The Dynamics of the U.S. Trade Balance and the Real Exchange Rate: The J Curve and Trade Costs?*

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Abstract
We study empirically and theoretically the dynamics of the US trade balance. We propose a theoretical decomposition of fluctuations in the trade balance into terms related to trade integration (global and unilateral) and terms related to asymmetries in the business cycle. We find three main results. First, the relatively large trade deficits as a share of GDP of the US in the 2000s compared to the 1980s mostly reflect a rise in trade share of GDP. Second, between 40 and 80 percent of the fluctuations in ratio of the trade balance to trade reflects an uneven pace of trade liberalization. Third, while asymmetries in the business cycle account for 20 to 60 percent of fluctuations in the trade balance over trade, over two-thirds of the business cycle induced movements in net trade flows are a lagged response to changes in the terms of trade and real exchange rate. That is, the short-run Armington elasticity is about 0.15 while the long-run is closer to 1.7 with only 7 percent of the gap closed per quarter. Constant elasticity models of trade explain less than 10 percent of the movements in the trade balance.

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1. Introduction

What leads a country to run a trade deficit or surplus? The traditional view is that these imbalances reflect differences in the business cycle from productivity, monetary, or fiscal shocks. In this paper, we show a surprisingly large share of fluctuations in the ratio of the trade balance to GDP over time actually reflect trade integration, both global and local, rather than asymmetries in business cycles across countries. We propose a theoretical decomposition of the trade balance into terms related to trade integration (both global and unilateral) and a term related to asymmetries in business cycles (from relative prices and relative expenditure). We then build a model of trade integration and the business cycle and use it to evaluate the contribution of trade integration and business cycles to trade balance dynamics.

To set ideas, figure 1 plots two salient features of the US economy's connection with the rest of the world: rising trade deficits and rising trade. For instance, in the 1980s the US trade deficit as a share of GDP peaked in 1986q3 at 2.6 percent. Twenty years on, it peaked at 5.6 percent of GDP. In both cases, the maximum trade deficit lagged the peak real exchange rate by about 6 quarters and the peak real exchange rates were of roughly similar magnitude. The near doubling of the peak of the US trade deficit across these two periods though occurred as trade doubled from 13.1 percent of GDP to 26.1 percent. We seek to sort out whether the much larger trade deficit of 2006 reflects greater substitution between domestic and foreign tradables or reflects growing integration. To make this point clear, we decompose the movements in the trade deficit to GDP ratio into the movements in the ratio of net exports to trade (NXTR) and trade to GDP (TRY),

$$(1) \quad TBY = \frac{X - M}{X + M}\frac{X + M}{Y} = TBTR * TRY$$

Figure 2 plots the US trade deficit to GDP ratio and a counterfactual US trade deficit with the same trade share as 1986. Not surprisingly, holding trade constant at its 1986 level leads

to a peak trade deficit in 2006 of only 2.7 percent, almost the same in 1986. This suggests that the movements in the trade balance as a share of overall trade where about the same in 2006 as in 1986.

Trade integration also contributes to fluctuations in the ratio of the trade balance to trade. We propose a simple theoretical decomposition of the trade balance to trade ratio into terms related to uneven trade integration and differences in the business cycle that builds on the Armington CES structure. Our decomposition extends the trade wedge accounting approach of Levchenko, Lewis and Tesar (2010) and Alessandria, Kaboski, and Midrigan (2013). The business cycle component is determined by relative expenditures, relative prices (both the terms of trade and real exchange rate), and the Armington elasticity. We undertake this analysis explicitly taking into account the well-known idea that the trade balance takes time to respond to movements in the real exchange rate and terms of trade. Indeed, a contribution of this paper is to estimate the short-run and long-run Armington elasticity along with the speed of adjustment and evaluate the role of these different elasticities on the dynamics of the trade balance.

We find three main results about the dynamics in the US trade balance. First, the relatively large trade deficits as a share of GDP of the US in the 2000s compared to the 1980s mostly reflects a rise in the trade share of GDP. Indeed, holding trade constant at the level from the 1980s would have reduced the average trade deficit roughly in half. Second, between 40 and 78 percent of the fluctuations in the ratio of the trade balance to trade over time reflects an uneven pace of trade liberalization. Third, while asymmetries in the business cycle, as reflected in movements of relative production and relative prices, account for the remaining 22 to 60 percent of fluctuations in the trade balance over trade, almost 2/3 of the business cycle induced movements in net trade flows are a lagged response to the business cycle. A simple way of seeing this is that the short-run elasticity is about 0.15 while the long-

run is closer to 1.65 and only about 6.6 percent of the gap gets closed each quarter.[1] Allowing for a gradual responses of trade to relative price movements, increases the importance of the business cycle (particularly relative price movements) and reduces the importance of uneven trade liberalizations.

Our empirical exercise summarizes the timing and state of trade integration. As in Levchenko, Lewis, and Tesar, (2010), Alessandria, Kaboski and Midrigan, (2013) we recover US import trade wedges. Unlike these other papers, we also measure the wedge on ROW imports from the US. Starting in 1980, these wedges suggest that foreign trade integration grew faster than that in the US, but some time in the early 2000s foreign integration actually reversed while the pace of US integration slowed. Since the Great Recession, it appears that trade integration has reversed in the ROW and stagnated in the US.

To address the features of the trade balance and international business cycles we build on the heterogeneous producer model of Alessandria and Choi (2007). This is a variation of the Backus, Kehoe, and Kydland (1994) international real business cycle model with heterogenous producers subject to idiosyncratic productivity shocks and a sunk and fixed cost of exporting as in Dixit (1989), Baldwin and Krugman (1989), and Das, Roberts and Tybout (2007). The heterogeneity and dynamic exporting decision leads the exporters to respond gradually to aggregate shocks. We extend the model along two dimensions. First, we introduce pricing-to-market by allowing the trade elasticity in foreign markets to be variable. Pricing-to-market is crucial to explain the persistent deviations from the law of one price across countries and to get the real exchange rate to fluctuate more than the terms of trade as in data (see Alessandria 2009). Additionally, pricing-to-market leads US firms to raise their markups when the US real exchange rate depreciates. These higher markups lead to a stronger expansion of US exporters than in the constant markup case. Second, we introduce shocks to the costs of trade in each country. The persistent component of trade costs is chosen to match the more

[1] These elasticities are about twice as large when we focus only on trade in goods excluding oil.

than doubling of US trade-to-GDP ratio from the 80s. The temporary shocks to trade costs are chosen to capture the highly cyclical nature of trade, particularly around turning points of the economy. Through a series of numerical exercises we show that uneven changes in trade integration can generate large and persistent movements in the trade balance and real exchange rate.

