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U.S. Trade and Inventory Dynamics*

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Abstract: We examine the source of the large fall and rebound in U.S. trade in the recent recession. While trade fell and rebounded more than expenditures or production of traded goods, we find that relative to the magnitude of the downturn, these trade fluctuations were in line with those in previous business cycle fluctuations. We argue that the high volatility of trade is attributed to more severe inventory management considerations of firms involved in international trade. We present empirical evidence for autos as well as at the aggregate level that the adjustment of inventory holdings helps explain these fluctuations in trade. (JEL E31, F12)

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We examine the substantial drop and rebound in international trade by the U.S.[1] in the period 2008 to 2010, which was large relative to the movements in either production or absorption of traded goods. From July 2008 to February 2009 U.S. real imports and exports each fell by about 24 percent while manufacturing production fell 12 percent. The rebound was equally impressive, with imports and exports expanding about 20 percent between May 2009 and May 2010 while manufacturing production rebounded only by 10 percent.[2] These relatively large movements in trade only arise in standard trade models when trade costs rise and fall substantially.[3]

The alternative hypothesis we explore here and in a companion paper (George Alessandria, Joseph P. Kaboski, and Virgiliu Midrigan, 2010b) is that the magnified movements in international trade reflect a severe adjustment of inventory holdings of firms. Since our aim is to understand the large *excess* drop in trade relative to either sales or domestic production, we emphasize that these adjustments are larger for firms involved in international transactions. We have argued, in Alessandria, Kaboski and Midrigan (2010a), that the frictions involved in international transactions - namely delivery lags and economies of scale in transaction costs - are more severe than for domestic transactions, leading firms involved in international trade to hold a much larger stock of inventories. We document these facts, using plant-level data, in our earlier work. Following a persistent negative shock to costs or demand, firms – especially those involved in international transactions – find themselves with too much inventory on hand and thus cut back sharply on ordering, selling out of the existing stock. Intuitively,

[1] For a study of global trade flows see Rudolfs Bems, Robert Johnson, and Kei-Mu Yi (2010) and Jonathan Eaton et al. (2010).

[2] We measure industrial production (IP) as a trade-weighted average of durable and non-durable IP. It thus controls for major compositional differences between trade and production.

[3] For example, Davin Chor and Kalina Manova (2010) and Mary Amiti and David Weinstein (2009) attribute part of the decline in trade to the cost of finance for international transactions rising by more than for domestic transactions.

since, by definition, imports (production) are equal to sales plus inventory investment, and both sales and inventory investment decline during a recession, imports (production) are more volatile than sales. Moreover, since importers hold larger stocks of inventories than domestic firms, the response of imports is much larger than that of production.

In Alessandria, Kaboski and Midrigan (2010b) we study a general equilibrium two-country model of international trade in which firms face fixed costs of exporting and a stockout-avoidance motive for holding inventories. The model, when parameterized to match the evidence on the inventory holding premium of importers, is capable of accounting for the salient features of the dynamics of trade in the recent recession. In particular, the model predicts a response of imports that is much larger than that of domestic sales or production.

Our goal here is to present empirical evidence consistent with the view that the magnified dynamics of trade are, to a large extent, shaped by inventories. In particular, we show that the fluctuations in trade in the current recession were not unusual relative to the size of fluctuations of other macroeconomic variables. What is unusual is the depth of the recession. The similarity of current trade dynamics with those in previous recessions calls for an explanation of the recent trade collapse that is about the nature of trade, rather than the source of the business cycle. Next, using data from the auto industry, a sector for which we have measures of both inventories and sales of imported cars, we illustrate the role of inventories. For autos we find that about two-thirds of the peak decline in imports in the auto sector can be attributed to firms running down their stocks rather than a fall in final sales of autos. Similarly, trade only recovered when inventory levels had stabilized. Finally, we present evidence that a sizable fraction of the unexplained movements, or "wedges," in trade both in the current recession and over time are accounted for by changes in inventories.

1. Response of trade in recent recession was not unusual

Figure 1 depicts the recent deviations of U.S. imports, exports, and several other macroeconomic variables from a Hodrick-Prescott (1600) trend. From the third quarter of 2007 to the second quarter of 2009 GDP (Y) fell by about 5 percent relative to trend, while industrial production (IP) and a trade-weighted measure of final expenditure on goods ($Demand$) each fell by about 13 percent. In contrast, the collapse in trade was much more severe: exports and imports fell by around 20 percent. Although these numbers are striking, we argue below that the recent decline in trade (relative to the decline in other macroeconomic aggregates) was not unusual relative to past recessions.

