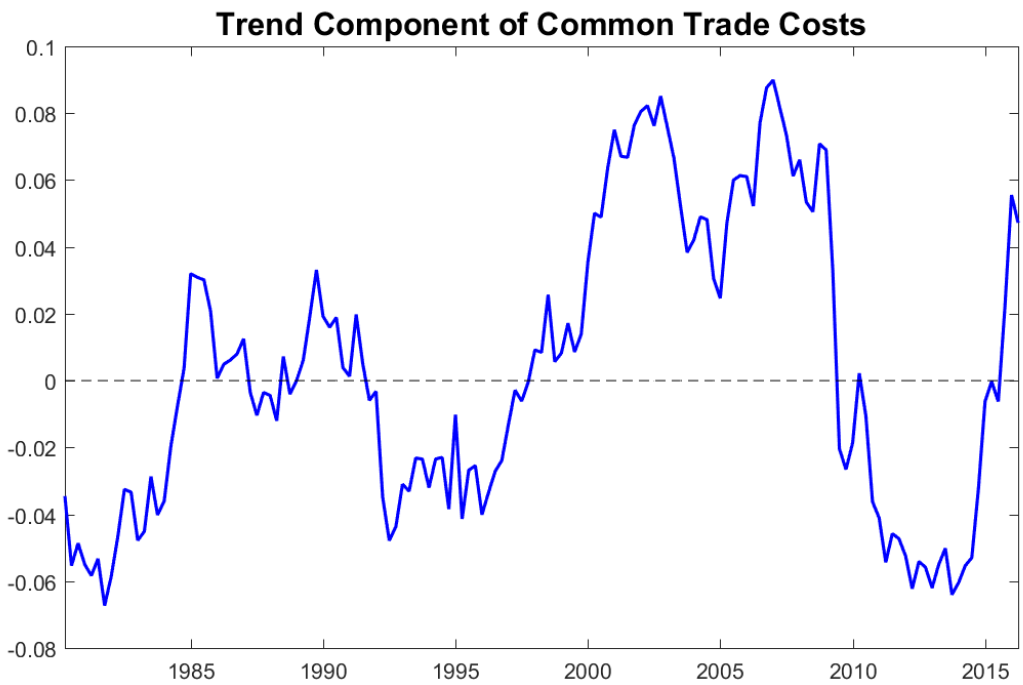


Figure 10: Trend component of common trade costs.

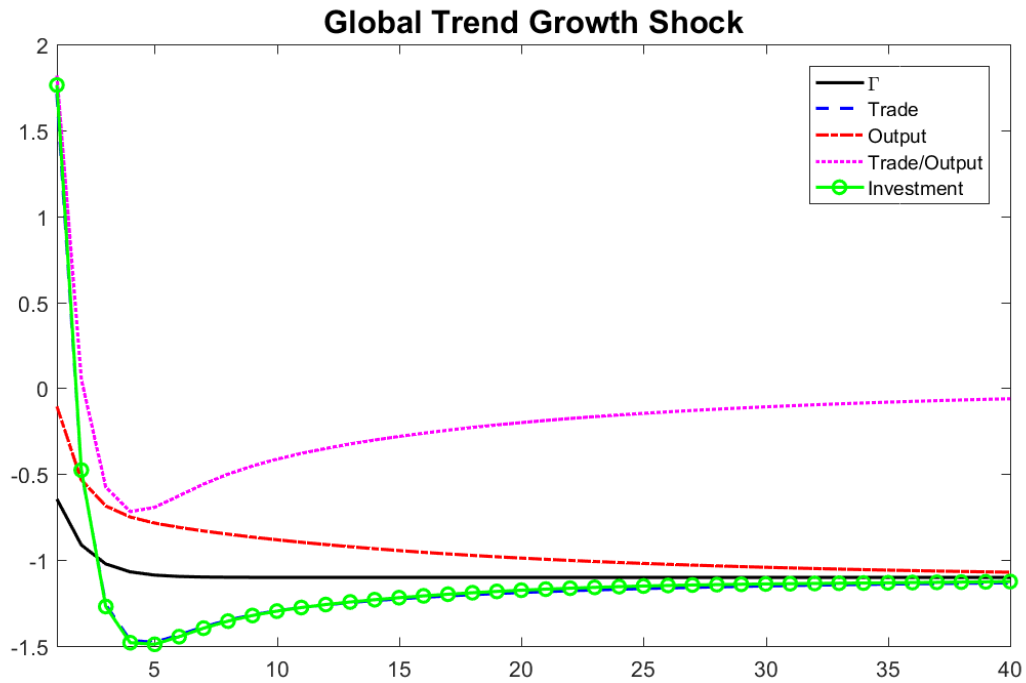


Figure 11: Impulse responses to a one standard deviation shock to ε_g^c .