We then apply the model to examine the contribution of asymmetric trade shocks to trade balance to trade ratio. We find that about 27 to 30 percent of the fluctuations in the trade balance to trade ratio since 1980 are attributable to uneven trade integration. This number though hides some important variation over time. For instance, since 2012 the uneven trade shocks account for more than half of the US trade deficits.

This paper is related to models of international transmission with flexible and sticky prices such as Backus, Kehoe and Kydland (1994), Chari, Kehoe and McGrattan (2002) and Corsetti, Dedola and Leduc (2008). The paper is most closely related to models with a different short-run and long-run trade response (Alessandria and Choi (2007), Drozd and Nosal (2011), Engel and Wang (2012), Alessandria, Pratap and Yue (2011) and Imura (2013). This paper is also related to models that consider trade costs in aggregate fluctuations (Levchenko, Lewis, and Tesar, 2010, Alessandria, Kaboski and Midrigan, 2010, 2011, 2013). This paper is also related to papers that estimate trade elasticities. Like this paper, Hooper, Marquez, and Johnson (2000) estimate error correction models of US import demand while Gallaway, McDaniel and Rivera (2003) estimate these at the industry level. This paper also contributes to the recent literature on global imbalances (Caballero, Farhi, and Gourinchas, 2008) and the adjustment required to close these imbalances (Obstfeld and Rogoff, 2005 , Dekle, Eaton, and Kortum, 2008). A key conclusion of our analysis is that the same theory of trade balance dynamics can explain the 1980's and 2000's US trade balance dynamics.

In section 2, we focus on decomposing the source of net export fluctuations. In section 3, we build a two country general equilibrium model of endogenous trade participation, trade

integration, and the business cycle. In section 4, we examine the properties of the model in response to changes in trade costs and productivity. Section 5 concludes.

2. Evidence

In this section we extend the simple decomposition from equation 1 to include some theoretical structure. This theoretical structure is used to relate the conventional view of the determinant of the comovement between the real exchange rate and trade balance from Backus, Kehoe and Kydland (1994) to our findings. We then estimate the key parameters of the theoretical model determining the trade balance. The estimated model is used to decompose the fluctuations in the US trade balance. Finally, we present the inferred shocks to trade integration.

The simple decomposition of the trade balance in equation 1 is easy to extend to include the Armington trade model common to multi-country trade models of integration and business cycles. In the Armington trade model with home and foreign goods that are imperfect substitutes the ratio of exports to imports is described by the following structural relationship

$$(2) \quad \ln(X/M) = \ln(\omega^*/\omega) - \rho\left[\ln\left(P_x(1+\tau^*)/P^*\right) - \ln\left(P_m(1+\tau)/P\right)\right] + \ln(D^*/D),$$

where ρ is the elasticity of substitution between home and foreign goods, τ, τ^* are trade costs/taste shifters, P_x and P_m are the export and import prices, P, P^* are the home and foreign price levels, D, D^* denote home and foreign domestic absorption. It is straightforward to show that

$$\ln(X/M) \approx 2NXTR = 2\frac{X-M}{X+M}$$

so that we can decompose the trade balance in the following way[2]

$$NXY \approx 0.5\ln(X/M) * TRY$$

[2] This measure overstates the maximum deficit by 0.4 percentage points (22.7 percent vs 23.1 percent).

For our purposes it is useful to combine the changes in trade costs and tastes together into T*,T and define the terms of trade and real exchange rate as

$$TOT = P_m/P_x \text{ and } RER = P^*/P$$

and then rewrite our equation as

$$\ln(X/M) = \ln(T^*/T) + \rho[TOT + RER] + \ln(D^*/D)$$

This provides a simple decomposition of the trade ratio into changes in trade costs, substitution from relative prices, and relative expenditures.

This key equation also sheds light on the famous "S-curve" result from Backus, Kehoe, and Kydland (1994) that echoes an earlier literatures emphasis on the J-curve. They show that the tendency for the trade balance to decrease initially and then gradually increase following a depreciation of the real exchange rate[3] is well-described by a two country dynamic stochastic general equilibrium model with productivity shocks and capital accumulation.[4,5] In that model a positive productivity shock leads both to a depreciation of the real exchange rate and a trade deficit. The cross country productivity gap lowers the price of the home good yielding a depreciation while temporarily stimulating investment leading to a trade deficit.

The apparent success of the two country RBC model in explaining the comovement between the trade balance and the real exchange rate is actually rooted in its two well-known failures: the quantity and price puzzles. The quantity puzzle is the inability of the model to generate synchronized business cycles. The price puzzle is the inability of the model to generate large enough relative price movements. Whenever the real exchange rate depreci-

[3]BKK focus on the dynamics between the trade balance and the terms of trade not the real exchange rate. However, in their framework the terms of trade and real exchange rate are perfectly correlated.

[4]Raffo (2008) points out that in the BKK model that real trade balance to gdp ratio and nominal trade balance to gdp are negatively correlated when investment is constrained to match the observed pattern in the data while in the data they are quite positively correlated. By making consumption more volatile he can fix this problem.

[5]Heathcoate and Perri (2014) use this model as the benchmark for international business cycles in the recent handbook of international economics chapter.

ates, say from an increase in productivity, this makes the ratio of exports to imports increase. To generate a trade deficit with a depreciation then requires the second term, which is the difference in foreign and domestic expenditures, to respond strongly to offset the substitution effect. Taken together the quantity and price puzzles make the expenditure effect quite strong and the substitution effect weak. With a strong but temporary gap in cross country expenditures the ratio of expenditures will move from deficit to surplus over time explaining the gradual response of the trade balance following the depreciation.

By controlling for movements in relative expenditures it is straightforward to see that the trade-expenditure ratio equals

$$(3) \quad \ln(X/M) - \ln(D^*/D) = \ln(T^*/T) + \rho\,[TOT + RER]\,,$$

With this in hand, it is clear that once one controls for movements in relative expenditures all that is left is the substitution effect and so a depreciation will always lead to a surplus in this alternative measure of the net trade flows. Moreover, correlations of the left hand side with lags of the real exchange rate will equal to the autocorrelation of the trade-expenditure ratio.

