ABSTRACT

We study dynamic extensions of international trade models and their ability to explain the behavior of imports at business cycle frequencies where static models fail. Our premise is that because international trade is time intensive, then variation in the rate at which agents are willing to substitute across time will affect how trade volumes respond to changes in income and prices. We formalize this idea and find that our calibrated model is quantitatively consistent with cyclical properties of U.S. trade volumes. We then show that given the behavior of output and relative prices during the 2008-2009 crisis, our model goes a long way to explaining the collapse in U.S. imports during this time period.
1. Introduction

This paper studies dynamic extensions of international trade models and their ability to explain the behavior of trade volumes at business cycle frequencies where static models fail. Static trade models have difficulty explaining the response of trade volumes to changes in income and prices. For example, the empirical elasticity of imports to measures of output is well over one; standard models predict a unit income elasticity. The empirical elasticity of import volumes to measures of relative prices is well below one; calibrations of standard models use values well above one. Accounting exercises using static trade models to measure deviations between predicted and observed fluctuations in imports find these deviations to be pro-cyclical. All these features of the data are at odds with standard static models of international trade.

We show how introducing dynamics can help trade models rationalize these features of the data. The extensions we focus on are a time-to-ship friction to import goods and finite intertemporal elasticity of substitution. The time-to-ship friction makes the importing decision dynamic because resources must be sacrificed today for the delivery of goods tomorrow. With a finite intertemporal elasticity of substitution, the rate at which agents are willing to substitute across time—intertemporal marginal rate of substitution—depends on the trade-off between consumption today versus expectations of consumption tomorrow. Our insight is that variation in the intertemporal marginal rate of substitution with changes in income and relative prices will break the unitary income elasticity, bias the estimated price elasticity relative to static trade models, and it will show up as a time varying trade friction.

We formalize these ideas by building a pure exchange, small-open economy model designed to answer a specific quantitative question: Given a stochastic process describing output and prices like in U.S. data, how does the time-to-ship friction and finite intertemporal elasticity of substitution shape the decision to import? In the model, there are a large number of countries. An agent within a country receives a stochastic endowment of its own nationally differentiated good. Agents have time-separable preferences of the constant relative risk aversion class over an aggregate consumption good. The aggregate consumption good is a composite of the nationally differentiated goods and the aggregator of the goods is of the constant elasticity of substitution class. Agents take prices as given and we model the evolution of relative prices as following a stochastic process. The only friction that agents face is that they must commit resources today for the delivery of imported goods in subsequent periods.

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1 Examples of models of this type are those of Krugman (1980), Eaton and Kortum (2002), Anderson and van Wincoop (2003), and Melitz (2003). This also includes international real business cycle models as summarized in Backus, Kehoe, and Kydland (1995).

The main result is that our model can quantitatively deliver the high income elasticity and low price elasticity, consistent with U.S. time series data. We use standard values to calibrate the intertemporal elasticity of substitution and the elasticity of substitution across goods. We estimate the stochastic process for endowments and prices from U.S. data. We then simulate the model and estimate implied income and price elasticity using the simulated data. Consistent with U.S. data, we find that the income elasticity in our model is well over one and the price elasticity is well below the underlying elasticity of substitution for plausible values of the intertemporal elasticity of substitution. Performing the same exercise but removing the time-to-ship friction or with infinite intertemporal elasticity of substitution we find the estimated income elasticity is effectively one and the price elasticity is the same as our calibrated elasticity of substitution.

Our results have much to say about the large drop in trade during the 2008-2010 recession. While we are not focused per-se on this episode and the specifics behind it, we explore our model’s implications for it given the attention that this episode has received.³ To do so we apply the Kalman smoother to our model using US data on relative prices and absorption to generate a predicted series of imports. We show that for plausible values of the intertemporal elasticity of substitution, our model explains a large majority of the collapse in U.S. import data (see figures 5(a) and 6). In contrast, the model without the time-to-ship friction or endowing agents with infinite intertemporal elasticity of substitution performs poorly (see figure 5(b)). Our story is that a bad output state of the world was realized and agents become unwilling to substitute (on the margin) across time periods. Because international trade is time intensive, imports declined more than absorption resulting in a trade collapse.

Trade elasticities play critical roles in formulating predictions and recommendations for policymakers to questions like the effects of a one percent depreciation of the U.S. dollar (see e.g. the discussion in Hooper, Johnson, and Marquez (2000)). This has generated a large literature on the estimation of income and price elasticities for imports motivate this paper (see e.g. Marquez (2002) for a discussion of this research). The key questions surrounding the empirical estimates of trade elasticities are their stability and hence their usefulness in making predictions and the disconnect with the predictions of standard trade models.

We contribute to this literature by providing answers to these open questions. First, we rationalize the disconnect between empirical trade elasticities and standard trade models by introducing dynamics. Moreover, while our model does not have constant price and income elasticities, it retains the parsimony and performance of statistical models with constant elasticities. These two features— theoretical consistency and statistical performance—suggest that our model can contribute to answering certain forecasting and policy questions.

³See for example, the papers in Baldwin (2010); Alessandria, Kaboski, and Midrigan (2010a); Amity and Weinstein (2009); Bems, Johnson, and Yi (2010); Chor and Manova (2010); Eaton, Kortum, Neiman, and Romalis (2010); Jacks, Meissner, and Novy (2009); Levchenko, Lewis, and Tesar (2010).
This paper also contributes to a growing set of findings in the international trade literature showing how models with dynamic considerations modify the implications of otherwise standard trade models. Ruhl (2008) shows how the response of forward looking firms to temporary versus permanent shocks (such as trade liberalizations) rationalize the findings of low Armington elasticities in high frequency data versus high Armington elasticities in low frequency data. Alessandria, Kaboski, and Midrigan (2010b) study how time-to-ship plus fixed costs of ordering give rise to inventory considerations that help explain the response of imports to terms of trade and interest rate shocks. Alessandria, Kaboski, and Midrigan (2010a) building on their previous work study the collapse in trade during the 2008-2010 recession. Unlike these papers, we focus on: (i) a different mechanism, i.e. how dynamics give rise to an endogenous discount factor that shapes the import decision and (ii) how this mechanism — within an otherwise standard trade model — generates a greater than unit income elasticity and biases the price elasticity below the elasticity of substitution in the model.