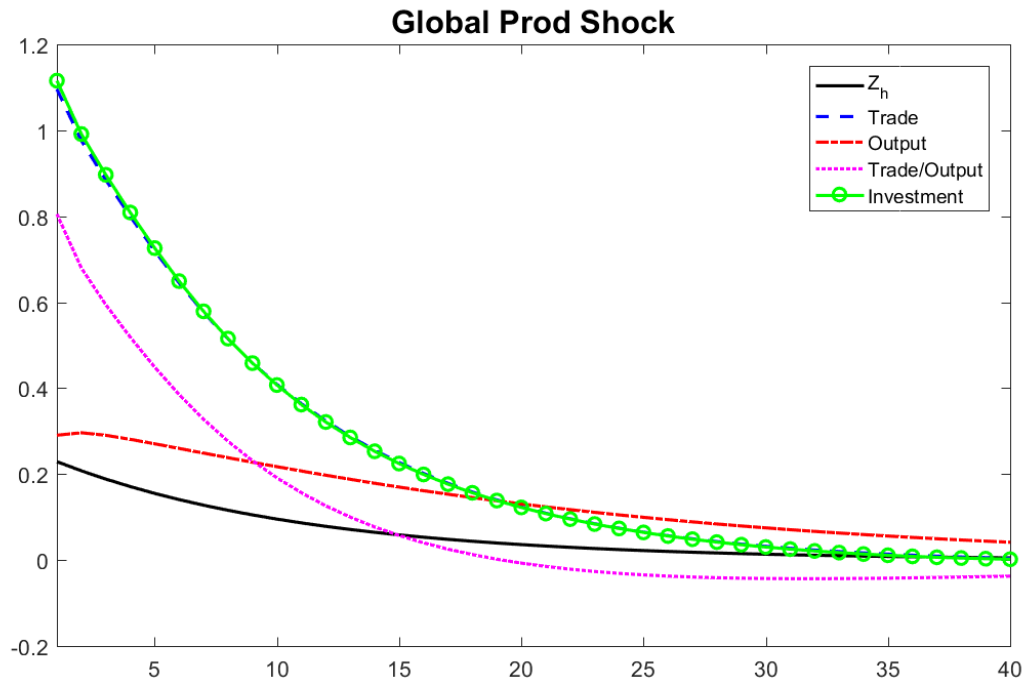


Figure 12: Impulse responses to a one standard deviation shock to ε_z^c .

