Trade adjustment and the composition of trade

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Abstract

A striking feature of U.S. trade is that both imports and exports are heavily concentrated in capital goods and consumer durables. However, most open economy general equilibrium models ignore the marked divergence between the composition of trade flows and the sectoral composition of U.S. expenditure, and simply posit import and exports as depending on an aggregate measure of real activity (such as domestic absorption). In this paper, we use a DSGE model (SIGMA) to show that taking account of the expenditure composition of U.S. trade in an empirically realistic way yields implications for the responses of trade to shocks that are markedly different from those of a 'standard' framework that abstracts from such compositional differences. Overall, our analysis suggests that investment shocks, originating from either foreign or domestic sources, may serve as an important catalyst for trade adjustment, while implying a minimal depreciation of the real exchange rate.
Published by Elsevier B.V.

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1. Introduction

A striking feature of U.S. trade is that both imports and exports are heavily concentrated in capital goods and consumer durable, with roughly three-quarters of U.S. non-fuel imports and exports appearing to fall into these categories. This contrasts with the relatively low production share of the capital goods and consumer durables sectors in the U.S. economy of under 20%. But despite the marked divergence between the composition of trade flows and the sectoral composition of U.S. production, open economy models typically posit imports and exports as depending on an aggregate measure of activity such as real GDP or domestic absorption (as well as on relative prices).[1]

In this paper, we show that a modeling framework that takes account of the expenditure composition of U.S. trade in an empirically realistic way yields implications for the responses of trade to shocks that are markedly different from those of a 'standard' framework that abstracts from such compositional differences. Our methodology consists in contrasting the implications of alternative versions of an open economy DSGE model ('SIGMA') that embed different trade specifications.[2] In the version adopting a commonly used trade specification, the activity variable driving real imports is simply domestic absorption, while exports depend on foreign absorption. We refer to this version as the absorption-based trade (AT) specification. In contrast, our benchmark version of SIGMA posits separate behavioral equations for trade in non-durable consumer goods and for trade in investment goods, where the latter includes both consumer and producer durables (i.e., capital goods). These behavioral equations are derived from underlying technologies for producing final consumer and investment goods that differ by allowing the production of investment goods to be more import-intensive. We refer to this version as the disaggregated trade (DT) specification.[3] From an intuitive perspective, the activity variable driving imports and exports in the DT specification weights consumption and investment by their share in trade, rather than by their share in production: this implies an effective weight on investment in the import and export demand functions that is several times larger than in the AT specification.

We examine the responses of each model variant to several domestic and foreign shocks. We show that the differences in implications across the alternative trade specifications are particularly large for shocks which exert disparate effects on consumption and investment spending either at home or abroad. Examples include

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[1]Examples of studies that specify imports as depending on absorption include: Backus et al. (1994), Chari et al. (2002), Laxton and Pesenti (2003).

[2]An extended description of the model and its properties with respect to a wide range of shocks is given in Erceg et al. (2006).

[3]Our DT specification is closely related to important prior work by Boileau (2002). Boileau formulated an international real business cycle model allowing for differential import intensities for consumption and equipment investment, and showed that it could generate greater volatility of net exports than typical AT specifications. While Boileau focused on explaining the unconditional volatility of trade in response to technology shocks, we analyze the time-series behavior of imports more broadly, and consider trade adjustment in response to a variety of shocks.

shocks that affect the rate of return on investment ('investment shocks'), and preference shocks for consumption ('consumption shocks').

Our results show that in our preferred DT specification, investment shocks (foreign or domestic) generate substantial movements in trade flows, even in the absence of a significant movement in the exchange rate. This reflects that the activity measure driving exports and imports depends heavily on changes in foreign and domestic investment, so that shocks that move investment have large direct effects on trade flows. Importantly, given that these shocks have much smaller effects on absorption, they elicit much smaller movements in exports and imports in a standard AT specification, with most of the trade adjustment under that specification attributable to real exchange rate changes. To illustrate the quantitative differences between specifications, we find that a foreign investment shock associated with a 1% rise in foreign absorption induces the home trade balance to improve by 0.8% of GDP under our DT specification, or nearly twice as much as under the AT specification. Moreover, most of the rise in exports and compression of imports that occur under our DT specification reflect changes in foreign and domestic investment, rather than exchange rate depreciation, in contrast to the AT case where more of the adjustment rests on exchange rate depreciation.

While our DT specification accentuates the ability of investment shocks to move trade flows through an activity channel (relative to an AT specification), it tends to weaken the activity channel in the case of consumption shocks. Thus, under our preferred DT specification, consumption shocks scaled to generate an improvement of the domestic trade balance operate almost exclusively through an induced depreciation of the real exchange rate.

Overall, both our empirical and theoretical analysis suggests a prominent role for investment shocks, originating from either foreign or domestic sources, in driving trade flows.[4] Moreover, it identifies channels that can lead to substantial improvements in the trade balance without entailing a large depreciation of the domestic currency. The important role that we identify for investment shocks in our analysis would seem to complement the empirical work of Freund (2000) and Croke et al. (2005). These authors used an event study methodology examining a large number of historical episodes of trade adjustment in industrial countries, and found that trade adjustment has typically been driven by a large decline in the rate of investment spending, while consumption rates have moved little.

The remainder of this paper is organized as follows. Section 2 presents some stylized facts about the composition of U.S. imports and exports that motivate the trade structure adopted in our benchmark model. These facts are utilized subsequently in the calibration. Section 3 presents our SIGMA model, including the alternative trade specifications, while the calibration and solution methodology is discussed in Section 4. Section 5 compares the ability of the alternative trade specifications to account for the empirical behavior of U.S. imports. Section 6

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[4] Burda and Gerlach (1992) and Warner (1994) estimated statistical models that identified investment as playing a prominent role in driving U.S. trade flows.

contrasts model responses to an array of domestic and foreign shocks across the alternative trade specifications. Section 7 concludes.

2. The composition of U.S. trade

Table 1 examines the composition of U.S. non-energy imported goods in 2004. The underlying data used to construct the table are from the U.S. Bureau of Economic Analysis (on a balance-of-payments basis), although it has been reorganized to correspond more closely to the coarser disaggregation adopted in our theoretical model. In particular, we divide nominal non-energy imports into four categories, including consumer non-durable goods, consumer durables, capital goods, and non-energy industrial supplies utilized in producing durable goods (either for households or firms). The major components of the first three of these categories are derived fairly straightforwardly from the corresponding BEA data, aside from the estimate of non-energy industrial supplies used in producing non-durable consumer goods (item 1d). Our estimate of the latter category is derived by assuming that the share of imports of non-energy industrial goods that are used in producing consumer non-durables is equal to the share of consumer non-durables in total manufacturing production (of about 40%).

The table suggests that nearly three-quarters of U.S. non-energy goods imports consist of either consumer or producer durable goods, or of industrial supplies used in manufacturing such goods. In contrast, only a little over 25% of U.S. goods imports consist of consumer non-durables (including raw materials). While our taxonomy for classifying imports is admittedly imperfect – for example, imports of

Table 1
Composition of U.S. non-energy imports in 2004

	Billions of $US	Percent of imports
1. Consumer non-durable goods	335	28
1.a. Foods, feeds, beverages	62	
1.b. Manufactured consumer goods	174	
1.c. Non-manufactured consumer goods	18	
1.d. Non-energy industrial supplies used in non-durable consumer goods	81	
2. Consumer durable goods	389	32
2.a. Automotive less trucks, buses	208	
2.b. Manufactured durables	181	
3. Capital Goods	364	30
3.a. Non-auto capital goods	343	
3.b. Trucks, buses, etc.	21	
4. Non-energy industrial supplies used in producing durables	121	10
Total nonenergy imports	1209	100

Source: Bureau of Economic Analysis, U.S. International Accounts Data, Table 2. U.S. Trade in Goods. The categories reported were aggregated using the following lines from the source table:
1.a. $=$ l77; 1.b. $=$ l136; 1.c. $=$ l144; 1.d. $= 0.4 \times (l88 - l91)$; 2.a. $=$ l126 + l128 + l129 + l131 + l133 + l134; 2.b. $=$ l139; 3.a. $=$ l107; 3.b. $=$ l127 + l132; 4. $= 0.6 \times (l88 - l91)$.

Table 2
Composition of U.S. non-energy exports in 2004

	Billions of $US	Percent of exports
1. Consumer non-durable goods	186	25
1.a. Foods, feeds, beverages	57	
1.b. Manufactured consumer goods	49	
1.c. Non-manufactured consumer goods	8	
1.d. Non-energy industrial supplies used in non-durable consumer goods	72	
2. Consumer durable goods	123	16
2.a. Automotive less trucks, buses	77	
2.b. Manufactured durables	46	
3. Capital goods	343	45
3.a. Non-auto capital goods	331	
3.b. Trucks, buses, etc.	12	
4. Non-energy industrial supplies used in producing durables	107	14
Total nonenergy exports	759	100

Source: Bureau of Economic Analysis, U.S. International Accounts Data, Table 2. U.S. Trade in Goods. The categories reported were aggregated using the following lines from the source table:
1.a. = l4; 1.b. = l68; 1.c. = l85; 1.d. = $0.4 \times (l15 - l22)$; 2.a. = $l58 + l60 + l61 + l63 + l65 + l66$; 2.b. = l70; 3.a. = l39; 3.b. = $l59 + l64$; 4. = $0.6 \times (l15 - l22)$.

consumer durables may be somewhat inflated due to extensive cross-border trade in automotive parts – it is unlikely that reasonable alternative breakdowns would markedly affect our results.

Table 2 reports a similar breakdown for U.S. non-energy goods exports in 2004. Clearly, capital goods are a noticeably larger fraction of U.S. exports than of U.S. imports, while consumer durables are a somewhat smaller fraction of exports. But notwithstanding these differences, nearly three-quarters of U.S. non-energy exports consist of either consumer or producer durable goods, or of industrial supplies used in producing such goods – the same fraction as for U.S. non-energy imports. Thus, the composition of U.S. imports and exports is heavily oriented toward durable goods, which in our model we interpret broadly as investment goods.