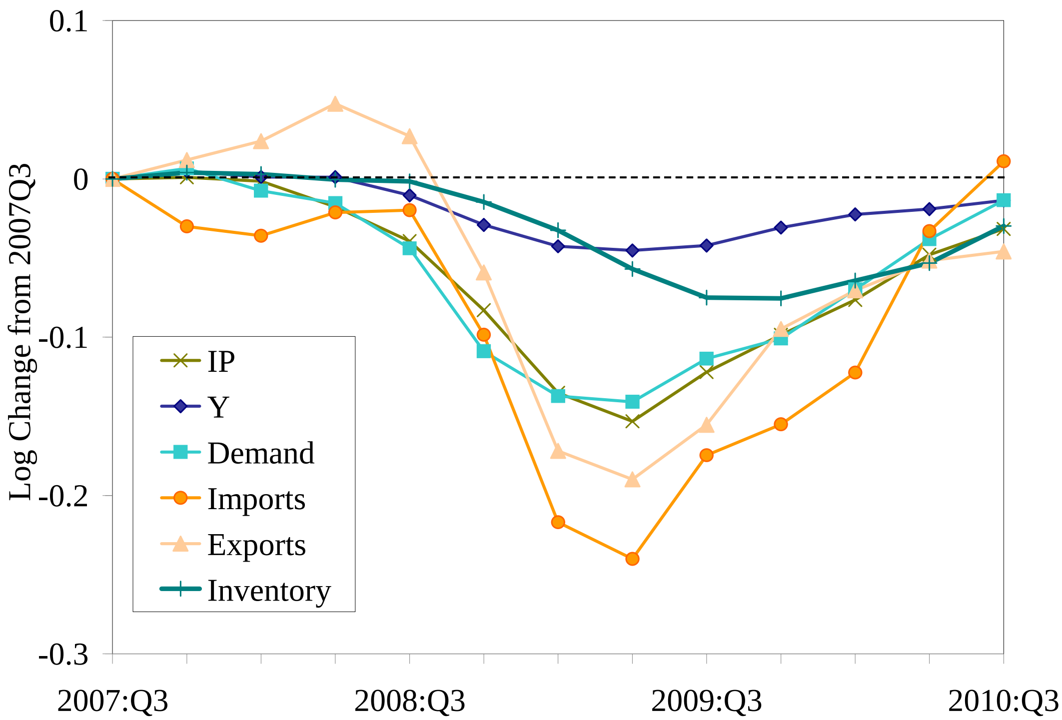

Figure 1: Recent U.S. Aggregate Dynamics

Table 1 reports the characteristics of some measures of aggregate activity (GDP, IP, and trade-weighted expenditure) in the current and previous recessions. In the first two columns, we report a trade elasticity as the change in the log of imports or exports relative to the change in the log of each respective variable. The change is computed from peak-to-trough. The last column reports the relative volatility of imports and exports over the entire sample, measured as the ratio of each series' standard deviation.

Table 1: Trade Dynamics

		Peak-to-Trough Elasticity		Relative
		2009Q2	Median	Volatility
IMPORTS				
	GDP	5.3	4.7	3.8
	IP	1.6	1.6	1.6
	Demand	1.7	2.4	1.8
EXPORTS				
	GDP	5.2	3.3	3.4
	IP	1.5	1.5	1.5

Notes: Data are from 1967q1 to 2010q3, Trade and GDP from BEA. IP is from the Federal Reserve. Each series is HP-filtered with a smoothing parameter of 1600.

Table 1 shows that imports fell about 5 times more than GDP, twice as much as expenditures on tradeable goods and about 60 percent more than industrial production. Most importantly, compared to the median U.S. recession, the fall in imports in the current (2009Q2 column) recession does not look unusual. For exports, our findings are similar.

The last column of Table 1 shows that our conclusions are not driven by our focus on recessions, rather than business cycle fluctuations in general. We note that exports and imports are roughly 50 and 60 percent more volatile than industrial production, around 3.5 times more volatile than GDP, and around 60 and 80 percent more volatile than expenditure on tradeables. Finally, while not reported in the table, exports and imports are also more volatile than consumption, as well as consumption of durable goods (exports and imports are

1.2 and 1.4 times more volatile than durable goods consumption).[4] We thus conclude that the excess volatility of international trade does not simply reflect the fact that trade is more intensive in durable goods.[5]

2. Evidence for auto industry

The challenge in isolating the role of inventories in the dynamics of international trade is the lack of data on inventories of imported goods at either the industry or aggregate level. The auto industry is an exception as U.S. data exists on inventories, sales, and imports of foreign-produced autos. We use these data to show that inventory adjustment was an important determinant of the collapse of international trade in autos. These data also alleviate concerns that the fall in trade relative to expenditures or production is attributed to the composition of trade differing from production or expenditure.

The evidence on autos is, we argue, important in its own right, since autos are an important traded good, accounting for 18 percent of U.S. non-petroleum imports from 2005 to 2007. Moreover, the drop in auto imports was much steeper than that for other goods: the decline in auto imports alone accounted for about one-third of the fall of U.S. imports in this episode. Any explanation of the recent trade collapse must also be able to explain autos

[4] We have also studied more disaggregate measures of trade flows and production and generally find that trade is more volatile than either production or sales of the same goods. These results are discussed in the online appendix.

[5] Martin Boileau (1999) and Charles Engel and Jian Wang (2011) attribute the volatility of trade to trade being intensive in cyclical goods like capital equipment or durables. Bems, Johnson, and Yi (2010) and Eaton, et al. (2010) show that a large part of the global fall in trade relative to GDP can be accounted for by this composition mismatch.

to have any chance at explaining aggregates more generally.