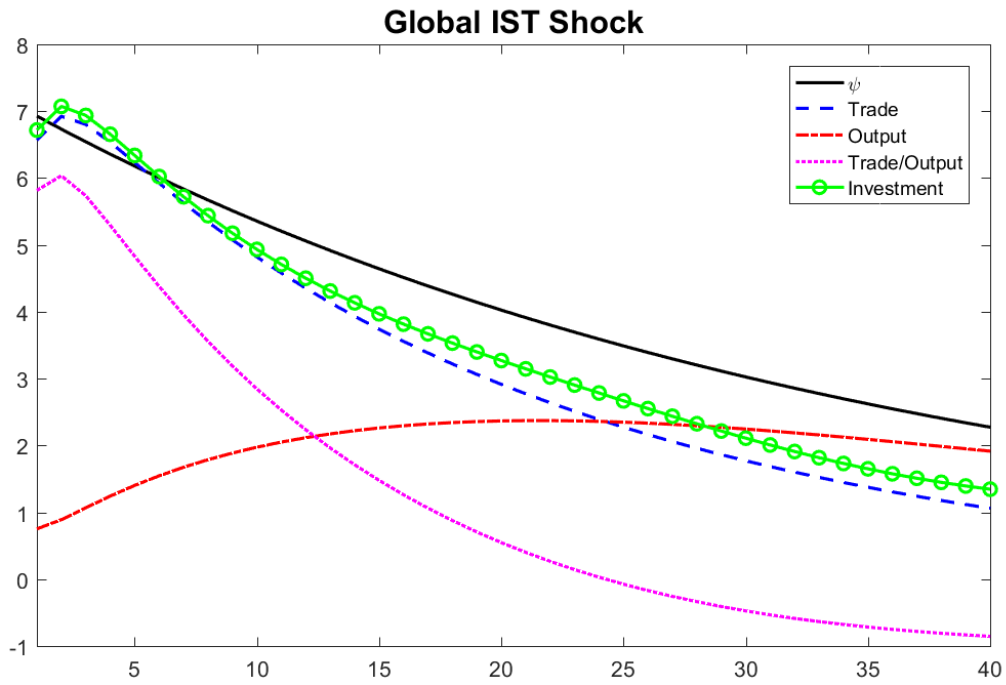


Figure 13: Impulse responses to a one standard deviation shock to ε_{ψ}^c .

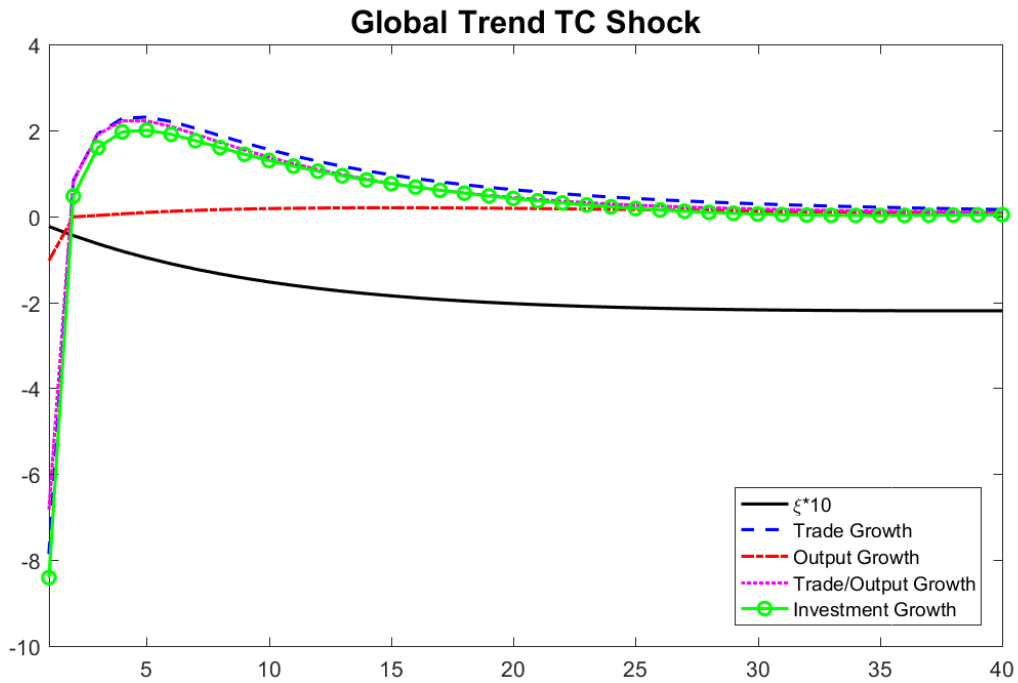


Figure 14: Impulse responses to a one standard deviation shock to ε_{Δ}^c .