3. The model

This section provides an abbreviated description of a two country version of our SIGMA model, focusing on the alternative trade specifications. A complete description of our benchmark SIGMA model is provided in Erceg et al. (2006).

3.1. Firms and price setting

SIGMA incorporates a relatively standard framework with monopolistic competition among intermediate goods-producing firms in order to rationalize

stickiness in aggregate prices. Each intermediate-goods producer has an identical CES production function, and rents capital and labor from competitive factor markets. Intermediate goods prices are set in Calvo-style staggered contracts, and producers practice 'local currency pricing'. Thus, each firm faces a constant probability, $1 - \xi_p$, of receiving a signal allowing it to optimally adjust its price in the domestic market ($P_{Dt}(i)$) in each period, and similarly, a constant probability $1 - \xi_{p,x}$ of receiving a signal to reset its price in the foreign market ($P^*_{Mt}(i)$). These probabilities are assumed to be independent across firms, time, and countries. For those firms not allowed to re-optimize their price, we follow Christiano et al. (2005) in assuming that they mechanically adjust their price based on lagged aggregate inflation. This indexation scheme introduces structural inflation persistence into the aggregate pricing equations.

Following a standard approach in the literature, the intermediate goods sold in the domestic market are assembled into a single composite domestic good Y_{Dt} by a representative 'aggregator'. This firm has a CES production function over the intermediate goods $Y_{Dt}(i)$ of the Dixit–Stiglitz form, behaves competitively in factor and product markets, and sells the composite domestic good at a price P_{Dt}. Similarly, there is a representative aggregator in the foreign economy that combines the differentiated home goods into a single foreign import index M^*_t, which it sells at a price P^*_{Mt}.

3.1.1. Production of consumption and investment goods

We consider two alternative specifications for the production of consumption and investment goods. In our benchmark specification of SIGMA, there are different technologies for the production of final consumption and investment goods. Because this leads to a specification in which imports are segmented into consumption and investment goods, with separate demand functions for each category of imports, we call this the DT specification. In our alternative specification, we assume that the technology for producing final consumption and investment goods is the same. We call this alternative the AT specification, because import demand depends only on the sum of private consumption and investment, i.e., private absorption.

We begin by describing our benchmark version of the model which uses the DT specification. In this case, we assume that final consumption goods are produced by a representative consumption good distributor, and investment goods are produced by a representative investment goods distributor. Letting $V_t \in \{C_t, I_t\}$ be the good each type of distributor produces, a representative distributor's production technology is given by

$$V_t = \left(\omega_V^{\frac{\rho_V}{1+\rho_V}} V_{Dt}^{\frac{1}{1+\rho_V}} + (1-\omega_V)^{\frac{\rho_V}{1+\rho_V}} (\varphi_{Vt} M_{Vt})^{\frac{1}{1+\rho_V}} \right)^{1+\rho_V}, \tag{1}$$

where $V_{Dt} \in \{C_{Dt}, I_{Dt}\}$ is a distributor's demand for the index of domestically produced goods, $M_{Vt} \in \{M_{Ct}, M_{It}\}$ is a distributor's demand for the index of foreign-produced goods, and ρ_V is parameter determining the substitutability of home and foreign goods. The quasi-share parameter ω_V may be interpreted as

determining a household's preference for home relative to foreign goods, or equivalently the degree of home-bias in private consumption or investment. Because ω_V can differ depending on whether the final good is an investment or consumption good, this specification allows the import-content of consumption and investment to differ. The term φ_{Vt} reflects a cost to adjusting imports, which are assumed to be quadratic:

$$
\varphi_{Vt} = \left[1 - \frac{\varphi_{M_V} \omega_V}{2} \left(\frac{\frac{M_{Vt}}{V_{Dt}}}{\frac{M_{Vt-1}^A}{V_{Dt-1}^A}} - 1 \right)^2 \right]. \tag{2}
$$

This adjustment cost implies that it is costly for a firm to change its share of consumption imports in final consumption, or of investment imports in final investment, relative to their respective lagged aggregate shares (denoted by the superscript 'A'). It has the attractive feature that the import share of either consumption or investment goods is relatively unresponsive in the short-run to changes in the relative price of imported goods, even while allowing the level of imports to jump costlessly in response to changes in overall consumption or investment demand.[5] Thus, these adjustment costs influence the short-run elasticity of substitution between home and foreign goods. In steady state, adjustment costs on imports are zero and the elasticity of substitution between home and foreign goods is governed exclusively by ρ_V.

Each type of representative distributor chooses V_{Dt} and M_{Vt} to minimize its costs of producing the final good $V_t \in \{C_t, I_t\}$:

$$
\min_{V_{Dt}, M_{Vt}} P_{Dt} V_{Dt} + P_{Mt} M_{Vt}
$$
$$
+ P_{Vt} \left[V_t - \left(\omega_V^{\frac{\rho_V}{1+\rho_V}} V_{Dt}^{\frac{1}{1+\rho_V}} + (1 - \omega_V)^{\frac{\rho_V}{1+\rho_V}} (\varphi_{Vt} M_{Vt})^{\frac{1}{1+\rho_V}} \right)^{1+\rho_V} \right]. \tag{3}
$$

The distributor sells V_t to households at a price $P_{Vt} \in \{P_{Ct}, P_{It}\}$ so that there is a different price for consumption and investment, reflecting the different technologies for aggregating these goods.

In the alternative AT specification, there is effectively only one final good (A_t) that may be used for consumption or investment (i.e., $A_t \equiv C_t + I_t$, noting that A_t can be interpreted as private absorption). Accordingly, there is effectively a single distributor which combines its purchases of the domestically produced goods with imported goods to produce final goods A_t according to

$$
A_t = \left(\omega_A^{\frac{\rho_A}{1+\rho_A}} A_{Dt}^{\frac{1}{1+\rho_A}} + (1 - \omega_A)^{\frac{\rho_A}{1+\rho_A}} (\varphi_{At} M_t)^{\frac{1}{1+\rho_A}} \right)^{1+\rho_A}, \tag{4}
$$

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[5]Hooper et al. (2000) find that the short-run trade-price elasticity is significantly smaller than the long-run elasticity in their study using aggregate data. This is qualitatively consistent with the results of industry studies as surveyed by McDaniel and Balistreri (2003).

where A_{Dt} denotes the distributor's demand for the domestically produced good and M_t denotes the distributor's demand for imports. The quasi-share parameter ω_A determines the degree of home-bias in private absorption, and ρ_A determines the elasticity of substitution between home and foreign goods in the long-run. In the short-run, this elasticity is lower, because we allow for adjustment costs φ_{At}:

$$\varphi_{At} = \left[1 - \frac{\varphi_{M_A}\omega_A}{2} \left(\frac{\frac{M_t}{A_{Dt}}}{\frac{M_{t-1}^A}{A_{Dt-1}^A}} - 1 \right)^2 \right]. \tag{5}$$

Note that the adjustment costs in this case depend on the ratio of total imports to total absorption, rather than depending on each of the components of absorption separately.

Distributors of A_t solve an intertemporal cost minimization problem analogous to the consumption and investment distributors of the DT specification. The distributor sells its good to households at price P_{At} which may be interpreted as the price of consumption or investment, since in this case $P_{At} = P_{Ct} = P_{It}$.

3.2. Households and wage setting

We assume that there are two types of households: households that maximize utility subject to an intertemporal budget constraint (FL households, for 'forward-looking'), and the remainder that simply consume their after-tax disposable income (HM households, for 'hand-to-mouth' households). We denote the share of FL households by ς and the share of HM households by $1 - \varsigma$.

We first consider the problem faced by FL households. The utility functional of a representative member of FL household h is

$$\widetilde{\mathbb{E}}_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\sigma} (C_{t+j}(h) - \varkappa C_{t+j-1}^O - v_{ct})^{1-\sigma} \right.$$
$$\left. + \frac{\chi_0}{1-\chi}(1 - N_{t+j}(h))^{1-\chi} + \frac{\mu_0}{1-\mu} \left(\frac{MB_{t+j+1}(h)}{P_{Ct+j}} \right)^{1-\mu} \right\}, \tag{6}$$

where the discount factor β satisfies $0 < \beta < 1$. As in Smets and Wouters (2003), we allow for the possibility of external habits, where each household member at date t cares about its consumption relative to the lagged consumption per capita of FL households, C_{t-1}^O. The period utility function depends on each member's current leisure $1 - N_t(h)$, his end-of-period real money balances, $(MB_{t+1}(h))/(P_{Ct})$, and a preference shock, v_{ct}. The preference shock follows an exogenous first-order process with a persistence parameter of ρ_v.

These households allocate their income optimally between consumption goods, investment goods, and financial assets. The effective price of a new investment good consists of the purchase price scaled up by a quadratic adjustment cost term, i.e. $P_{It}(1 + \phi_{It}(h))$, where we follow Christiano et al. (2005) in specifying the adjustment cost $\phi_{It}(h)$ as depending on the change in the level of gross investment from the

previous period:

$$\phi_{It}(h) = \frac{1}{2}\phi_I \frac{(I_t(h) - I_{t-1}(h))^2}{I_{t-1}(h)}. \tag{7}$$

Investment in physical capital augments the household's capital stock $K_{t+1}(h)$ according to a linear transition law of the form:

$$K_{t+1}(h) = (1 - \delta)K_t(h) + I_t(h), \tag{8}$$

where δ is the depreciation rate of capital.

Households also choose optimal portfolios of financial assets, which include domestic money balances, government bonds, state-contingent domestic bonds, and a non-state contingent foreign bond. We follow Turnovsky (1985) by assuming that households in the home country pay an intermediation cost when purchasing foreign bonds, which ensures the stationarity of net foreign assets.