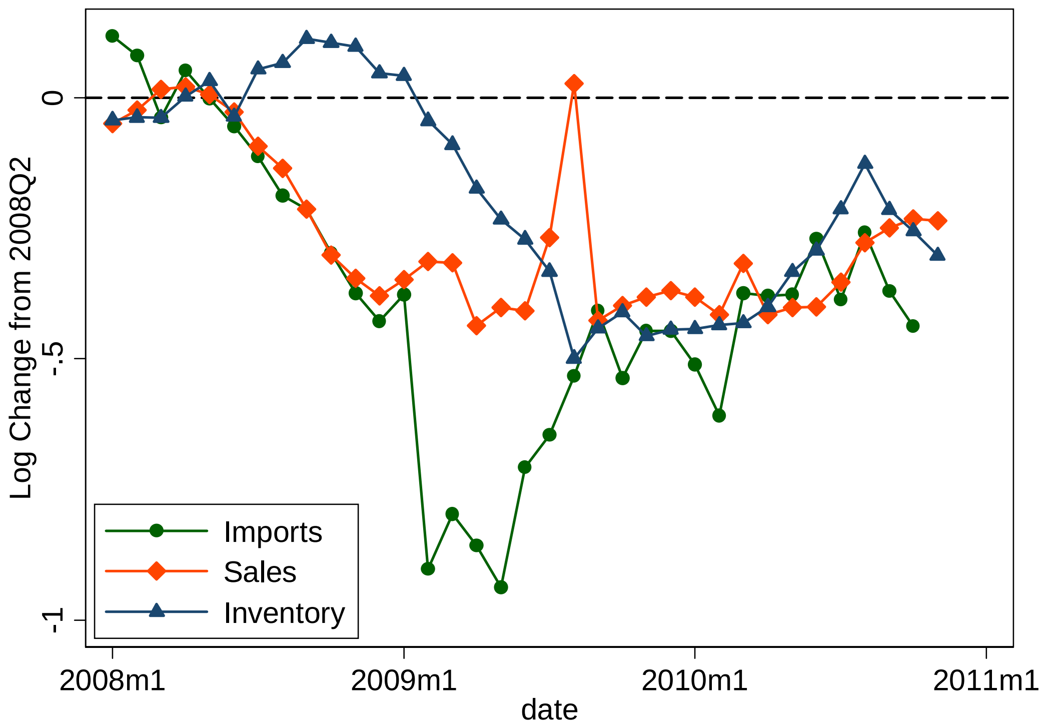

Figure 2: Dynamics of Foreign Autos

Figure 2 plots the evolution of imports, sales, and inventories of autos produced outside North America since 2008. At its worst, over the 7 months from February 2009 to August 2009, real imports and sales were, respectively, on average 77 log points and 30 log points below their 2008Q2 averages.[6] Thus for autos, the drop in imports over this period was over 2.5 times the drop in sales. Since, by definition, imports are equal to sales plus inventory investment, the evidence in Figure 2 suggests that inventory adjustment accounted for about two-thirds of the drop in imports. Additionally, we see that the recovery in trade did not

[6]The abrupt, mid-figure, upward spike in sales is the Car Rebate Allowance System (i.e., "cash for clunkers") program.

result from a persistent increase in final sales of autos, but rather from the stabilizing of inventory holdings. These import and sale dynamics are similar for other countries and during previous recessions (see Alessandria, Kaboski and Midrigan, 2010b), and, since these data do not suffer from a mismatch between the composition of imports and absorption, they provide very strong evidence for a high elasticity of imports.

3. Aggregate evidence

We next explore the role of inventories in aggregate trade fluctuations by measuring the departures in trade flows from those predicted by theory. This approach involves deriving a simplified aggregate import demand equation, calibrating its parameters, and then measuring deviations from predicted imports given fundamentals. Andrei Levchenko, Logan Lewis, and Linda Tesar (2010) use this approach to document large deviations in trade flows, m_t^D, from the predictions of the theory, m_t^T. These deviations, or wedges, in import demand might be interpreted as changes in trade barriers. We show, however, that inventory adjustment is important for both the magnitude and the interpretation of these wedges.

To motivate our analysis, consider the following accounting identity:

$$(1) \quad M_t = S_t + I_t - I_{t-1},$$

where M_t are imports, S_t are sales of imported goods, and I_t is the inventory stock of imported goods so that $I_t - I_{t-1}$ is inventory investment. We also assume a constant elasticity demand for imported goods:

$$(2) \quad S_t = P_t^{-\gamma} C_t,$$

where P_t is the relative price of imports and C_t is aggregate absorption. Equation (1) is an accounting identity, while (2) characterizes a large class of models of international trade.