To evaluate the determinants of the fluctuations in the trade ratio we estimate equation 3, where now $\ln(T^*/T)$ can be interpreted as a combination of trade integration shocks plus a residual. Table 1 reports the results of three types of regressions, in first differences, levels, and first differences with an error correction term.[6] All coefficients are quite significant. We find that the Armington elasticity is quite low in the short run, between 0.15 and 0.18. The level regression suggests an elasticity closer to 0.53, but this mixes the short-run and long-run. The error correction model suggests a short run elasticity of 0.14 and a long-run elasticity of 1.65 with 6.6 percent of the gap between the current net export ratio of the long-run closed

[6] The error correction model is $d.nxrdd = d.tot + l.nxrdd + l.tot$ where nxrdd is the dependent variable, tot is the relative price term, d denotes difference and l denotes lag.

each quarter. [7]

The fit of the empirical model of changes in the trade-expenditure ratio rises from 4.7 percent in differences to 28.1 percent in our short-run/long-run model. The relatively poor fit of the empirical models suggests there are substantial movements in the trade-expenditure ratio that are related to trade integration. These shocks could reflect a different pace of liberalization (contemporaneous and lagged effects) or perhaps inventory type considerations (see Alessandria, Kaboski, and Midrigan, 2013). While inventory considerations are a reasonable source of short-run trade wedges, they are unable to account for the long-run changes in the wedges we observe. The much better fit of the SR/LR model (error correction) suggest that most of the effect of relative prices occurs only gradually.

The estimated coefficients from the regression of changes in the trade-expenditure ratio are used to come up with a predicted path of the trade-expenditure ratio. Figure 3 plots the predicted trade-expenditure ratio from the data and these three statistical models along with the US real exchange rate. The error correction model clearly captures the gradual movements in the trade-expenditure ratio to movements in the real exchange rate. In particular, the delayed response of the trade-expenditure ratio to the Plaza Accord and the depreciation of the dollar in the early 2000's are quite evident.

Table 2 reports how well these models explain the movements in the trade-expenditure ratio. To construct a trade-expenditure measure from the models estimated on changes we accumulate the changes. To measure the fit of the model in differences we chose the mean of these series to minimize the sum of squared residuals between the model and data.[8] Not surprisingly, the SR/LR elasticity model captures between 2.2 to 3 times as much of the variation in our trade-expenditure ratio measure as the constant elasticity models (59.6

[7] We also run the regressions allowing the coefficient on relative expenditure to differ from 1 in the short-run. This generally improves the fit but has a minimal impact on our estimate of the Armington elasticity.

[8] This perhaps overstates the importance of the model in differences since it assumes the US is running a permanent trade deficit.

percent vs 21.2 to 25.9 percent).

Focusing just on the trade ratio by adding back in the differences in expenditures, boosts the contribution of the business cycle slightly to 62.5 percent for the SR/LR model and 26.7 to 31.1 percent for the constant elasticity model. The small additional role of the business cycle arises because business cycles are quite synchronized in the data and thus the gap in expenditures/production across countries never is very large compared to the movements in the real exchange rate, reinforcing our explanation of why the standard IRBC model generates fluctuations in the trade balance through a counterfactual mechanism - quite asymmetric business cycles.

We attribute the movements of the trade ratio that are not explained by the movements in relative prices or expenditures as arising from asymmetric trade integration shocks. Thus depending on our empirical model, uneven trade liberalization explains between 40 and 73 percent of the fluctuations in the export ratio.

Table 3 reports the average US trade deficit in the data since 1991 and a counterfactual holding the share of GDP in trade at its 1986 level. Without trade growth, the average US trade deficit would have been slightly more than half as big (1.58 percent vs 2.95). Attributing the gap between the data and this counterfactual to trade integration, suggests that just under half of the average US trade deficit since 1991 was due to increased multilateral trade integration.

Table 4 combines the results of the previous two tables to decompose the source of fluctuations in the trade balance to GDP from 1991 to 2014.[9] Trade integration has been the main driver of fluctuations in the trade balance, accounting for between 66 and 85 percent of US trade deficits.

[9] This is a decomposition of the source of fluctuations in the trade-balance to gdp coming from the accounting identity. It is in no way attributing the fluctuations in the trade balance to particular shocks. We will use the model to decompose the shocks leading to these fluctuations.

Trade Wedges and the pace of integration

Our empirical analysis concludes with a presentation of the inferred trade wedges. This provides a sense of the dynamics of integration. So far, our empirical work yields the gap in the ROW and US trade wedge. To actually come up with a series for the level of trade wedges in each country, we use our coefficient estimates and solve for the trade wedge as a residual.

Figure 4 plots the gap in the trade wedges for the three models along with the trade ratio. Each wedge is demeaned over the window. Not surprisingly, the gap in the wedge across countries from the error correction model is much smoother than the other two models.

Figure 5 plots the home and foreign wedge since 1980 that comes from the dynamic trade model. A few interesting points are evident. First, trade integration was fairly steady until the early 2000's but has stagnated since. Second, initially trade integration was roughly balanced, but in the late 80s foreign liberalization picked up relative to that in the US. Since, the mid 2000s foreign liberalization has regressed relative to the US. Indeed, it appears that trade integration has reversed somewhat since the mid 2000s.

3. Model

We now develop a two country model with heterogenous producers entering and exiting the export market. We extend the model of Alessandria and Choi (2007) to include shocks to trade costs and variables markups. We use the model to evaluate the impact of symmetric and asymmetric changes in trade costs on the aggregate economy.

Home and foreign prices are normalized to 1: $P_t = P_t^* = 1$.

Consumers:

$$\max E_0 \sum_{t=0}^{\infty} \Theta_t U\left(C_t, L_t\right),$$

subject to

$$C_t + V_t B_t = W_t L_t + B_{t-1} + \Pi_t,$$

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. In a standard model with $\Theta_t = \beta^t$, we apply small bond holding cost of $\frac{\zeta_b}{2}\left(\frac{V_t B_t}{Y_t^N}\right)$ for home with Y_t^N being nominal home GDP and $\frac{\zeta_b}{2}\left(\frac{V_t B_t^*}{q_t Y_t^{N*}}\right)$ for foreign.

The stochastic cumulative discount factor evolves as

$$\begin{aligned} \ln(\Theta_{t+1}/\Theta_t) &= \ln \beta_t \\ &= (1-\rho_b)\ln\overline{\beta} + \rho_b \ln \beta_{t-1} - \psi\left(\ln \widetilde{C}_t - \ln \overline{C}\right), \end{aligned}$$

where $\overline{\beta}$ is the steady state β, $\overline{C}$ is the steady state C, and $\widetilde{C}_t$ is the average (aggregate) consumption in the economy. Thus, the discount factor β_t is external.

Aggregation Technology or Consumption Index:

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

Note that the elasticity of substitution for imported goods is allowed to be time varying, $\theta_t = \theta q_t^{\zeta}$ with q_t being the real exchange rate in terms of home aggregate (a rise in q means

real depreciation of home). The price indices for the aggregates are

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

In equilibrium $D_t = C_t$.