Household income consists of after-tax capital income, wage income, and an aliquot share of firm profits, minus net lump-sum taxes paid to the government. Capital rental income is taxed at the stochastic rate τ_{Kt}, but is partly offset by a depreciation writeoff of $P_{It}\tau_{Kt}\delta$ per unit of capital (the capital tax rate is assumed to follow a first order autoregression with persistence parameter ρ_K). Households earn wage income by renting their labor to firms. We assume that each household is a monopolistic competitor in the labor market, and sets its nominal wage in Calvo-style staggered contracts that are analogous to the price contracts discussed earlier. The probability that members of a household receive a signal which allows them to optimally reset their nominal wage is $1 - \xi_w$. The remaining ξ_w households that do not receive such a signal simply adjust their wage mechanically to aggregate wage inflation in the previous period.

Finally, we consider the determination of consumption and labor supply of the HM households. A typical member of the HM household simply equates his nominal consumption spending to his current after-tax disposable income, which consists of labor income minus net lump-sum government taxes. The HM households are assumed to set their wage each period equal to the average wage of the forward-looking households. Since HM households face the same labor demand schedule as the forward-looking households, each HM household works the same number of hours as the average forward-looking household.

3.3. Monetary and fiscal policy

We assume that the central bank follows an interest rate reaction function similar in form to the historical rule estimated by Orphanides and Wieland (1998) over the Volcker–Greenspan period. Thus, the short-term nominal interest rate is adjusted so that the *ex post* real interest rate rises when inflation exceeds its constant target value, or when output *growth* rises above some target value:

$$i_t = \gamma_i i_{t-1} + \overline{r} + \overline{\pi}_t + \gamma_\pi(\pi_t^{(4)} - \overline{\pi}) + \gamma_y(y_t - y_{t-4} - g_y) + \varepsilon_{it}. \tag{9}$$

In the above, i_t is the annualized nominal interest rate, $\pi_t^{(4)}$ is the four-quarter inflation rate of the GDP deflator (i.e., $\pi_t^{(4)} = \sum_{j=0}^{3} \pi_{t-j}$), $\bar{r}$ and $\bar{\pi}$ are the steady-state real interest rate and the central bank's constant inflation target (both expressed at annual rate). Also, $y_t - y_{t-4}$ is the four-quarter growth rate of output, and g_y is its corresponding steady-state value.

Some of the domestically produced good is purchased by the government, although government purchases make no direct contribution to household utility. Government purchases are assumed to be a constant fraction of output $\bar{g}$.

Government revenue consists of income from capital taxes (net of the depreciation writeoff), seignorage income, and revenue from lump-sum taxes (net of transfers).[6] The government issues bonds to finance the difference between government revenue and expenditure, where the latter consists entirely of government purchases. Lump-sum taxes (as a share of GDP) are adjusted both in response to deviations of the government debt/GDP ratio from a target level (with a coefficient v_1) and to the change in that ratio (with a coefficient v_2); this allows the government to satisfy its intertemporal resource constraint.

3.4. Resource constraints

The home economy's aggregate resource constraint can be written as

$$Y_{Dt} = C_{Dt} + I_{Dt} + G_t + \phi_{It}. \tag{10}$$

Thus, the composite domestically produced good Y_{Dt} (net of investment adjustment costs ϕ_{It}) can be used as an input into final consumption or investment goods (or into final absorption in the AT specification), or can be used directly to satisfy government demand. Moreover, since each individual intermediate goods producer can sell its output either at home or abroad (which is in turn 'bundled' by the respective aggregator), there are also a continuum of resource constraints that apply at the firm level.

4. Solution method and calibration

Because the level of technology is non-stationary due to deterministic growth in technology (at a common rate of $e^{(g_z t)}$ in each country), real variables are also non-stationary. Accordingly, prior to solving the model, we scale real variables in each country by this deterministic trend. Nominal variables are scaled to account both for growth in the corresponding real variables, and for the steady-state inflation rate.

We solve the model by log-linearizing the equations (specified in terms of the transformed variables) around the steady state associated with common growth rates of technology in the two countries. To obtain the reduced-form solution of the model, we use the numerical algorithm of Anderson and Moore (1985), which

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[6]Given that we calibrate the model so that the parameter determining the importance of real money balances in the household utility function (μ_0) is arbitrarily small, seignorage revenue is essentially zero.

provides an efficient implementation of the method proposed by Blanchard and Kahn (1980).

4.1. Calibration of parameters

The model is calibrated at a quarterly frequency. The values of key parameters are presented in Table 3. Given that we provide a description of the parameters associated with household preferences, technology, and monetary and fiscal policy in Erceg et al. (2006), our present discussion focuses only on the parameters affecting trade flows under the alternative trade specifications considered.

For both specifications of import demand, the steady-state ratio of aggregate imports to GDP is 0.12. In the AT specification we choose $\omega_A = 0.15$ to be consistent

Table 3
Calibration

Parameter	Used to determine	Parameter	Used to determine
Parameters governing households' behavior			
$\beta = 0.997$	Discount factor	$\chi = 10$	Labor supply elasticity[a]
$\sigma = 2$	Consumption elasticity[a]	$\varkappa = 0.8$	Consumption habits
$\varsigma = 0.5$	Frac. of HM households	$\phi_I = 3$	Investment adj. cost
$\phi_b = 0.001$	Financial intermediation cost	$\bar{g} = 0.18$	Govt. spending share
Parameters governing firms' behavior			
$g_z = 1.0037$	Rate of technological growth	$\delta = 0.025$	Depreciation rate
$\theta_p = 0.20$	Price markup	$\theta_w = 0.20$	Wage markup
$\xi_p = 0.75$	Avg. duration of domestic price	$\xi_w = 0.75$	Avg. duration of wage
$\xi_{p,x} = 0.5$	Avg. duration of export price	$\rho = -2$	K–L substitution elasticity
$\tau_K = 0.30$	Steady-state capital tax rate		
Parameters governing monetary policy			
$\gamma_\pi = 0.6$	Infl. target elasticity	$\gamma_y = 0.28$	Output growth elasticity
$\gamma_i = 0.8$	interest rate smoothing		
Parameters governing fiscal policy			
$v_0 = 1$	Tax rate smoothing	$v_1 = 0.1$	Debt target elasticity
$v_2 = 0.0001$	Debt growth elasticity	$b_G = 0$	Target debt-to-GDP ratio
Parameters governing trade			
$\zeta_0 = 1$	Home population size	$\zeta_0^* = 3$	Foreign population size[b]
$\omega_A = 0.15$	Import/absorption (AT spec.)	$\rho_A = 2$	Import price el. (AT spec.)
$\varphi_{M_A} = 10$	Import adj. cost (AT spec.)		
$\omega_C = 0.052$	Cons. import/cons. (DT spec.)	$\omega_I = 0.36$	Inv. import/inv. (DT spec.)
$\rho_C = 2$	Cons. import price el. (DT spec.)	$\rho_I = 2$	Inv. import price el. (DT spec.)
$\varphi_{M_C} = 10$	Cons. import adj. cost (DT spec.)	$\varphi_{M_I} = 10$	Inv. import adj. cost (DT spec.)

[a]The long-run intertemporal elasticity of substitution in consumption is $1/\sigma = 0.5$, while the Frisch elasticity is $2/\chi = 0.2$.

[b]In order to ensure that all prices are equal to 1 in steady state, the import shares for the foreign country are scaled down using the foreign population size. All remaining parameters are set at the same value as for the home country.

with this import share. In the DT specification, we set $\omega_C = 0.052$ and $\omega_I = 0.36$, so that roughly 5% of consumption goods and 36% of investment goods are comprised of imports. These choices for ω_C and ω_I are consistent with the evidence presented in Table 1 (and GDP expenditure data from the national income accounts). We choose the population levels so that the home country constitutes about 25% of world output. This implied an import (or export) share of output of the foreign country of about 4%. Because the foreign country is assumed identical to the home country except in its size, in the AT specification, $\omega_A^* = 0.05$. In the DT specification we set $\omega_C^* = 0.01$ and $\omega_I^* = 0.07$, both consistent with the evidence presented in Table 2.

We assume that the trade-price elasticities of import demand are the same across the two specifications. In particular, we set $\rho_C = \rho_I = \rho_A = 2$, consistent with a long-run price elasticity of demand for imported consumption and investment goods of 1.5.[7] Our setting of the adjustment cost parameters $\varphi_{M_C} = \varphi_{M_I} = \varphi_{M_A} = 10$ implies a price elasticity of 1/3.

5. Alternative trade specifications: empirical fit

In this section, we examine the ability of the DT specification to account for the empirical behavior of U.S. real non-energy imports, and compare its performance to the AT specification. In particular, we construct empirical counterparts to the activity and relative import price variables that drive real imports under each trade specification, and assess how closely the fitted series track data on real U.S. imports. As we argue below, the difference between specifications is driven almost exclusively by the alternative activity variables, and do not hinge on the particular features of the adjustment cost specification.

The log-linearized behavioral equation determining import demand under the AT specification may be expressed as

$$\tilde{x}_t = -\frac{\varepsilon_A}{1 + \varepsilon_A \varphi_{M_A}} \tilde{\psi}_t + \frac{\varepsilon_A \varphi_{M_A}}{1 + \varepsilon_A \varphi_{M_A}} \tilde{x}_{t-1}. \tag{11}$$

We use tildes to indicate the logarithmic deviation of a variable from steady state. In this equation, x_t is the ratio of real imports to private absorption (i.e., $\tilde{x}_t = \tilde{M}_t - \tilde{A}_t$), ψ_t is the ratio of the import price to the absorption price deflator, and $\varepsilon_A = (1 + \rho_A)/(\rho_A)$ is the absolute values of the (long-run) price elasticity of import demand. Eq. (11) can be easily manipulated to yield:

$$\tilde{M}_t = \tilde{A}_t - \frac{\frac{\varepsilon_A}{1 + \varepsilon_A \varphi_{M_A}}}{1 - \left(\frac{\varepsilon_A \varphi_{M_A}}{1 + \varepsilon_A \varphi_{M_A}}\right) L} \tilde{\psi}_t. \tag{12}$$

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[7]There is conflicting empirical evidence on whether the trade-price elasticity for durable goods is different from that for non-durable goods. For instance, Erkel-Rousse and Mirza (2002) found that the trade-price elasticity tends to be higher for durable goods industries, while Gallaway et al. (2003) found no discernable difference between durable and non-durable products.