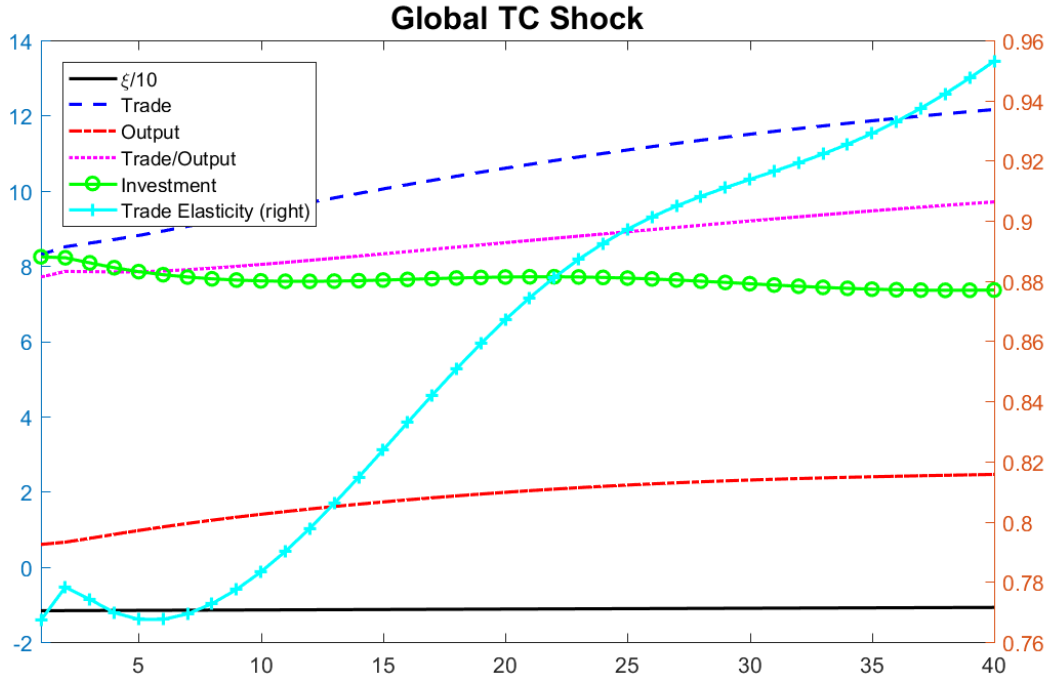


Figure 15: Impulse responses to a one standard deviation shock to ε_{ξ}^c .

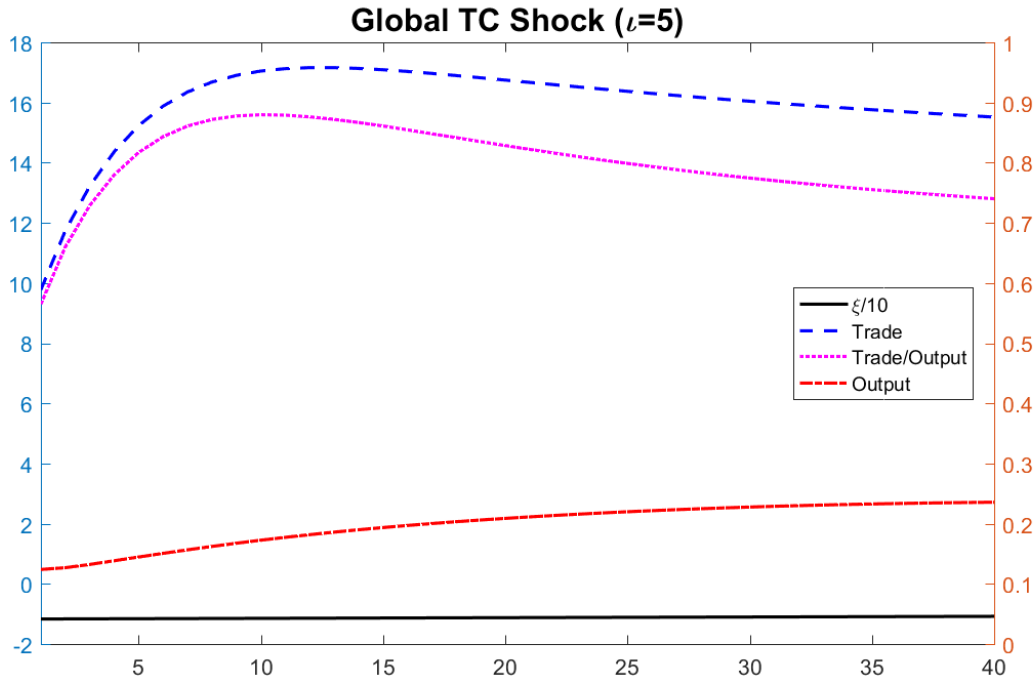


Figure 16: Impulse responses to a 1% shock to ε_{ξ}^c with no adjustment cost on the import share.