We assume that in the long-run sales of foreign goods equals imports, $\bar{S} = \bar{M}$, so that inventory investment, is zero. Then we have:

$$\frac{M_t - \bar{M}}{\bar{M}} = \frac{S_t - \bar{S}}{\bar{S}} + \frac{\bar{I}}{\bar{S}} \frac{I_t - I_{t-1}}{\bar{I}},$$

where $\bar{I}$ is the long-run stock of inventories and $\bar{I}/\bar{S}$ is the inventory-to-sales ratio. Combining (2) and (3), using a log approximation for small deviations, and letting lower-case variables denote log-deviations from trend, yields:

$$(3) \quad m_t^T = -\gamma p_t + c_t + \frac{\bar{I}}{\bar{S}}(i_t - i_{t-1}).$$

We obtain a standard Armington demand equation by setting inventory adjustment to zero:

$$(4) \quad \hat{m}_t^T = -\gamma p_t + c_t$$

Assuming a conventional value of the Armington elasticity of $\gamma = 1$, we can contrast the time-series of U.S. imports with those predicted by the theory and define $\hat{\omega}_t = m_t^D - \hat{m}_t^T$ as the implied trade wedge when ignoring inventory adjustment. Similarly, we define $\omega_t = m_t^D - m_t^T$ as the wedge predicted by a theory that allows for inventory adjustment. We measure p_t as the ratio of the non-petroleum import price index relative to a price index on final expenditures of goods. Our measure of aggregate expenditure, C_t, is domestic expenditures on goods and investment.

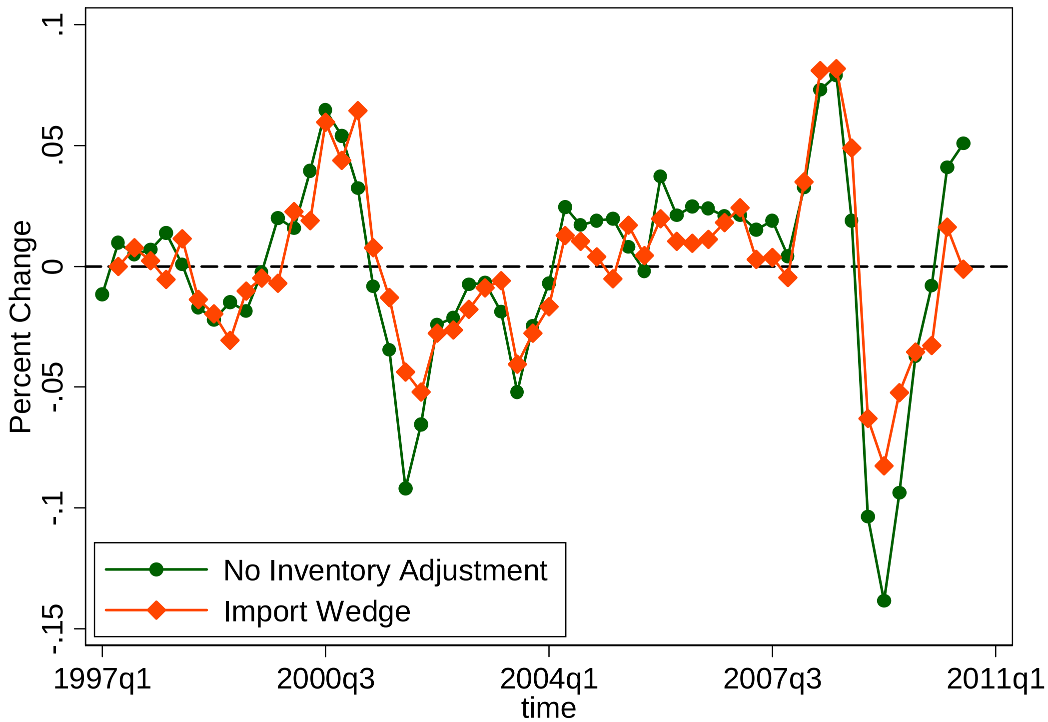

Figure 3: Wedges

Figure 3 plots the evolution of this wedge without the inventory adjustment since 1997q1, measured as deviations from a Hodrick-Prescott (1600) trend. In this past recession, the wedge declines by almost 15 percent, and thus accounts for about two-thirds of the drop in trade. Moreover, the wedge in this current recession appears quite large compared to previous fluctuations (roughly 15 percent versus 5 to 10 percent in previous declines). By these measures, the behavior of imports appears quite unusual given the movements in expenditure and relative prices.

We next explore how inventory fluctuations affect the magnitude of the wedge. Comparing (3) with (4), the actual import wedge subtracts out inventory adjustment from the implied wedge, $\omega_t = \hat{\omega}_t - (\bar{I}/\bar{S})(i_t - i_{t-1})$.

To measure the import wedge then requires a measure of the inventory-to-sales ratio of imported goods as well as the changes in imported inventory. Unlike autos, we lack direct measures of imported inventories and thus use the entire stock of U.S. inventories as a proxy. Consistent with the micro evidence in Alessandria, Kaboski and Midrigan (2010a) that importers hold about double the inventory of non-importers, we set $\bar{I}/\bar{S}$ equal to 2.25, about twice the average inventory-to-sales ratio since 1997. We assume that fluctuations in imported inventories are perfectly correlated with fluctuations in aggregate inventories.

Figure 3 shows that fluctuations in the actual import wedge, ω_t, are generally smaller than fluctuations in the wedge that ignores inventory adjustments, $\hat{\omega}_t$. Indeed, in the current recession, nearly one-third of the decline and all of the increase in our first measure of the wedge disappears and the size of the import wedge appears less unusual. Thus, inventory adjustments made a sizable contribution to recent trade fluctuations.