Thus, real imports depend on private absorption (A_t), and on a distributed lag of the ratio of the import price to the private absorption deflator (ψ_t). The distributed lag polynomial on import prices, which dies out at the rate $(\varepsilon_A \varphi_{M_A})/(1 + \varepsilon_A \varphi_{M_A})$ (set at a value of 0.9375 by our calibration), arises due to the presence of trade adjustment costs. The sum of the lag coefficients equals 1.5, the long-run trade-price elasticity. As discussed in Section 3, our specification of adjustment costs implies that imports react immediately to changes in real activity (i.e., private absorption under the AT specification), but only gradually to relative price changes.

Given that our calibration for the DT specification imposes trade adjustment costs and the trade-price elasticities for both consumption and investment imports that are identical to the AT specification, the equation for aggregate imports under the DT case can be expressed in a symmetric form:

$$\tilde{M}_t = \tilde{A}_t^{\mathrm{DT}} - \frac{\frac{\varepsilon_A}{1+\varepsilon_A \varphi_{M_A}}}{1 - \left(\frac{\varepsilon_A \varphi_{M_A}}{1+\varepsilon_A \varphi_{M_A}}\right) L} \tilde{\psi}_t^{\mathrm{DT}}. \tag{13}$$

The only differences are that the DT activity measure A_t^{DT} replaces absorption A_t as the activity variable, and that the relative import price measure ψ_t^{DT} replaces ψ_t. The activity variable under the DT specification weights consumption and investment by their respective share in total imports, that is:

$$\tilde{A}_t^{\mathrm{DT}} = \left(\frac{M_C}{M}\right) \tilde{C}_t + \left(\frac{M_I}{M}\right) \tilde{I}_t, \tag{14}$$

where we denote steady-state values by omitting time subscripts. This contrasts with the AT specification, in which the activity variable A_t weights these components by their share in total private absorption:

$$\tilde{A}_t = \left(\frac{C}{A}\right) \tilde{C}_t + \left(\frac{I}{A}\right) \tilde{I}_t. \tag{15}$$

Thus, using our calibration, investment receives a weight of 3/4 in the activity variable driving imports under the DT specification, which is more than three times the weight it receives under the AT specification. Similarly, the relative price term ψ_t^{DT} is the ratio of the import price to a 'DT absorption price' that weights the consumption and investment deflators by the share of each component in total U.S. non-energy imports.

We next examine how the specifications (12) and (13) fit the historical behavior of U.S. real non-energy imports over the 1975:1–2005:3 period. Beginning with the AT specification, we use data on real private absorption and the ratio of the price of non-energy imports to the absorption deflation (i.e., ψ_t in Eq. (12)) to construct a fitted real import series. The (log of the) HP-filtered series is plotted in Fig. 1A against HP-filtered U.S. real non-energy imports. The figure also plots the relevant activity variable, HP-filtered private absorption, to help assess the relative importance of the activity and relative price terms in determining real imports (thus, the contribution of the distributed lag of the relative import price is simply the difference between the
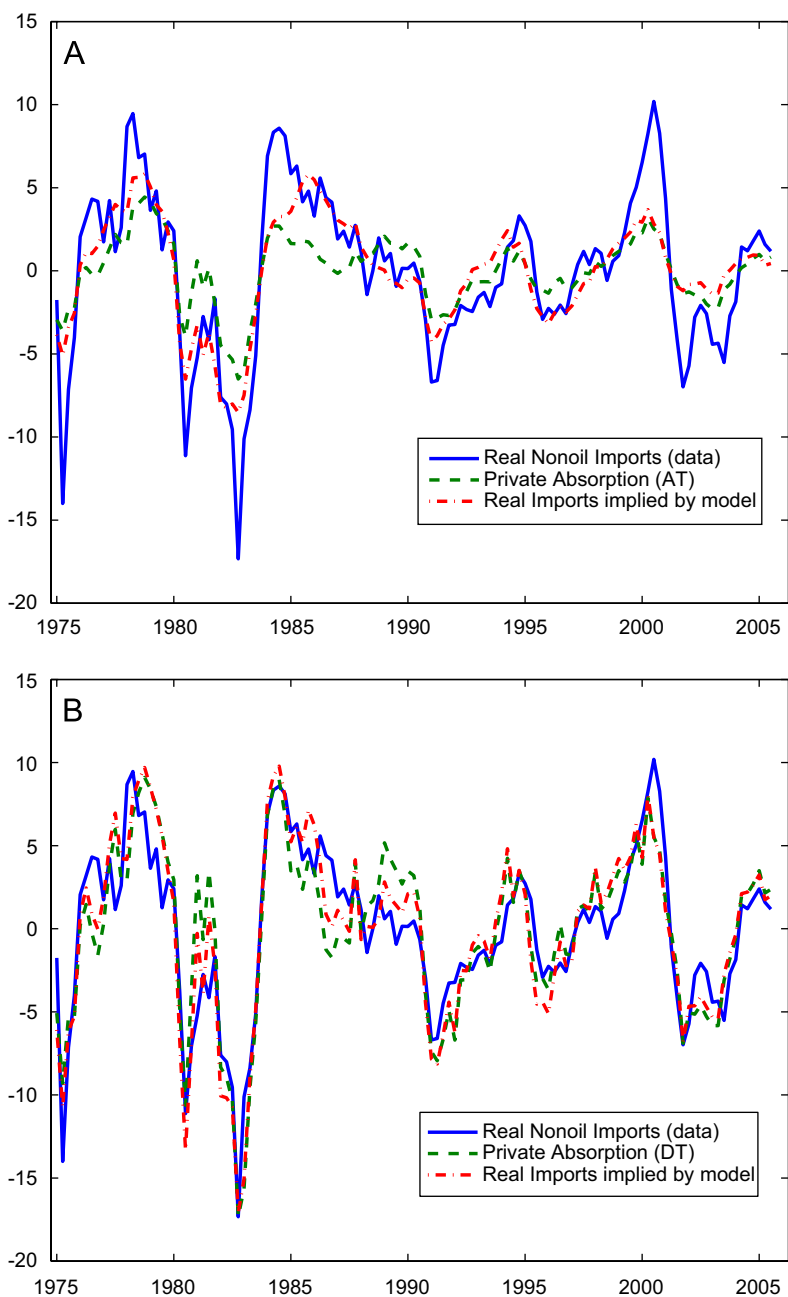
Fig. 1. U.S. real imports of goods and alternative activity measures. (A) AT Specification; (B) DT Specification.
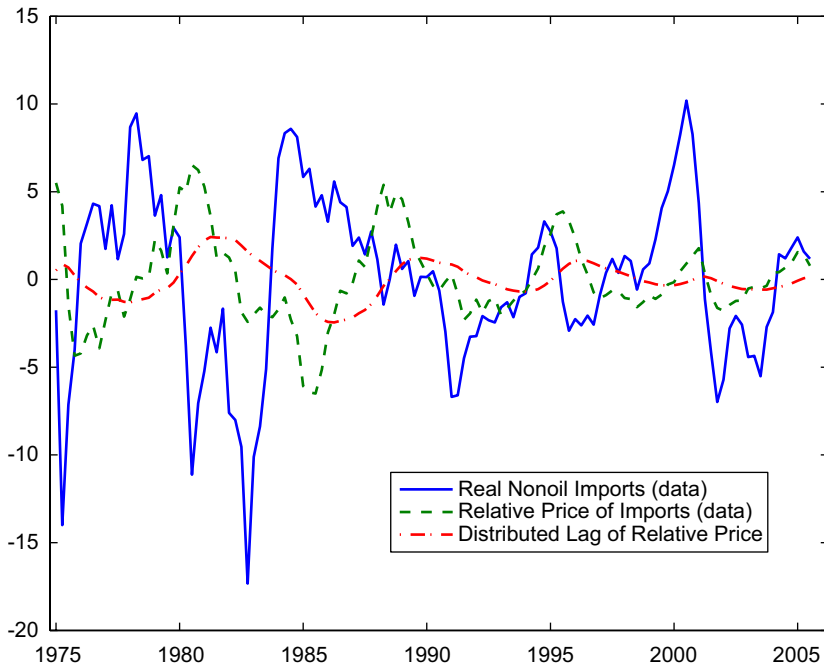
Fig. 2. Real imports and the relative price of imports.

fitted series, the dashed–dotted red line, and private absorption, the dashed green line).

While the fitted real import series under the AT specification exhibits strong positive comovement with the corresponding data, the former is much less volatile. The relative smoothness in the fitted import series reflects that private absorption – the activity variable – is much less volatile than real imports, and that relative prices make a fairly small contribution to the volatility of the fitted series. To help understand this small price contribution, Fig. 2 plots the ratio of the price of imports to the absorption price, as well as real imports (both series are again HP-filtered). Clearly, real imports exhibit much more volatility than the relative import price over the entire sample period, with the disparity even more pronounced since the early 1990s.[8] Thus, even assuming that trade-price elasticities are in the range of 1.5 as in our benchmark calibration (which is at the high end of the empirical literature), this evidence suggests that relative prices have played a modest role in explaining cyclical import variation, and especially the pronounced swings in imports of the last 15 years.