2. Cyclical Properties of International Trade Volumes

In this section, we outline some key features of cyclical fluctuations in imports, prices, and income and their co-movement in U.S. time series data. In many ways the data features we describe are not new, e.g. see Houthakker and Magee (1969) on the income elasticity of trade, Ruhl (2008) on the low price elasticity, and Jacks, Meissner, and Novy (2009), and Levchenko, Lewis, and Tesar (2010) on the wedge analysis. However, they are important to summarize as motivation for our model and results.

To summarize the statistical properties of cyclical fluctuations in imports, prices, and income in U.S. time series data, we use a log-linear relationship relating imports to prices and income. The rationale for using this relationship comes from standard models of international trade based on CES preferences or production functions. These models have the following demand function for imports

$$\log M_t = \omega_t + -\theta \log \left( \frac{p_{m,t}}{P_t} \right) + \log Abs_t. \tag{1}$$

This relationship relates real imports $M$, real absorption $Abs$, the price of imports $p_{m,t}$ and the absorption price index $P$, in a log-linear way. The parameter $\theta$ controls the price elasticity of

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4We think of standard models as those which generate which generate log-linear import demand functions also known as gravity equations. Examples of standard models are those of Krugman (1980), Anderson and van Wincoop (2003), Eaton and Kortum (2002), and Melitz (2003) or international business cycle models as summarized in Backus, Kehoe, and Kydland (1995).

5Absorption is gross domestic product plus imports minus exports. Because static trade models typically impose balanced trade, absorption corresponds with income. Hence we will use absorption and income synonymously.
imports. The parameter $\omega_t$ is a “wedge” which we will describe in more detail below.

We use data and the structure of equation (1) to perform two exercises. The first exercise runs the regression

$$\log M_t = \alpha \log \left( \frac{p_{m,t}}{P_t} \right) + \beta \log Abs_t + \epsilon_t. \quad (2)$$

Relative to equation (1), the coefficient $\alpha$ measures the empirical price elasticity and $\beta$ measures the empirical income elasticity in the context of standard trade models. While we use the language “elasticity”, the estimates of $\alpha$ and $\beta$ are best thought of summarizing the statistical properties of how imports, relative prices, and absorption behave in the time series.

The second exercise imposes the theoretical restrictions implied by equation (1), a unit income elasticity and an assumed value for the price elasticity, and then infers the wedge $\omega$ by comparing predicted imports versus actual imports. Specifically the wedge is computed as

$$\omega_t = \log M_t - \left( -\theta \log \left( \frac{p_{m,t}}{P_t} \right) + \log Abs_t \right). \quad (3)$$

We set $\theta = 1.5$ which is the standard international business cycle calibration of this parameter. This exercise is similar to that of Jacks, Meissner, and Novy (2009), and Levchenko, Lewis, and Tesar (2010). Following the arguments of Chari, Kehoe, and McGrattan (2007), this exercise is meaningful because systematic deviations between theory and data shed light on mechanisms through which underlying primitives operate. Specifically, if $\omega_t$ varies systematically with the business cycle then this suggests: (i) there are economic forces that are not reflected in equation (1) and (ii) any new mechanism posited to explain these deviations should operate through the wedge.

### A. Measurement Issues

There are several issues in constructing data for use in the regression (2) and wedge analysis in (3). They are: (i) the appropriate definitions of imports and absorption and (ii) how to construct the appropriate real measures and the associated price indices. These are important issues, thus we will spend several paragraphs here describing the construction of our data series.

We will focus our analysis on imports and absorption of goods, excluding oil. The National Income and Product Accounts (NIPA) reports measures of imports and exports of goods and GDP coming from goods production. Adding nominal values of imports and subtraction exports of goods to nominal goods GDP one arrives at a measure of nominal absorption.

We should note that the focus on goods GDP helps address compositional issues of the sort described by Eaton, Kortum, Neiman, and Romalis (2010) because we will focus on an absorption
measure where most trade occurs. To address compositional issues within goods (i.e. durable vs. non-durable) emphasized by Boileau (1999), Engel and Wang (2009), we perform the same analysis later in this section using only durable or non-durable goods.

Constructing real measures of these activities and the associated price indices is not as straightforward as this might seem. Real values in the U.S. NIPA accounts are chain-type indexes using an “ideal” chain index advocated by Fisher (1922). While these indexes have desirable properties they are not additive across categories (see Ehemann, Katz, and Moulton (2002) and Whelan (2002) for detailed discussions). For our purposes the implication is that one can not compute real absorption simply by adding real goods GDP to real imports and subtracting real exports. An (approximate) solution to this problem is to use a “Fisher of Fishers” approach suggested by Diewert (1978). The basic idea is to take the real values and the associated price indexes for the categories of interest and then compute Fisher indexes of these measures — hence the “Fisher of Fishers” name.

Using this approach we construct data series for real absorption of goods, real imports of goods, and the associated price indexes starting in the second quarter of 1967 and ending in the second quarter of 2010. To deal with trends, we HP-filtered the logarithm of these data with smoothing parameter 1600. Results using log-first-differences yielded no significant differences.

B. High Income Elasticity, Low Price Elasticity, Pro-Cyclical Wedges

Table 1 presents the results of the estimated income and price elasticities of imports. Figure 2(a) plots the results from the wedge exercise. Below we outline three observations.

O.1. Income elasticity \( > 1 \). The estimated income elasticity of imports is nearly 2, i.e. a one percent increase in absorption translates to a two percent increase in imports. This contrast with equation (1) which shows that the elasticity of imports to real absorption is one. Thus the unit income elasticity implied by standard models seems at odds with the results in Table 1.

Figure 1(a) illustrates this finding. It plots the percent deviations from trend of real absorption (as measured using goods GDP) and import data. Consistent with the findings in Table 1 absorption correlates strongly with imports, yet it is about a third as volatile.

The fact that the estimated income elasticity of demand for U.S. imports exceeds unity is a well known fact, dating back to Houthakker and Magee (1969). Marquez (2002) examines this puzzle from a modern perspective and finds that it is intractable to alternative econometric specifications, different frequencies, and commodity disaggregation.