Firms: The production function of a firm is given by

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

where Z_t is the country-wide productivity, η_{it} is the firm specific productivity with $\eta_{it} \overset{iid}{\sim} N\left(0, \sigma_\eta^2\right)$. The country productivity follows

$$\begin{bmatrix} Z_t \\ Z_t^* \end{bmatrix} = A_z \begin{bmatrix} Z_{t-1} \\ Z_{t-1}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{Zt} \\ \varepsilon_{Zt}^* \end{bmatrix}, \qquad \begin{bmatrix} \varepsilon_{Zt} \\ \varepsilon_{Zt}^* \end{bmatrix} \overset{iid}{\sim} N\left(0, \Sigma_Z\right)$$

Exporting costs are given by $W_t f_0$ for starters, and $W_t f_1$ for continuing exporters. The (gross) marginal trade cost is given by ξ_t^* for home exporters, and ξ_t for foreign exporters. The resource constraint for each good is given by

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

where m_{it} is the exporting status of firm i. The marginal trade cost is stochastic with

$$\begin{bmatrix} \ln \xi_t \\ \ln \xi_t^* \end{bmatrix} = A_\xi \begin{bmatrix} \ln \xi_{t-1} \\ \ln \xi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{\xi t} \\ \varepsilon_{\xi t}^* \end{bmatrix}, \qquad \begin{bmatrix} \varepsilon_{\xi t} \\ \varepsilon_{\xi t}^* \end{bmatrix} \overset{iid}{\sim} N\left(0, \Sigma_\xi\right)$$

Firms will move in and out of the export market in response to shocks to idiosyncratic and aggregrate shocks.

Aggregate Variables: The nominal output (GDP) is given by

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

The real GDP is given by

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

The nominal export is given by

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

The export price index is given by

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

The real export is given by

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

The nominal import is given by

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

The import price index is given by

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

The real import is given by

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

We define the terms of trade as

$$
TOT_t = \frac{P_{Mt}}{P_{Xt}}.
$$

So, we have

$$
\ln\left(EX_t^R / IM_t^R\right) = (\rho - 1)\ln\left(\xi_t / \xi_t^*\right) + \rho\left(\ln q_t + \ln TOT_t\right) + \ln\left(D_t^* / D_t\right).
$$

The trade balance to GDP ratio is given by

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

4. Calibration

The time period is a quarter and so we set $\beta = 0.99$. The risk aversion parameter, $\sigma = 2$. The weight on leisure is set so that hours worked is equal to a 1/4. The bond adjustment cost is set to 0.0001 and the externality on the discount factor is set to 0.005. The trade costs (f_0, f_1) and standard deviation of shocks (σ_η) and the weight in the aggregator are chosen so that trade is 10%, export participation is 20 percent, the quarterly exporter exit rate is 2.5 percent, and exporters are 50 percent larger than non-exporters. The elasticity of substitution is set to 4, while the Armington elasticity is set to 1.65, essentially equal to our long-run elasticity. The pricing-to-market parameter is chosen to generate 50 percent pass-through (Goldberg and Knetter, 1997).

5. Results

We now examine the aggregate impact of changes in trade integration. As our main interest is in examining the impact of trade integration on the dynamics of the trade ratio, we consider transitory asymmetric shocks to trade costs. These asymmetric movements in trade costs generate fluctuations in the trade balance to GDP ratio, the trade ratio, and the real exchange rate. We first consider the impact of the path of uneven trade integration on the US trade ratio. Then, we explore the aggregate impact of a decline in the iceberg cost for delivering products to the home market.

To examine the impact of asymmetric trade costs on the US trade ratio, the model economy is hit with the relative shocks inferred from trade ratio. We split the differential wedge equally between home and foreign trade costs. The shocks are assumed to have an autocorrelation of 0.965 as in the data.

Figure 6 plots the gap in the trade wedge and the trade-ratio in the model and the data. The top panel shows that the trade wedge in the model tracks that inferred from the data. The fit need not be perfect since we are using production as a measure of expenditure, but it is generally quite good. The bottom panel shows that the trade-ratio from the wedge shocks fluctuates considerably less than the trade-ratio in the data. The differential pace of integration was influential in the shrinking of the trade deficit in the 1980s, while the differential pace of integration since the mid 90s has lead to substantially larger trade deficits. Indeed, at the end of the sample, we see that since the Great Recession that the trade ratio would have moved closer to balance without the differential trade costs and that nearly half of the deficit in 2014 is due to differential trade costs. Table 6 reports a variance decomposition of the trade-ratio. It shows that the asymmetric shocks account for 27.4.6 to 30.2 percent of the fluctuations in the trade ratio, depending on the period. These are sizeable, but not nearly as important as our empirical work indicates.

Figure 7 considers the dynamics of the trade ratio when we eliminate the externality on the

discount factor and pricing-to-market. Eliminating the externality reduces the contribution of asymmetric trade integration shocks by about 60 percent, to 12.6 to 13.2 percent, again depending on the period. Eliminating pricing-to-market reduces the variance of the trade ratio half again so that they now account for 5 to 6 percent of the fluctuations in the trade ratio.

To understand these results, we consider various parameterizations of the model, and always choose the size of the shock to generate a 1 percentage point increase in the home trade share on impact.

Figure 8 plots the impact of a decline in the home iceberg cost when the persistence is 0.95. The trade share expands 1 percentage point on impact and then gradually mean reverts. The trade share mean reverts more slowly than the shock owing to an expansion in home export participation. The shock generates a home deficit of about 0.30 percent of GDP on impact. The trade deficit turns to surplus gradually. These dynamics are largely driven by the movements in the trade ratio. The real exchange rate depreciates sharply, by about 3.25 percent and gradually mean reverts.

Figure 9 plots the impact with a less persistent shock with an autocorrelation of 0.75. This shock generates a larger trade deficit of almost 0.55 percent of GDP. The trade deficit is not as persistent, turning to a surplus four quarters later. The real exchange rate depreciates by 3 percent.

Figure 10 plots the impact of a decline in the home iceberg cost when the persistence is 0.95 and we boost the trade elasticity to 3.3. The trade share expands 1 percentage point on impact and then gradually expands further, peaking at 1.31 percent 5 quarters later. The shock generates a home deficit of about 0.25 percent of GDP on impact. The trade deficit turns to surplus gradually. These dynamics are largely driven by the movements in the trade ratio. The real exchange rate depreciates sharply, by about 1.5 percent and gradually mean reverts. The home and foreign country export participation expands, but the home country

expands by more owing to the depreciation.