To quantify the contribution of inventory investment, we calculate the fraction of the variance of the wedge without the inventory adjustment, $\hat{\omega}_t$, that is accounted for by inventory investment. Given our lack of data on the stock of imported inventory, we consider a range of inventory-to-sales ratios for importers, $\bar{I}/\bar{S}$, equal to 1.12 and 2.25, and also several different values of the Armington elasticity, γ. As Table 3 shows, with an importer-specific inventory-to-sales ratio of 2.25, the inventory term accounts for 30 to 49 percent of the trade wedge from the simple Armington import demand equation. This is substantial, since this result is likely biased downward due to our imperfect measure of importers' inventories.[7] If we lower

[7] Focusing on a longer period starting in 1972q2, the contribution of inventory adjustments is smaller,

the inventory-to-sales ratio to an economy-wide 1.12, the value for the U.S. (mainly reflecting domestic goods), the contribution of inventories falls some, to between 10 to 33 percent, but is still substantial.[8]

Table 2: Inventories' Contribution to Import Wedge

Armington Elasticity (γ)	Inventory-Sales Ratio (I/S) 1.12	2.25
0	0.33	0.49
1	0.23	0.38
2	0.10	0.30

Notes: Using HP-filtered data from 1997:q1 to 2010:q3. The contribution is equal to 1 - variance(ω_t)/ variance($\hat{\omega}_t$).

4. Conclusions

We have presented evidence that international trade fluctuated more than economic activity in the recent recession, and that inventories have played an important role in these fluctuations. While we have focused on the recent recession, these empirical phenomena appear relevant more generally, both across U.S. recessions and across countries.

Our results have implications for future work. With the magnified response of trade they generate, inventory considerations for storable goods may influence the international transmission of business cycles. For example, the massive drop in U.S. auto sales together with large inventory holdings led to a sharp contraction in the production of exports for the U.S. in Japan, roughly 2.5 times the drop in sales. Inventories held outside of Japan may

ranging between 19 to 46 percent. We conjecture that aggregate inventories are a much worse proxy for imported inventories in this earlier period, since relative price movements were more important, and imports were a smaller share of absorption.

[8] An alternative approach to evaluate the contibution of inventory dynamics on trade flows is to estimate the import demand equation derived above. This regression is normally run in first differences and omits an inventory term. We found that including this inventory term substantially increases the R^2 fit of these regressions.

therefore have contributed to the severity of Japan's recession. We are currently exploring this idea in Alessandria, Kaboski, and Midrigan (2011). On the micro side, the growing availability of plant- and transaction-level datasets should enable detailed and precise examination of how inventory considerations affect the timing and level of trade, especially international trade. In a more globally integrated world, with inputs from and sales to distant markets, inventories and inventory management are becoming an ever more critical element in the production and sales process.

References

[1] **Alessandria, George, Joseph P. Kaboski, and Virgiliu Midrigan.** 2010a. "Inventories, Lumpy Trade, and Large Devaluations," *American Economic Review*, 100(5): 2304–39

[2] **Alessandria, George, Joseph P. Kaboski, and Virgiliu Midrigan.** 2010b. "The Great Trade Collapse of 2008–09: An Inventory Adjustment?" *IMF Economic Review*, 58(2): 254-94

[3] **Alessandria, George, Joseph P. Kaboski, and Virgiliu Midrigan.** 2011. "Inventories and International Business Cycles." mimeo.

[4] **Amiti, Mary and David Weinstein.** 2009. "Exports and Financial Shocks." NBER working paper 15556.

[5] **Bems, Rudolfs, Robert C. Johnson, and Kei-Mu Yi.** 2010, "The Role of Vertical Linkages in the Propagation of the Global Downturn of 2008," *IMF Economic Review*, 58(2): 295-326.

[6] **Boileau, Martin.** 1999. "Trade in Capital Goods and the Volatility of Net Exports and the Terms of Trade," *Journal of International Economics*, 48(2): 347–65.

[7] **Chor, Davin and Manova, Kalina.** 2010. "Off the Cliff and Back: Credit Conditions and International Trade During the Global Financial Crisis." NBER Working Paper 16174.

[8] **Eaton, Jonathan, Samuel Kortum, Brent Neiman, and John Romalis.** 2010. "Trade and the Global Recession." mimeo.

[9] **Engel, Charles, and Jian Wang.** 2011. "International Trade in Durable Goods: Understanding Volatility, Cyclicality, and Elasticities," *Journal of International Economics*, 83(1): 37-52.

[10] **Levchenko, Andrei A., Logan T. Lewis and Linda L. Tesar.** 2010. "The Collapse of International Trade During the 2008-2009 Crisis: In Search of the Smoking Gun," *IMF Economic Review*, 58(2): 214-53.

Appendix for US Trade and Inventory Dynamics

Below, we discuss the robustness of our findings as well as the data sources and calculations.