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6We used least squares to estimate the regression in (2). We also explored a Cochrane-Orcutt estimator to adjust for serial correlation in the error term. The presence of serial correlation is found, but the price and income elasticity declined only slightly relative to those in Table 1. Moreover, our model provides a rationale for why one might find serial correlation in the error term.
Figure 1: Absorption, Relative Prices, and Import Data
<table>
<thead>
<tr>
<th>Data</th>
<th>Price Elasticity, $\hat{\alpha}$</th>
<th>Income Elasticity, $\hat{\beta}$</th>
<th>$R^2$</th>
<th># Obsv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goods GDP</td>
<td>$-0.47$ (0.10)</td>
<td>$1.98$ (0.14)</td>
<td>0.63</td>
<td>173</td>
</tr>
</tbody>
</table>

**Note:** Data are in logs and HP filtered over the time period from Q2 1967 to Q1 2010. Heteroskedastic robust standard errors are in parenthesis.

The key feature we wish to emphasize here is that at short-run or business cycle frequencies the greater than unity income elasticity persists. This is an important distinction because prominent explanations of the high income elasticity of demand are based on expanding product variety (see Krugman (1989) and Feenstra (1994)) which are best thought of as medium/long-run explanations.\(^7\)

**O.2. Low price elasticity.** The second point is that the estimated import price elasticity is $-0.47$. Figure 1(b) illustrates this finding. It plots the percent deviations from trend of relative prices $p_{m,t}/p_t$ and import data. Notice that the prices and imports weakly correlate with each other and in some instances even move in the same direction. Thus the low price elasticity in Table 1 is not a surprise.

Unlike the high income elasticity, there is nothing per-se wrong with a low price elasticity. Modelers have a choice over this parameter. However, this estimate is low relative to typical calibrations/estimations of static trade models or international business cycle models. High values of $-\theta$ typically come from using changes in trade flows during trade liberalizations. Lower values of $-\theta$ typically come from imposing a unitary income elasticity and using time series variation in prices and trade flows relative to absorption. Ruhl (2008) provides an extensive discussion of the conflicting estimates of this elasticity.

**O.3. Pro-cyclical wedges.** The final point is that the wedges inferred using equation (3) are pro-cyclical. Figure 2(a) simply plots the wedge versus hp-filtered real import data. For interpretation, note that this wedge equals the negative value of the implicit trade cost.

For most the time period the wedge tracks imports very closely. Confirming this, a regression of imports on the wedge yields a slope coefficient of 0.65 and an $R^2$ of 0.41. This suggest systematic variation in the wedge is quantitatively important to explaining variation in imports. Given the

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\(^7\)Quantitatively, Feenstra (1994) shows the expanding product variety explanation can only account for part of the high income elasticity. Ruhl (2008) shows that this margin is not quantitatively important at business cycle frequencies. Kehoe and Ruhl (2009) measure changes in the extensive margin and find that it plays little role outside of significant structural transformations or trade liberalization.
Figure 2: Wedges and Import Data

(a) Wedges and Real Imports

(b) Wedges and Real Imports, Durables Only
discussion above this observation suggests that there are economic forces that are operative in the data but not in models consistent with equation (1).

Systematic variation in the trade wedge is not distinct from observations O.1 and O.2. Standard models basically have stronger substitution effects relative to income effects, i.e. imports should be more responsive to a one percent change in prices relative to a one percent change in income. The data observations O.1 and O.2 suggest the complete opposite pattern. Thus the wedge analysis with standard models that put more weight on relative price changes versus changes in income are bound to find systematic variation in the trade wedge.

The 2008-2010 recession illustrates this point well. During this time period, absorption decreased and imports decreased even more — this is the high income elasticity. When the income elasticity is constrained to be one the wedge must then decrease to rationalize the drop in imports. Second, relative prices decreased and imports did not increase as predicted by the standard model — this is the low price elasticity. When the price elasticity is constrained to take on a standard value, this implies the wedge must decrease even more. Thus the fact that imports over-respond to income and under-respond to prices manifests itself as a pro-cyclical wedge when events like the 2008-2010 recession are analyzed in the context of a standard trade model.

C. Discussion — Durables and Inventories

In recent papers on the trade collapse during the 2008-2010 recession, two issues have been raised about cyclical movements in trade flows: the distinction between durables and non-durables and inventories. Here we show that by focusing on durables only or incorporating inventories do not contradict observations O.1-3.

Durables vs. Non-Durables. One concern is that observations O.1-3 are just picking up compositional effects of the sort described by Boileau (1999) and Engel and Wang (2009). The argument is that a larger fraction of imports are classified as durables than in, say, absorption of total goods. This idea combined with the fact that consumption of durables is more volatile than that of nondurables, suggests that an income elasticity larger than unity or pro-cyclical trade wedges may arise because of the compositional difference.

The durables composition story suggests that if we focused on only durables, then observations O.1-3 would disappear. The top row in Table 2 addresses this argument by restricting the import, absorption, and price data to only durable goods and re-estimating equation (2). The results in Table 2 show that the income elasticity of imports is well above one (albeit mitigated), and the import price elasticity is similar to that found in Table 1.

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8The appendix of Levchenko, Lewis, and Tesar (2010) provide a rationale for why this regression is theoretically appropriate under plausible assumptions of the evolution of the stock of durables.
Table 2: Empirical Price and Income Elasticities — Durables and Inventories

<table>
<thead>
<tr>
<th>Data Series / Approach</th>
<th>Price Elasticity</th>
<th>Income Elasticity</th>
<th>Inventory Elasticity</th>
<th>$R^2$</th>
<th># Obsv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durable Goods</td>
<td>$-0.47$</td>
<td>1.35</td>
<td>—</td>
<td>0.61</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Durable Goods</td>
<td>$-0.16$</td>
<td>2.97</td>
<td>—</td>
<td>0.49</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goods &amp; Δ Inventories</td>
<td>$-0.43$</td>
<td>1.68</td>
<td>0.22</td>
<td>0.72</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.11)</td>
<td>(0.02)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Data are in logs and HP filtered. Heteroskedastic robust standard errors are in parenthesis.