Figure 11 plots the case with a trade elasticity to 0.55. Now, to get trade to increase we need to actually increase trade costs. Once again, the economy runs a persistent nominal trade deficit, but in real terms it immediately runs a surplus. The real exchange rate depreciates by almost 4 percent and remains elevated. Home export participation gradually expands while foreign export participation declines. The participation decisions imply that the real trade balance grows gradually, peaking almost 30 quarters after the shock and almost 20 quarters after the real exchange rate.

6. Summary

We present evidence that a substantial fraction of the fluctuations in the US trade balance as a share of GDP reflect global and unilateral movements towards greater trade integration. Indeed, the relatively large trade deficits to GDP of the 2000s compared to the 1980s mostly reflect mostly an expansion of trade rather than an increase in the substitution between imported and domestic products over the business cycle. We actually find that, if anything, the imbalances were relatively small compared to the movements in relative prices and relative expenditures.

We present empirical evidence on the contribution of the business cycle and trade integration on the trade balance. Depending on our empirical model, we find that the traditional source of movements in net exports, relative prices and relative expenditure movements, account for at most one-third of the movements in the trade balance, with most of the movements due to movements in the terms of trade and real exchange rate. We also show that two-thirds of the contribution of relative prices to net exports arise from gradual trade dynamics.

Our empirical work makes clear that standard models of the international business cycle

with a constant Armington elasticity, despite their pervasiveness[10], are ill-suited to explain the cyclical behavior of net exports. We suggest more work should be done with models with endogenous trade participation arising from a dynamic decision and fluctuations in trade costs. We take a first step in this direction by analyzing the aggregate effect of persistent, asymmetric changes in trade costs in a dynamic trade model. We find that these asymmetric trade shocks can generate sizeable movements in the trade balance, although more quantitative work remains to be done.

[10] See the recent handbook chapter by Heathcoate and Perri (2014).

7. Data

Recall that our main equation is

$$\ln(X/M) = \ln(\omega^*/\omega) - \rho\left[\ln\left(P_x(1+\tau^*)/P^*\right) - \ln\left(P_m(1+\tau)/P\right)\right] + \ln(D^*/D),$$

- D is proxied by US Industrial Production Index (SA, 2007=100) (Federal Reserve Board)
- D^* is proxied by a US trade weighted Advanced Economies Industrial Production (Dallas Fed)
- P/P^* is measured as the Real Broad Trade-Weighted Exchange Value of the US$ (Mar-73=100) (Federal Reserve Board)
- X Real Exports of Goods & Services (SAAR, Bil.Chn.2005$) (Bureau of Economic Analysis)
- M Real Imports of Goods & Services (SAAR, Bil.Chn.2005$) (Bureau of Economic Analysis)
- P_XExports of Goods & Services: Chain Price Index (SA, 2005=100) (Bureau of Economic Analysis)
- P_M Imports of Goods & Services: Chain Price Index (SA, 2005=100) (Bureau of Economic Analysis)
- To measure the US trade wedge on imports we use the BEA's consumption price deflator (Consumption : Chain Price Index (SA, 2005=100)*/)

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Table 1: NXTR Regression			
d.tot	-0.176**		-0.143*
tot		-0.529***	
l.nxrdd			-0.066***
l.tot			-0.109***
LR Price			-1.65
N	138	139	138
r2_a	0.047	0.259	0.281

Table 2: Contribution of business cycle to trade balance

	Diff	Levels	SR/LR
Trade-expenditure ratio	21.2	25.9	59.6
Trade ratio	26.7	31.1	62.5

Table 3: Avg. Trade balance to gdp since 1991

	Levels	Contribution
Data	-2.95	100%
Counter factual*	-1.58	53.5%
Trade contribution Global	-1.37	46.5%

*Based on (1986 trade share)

Table 4: Decomposition of trade balance to gdp since 1991

	Diff	Levels	SR/LR
Business Cycle	14.3	16.7	33.4
Rel. Prices	11.3	13.9	31.9
Expenditures	3.0	2.8	1.5
Trade Integration	85.7	83.3	66.6
Uneven	39.2	36.8	20.1
Global	46.5	46.5	46.5