A. Robustness

Here we discuss the robustness of our findings. First, we show that the finding of a relatively high volatility of trade is robust across alternate filters of the data. Next, we show that controlling for the different composition of trade from production or sales does not alter our findings of a high trade elasticity. Finally, we show that including inventory adjustment improves the fit of standard import demand regressions.

Filtering: To evaluate the role of filtering on our finding that the declines in trade in 2008-09 are not unusual, in Table A1 we report the elasticity of trade under alternative filtering methods. In particular, we 1) HP filter with a smoothing parameter of 10^5 and 2) remove a linear trend from each data series. These detrending methods remove very low frequency trends from each data series and generate quite similar results. In the final two columns, we report the results on the raw, unfiltered data. Here, we find that the decline in trade in the current recession is indeed unusual, particularly for imports with respect to GDP (an elasticity of 7.6 vs 3.2). The fall in exports also appears unusual. Given that the rising importance of trade is often attributed to factors outside of growth in income or production, say falling trade barriers, we believe the appropriate way to analyze the data is to detrend them. Moreover, this detrending allows us to compare mild and severe recessions.

Composition I: Trade is substantially less volatile when compared to industrial production rather than GDP. Obviously, this reflects in large part the fact that the industry composition of trade is more similar to industrial production than GDP. One might still be concerned that the relatively high volatility of trade relative to industrial production may also reflect compositional differences. The potential for composition to explain the high volatility of trade is evident in Table A2, which reports business cycle statistics of a variety of macroeconomic aggregates. Here we see that consumer durables and investment are more volatile than measures of consumer non-durables or GDP. However, we still find that consumer durables and investment are less volatile than imports or exports. Thus, it appears unlikely that the relatively high volatility of trade is purely due to it being more intensive in durables and investment goods.

An alternative way to account for compositional concerns is to construct a trade-weighted measure of industrial production that more closely matches the composition of trade. In particular, we construct a measure of trade-weighted industrial production as

$$IP_t^{TW} = \alpha_{D\_exMV} IP_t^{D\_exMV} + \alpha_{autos} IP_t^{MV} + \left(1 - \alpha_{D\_exMV} - \alpha_{MV}\right) IP_t^{ND}$$

The data for these series are available from 1972M1 to 2010M10 and aggregated to a quarterly basis. Based on the 2003-07 shares of each good in non-petroleum imports we set $\alpha_{D\_exMV} =$

0.55, $\alpha_{MV} = 0.15$, $\alpha_{ND} = 0.30$. These shares overstate the importance of durables and motor vehicles in trade since they are based on trade shares excluding petroleum for imports. Panel A of Table A3 shows that this trade-weighted measure of industrial production that places a larger weight on durables and motor vehicles is approximately 10 percent more volatile than U.S. manufacturing production, suggesting that only a small part of the high volatility of trade can be attributed to the different composition of industrial production from trade.

Composition II: One might still be concerned that our trade-weighted measure of industrial production is not disaggregated enough. To consider this, we examine the cyclical properties at the industry level, focusing on motor vehicles. Due to data limits (we would like a real series of motor vehicle trade and shipments), we consider monthly data from 1997:01 to 2010:10. Panel B of Table A3 shows that imports and exports are about 25 to 30 percent more volatile than production, about 40 percent more volatile than manufacturers' shipments, and two and a half times as volatile as retail sales. Thus, it appears clear that trade is more volatile than production and domestic shipments even once we control for industry composition.

Import Demand Regressions: It is common to estimate the import demand equation we derived. These regressions are typically run in differences for reasons of stationarity (see Gallaway, McDaniel, and Rivera, 2003, for example). For this reason, we estimate an equation of the form:

$$(5) \quad \Delta m_t = -\gamma \Delta p_t + \alpha \Delta c_t + \beta \Delta x_t,$$

where $\Delta x_t = (i_t - i_{t-1}) - (i_{t-1} - i_{t-2})$ denotes the change in inventory investment.

In Table A4 we present the results of this regression on the data used in our wedge analysis. Columns I and II present the results of the specification above. Column I presents the results of the standard import equation that omits the inventory term. Column II is the unrestricted equation. As the table indicates, adding inventories raises the R^2 measure from 60 percent to 70 percent.

Columns III and IV of Table A4 report estimates of an error-correction model in which we also include lagged values of all variables. The idea here is to capture the gradual response of imports, maybe due to adjustment costs or lags between orders and deliveries of goods. Specifically, we estimate the following equation

$$(6) \quad \Delta m_t = -\gamma_0 \Delta p_t + \alpha_0 \Delta c_t + \beta_0 \Delta x_t + \delta m_{t-1} - \gamma_1 p_{t-1} + \alpha_1 c_{t-1} + \beta_1 x_{t-1},$$

Notice here that in this specification the role of inventories is much more pronounced. The R^2 increases from 66 percent to 82 percent. In this sense inventory dynamics account for a sizable fraction of the dynamics of imports in the data. Clearly, these results understate the role of inventories, since we have used aggregate inventories to proxy for the stock of imported goods inventories, an admittedly imperfect proxy.[9]

B. Data Sources and Calculations

[9] We have also run these regression on a longer time series (1972q2 to 2010q3) and find that the R^2 increases from 23 to 46 percent in differences. With the error correction terms, the R^2 increases from 44 to 66 percent.