The durable trade wedge still accounts for a lot of the variation in imports. Figure 2(b) illustrates this by plotting the trade wedge for durable goods only. Similar to the results discussed in O.3, a regression of imports on the wedge yields a slope coefficient of 0.75 and an $R^2$ of 0.40. The reasoning is the same as discussed above: the data suggests imports are more responsive to income than to changes in relative prices, standard models predict the opposite. Thus while the income elasticity is mitigated, the relative weighting of the income and substitution effects conflict with what the data suggest.

Table 2 also presents the results when the data are restricted to only non-durable imports, absorption, and prices. Again one finds high income elasticities and low price elasticities. Note that some care must be taken with these results because non-durable imports include petroleum products unlike our other results. This may explain the rather large income elasticity. However, this provides another piece of evidence suggesting that a simple composition story explains the main findings in Table 1.

Inventories. Another concern is that O.1-3 arises because we abstract from changes in inventories.\footnote{Feenstra (1994) suggests this as well and uses real personal consumption to instrument for the fact that changes in inventories are not controlled for. We did this and found the estimated price and income elasticity are $-0.52$ and $2.32$.} Alessandria, Kaboski, and Midrigan (2010a) make this argument while studying the decline in trade flows during the 2008-2010 recession. An implication of Alessandria, Kaboski, and Midrigan’s (2010a) model is that the regression equation in (2) should be augmented with the change in imported inventories (Alessandria, Kaboski, and Midrigan (2011) provide this derivation).
We followed this argument by augmenting the regression in (2) by including data on the real change in private inventories as an additional explanatory variable. Separate information on changes in imported vs. non-imported varieties is unavailable. The second row in Table 2 reports the results. After controlling for changes in inventories, the income elasticity is 1.68 relative to 1.98 without controlling for inventories. Including inventories also improves the fit of the regression from an $R^2$ of 0.63 without inventories to 0.71 with inventories. These results suggest that inventory adjustments are a partial, but not a complete explanation of the high income elasticities observed at cyclical frequencies.

A final point is that the inventory is complementary to the central mechanism we described below. Flesh this out more.

3. Model

In this section we describe a pure exchange, small open economy model. The model we describe is designed to ask a specific question: given an endowment and price process, how does the time-to-ship friction and finite intertemporal elasticity of substitution affect how imports respond to income and price shocks?

The world economy consists of a large number of countries of two types, home and foreign. In each country there is an infinitely lived representative consumer. This consumer has time-separable preferences over a period utility function. Period utility is of the constant relative risk aversion class and defined over a composite consumption good $Q_t$, defined below. Expected discounted future utility is given by:

$$
E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{Q_t^{1-\gamma}}{1-\gamma} \right\}
$$

where $\gamma > 0$ and $\beta \in (0, 1)$. The value $\gamma$ relates to both the coefficient of risk aversion and the elasticity intertemporal of substitution. The parameter $\beta$ is the discount factor. $E_0$ is the mathematical expectation operator at date zero.

The composite consumption good $Q_t$ is a CES aggregate over two goods, $x$ and $y$:

$$
Q_t = (x_t^\rho + y_t^\rho)^{1/\rho}
$$

where $\rho \in (0, 1)$. The parameter $\rho$ controls the elasticity of substitution across goods with this elasticity defined to be $\theta = \frac{1}{1-\rho}$.

Every period, the consumer in a typical home country receives a stochastic endowment of good $x$, while the consumer in a typical foreign country receives a stochastic endowment of
good $y$. These endowments are idiosyncratic to each particular country. These endowments are not storable: they can either be consumed domestically or used to acquire foreign goods through a centralized goods market. Goods cannot be re-exported.

International trade is the exchange of one type of good in exchange for another type of good. International trade is subject to two technological constraints. First, agents in each country face iceberg trade costs, $\tau > 1$, to move goods across borders. This implies that for every $\tau$ units of a good that are shipped, only one unit arrives at a destination.

Second, international purchases are subject to time-to-ship. We model this such that if one unit of good $y$ is purchased by the home country at date $t$, it only arrives (and is only available for consumption) at date $t + 1$. In section 4 we explore modifications of the strict one period time-to-ship assumption. Along with this assumption, we assume that goods must be paid for first and then they are delivered.\(^\text{10}\)

Underlying this international trading structure is an assumed enforcement technology that allows countries to coordinate the dynamic exchange of goods across international borders.

We abstract from trade in international financial assets.\(^\text{11}\) This does not imply that the typical agent is in financial autarky. Because of the timing assumption on international trade, trade is equivalent to purchasing a one period non-state contingent bond that pays out one unit of the foreign good next period. Thus international trade acts implicitly like financial asset in this model. With this insight and noting that each country faces idiosyncratic risk in endowments, this model is closely related to the one good incomplete market models of Huggett (1993) and Aiyagari (1994) and Castro’s (2005) reinterpretation of these models to countries rather than individuals.

With these assumptions the consumer in a typical home country faces the following budget constraint:

\[
p_{xt}x_t + \tau p_{yt}y_{t+1} \leq p_{xt}z_t
\]

where $p_{yt}$ and $p_{xt}$ are the prices that the typical consumer faces. The term $z_t$ is the idiosyncratic endowment of the $x$ good that the consumer typical the home country receives. The term $x_t$ is the amount of the home good purchased for consumption today; $y_{t+1}$ is the amount of the foreign good purchased today for consumption next period.

Inspecting the budget constraint (6) one realizes that the value of orders of imports at date $t$ (i.e. imports delivered tomorrow) must equal the value of exports shipped at date $t$. Thus

\(^{10}\)In reality, there are a variety of payment arrangements used. This is known as “cash in advance”, see Capela (2008) for a description of how transactions take place.

\(^{11}\)Evidence on the proper international asset structure to allow agents to trade is limited and what is available points towards financial autarky; see for example Heathcote and Perri (2002).
our model has a “dynamic trade balance” condition holding for every pair of contiguous time periods:

\[ \tau p_{yt+1} = p_{xt}(z_t - x_t) . \]  

This observation is interesting because trade is not balanced period by period as in static trade models and thus our model will have a non-zero current account. One can show the current account is equal to the difference in the orders of imports (for delivery tomorrow) and the arrivals of imports. Consistent with the idea of international trade being equivalent to trade in a particular asset, if the current account becomes positive then this as if savings increased because consumption of the home good is forgone today for consumption of the foreign good tomorrow.