Table 5: Parameters

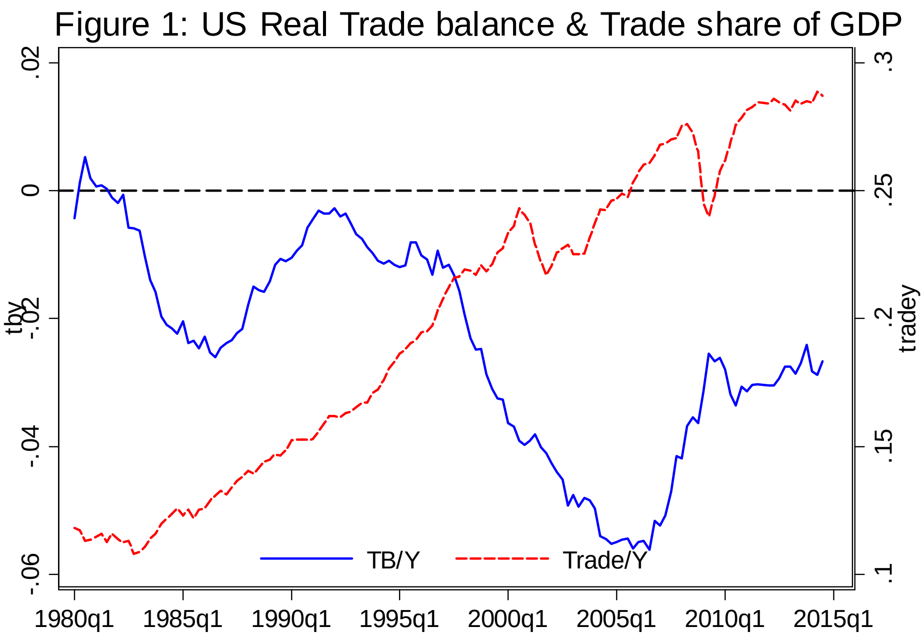
β	σ	ζ_b	ψ
0.99	2	0.001	0.005

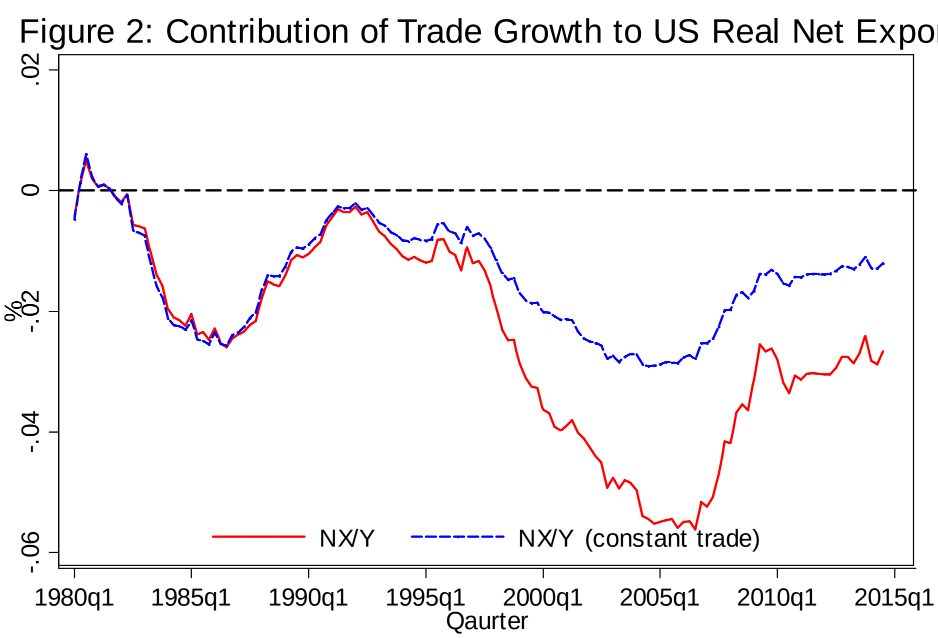
Parameter	Value	Target
γ	0.30	L=1/4
a_1	0.1551	10% trade share
f_0	0.1278	20% export
f_1	0.0373	2.5% exit rate from exporting
σ_η	0.15	50% exporter premium
θ	4	33% Markup
ζ	0.5	50% pass-through
ρ	1.65	Armington Elasticity

Table 6: Decomposition of trade ratio

	Data		No Externality	
		Benchmark	PTM	No PTM
Variance*100^2	240	89.1	34.5	11.6
Share*	100	27.4	12.6	5.1
Since 1991				
Share*	100	30.5	13.2	5.6

* Allocates covariance in proportion to variance





Note: Trade to GDP based on 1986 avg

Figure 3: US Trade Ratio Data and Empirical Models

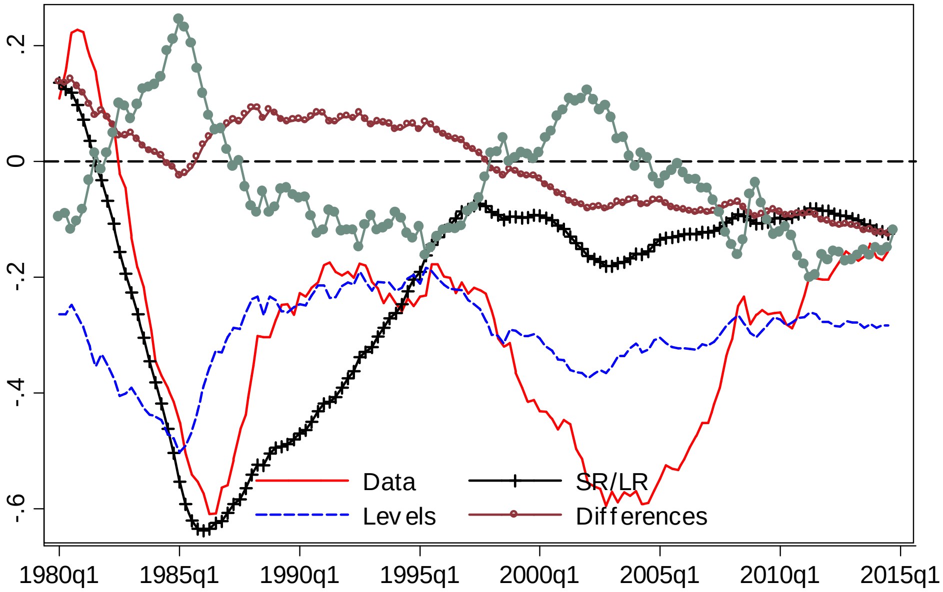
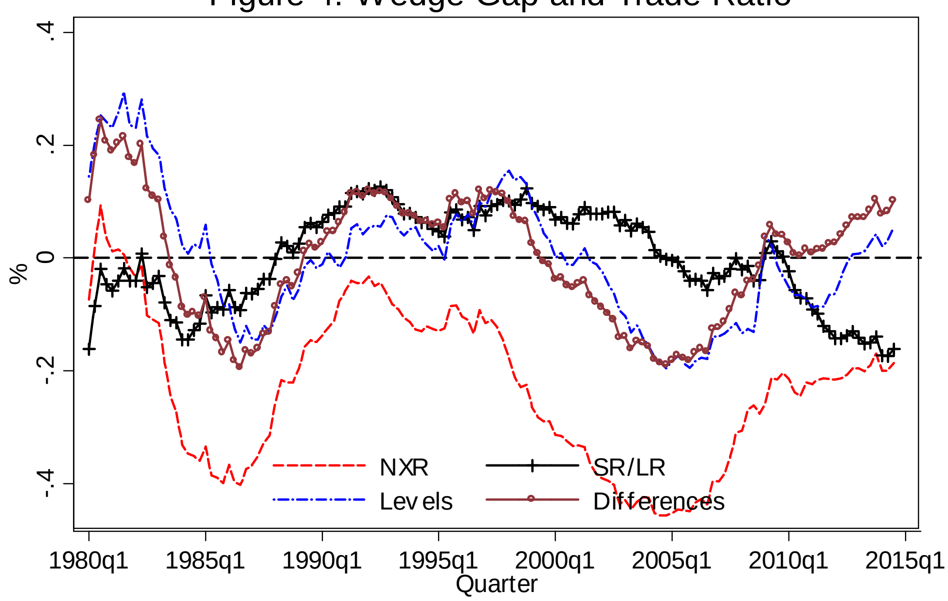
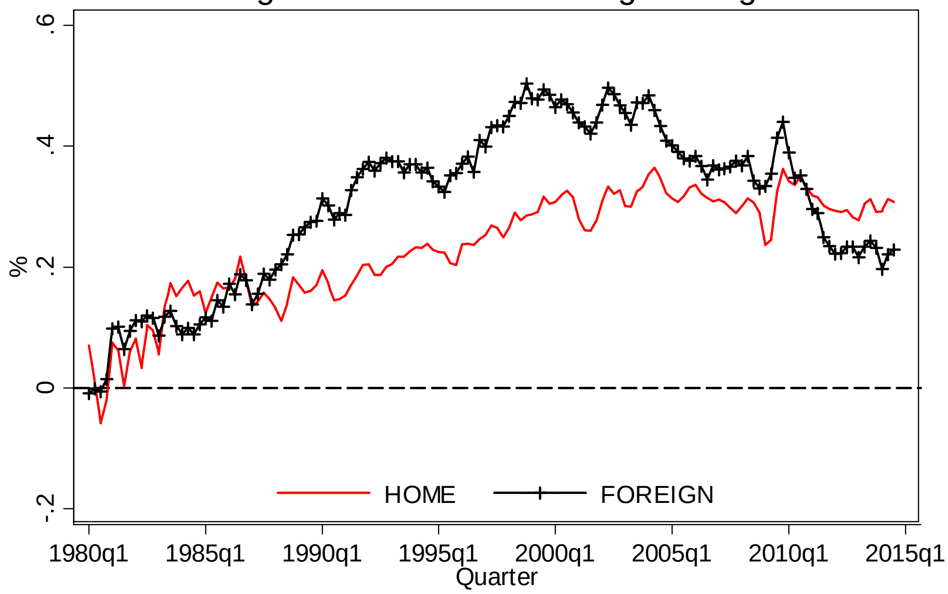