This specific data series used in the paper U.S. Trade and Inventory Dynamics are described below.
The numbers in the opening paragraph were based on the following four data series

- IP: Durable Goods [NAICS] (SA, 2002=100) Federal Reserve, IPMDG@USECON
- IP: Nondurable Manufacturing (SA, 2002=100), IPMND@USECON
- Exports: Nonpetroleum Products (SA, Mil.Chn.2005$) Census, TMXENPH@USINT
- Imports: Nonpetroleum Products (SA, Mil.Chn.2005$), TMMENPH@USINT

Figure 1, Table 1, and Tables A1-A2: Most data are downloaded through Haver. The data series are

- IP: Mfr [SIC] (SA, 2002=100), IPMFG@USECON ;
- Real GDP (SAAR, Bil.Chn. 2005$), GDPH@USECON;
- Real PCE: Goods (SA, Bil.Chn. 2005.$), CTGH@USECON;
- Real PCE: Durable Goods (SAAR, Bil.Chn. 2005$), CDH@USECON;
- Real PCE: Nondurable Goods (SAAR, Bil.Chn. 2005$), CNH@USECON;
- Real Private Nonres. Invest: Equip. & Software (SAAR, Bil.Chn. 2005$), FNEH@USECON;
- Real Private Investment: Software (SAAR,Bil.Chn. 2005$), FNENSH@USECON;
- Real Change in Private Farm Inventories (SAAR, Bil.Chn. 2005$), VFH@USECON;
- Real Exports of Goods (SAAR, Bil.Chn. 2005$), XMH@USECON;
- Real Imports of Goods (SAAR, Bil.Chn. 2005$), MMH@USECON;
- Real Mfr & Trade Inventories: All Industries (EOP, SA, 2005$), TITH@USECON;
- Real Mfr & Trade Sales: All Industries (SA, 2005$), TSTH@USECON;

We measure final expenditures, $Y_t^T = \alpha\left(I_{EQ,t} + C_{D,t}\right) + (1-\alpha)\, C_{ND,t}$ where $I_{EQ,t} = I_{EQS,t} - I_S$ and I_{EQ} =Investment in Equipment, I_{EQS} =Investment in Equipment and Software, I_{EQ} =Investment in Software, C_D =Consumption of Durables, C_{ND} =Consumption of Nondurables and α is share of durables in total nonpetroleum imports and is measured as the average share from 2003 to 07, or

$$\alpha = \frac{1}{5}\sum_{t=2003}^{2007} M_t^D / M_t = 0.70,$$

where M^D is annual real imports of durables and M_t is annual real non-petroleum imports (from the BEA table 4.2.6, $2005). Note, relative to all imports (including petroleum), the durable share is approximately 0.60.

Figure 2 and Table A5.
Here we plot dynamics of imports, sales, and inventory of imported autos.

- Sales = from Ward's automotive: U.S.: Imported Car Sales ex Canada & Mexico (NSA, Units) + U.S.: Imported Light Truck Sales ex Canada & Mexico (NSA, Units). The Sales series is seasonally adjusted using the Board of Governors' Combined Seasonal, Trading-day Factor for Imported Auto Sales.

- Imports = downloaded from the USITC based on selected Harmonized codes for passenger cars and light trucks from the Census. Measured as total imports minus imports from Mexico and Canada. Seasonally adjusted using the X-12.
- Inventory = from Ward's automotive: U.S.: Imported Light Vehicle Inventory ex Canada & Mexico (NSA, Units). Seasonally adjusted using the X-12.

Figure 3, Table 2, and Table A4.
Here we plot wedges

- Final Expenditure is the same as in Figure 1.
- Real Imports of Nonpetroleum Goods (SAAR, Bil.Chn.2005$) MMXPH@USNA
- PCE Excluding Energy Goods & Services: Chain Price Index (SA, 2005=100) JCXEG@USECON
- Personal Consumption Expenditures: Durable Goods: Chain Price Index(SA,2005=100) JCD@USECON
- Private Nonres Investment: Equipment & Software: Chain Price Index(SA, 2005=100) JFNE@USECON
- Imports: Nonpetroleum Goods: Chain Price Index (SA, 2005=100) JMMXP@USNA
- Real Manufacturing & Trade Inventories: All Industries (EOP, SA, Mil.Chn.2005$) TITH@USECON
- We define the relative price of imports to absorption as the case in which each term is in logs and the weights are chosen so that durables, non-durables, and capital have equal weights.

$$p = JMMXP - (JCXEG + 3xJCD + 2xJFNE)$$

Table A3, Panel A: The data for these calculations are:

- IP: Durable Goods Mfg Ex. Motor Vehicles/Parts (SA, 2002=100), IPMDXMV@USECON;
- IP: Motor Vehicles and Parts (SA, 2002=100), IPG61T3@USECON;
- IP: Nondurable Mfr (SA, 2002=100), IPMND@USECON.