The small open economy aspect deserves some discussion. First, the consumer in a typical country takes the prices \( p_{yt} \) and \( p_{xt} \) as given — this is standard. Second, we will model these prices as following a stochastic process. This is in contrast to solving for the prices that clear the world market as in Huggett (1993) or Aiyagari (1994). The primary motivation for this assumption is so we can answer the following question in a simple way: if a typical agent faces an endowment and price process like we observe in data, then what are the implications for imports? By directly specifying a stochastic process over prices, this allows us to sidestep a more involved alternative. That is specifying a joint stochastic process over the aggregate states to generate time varying prices, using techniques from Krusell and Smith (1998) to approximate the infinite dimensional state space, and computing an equilibrium that would ultimately lead to a price process like that observed in the data.

Given the discussion above, we model the value of a typical home country’s (idiosyncratic) endowment \( z_t \) in units of good \( x \) and the prices \( p_{yt} \) and \( p_{xt} \) as following a stationary VAR(1) process:

\[ \log S_t = A \log S_{t-1} + \nu_t \]  

where \( S_t = \{ z_t, p_{yt}, p_{xt} \} \) and the innovations \( \nu_t \) are jointly normally distributed with mean zero and variance covariance matrix \( \Sigma \).

Given the description of the model, we summarize the problem of a consumer in the typical
home country as facing the following dynamic programming problem

$$V(S, y) = \max_{x, y'} \left\{ \frac{(x^\rho + y^{\rho})^{(1-\gamma)/\rho}}{1 - \gamma} + \beta E[ V(S', y') \mid S] \right\}$$

subject to \( p_x x + \tau p_y y' \leq p_x z \).

$$S' = g(S), \text{ and } S = \{z, p_y, p_x\}. $$

The exogenous state variables for a typical country are its idiosyncratic endowment realization \( z \) and prices \( p_y \) and \( p_x \). These evolve according to law of motion \( g(S) \) described above in (8). The endogenous state variable is last periods orders of imports arriving this period. Given the state variables, the consumer chooses the quantity of good \( x \) to be consumed and chooses the quantity of good \( y' \) to order internationally for consumption in the following period. Note that consumption in the current period is the amount of good \( y \) delivered in the current period and the amount of good \( x \) not used to purchase good \( y' \) for tomorrow.

**A. Qualitative Features**

In this section we describe the key qualitative features of the model and intuition behind them. Specifically we describe the intuition behind the mechanism that delivers a higher than unity income elasticity, a price elasticity lower than \( \theta \), and terms that look like wedges co-varying with fluctuations in endowments and prices.

**Dynamic Import Demand.** The key relationship in our model is the dynamic demand function for imports. After solving the representative consumer’s problem, the demand for imports in the home country can be written as:

$$\frac{p_{xt} z_t}{P_t} \left[ \frac{\tau}{E_t(m_{t+1})} \frac{p_{yt}}{P_t} \right]^{-\theta} = y_{t+1} \quad \text{and} \quad m_{t+1} = \beta \left( \frac{Q_{t+1}}{Q_t} \right)^{-\gamma + \frac{1}{\theta}}$$

$$P_t = \left[ p_{xt}^{1-\theta} + \left( \frac{\tau p_{yt}}{E_t(m_{t+1})} \right)^{1-\theta} \right]^{1/\theta}.$$

Equation (10) is the key relationship in the model. There are several points to note about Equation (10) and how they affect the decision to import. First the timing differs. Now absorption and prices at date \( t \) are affecting imports tomorrow at date \( t + 1 \).\(^{12}\) This is a direct result of the

\(^{12}\)This raises issues in that static models are about contemporaneous movements in endowments and imports versus ours that relates values across time periods. Our results are not driven simply because of differences in
time-to-ship assumption.

Second, the discounted expected ratio of marginal utilities of consumption across time periods enters equation (10)—the intertemporal marginal rate of substitution (IMRS). Now the demand for imports are partially based on how the agent is willing to substitute consumption today (i.e. spending less on home goods today) versus expected consumption tomorrow (i.e. imported goods arriving tomorrow); the intertemporal marginal rate of substitution reflects this valuation.

A related point is that \( \frac{1}{\theta} \) shows up along with the parameter \( \gamma \) contrary to standard representations of the intertemporal marginal rate of substitution in one good models with power utility. The reason is because one unit of \( x \) is not a perfect substitute for one unit of \( y \), thus elasticity of substitution \( \theta \) between \( x \) and \( y \) shows up. The special case with \( \rho = 1 \) (when \( x \) and \( y \) are perfect substitutes) implying \( \theta = \infty \) and then only the curvature parameter \( \gamma \) shows up in \( m_{t+1} \), illustrates this point.

Finally, note that when \( \gamma \neq \frac{1}{\theta} \) the intertemporal marginal rate of substitution will change endogenously with the state variables endowment \( z_t \) and prices \( p_{xt} \) and \( p_{yt} \). Because the intertemporal marginal rate of substitution systematically varies across different states of the world, the model’s income elasticity will be different than one and the price elasticity will be different than \( \theta \) as static trade models predict. Below we discuss the intuition behind each of these outcomes.

**Income Elasticity Greater than Unity.** Our economy can generate an income elasticity of imports that is greater than one. To understand this statement assume that \( \gamma - \frac{1}{\theta} > 0 \) (which is the empirically relevant case) and that the economy is initially in steady-state and then hit by a negative endowment shock to \( z_t \) at date \( t \).

Two forces occur as a result of the shock. First, a negative shock to \( z_t \) directly lowers imports tomorrow. This is the standard force in static trade models. Second, a negative shock negatively impacts the agents willingness to substitute across time periods (i.e. \( E_t(m_{t+1}) \downarrow \)) further lowering imports. This is where dynamics bite. Because the decline in the endowment and the decline in \( E_t(m_{t+1}) \) both contribute to lowering imports, this implies that imports will drop more than proportional to the drop in the endowment.