Figure 4: Wedge Gap and Trade Ratio



Note: Based on US from 1980q1 to 2014q4

Figure 5: Home and Foreign Wedge



Note: Based on US from 1980q1 to 2014q4

Figure 6: Trade Ratio and Trade Wedge.

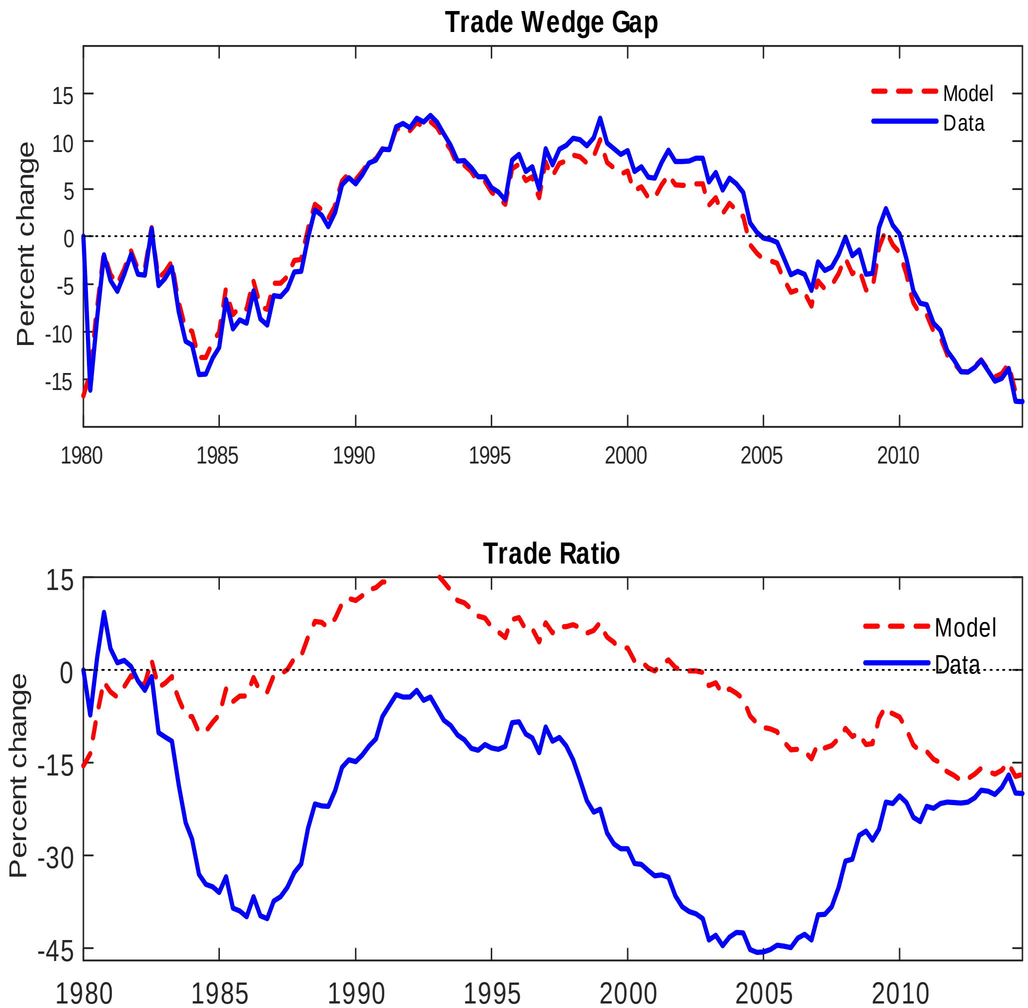


Figure 7: Trade Ratio Fluctuations with and without pricing-to-market.

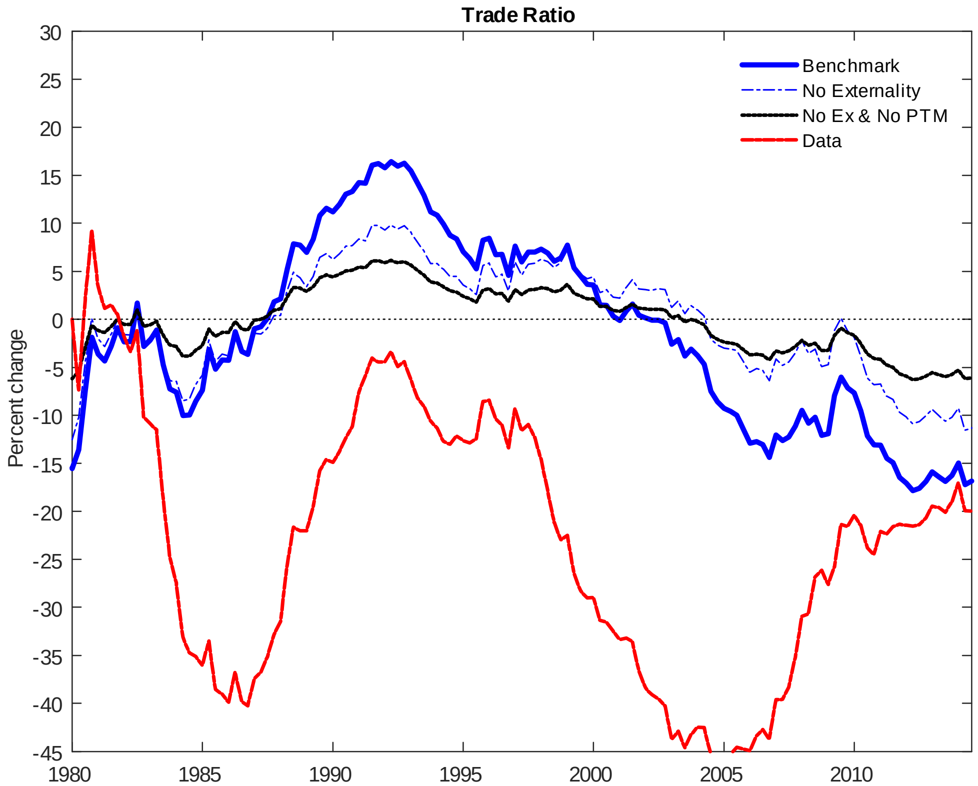


Figure 8: Persistent trade shock (0.95)