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[8]The fall in import price variability is consistent with a recent literature suggesting a marked decline in the passthrough of exchange rate changes to import prices, e.g., Marazzi et al. (2005).

Table 4
MSE of predicted imports (1975–2005)[a],[b]

Experiment	AT specification	DT specification
1. Benchmark calibration ($\varepsilon_A = 1.5$, $\varphi_{M_A} = 10$)	2.63	2.24
2. Activity measure only	3.08	2.45
3. Minimized MSE[c]	2.53	2.11
4. Alternative trade-price elasticity[d]		
$\varepsilon_A = 1$	2.64	2.20
$\varepsilon_A = 3$	2.67	2.31
5. Alternative Adjustment Cost Parameter[d]		
$\varphi_{M_A} = 5$	2.54	2.20
$\varphi_{M_A} = 30$	2.90	2.36

[a] Entries report the square root of the MSE.

[b] AT and DT specifications refer to AT and DT specifications implied by Eqs. (12) and (13), respectively.

[c] In this case, the parameters ε_A and φ_{M_A} are chosen to minimize the MSE. For the AT specification, $\varepsilon_A = 1.65$ and $\varphi_{M_A} = 5.53$, and for the DT specification, $\varepsilon_A = 0.80$ and $\varphi_{M_A} = 4.50$.

[d] The parameter values are the same as in the benchmark calibration except for the alternative parameter under consideration.

More broadly, our finding of a fairly modest contribution for the relative price term does not seem likely to hinge on particular features of our adjustment cost specification or our calibration. The first column of Table 4 extends our graphical analysis by reporting the (the square root) of the mean squared error (MSE) between the data and fitted values for alternative calibrations of the AT specification. The results for our benchmark calibration are shown in the first row. Including the relative price term results in some decline in the MSE relative to the case in which this term is effectively excluded (row 2); however, varying the parameters that affect the response of imports to relative prices (i.e., the trade-price elasticity and the adjustment cost parameter) does not yield MSE much lower than the benchmark. In fact, even when we optimize the adjustment cost and trade-price elasticity parameters to minimize the MSE (row 3, which coincides with an ordinary least squares estimator), the implied MSE is only a tad lower than under the benchmark. Overall, our results suggest that a specification in which the real activity variable in the import equation fails to 'soak up' most of the pronounced variation in imports will perform relatively poorly in accounting for import behavior.

Fig. 1B compares real U.S. non-energy imports to the fitted values of real imports implied by our DT specification (both HP-filtered). The fitted series tracks import demand remarkably well, including during periods involving large cyclical swings in imports (the better fit is also reflected in a lower MSE in Table 4). The improved fit under this specification is almost wholly attributable to the activity component, as the relative price component is virtually identical to that under the DT specification.[9]

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[9] This reflects that the empirical counterparts of the relative price terms, i.e., of ψ_t and ψ_t^{DT}, behave almost identically.

Importantly, the DT activity measure A_t^{DT} is nearly as volatile as real imports. Recalling the high weight that investment receives in the DT absorption measure, our evidence suggests that investment swings might play a considerably more prominent role in determining import demand than implied by traditional absorption-based (or output-based) AT models; moreover, the DT specification seems to perform well in accounting for imports even given the imposition of the theoretical constraint of unity on the (DT-based) absorption elasticity.[10]

6. Simulations

6.1. A Foreign investment demand shock

Fig. 3 shows the effects of a rise in foreign investment demand under the two alternative trade specifications. The underlying shock is a highly persistent decline in the foreign capital income tax rate τ_{Kt}^*, although it can be interpreted more broadly as a shock that boosts the expected return on foreign capital.[11] For each trade specification, the shock is scaled so that the level of foreign absorption at its maximum rises 1% point above steady state.

We begin by focusing on the AT specification. To understand the channels through which the foreign investment shock affects the domestic economy, note that the foreign analogue of Eq. (12) may be written as

$$
\tilde{X}_t = \tilde{M}_t^* = \tilde{A}_t^* - \frac{\frac{\varepsilon_A}{1+\varepsilon_A \varphi_{M_A}}}{1 - \left(\frac{\varepsilon_A \varphi_{M_A}}{1+\varepsilon_A \varphi_{M_A}}\right)L}\hat{\psi}_t
$$

$$
= \left(\frac{C^*}{A^*}\right)\tilde{C}_t^* + \left(\frac{I^*}{A^*}\right)\tilde{I}_t^* - \frac{\frac{\varepsilon_A}{1+\varepsilon_A \varphi_{M_A}}}{1 - \left(\frac{\varepsilon_A \varphi_{M_A}}{1+\varepsilon_A \varphi_{M_A}}\right)L}\hat{\psi}_t.
$$

As shown in the upper left panel, domestic exports rise both because foreign absorption (i.e., $\tilde{A}_t^*$) increases, and because home goods become relatively cheaper in the foreign market. The relative price effect is driven by a depreciation in the home country's real exchange rate (as indicated by an upward movement in the figure), reflecting that foreign real interest rates rise relative to domestic real interest rates.

Notwithstanding this change in interest rate spreads, domestic real interest rates rise as the export stimulus boosts domestic real GDP, and pushes up price inflation.

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[10]There is an extensive literature studying the volatility of trade. For example, Sheffrin and Woo (1990) and Ghosh (1995) documented the inability of the standard intertemporal current account model to explain the observed volatility of the current account. Backus et al. (1994) and Baxter (1995) documented that standard international real business cycle models underpredict the observed volatility of net exports and the terms of trade. In work closely related to ours, Boileau (1999) showed how an international RBC model that explicitly took into account that trade is heavily concentrated in capital goods implies greater volatility for net exports and the terms of trade.

[11]In all simulations, we assume that the stochastic process for the specified shock is autoregressive of order 1, with a persistence coefficient equal to 0.95.
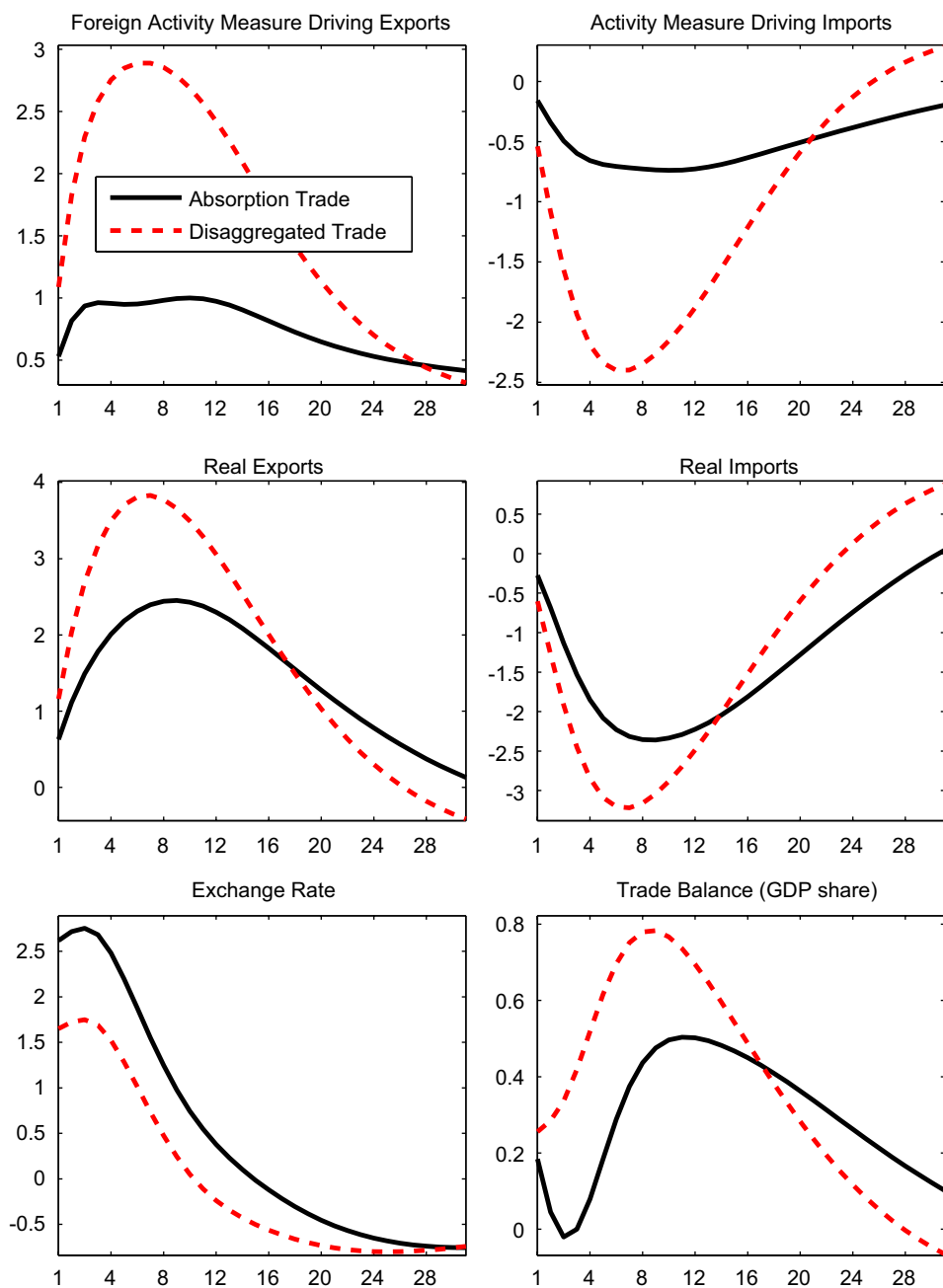
Fig. 3. A foreign investment demand shock.