The second dynamic force deserves more explanation. Because \( z_t \) is below its steady state value, the agents rational expectation of the endowment tomorrow is relatively higher, i.e. \( E_t(z_{t+1}) > z_t \). A relatively higher level of endowment means more consumption tomorrow decreasing expected marginal utility. Furthermore, because the endowment is scarce at date \( t \), marginal utility today is high, thus these forces imply that \( E_t(m_{t+1}) \) declines with a negative endowment shock. Because of how \( E_t(m_{t+1}) \) enters equation (10) and with \( \theta > 0 \), a decrease in \( E(m_{t+1}) \) timing.
lowers imports above and beyond the drop in the endowment.

Figures 3(a) and 3(b) trace these arguments out. Figure 3(a) plots the decline in the stochastic discount factor, $E_t(m_{t+1})$, when the $z_t$ is perturbed below its non-stochastic steady state value and the economy is allowed to transit back to the non-stochastic steady state value.

Figure 3(b) then plots the corresponding response of imports along with the change in endowments. The key observation is that imports decline by more than the endowment shock. The difference between imports and the endowment shock is purely because the intertemporal marginal rate of substitution is moving in response to the endowment shock as well further pushing imports down. Note that in a static model imports would one for one match the change in endowments.

**Low Price Elasticity.** Our economy can generate a price elasticity that is artificially below the elasticity of substitution $\theta$. To understand this statement again assume that $\gamma - \frac{1}{\theta} > 0$ and that the economy is initially in steady-state and then hit by a negative price shock to $p_{yt}$ at date $t$.

The reason for the artificially low price elasticity is that there are two forces working in different directions. First, a lower $p_{yt}$ directly increases imports tomorrow by $\theta$. This is the standard force in static trade models. Second, a negative price shock negatively impacts the agents willingness to substitute across time periods (i.e. $E_t(m_{t+1}) \downarrow$) which works in the opposite direction of the first force. Because these two forces work in opposing directions imports will respond by less than the $\theta$.

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13There is a small change in the aggregate price index $P$ as well, though this is often negligible because of home bias in consumption.
Why does a lower price of imports decrease $E_t(m_{t+1})$? Basically this shock makes one richer in the future because imports delivered tomorrow cost less. This leads to an increase in aggregate consumption next period lowering expected marginal utility next period and hence lowers $E_t(m_{t+1})$. Because of how $E_t(m_{t+1})$ enters equation (10) a decrease in $E(m_{t+1})$ is a force to decrease imports.

Figure 4(a) and 4(b) illustrate these arguments. Figure 4(a) plots the decline in the stochastic discount factor when the $p_{yt}$ is perturbed below its mean value and the economy is allowed to transit back to the non-stochastic steady state value.

Figure 4(b) plots the corresponding the response of imports and prices. Here the response in prices is the response of the term $(\frac{\theta}{\bar{P}})^{\frac{1}{1-\theta}}$ from (10). This is the object of interest because in the static model imports should respond in exactly the same way as this term. In contrast, Figure 4(b) shows that imports rise less than the response of the price term. The difference between the two is because the intertemporal marginal rate of substitution pushing against the decline in prices.

**Trade Wedges.** A final point to note is that the intertemporal marginal rate of substitution shows up like a trade wage. This is easy to see by simply relabeling $\hat{\tau} \equiv \frac{\bar{\tau}}{E_t(m_{t+1})}$. Then, accounting exercises backing out the measured trade wedge will be pro-cyclical: $E_t(m_{t+1})$ decreases in recessions, leading to higher values of $\hat{\tau}$. Similarly $\hat{\tau}$ will negatively correlate with changes in relative prices: $E_t(m_{t+1})$ decreases in response to an improvement in the terms of trade, leading to higher values of $\hat{\tau}$. This is an important observation because this mechanism operate through the trade wedge and is consistent with empirical observation O.3 and we showed that the trade wedge correlates highly with income and relative prices.
4. **Quantitative Analysis**

In this section we study the quantitative properties of our model and its ability to explain the high income elasticity and the low price elasticity observed in the data.

We calibrate our model using standard parameter values, simulate time paths of absorption, imports, and relative prices, and then use equation (2) to estimate the implied income and price elasticities. We then compare these results to data and to a standard model without the time-to-ship friction.

We then analyze our model’s predictions for the collapse in trade during the 2008-2010 recession. To do so we apply the Kalman smoother to our model using US data on relative prices and absorption to generate a predicted series of imports and we compare them to data. Again, we then compare these results to data and to the predictions from a standard model without the time-to-ship friction.

Below we describe the calibration of our model, the estimation of the stochastic process for prices and output using US data, and then our results.

**A. Calibration**

We take a time period to represent one quarter. We picked this value following *Alessandria, Kaboski, and Midrigan* (2010a) who calibrate their model such that imported goods arrive with a one-quarter lag.\(^{14}\) Later in this section, we explore alternative calibration that loosens this assumption.

We explore different values of the parameter \(\gamma = \{0, 2, 5, 10\}\) which controls the agents intertemporal elasticity of substitution. This value is important for our results, but the strictly positive values of \(\gamma\) we utilize are not implausible, see e.g. *Kocherlakota* (1996).

Given the time period, we set the discount factor \(\beta\) equal to 0.995. These values (with the choice of a imply that a steady-state real annual interest rate of 2\%. This value is consistent with data on ex-post real returns on near risk-free assets.

The baseline value we use for the elasticity of substitution is 1.5 which is the standard value used in calibrations of international real business cycle models, see *Backus, Kehoe, and Kydland* (1995). Note that only in the static model without time-to-ship will this value correspond with the price elasticity. In the dynamic model, the estimated price elasticity will differ from this value because of the arguments made in section A.

The top panel of Table 3 summarizes our calibration of preferences.

\(^{14}\)In their model, domestic goods arrive on average in 1.5 months. A one-quarter lag implies that the extra time to ship is 1.5 month which is consistent with empirical evidence on shipping times cited in *Djankov, Freund, and Pham* (2010)
Table 3: Summary of Calibration

<table>
<thead>
<tr>
<th>Preferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Period</td>
</tr>
<tr>
<td>Trade Friction</td>
</tr>
<tr>
<td>Discount factor</td>
</tr>
<tr>
<td>1/IES</td>
</tr>
<tr>
<td>Elasticity of Substitution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated parameters for ${z, p_x, p_y}$ process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Matrix</td>
</tr>
<tr>
<td>Std. dev. of innovations</td>
</tr>
<tr>
<td>Corr. of innovations</td>
</tr>
</tbody>
</table>

B. Estimation of Exogenous Process and Measurement

The exogenous process driving the fluctuations in the model is given by equation (8), which we estimate using HP filtered quarterly US data from the second quarter of 1967 to the second quarter of 2010. We estimate the process using real absorption, absorption price index, and the imports price index. All are for only the goods component of GDP and imports and the data is constructed in the same way described in section 2. The rationale for choosing these series is that one can show that $z$ corresponds with absorption (appropriately modified as discussed below) in the data and thus the absorption price index informs us about price of the domestic good.