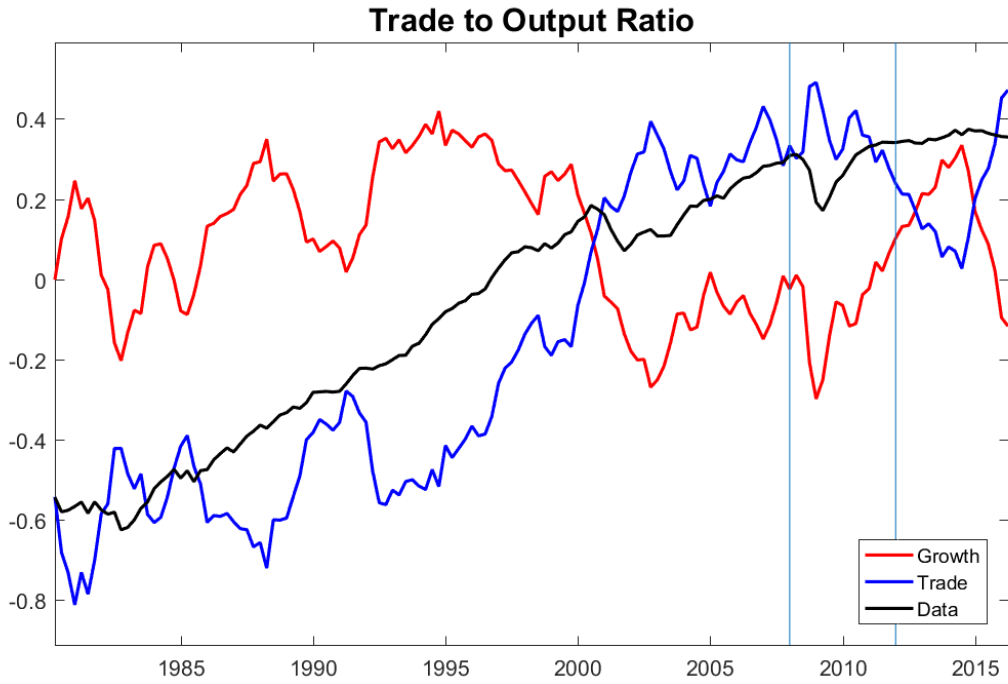


Figure 17: Trade to output ratio counterfactuals where growth shocks or trade cost shocks are eliminated.

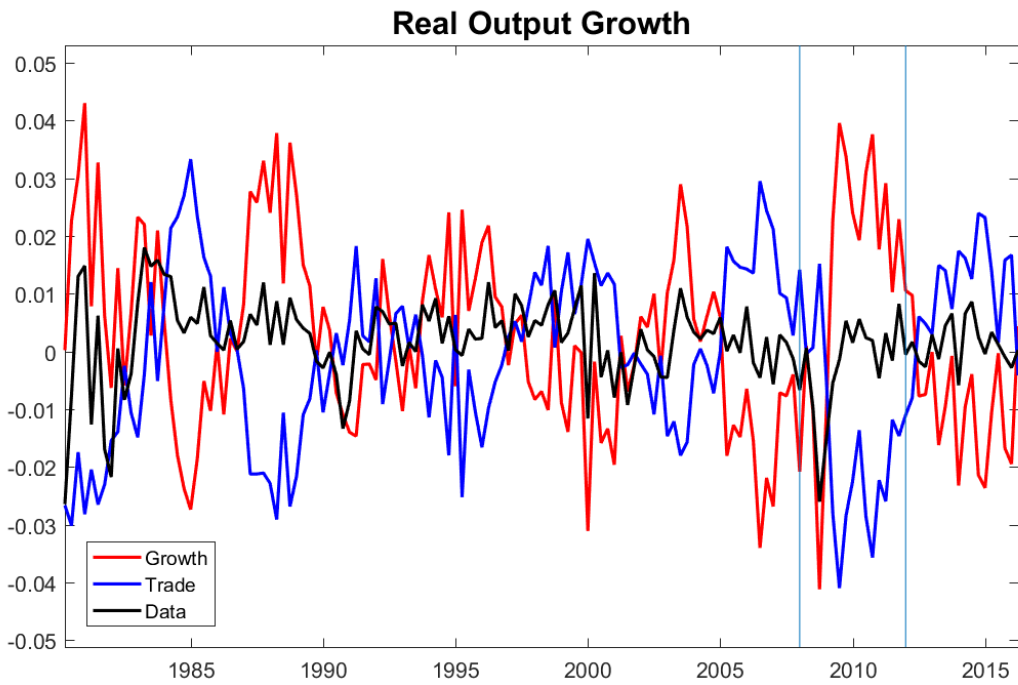


Figure 18: Output growth counterfactuals where growth shocks or trade cost shocks are eliminated.