Table A3, Panel B: The data for these calculations are:

- IP: Motor Vehicles and Parts (SA, 2002=100), IPG61T3@USECON;
- Exports: Autos, Parts and Engines (SA, Mil.Chn.2005$), TMXEAVH@USECON;
- Imports: Autos, Parts, and Engines (SA, Mil.Chn.2005$), TMMEAVH@USECON;
- Real Sales: Mfg: Motor Vehicles & Parts (SA, Mil.Chn.2005$), TSMG6MH@USECON.
- Real Sales: Retail Trade: Motor Vehicle & Parts Dlrs (SA, Mil.Chn.2005$), TSRI1H@USECON

Table A1: Elasticity of Trade in Previous Recessions

	A. HP = 1600		B. Linear		C. HP = 10^5		D. Raw data	
Imports	Median	2009Q2	Median	2009Q2	Median	2009Q2	Median	2009Q2
GDP	4.7	5.3	4.6	4.6	4.3	4.3	3.2	7.6
Industrial Production	1.6	1.6	1.6	1.6	1.6	1.6	1.4	1.4
Expenditure on tradeables	2.4	1.7	2.3	1.6	2.1	1.7	1.7	1.7
Exports								
GDP	3.3	5.2	2.8	3.3	2.6	3.0	5.7	5.7
Industrial Production	1.5	1.5	1.0	1.2	1.0	1.1	0.9	1.1

Notes: Imports are measured from start of recession based on the NBER dates. Exports are measured as the change from the peak, which may be after the recession has started. Median denotes the median (across all recessions) response of the variable in question and 2009Q2 denotes the dynamics in the current recession. Three seperate detrending methods were used. HP=1600 denotes applying an HP filter with a smoothing parameter of 1600; Linear stands for removing a linear trend; and HP=10^5 stands for HP filtered with a smoothing paramter of 100000. Thus, all drops are measured relative to the trend. Raw data are the unfiltered data.

Table A2: Summary Statistics on U.S. Business Cycles

	Standard Deviation (relative to IP)	Correlation with IP	Autocorrelation
Industrial Production (%)	3.6%	1.00	0.89
Exports	1.5	0.52	0.74
Imports	1.6	0.81	0.75
GDP	0.4	0.90	0.87
Expenditures onTradeables	0.9	0.87	0.87
Consumption on Goods	0.6	0.75	0.84
Consumption Durables	1.2	0.71	0.77
Consumption Non-durables	0.3	0.71	0.84
Investment on Equipment	1.5	0.89	0.90

Notes: Based on quarterly NIPA data from 67:1 to 10:3. Data are HP filtered with a smoothing parameter of 1600.

Table A3: Alternate Measures of Trade Volatility

A. Adjusting Trade Weights for Durables and Motor Vehicles (Quarterly)*

	SD (rel to IP)	Correlation with IP	IP TW	Exports	Imports	Autocorrelation
Industrial Production	3.6%	1.00	0.98	0.58	0.86	0.89
Industrial Production (TW)	1.10	0.98	1.00	0.48	0.90	0.87
Exports	1.46	0.58	0.48	1.00	0.34	0.85
Imports	1.63	0.86	0.90	0.34	1.00	0.84

B. Industry Analysis of Motor Vehicles and Parts (Monthly, 94M1 to 10M10)**

	SD (rel to IP)	Correlation with IP	Exports	Imports	Shipments	Autocorrelation
Industrial Production (IP)	8.2%	1.00	0.82	0.86	0.88	0.82
Exports	1.20	0.82	1.00	0.91	0.69	0.88
Imports	1.27	0.86	0.91	1.00	0.76	0.90
Mfr Shipments	0.83	0.88	0.69	0.76	1.00	0.75
Retail Sales	0.51	0.55	0.48	0.58	0.52	0.64

Notes: * Based on quarterly data from 72Q1 to 10Q3. HP-filtered with a smoothing paramter of 1600. IPTW uses 2003 to 2007 trade weights on durables excluding motor vehicles, motor vehicles, and nondurables.

** Based on monthly data from 97M1 to 10M10. HP filtered with a smoothing paramter of 14400. Industrial Production: Motor Vehicles and Parts (SA, 2002=100); Exports: Automotive Vehicles, Parts and Engines (SA, Mil.Chn.2005$); Imports: Automotive Vehicles, Parts, and Engines (SA, Mil.Chn.2005$) Real Sales: Mfg: Motor Vehicles & Parts (SA, Mil.Chn.2005$). Real Sales: Retail Trade: Motor Vehicle & Parts Dlrs (SA, Mil.Chn.2005$)

Table A4: Import Demand Regressions
(1997q1 to 2010q3)

	I	II	III	IV
$\Delta c(t)$	1.04	1.11	1.01	0.74
	6.25	7.52	5.45	4.88
$\Delta p(t)$	1.44	1.13	1.54	0.70
	4.10	3.50	4.37	2.46
$\Delta x(t)$		1.28		1.39
		3.76		4.74
m(t-1)			-0.33	-0.66
			-3.04	-5.66
c(t-1)			0.39	0.86
			2.84	5.62
p(t-1)			0.38	0.18
			1.46	0.89
x(t-1)				2.20
				5.42
# obs.	54	53	54	53
R^2	0.60	0.70	0.66	0.82

Note: t-stats below point estimates