In turn, higher real rates reduce domestic consumption and investment spending. Thus, real imports are depressed as the effects of weaker domestic absorption $\tilde{A}_t$ (shown in the upper right panel) are reinforced by the real exchange rate decline. The increase in real exports and contraction in real imports contribute to an improvement in the nominal trade balance of about 0.5% point of GDP.

Fig. 3 shows that the qualitative effects of the foreign investment shock on the home country's trade and real exchange rate are similar under the DT specification (using essentially the same logic as described above). Thus, the interesting issue is to explain the quantitative differences. In essence, the differences reflect that the activity variables driving home exports and imports under the DT specification ($\tilde{A}_t^{*DT}$ and $\tilde{A}_t^{DT}$, respectively) show much more pronounced variation than their counterparts under the AT specification (foreign and domestic absorption, respectively).[12] Reasoning from the foreign analogue of (14), the foreign activity variable under the DT specification weights the expenditure components by their share in foreign imports, rather than by their share in foreign private absorption. Accordingly, foreign investment receives a weight of roughly 3/4 under the DT specification, while only about 1/4 under the AT specification.

Given that the underlying shock has much larger stimulative effects on foreign investment than foreign consumption (which actually declines slightly under either trade specification), the effects on home exports arising from the foreign activity channel are much larger under the DT specification. As shown in the upper left panel, the foreign activity measure driving home exports (i.e., in $\tilde{A}_t^{*DT}$) rises 3% under the DT specification, roughly three times the increase under the AT specification (i.e., in $\tilde{A}_t^*$). Given that exports move proportionately to the relevant activity measure under either specification, this accounts for the much larger export response under the DT specification. Moreover, the upper right panel shows the activity measure ($\tilde{A}_t^{DT}$) driving home imports falls much more sharply under the DT specification, because domestic investment falls much more than consumption. This accounts for a larger fall in the volume of domestic imports. Interestingly, the larger movements in real exports and imports under the DT specification occur in spite of a somewhat smaller depreciation of the real exchange rate. The smaller exchange rate effects reflect that domestic real interest rates rise by more, because the foreign shock stimulates domestic external demand to a greater degree under the DT specification.

The larger activity-driven changes in real exports and imports under the DT specification translate into a more substantial improvement in the nominal trade balance (of about 0.8% point of GDP, relative to 0.5% point under the AT specification). Thus, a foreign investment shock has a bigger effect on the domestic trade balance under the DT specification than under the AT specification, even while generating a smaller depreciation of the domestic currency.[13]

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[12]The foreign activity channel relevant in the domestic export equation is the partial effect of a change in foreign activity holding relative prices constant.

[13]We considered an alternative calibration in which consumer durables are included as part of consumption instead of investment. This alternative attenuates the difference between the responses to shocks under the AT and DT specifications, but leaves our findings qualitatively unchanged.

6.2. A foreign consumption demand shock

Fig. 4 displays the effects of a foreign consumption demand shock under both trade specifications. This shock is modeled as a preference shift v_{ct}^* that has a highly persistent effect on the foreign marginal utility of consumption. The shock is scaled so that foreign absorption rises 1% at its peak.

Under the AT specification, the foreign consumption shock affects the home country through similar channels as the foreign investment shock considered above. Thus, it is unsurprising that the qualitative effects are similar, as can be seen by comparing Fig. 4 with Fig. 3. Importantly, the expansion of domestic exports is attributable both to the rise in foreign activity A_t^* (upper left panel), and to a depreciation of the real exchange rate.

While the responses of trade flows and the real exchange rate under the DT specification are similar qualitatively, there are salient differences in the channels through which this adjustment occurs. Most notably, because the foreign consumption shock causes foreign investment to decrease (due to crowding out from higher foreign interest rates), the foreign activity variable driving domestic exports under the DT specification (A_t^{*DT}) shows a pronounced contraction, falling 3% below baseline. Thus, given that the effects on exports arising from the activity channel are negative and sizeable, the improvement in exports that does occur is wholly attributable to real exchange rate depreciation. In contrast, while exports improve by less under the DT specification, imports show a larger contraction, and hence play a relatively more important role in accounting for trade improvement. The larger import decline reflects a bigger fall in the activity variable driving imports under the DT specification (since domestic investment declines more than consumption in response to higher domestic interest rates).

Notwithstanding the sharper contraction in the activity measure driving imports in the DT specification, the 'net' effect on real exports and imports arising from the activity channel would actually push toward a deterioration: as seen in the upper panels of Fig. 4, the activity variable driving exports falls 3%, while the activity variable driving imports falls only 2%. Thus, the substantial trade adjustment that does occur can be regarded as exclusively due to exchange rate depreciation, in contrast to the AT specification where changes in activity also play a significant role.

Finally, in comparing the effects of foreign investment and consumption shocks under our preferred DT specification, it is evident that foreign investment shocks can induce substantial improvements in domestic exports and the trade balance without requiring much exchange rate depreciation. In contrast, foreign consumption shocks rely almost exclusively on real exchange rate depreciation, with most of the trade improvement coming through a reduction in domestic imports.[14]

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[14]For sensitivity analysis, we increased the trade-price elasticity for investment goods, while simultaneously lowering the trade-price elasticity for consumption. These changes left the appropriately weighted aggregate trade-price elasticity unchanged. We found little difference between the results for our benchmark calibration of the DT specification and this alternative.
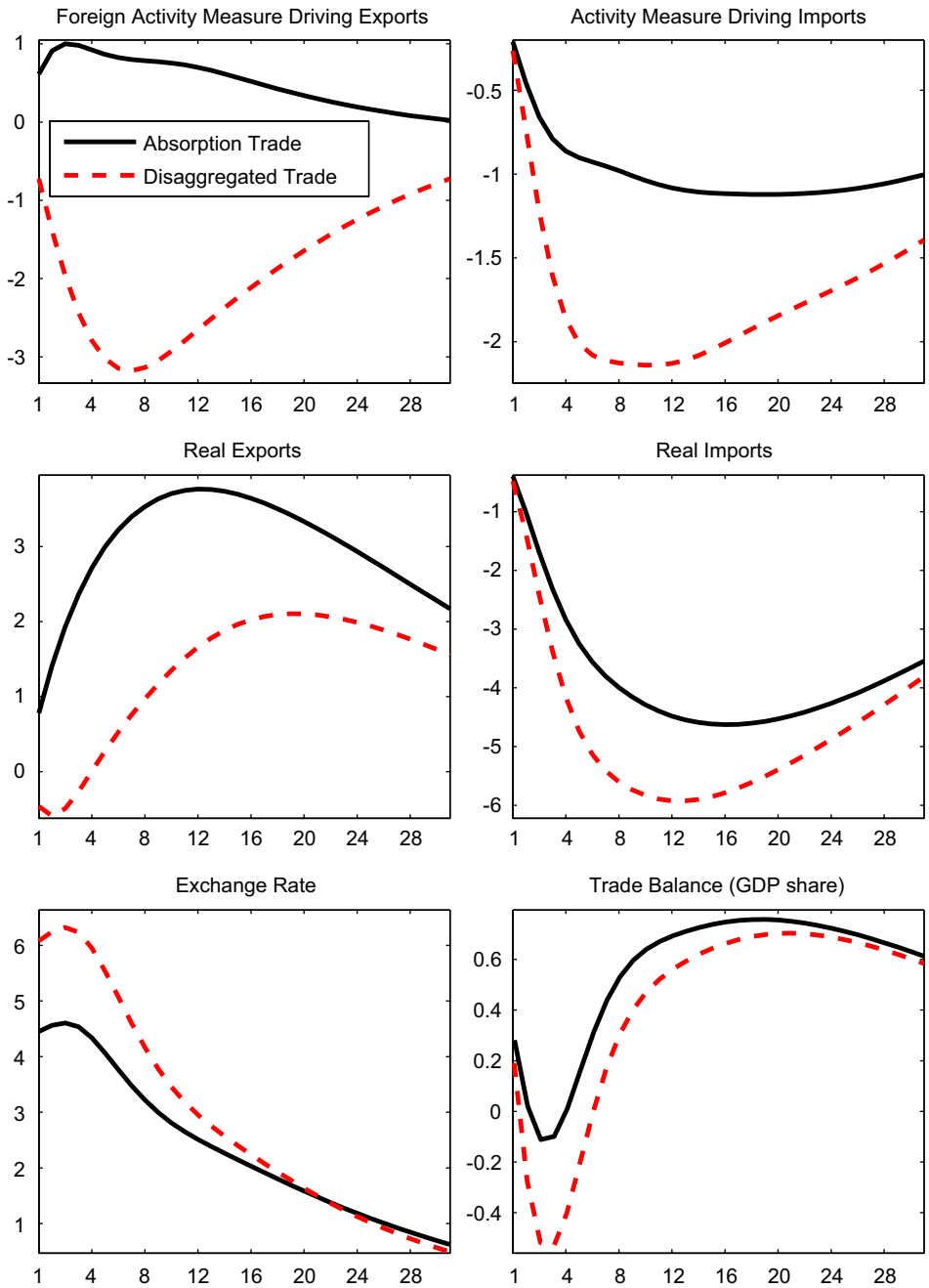
Fig. 4. A foreign consumption demand shock.

6.3. A domestic investment demand shock

Fig. 5 shows the effects of a fall in home investment demand under the two trade specifications. The underlying shock is a highly persistent rise in the domestic capital income tax rate τ_{Kt}, and is scaled so that domestic absorption decreases 1% below steady state at its trough.

Under either specification, the fall in domestic absorption triggers a decline in real interest rates, and associated fall in the real exchange rate. Foreign interest rates also decline (though by less than domestic interest rates), which stimulates foreign consumption and investment. The combination of lower domestic absorption, a depreciation of the home exchange rate, and rise in foreign absorption contribute to an improvement of the domestic trade balance as exports rise and imports contract.