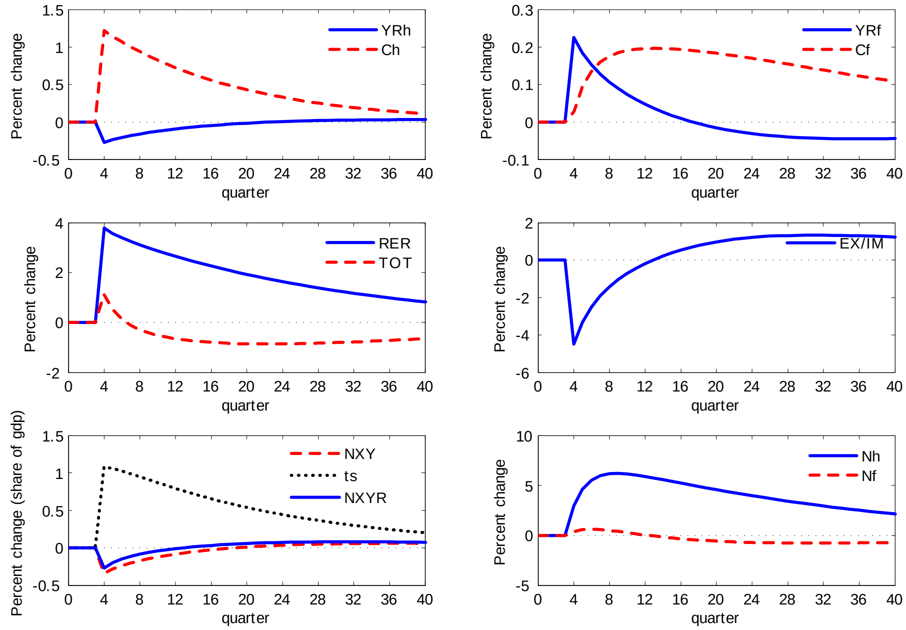


Figure 9: Persistent trade shock (0.75)

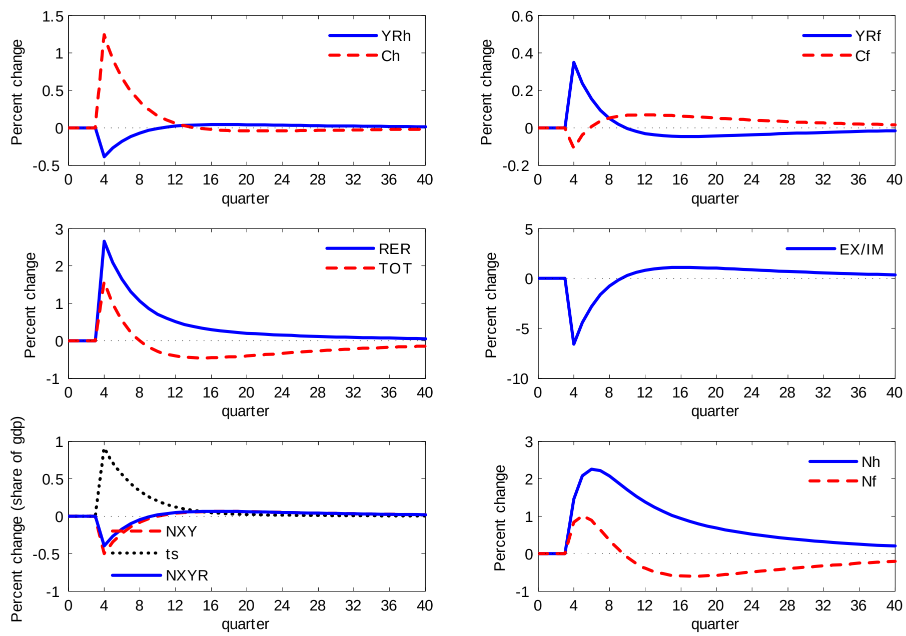


Figure 10: Persistent trade shock (0.95) and High Armington elasticity ($\rho = 3.3$)

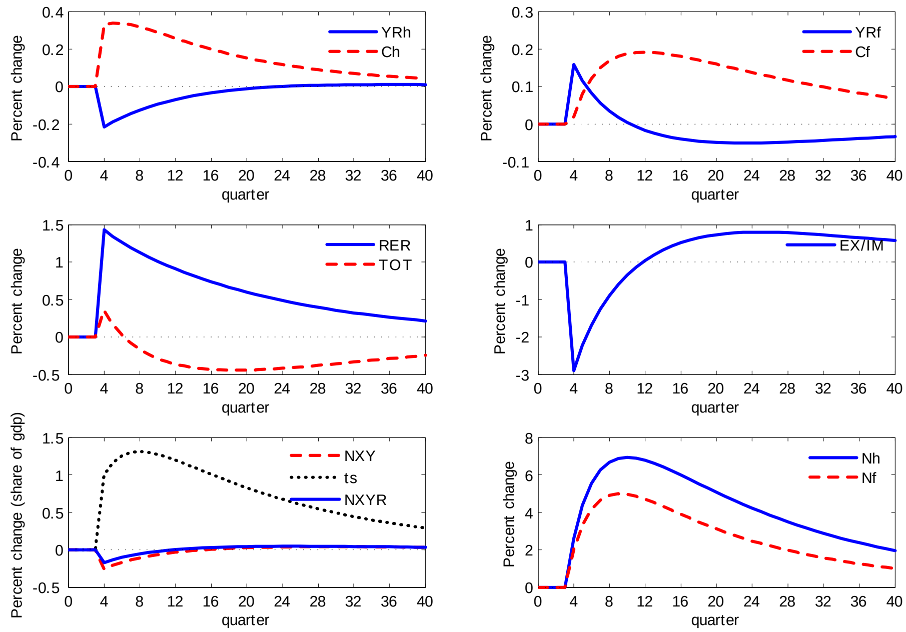


Figure 11: Persistent trade shock (0.95) and Low Armington elasticity ($\rho = 0.55$)