An issue in the estimation of the exogenous process for the time-to-ship model is that we must modify standard data series to correspond with the timing in the model. The basic issue is that import data and the prices of imports are measured on arrival at the border. Because of the timing in the model, the prices were in the information set of the agent in the previous period and imports were decided upon this information set in the previous period. So we need to adjust our empirical measures of absorption and prices accordingly to properly map the values observed in the data to the values in the information set of the agents.

The bottom panel of Table 3 summarizes the estimated relationship between $z_t, p_{yt}, p_{xt}$. 

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### Table 4: Elasticities from Data and Model

<table>
<thead>
<tr>
<th></th>
<th>Price Elasticity</th>
<th>Income Elasticity</th>
<th>RMSE((\hat{M}, M))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>−0.47</td>
<td>1.98</td>
<td>0.037</td>
</tr>
<tr>
<td>Model, (\gamma = 2)</td>
<td>−1.16</td>
<td>1.33</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td>([-1.20, -1.12])</td>
<td>([1.30, 1.36])</td>
<td></td>
</tr>
<tr>
<td>Model, (\gamma = 5)</td>
<td>−0.49</td>
<td>1.94</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>([-0.56, -0.43])</td>
<td>([1.86, 2.01])</td>
<td></td>
</tr>
<tr>
<td>Model, (\gamma = 10)</td>
<td>0.40</td>
<td>2.83</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td>([0.27, 0.56])</td>
<td>([2.68, 2.99])</td>
<td></td>
</tr>
<tr>
<td>Model, no time-to-ship</td>
<td>−1.50</td>
<td>0.92</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td>([-1.55, -1.44])</td>
<td>([0.84, 0.99])</td>
<td></td>
</tr>
<tr>
<td>Model, (\gamma = 0)</td>
<td>−1.72</td>
<td>0.86</td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td>([-1.77, -1.67])</td>
<td>([0.83, 0.89])</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Estimates of the elasticities are averages from 250 simulations with each simulation being 172 periods long; values in brackets report 95 percent confidence intervals. Section 2 describes the data. RMSE(\(\hat{M}, M\)) is the root mean square error of the difference between the predicted log imports and actual log imports.

---

### C. Conformance with National Income and Product Accounts

Because we have a multi-good model some care must be taken with our model output such that our measures conform with National Income and Product Accounts (NIPA). In all our simulations, we collect data from our model and compute quarterly chain-type quantity and price indexes for absorption. Appendix 1 in the “Guide to the National Income and Product Accounts” provides further details of the computation.

### D. Results

Table 4 presents our results. The first line replicates the empirical income and price elasticities seen in Table 1. The second to fourth line reports the results from our model with different values of \(\gamma\). These are the cases when the stochastic discount factor in equation (10) operates. The last two lines report cases when the stochastic discount factor is not operative.

Our model delivers an income elasticity greater than unity. Depending on the intertemporal elasticity of substitution, the income elasticities are 1.3, 1.9, and 2.8 and all are statistically different than one. This shows that with reasonable values of the intertemporal elasticity of substitution our model easily generates the high income elasticities observed in the data.

When time-to-ship is turned off or the agent has infinite intertemporal elasticity of substitution, the income elasticities are inconsistent with the data. In these cases, the income elasticity is just under one which is close to what the theory predicts, but contradicts what is seen in the
data. Note that because the income elasticity is a bit less than one, this suggests that using NIPA measures rather than ideal measures generates a slight downward bias in the income elasticity.

In our model, the price elasticity lies below the true elasticity of substitution. Depending on the risk aversion parameter, our model delivers a price elasticity of $-1.16, -0.49, 0.40$. All are meaningfully below the calibrated elasticity of substitution of $-1.5$. In fact, with high enough risk aversion, the price elasticity becomes significantly positive. Similar to the income elasticity results, the magnitude of the estimated price elasticity appears to vary monotonically with the intertemporal elasticity of substitution. When time-to-ship is turned off the price elasticity returns to effectively $-1.5$. This suggests that using NIPA measures rather than ideal measures generates little bias in the price elasticity.

E. Loosening the One Period Time-to-Ship Assumption

The results in Table 4 relied on the one period time-to-ship assumption. Given that our model is calibrated to a quarterly frequency, this may be too stark of an assumption. A way to loosen this assumption is to posit the following law of motion for how the consumption of imports relates to orders:

$$\text{imports}_t = \varphi y_{t+1} + (1 - \varphi) y_t.$$  \hspace{1cm} (11)

Imports delivered and consumed at date $t$ equal a fraction $\varphi$ of orders made today plus $1 - \varphi$ of last period orders that did not arrive immediately. Equation (11) reflects the idea that some orders may arrive immediately while other orders may until next period to arrive.
We performed the same exercise described above but with the problem in (9) solved subject to equation (11). To facilitate comparison, we set $\gamma = 5$ and varied $\varphi$.

Table 5 presents the results. The second row reports the results with $\varphi = 0$, i.e. the pure one period time to ship model. The third to fifth row report the results as we increase $\varphi$, i.e. the amount of orders that arrive within the period. Not surprisingly as $\varphi$ increases, the importance of time-to-ship diminishes and the model performs less well.

For intermediate values of $\varphi$, our model can perform extremely well in explaining fluctuations in imports. To do show this we applied the Kalman smoother to our model using US data on relative prices and absorption to generate a predicted series of imports. Note that only the model’s internal dynamics and the estimated process for absorption and relative price is used to make these predictions — there was no direct use of imports data.

Figure 5(a) plots our model’s predicted imports with $\gamma = 5$ and $\varphi = 0.25$, versus actual imports over the entire time period. Our model’s predictions track import data quite closely and capture both the overall magnitude of fluctuations and the timing of peaks and troughs. Figure 5(b) presents a contrasting image. It plots the predictions from the static model performing the same exercise described above. Unlike our model, the static model appears to have problems capturing both the overall magnitude of fluctuations and the timing of peaks and troughs.