As in the case of the foreign investment shock, the main difference between the alternative trade specifications is that the DT specification accentuates the role played by activity in driving the trade improvement. Thus, the activity measure driving domestic imports (A_t^{DT}) falls by 2.5% at its trough, accounting for almost all of the 3% decline in real imports; while the activity measure driving exports accounts for about half of the rise in exports. In contrast, the overall changes in real exports and imports are smaller under the AT specification, and rely more heavily on exchange rate depreciation.

6.4. A domestic consumption demand shock

Fig. 6 shows the response of key variables to a preference shock v_{ct} that is scaled so that it reduces domestic absorption by 1% relative to baseline.

Under the AT specification, the consumption shock operates through the same channels as the investment shock just described, and induces fairly similar effects on trade flows and the exchange rate. Both real activity and exchange rate depreciation play an important role in accounting for changes in real exports and imports.

In contrast, while exports also expand and imports contract under the DT specification, the improvement in real net exports owes entirely to exchange rate depreciation. In particular, the stimulative effect of higher foreign activity on real exports (of about 0.5%) is more-than-offset by a rise in the activity measure driving domestic imports (with A_t^{DT} rising because lower domestic interest rates stimulate investment). Thus, relative to the AT specification, the DT specification places much more weight on exchange rate depreciation as a channel for delivering trade balance improvement in response to a shock that reduces domestic consumption.

6.5. A technology shock

Fig. 7 shows the effects of a technology shock that boosts the level of real GDP by 1% in the long-run. The effects of the shock are qualitatively similar under either trade specification. In particular, because the technology shock pushes up the marginal product of capital, investment increases faster than output. Consumption also rises, though much less than output due to the restraining effect of higher real

Foreign Activity Measure Driving Exports

Activity Measure Driving Imports

Absorption Trade

Disaggregated Trade

Real Exports

Real Imports

Exchange Rate
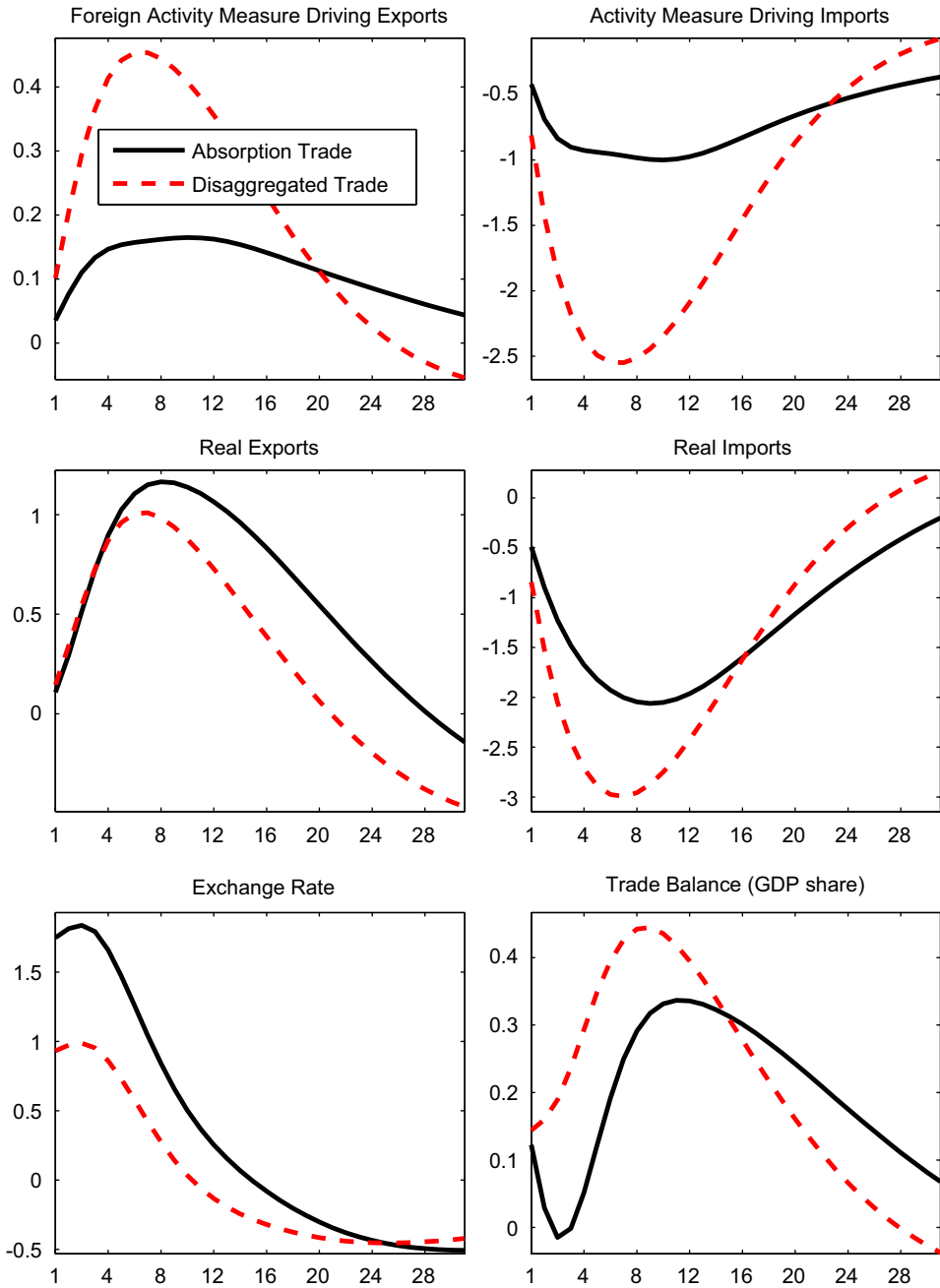
Trade Balance (GDP share)

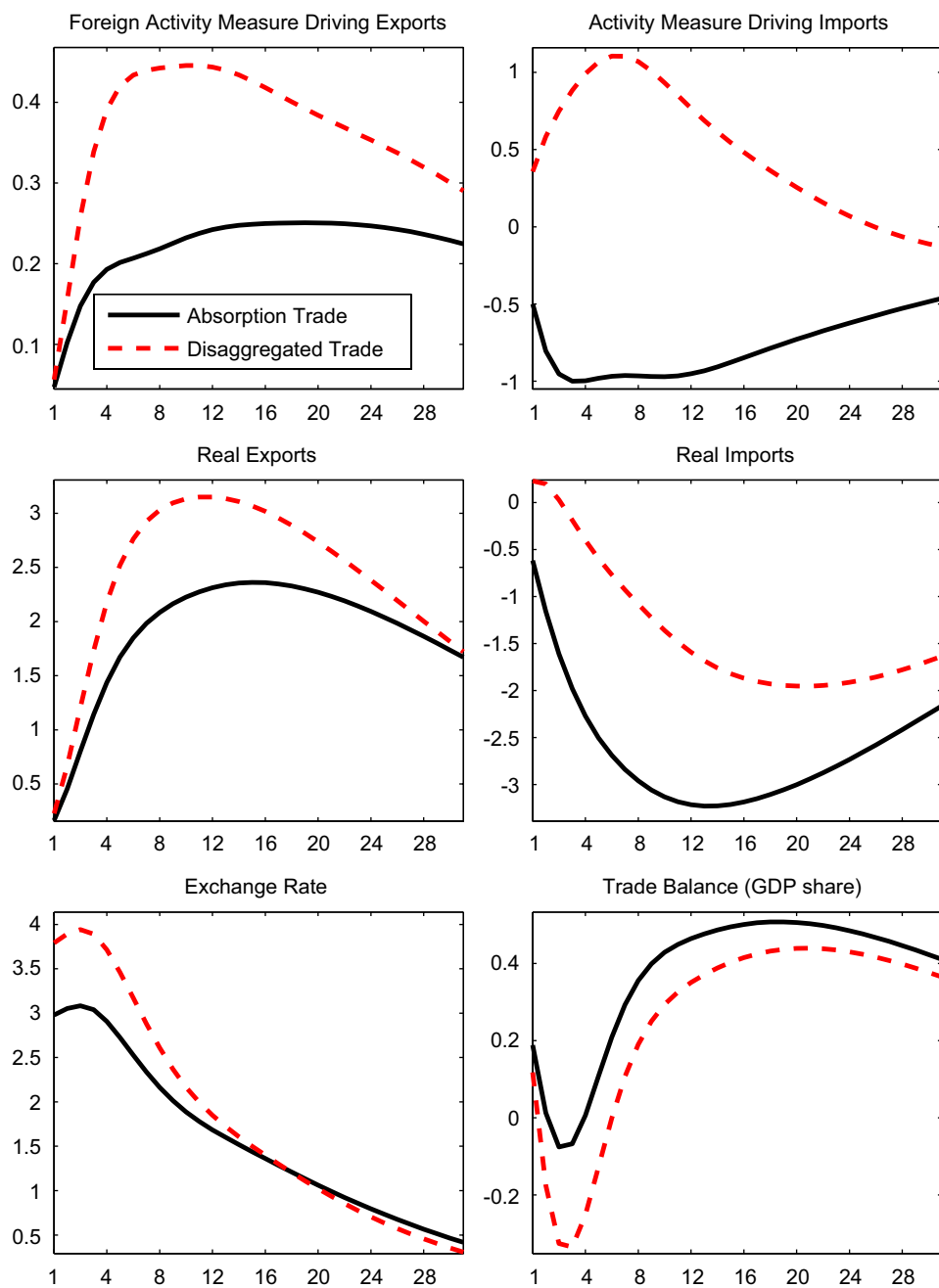Fig. 5. A domestic investment demand shock.

Fig. 6. A domestic consumption demand shock.

interest rates. The rise in absorption boosts imports under either trade specification, and causes the trade balance to deteriorate. However, given that the shock has a disproportionately large effect on investment spending, imports exhibit a more pronounced rise under the DT specification, and the trade balance deterioration is somewhat larger.