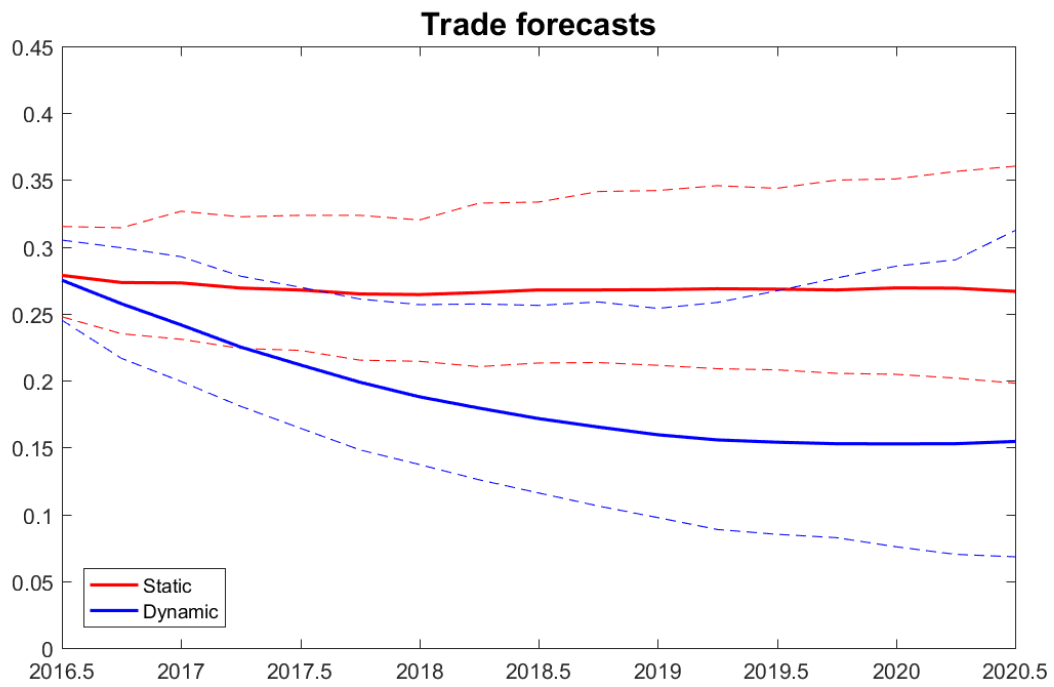


Figure 19: Forecasts of the trade to output ratio in the benchmark vs a static model.

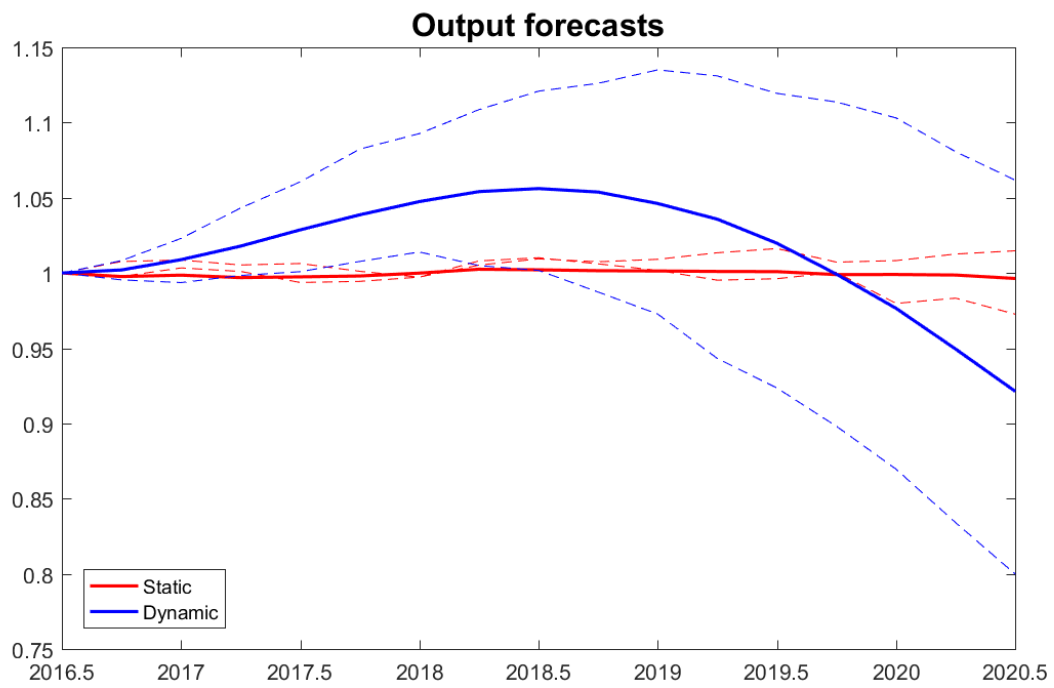


Figure 20: Forecasts of output in the benchmark vs a static model.