The final column in Table 4 and Table 5 formalizes these findings for all parameter values. It reports the root mean square error between the difference of actual imports and imports predicted by our model. Depending on $\gamma$ and $\varphi$, our model reduces the root mean square error significantly relative to the static model.

Interestingly, our model can outperform the least squares regression of import data on prices and absorption. This can be seen in a comparison of the root mean square error of the top row of Table 5 relative to the model with $\gamma = 5$ and $\varphi = 0.25$ (0.037 versus 0.034). Moreover, our model performs equally well relative to more sophisticated regressions. For example, augmenting regression (2) with one period lags of imports, absorption, and prices the root mean square error is 0.032 which is just below our best fitting model. That is our model and simple calibration—that did not directly use import data — outperforms a best fitting regression using import data.

5. The Great Trade Collapse of 2008-2010

As mentioned in the introduction, the collapse in international trade during the 2008-2010 recession has received a lot of attention. In this section we study the predictions of our model for this episode.

Figure 6 plots import data, predictions from the static model, and predictions from our model with $\gamma = 5$ and $\varphi = 0.25$ for the time period 2000-2010. Our model correctly predicts the
Figure 5: Model Predictions vs. Real Import Data
expansion in trade from 2003 to early 2008 and then the sharp drop in imports from mid-2008 to 2009. The key failure appears to be the speed of recovery — though on the whole there is little to quibble with.

In the context of our model, we can provide a narrative for the sharp drop in trade during mid-2008-2009. First, a bad absorption state of the world was realized increasing the marginal utility of consumption today relative to the future pushing the stochastic discount factor upward. Second, the price of imports relative to absorption decreased substantially further pushing the stochastic discount factor upward. These two forces interacted to push imports down substantially during mid-2008 to 2009.

Not surprisingly, the static model fails on both the magnitude and the timing. For most of the early 2000’s the static model predicts virtually no expansion in trade. In mid 2007 the model predicts a moderate drop in trade, then a recovery by mid 2008, early 2009.

The failure of the static model is precisely because the model puts relatively large weights on price movements and relatively less weight on income movements, i.e. high price elasticity and low income elasticity. For example, the counterfactual drop in trade prior during 2007 is driven by the increase in relative prices — in spite of absorption being significantly above trend. The counterfactual recovery of trade in mid 2008 is because relative prices decreased, and again it’s in spite of a sizeable drop in absorption. The success of our model is exactly because it is able to reverse these responses.

Figure 6: The Great Trade Collapse: Model Predictions vs. Real Import Data, 2000-2010
6. Discussion

A. General Equilibrium

What is the applicability of our mechanism to general equilibrium settings? To be completed.

B. Relation to Asset Pricing

Our model has implications for how changes in a risk free interest rate relate to changes in trade flows. To be completed.

7. Future Research

Our paper shows how incorporating dynamic and forward looking features into international trade models affects the inferences about various elasticities relative to static frameworks.\textsuperscript{15} And we used these ideas to put forth a potential resolution of a long standing puzzle regarding the high income elasticity of imports first observed by Houthakker and Magee (1969). We feel the results we have presented are promising, but we have several topics on our agenda to address in future versions of this paper.

One issue is to provide more evidence regarding the basic premiss of time-to-ship. Researchers such as Hummels (2001), Djankov, Freund, and Pham (2010), and Alessandria, Kaboski, and Midrigan (2010b) emphasize this feature of the trading process, but connecting this type of evidence with implications from our model would be informative on the plausibility of our mechanism.

A second issue is why a standard IRBC model with time-to-ship does not achieve similar results. We are currently exploring this topic, yet our preliminary findings is that its failure is largely a function of this class of model’s counterfactual predictions for the terms of trade. Our approach in this paper was agnostic about how the prices fed into the model are supported in equilibrium and simply take prices for what they are and then understand their implications for imports.

A final issue is to estimate the parameters of the model. We presented the results for various parameterizations to illustrate our model’s dependence of these parameters without taking a hard stand on them. In the next iteration of this paper, we hope to provide a more formal analysis of the parameters by using data to estimate them.

\textsuperscript{15}See Hendel and Nevo (2006) for an example of this point in industrial organization.
References


BALDWIN, R. (2010): The great trade collapse: Causes, Consequences and Prospects. CEPR.


Hooper, P., K. Johnson, and J. Marquez (2000): “Trade elasticities for the G-7 countries,”.


A. Data appendix

The data that we use for the estimation of the static CES import demand specification in section 2 come from the Bureau of Economic Analysis’ (BEA) National Income and Product Accounts (NIPA) and from the Federal Reserve’s industrial production indices.

A. More on Durables

A different argument against the durables composition story is the following: If this is driving the greater than unity income elasticity for all goods, then we should observe that the income elasticity for all goods should be lower when the share of durables in imports is low and vice versa. That is there should be a positive correlation between the income elasticity and the share of durables in imports.

To explore this implication of the durables story, we ran the regression in (2) for all goods on on a 40 quarter moving window, i.e. for 1967q2-1977q1, 1967q3-1977q2, etc. Figure 7 plots the estimated income elasticity on the y-axis. The x-axis reports the average share of durables in imports for the same 40 quarter window. Figure 7 displays a strong negative correlation (−0.77 and statistically different from zero) between the income elasticity and the share of durables in imports. Note that when durables played a (relatively) low role in trade in the late 1960’s and early 1970’s, the income elasticity was relatively high. As the durables share increased to around 65 percent in the late 1980’s the estimated income elasticity was at its lowest point and is actually below one. After this time period, the durables share of imports began to shrink again and the income elasticity systematically increased. To summarize, Figure 7 appears to be in stark contrast to the positive correlation the durables composition story implies.

To be completed

Engel and Wang (2009) emphasize the volatility of imports and the role of durables; the correlation between the volatility of imports of goods and the share of durables in trade is -0.92, the correlation between the relative volatility of imports to absorption and the share of durables is -0.81. Both are statistically different from zero.
Figure 7: Income Elasticity vs. Share of Durables in Imports