6.6. A persistent rise in foreign activity

We conclude with two simulations that involve simple dynamic extensions of the earlier experiments of one-time innovations to foreign investment and consumption. In particular, Fig. 8 considers the effects of a sequence of foreign investment innovations that gradually raises the foreign investment share by 1.5% points above baseline (the foreign investment innovations are identified with negative innovations to the foreign capital tax rate, as described in the first simulation). The 1.5% point rise in the investment rate is calibrated to reverse the estimated decline in the investment rate that has occurred in major U.S. OECD trading partners since the late 1990s. We compare the implications of a rise in foreign investment of this magnitude to the effects that would arise if the foreign consumption rate increased by a similar percentage of GDP.[15] Both simulations are conducted using our preferred DT specification.

As suggested by our analysis of the foreign investment and consumption shocks above, the foreign investment shock exerts a considerably larger effect on the U.S. trade balance than the foreign consumption shock, even while implying a much smaller depreciation of the real exchange rate. Thus, while the trade balance improves by over 1.0% point of GDP after 5 years and the real exchange rate depreciates less than 1%, the trade balance improves only 0.6% point in response to the foreign consumption shock, while the real exchange rate depreciates over 4%. Moreover, while the foreign investment shock induces a sizeable response of real exports and comparatively small import contraction, the foreign consumption shock is associated with a much weaker rise in exports, and larger import decline.

7. Conclusion

In this paper, we have used simulations of a DSGE model to show that taking account of the expenditure composition of U.S. trade yields implications for the responses of trade flows to shocks that are markedly different from those of a 'standard' framework that abstracts from such compositional differences. Overall, our preferred trade specification implies that investment shocks, originating from either foreign or domestic sources, may serve as a strong catalyst for trade balance adjustment, without much dollar depreciation. From a policy perspective, our results suggest that while policy changes that boost foreign investment would improve the

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[15]Notice that the increase in foreign consumption leads to a substantial crowding out of foreign investment.
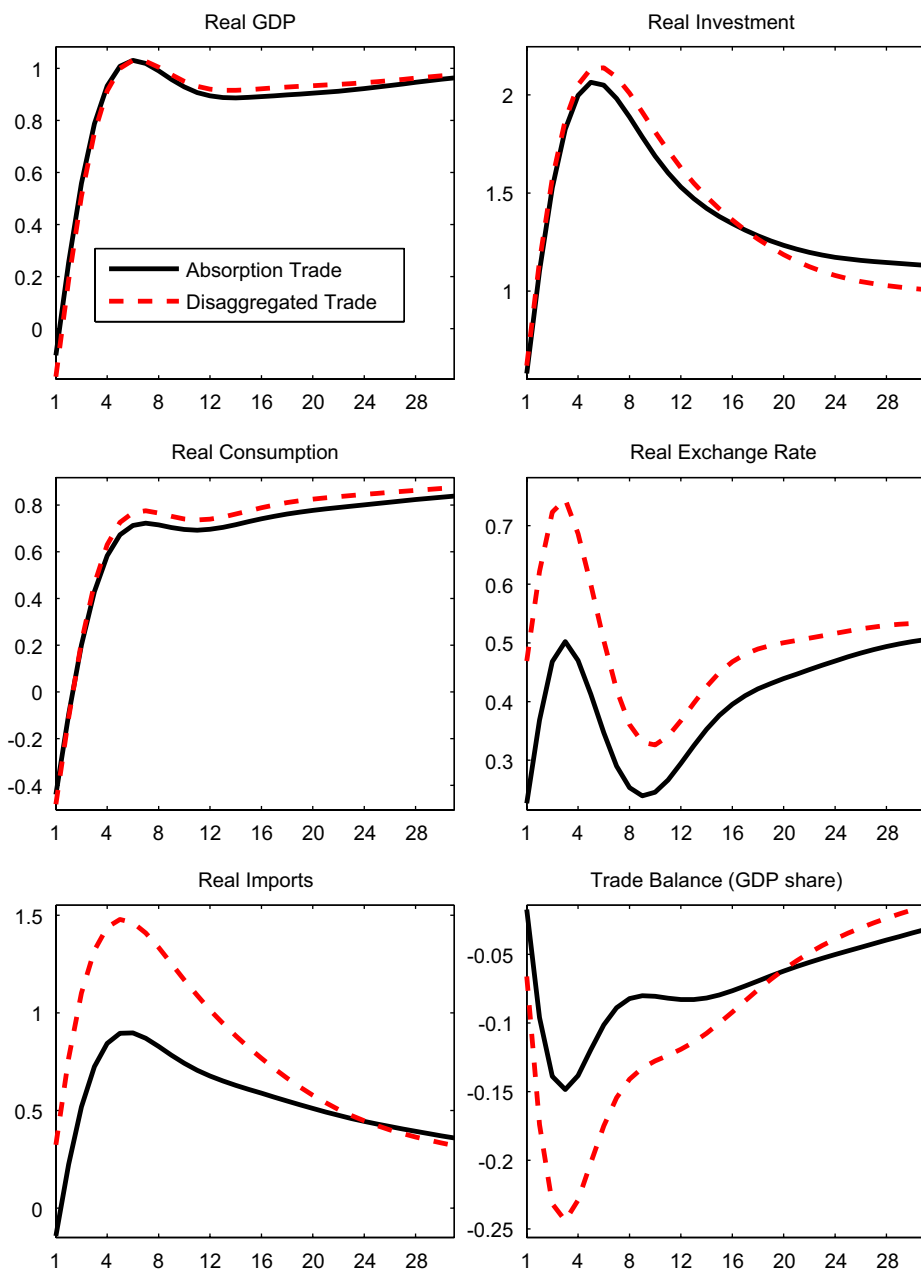
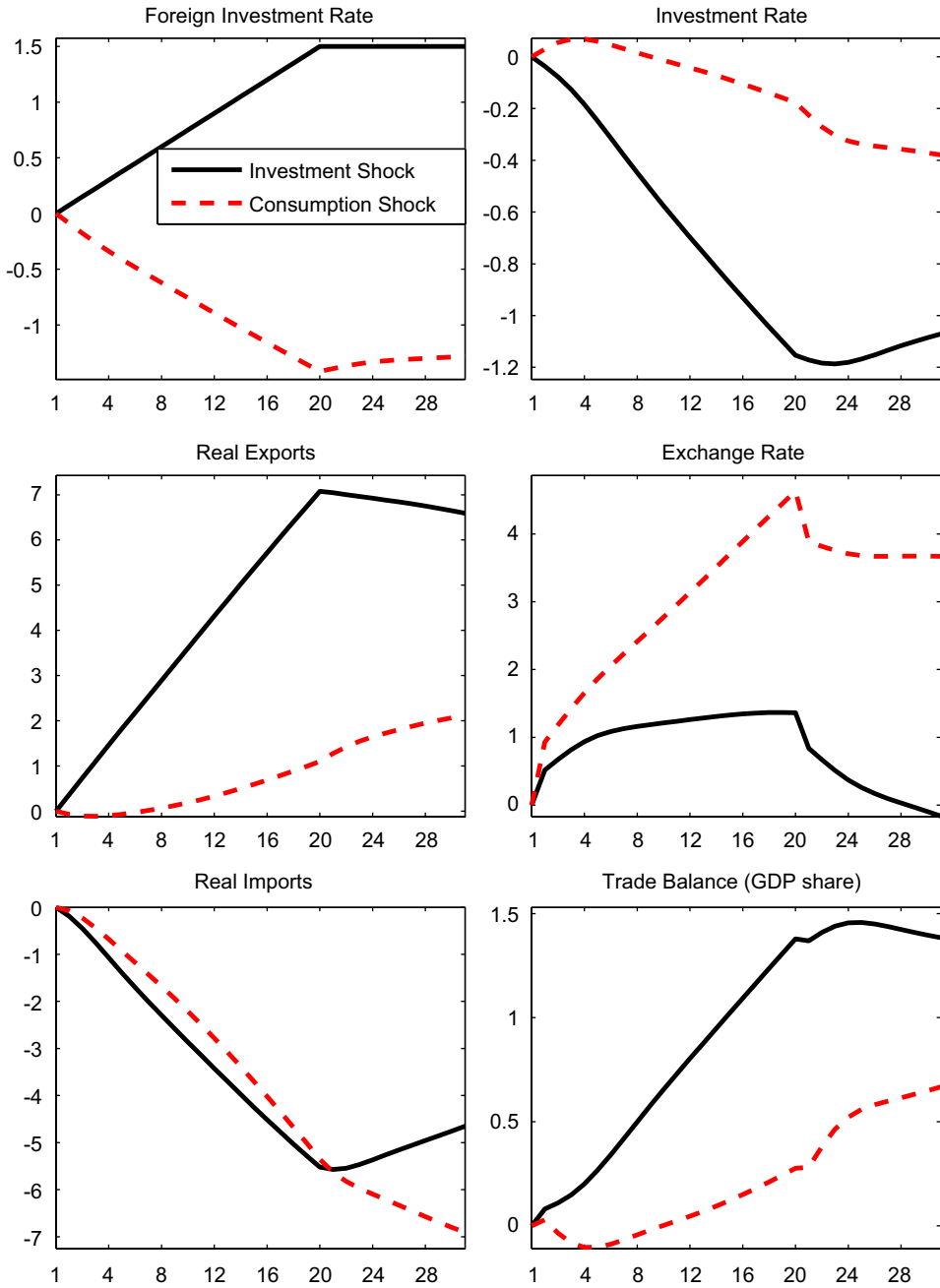Fig. 7. A technology shock that boosts real GDP by 1% in the long-run.

Fig. 8. A persistent increase in foreign demand (DT Specification).

U.S. trade balance significantly through the effect of higher foreign activity on exports, reforms oriented at stimulating foreign consumption would be associated with a much larger decline in the real dollar.

Acknowledgements

Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jedc.2007.09.015.

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