

International Trade Price Stickiness and Exchange Rate Pass-through in Micro Data: A Case Study on US-China Trade*

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Abstract

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1 Introduction

Using unique goods-level micro data of import and export prices, we study the effects of RMB appreciation on trade prices between China and the US. We are particularly interested in two issues. First, we investigate whether the pricing behaviors of Chinese and US exporters have changed following China's switching of its exchange rate regime in 2005. Second, we want to study how much of the appreciation of the Chinese Yuan since 2005 is passed on to import and export prices between China and the US (exchange rate pass-through, or ERPT).

In this paper, we use a dataset containing very detailed goods-level monthly import and export prices between China and the US. The data are collected by the US Bureau of Labor Statistics (BLS) to calculate import and export price indexes for the US and China. The goods-level micro price data have detailed information to help study exporting firms' pricing behaviors, such as the choice of invoicing currency and the frequency and size of price adjustments. Such behaviors are very important factors in determining the international transmission of inflation and other shocks. For instance, Betts and Devereux (2000) and Devereux and Engel (2003) emphasize that the invoicing currency used in trade critically determines the short-run exchange rate pass-through. Most prices of Chinese exports to the US are set in the US dollar. In this case, the appreciation of the RMB has no short-run effect on the US-dollar prices of Chinese products at all. At the same time, firms' pricing behaviors are also endogenously chosen by firms and this choice can change when the economic environment changes. Gopinath, Itskhoki, and Rigobon (2010) find evidence that the firms' choice of invoicing currency is based on their desired ERPT. Firms that prefer a low exchange rate pass-through rate will choose importing country's currency, while exporters that prefer a high exchange rate pass-through rate will set prices in their own currency.

China has switched from a fixed exchange rate regime to a managed floating one since the summer of 2005. It provides a great opportunity to study the relationship between the macroenvironment and firm's pricing behaviors. When the exchange rate is fully flexible, both the exchange rate and the firm's pricing behaviors are endogenously determined, and so it is difficult to pin down a causal relationship between these two variables. The exchange rate regime switching in China can be interpreted as an exogenous event for exporting firms. We can therefore study whether this change in the exchange rate regime will change exporting firms' pricing behaviors. When facing higher exchange-rate risks, firms may want to change their prices more frequently resulting in a decline of price stickiness. Other pricing behaviors that might be affected include the size of price changes and the currency used to price exports. Will the change in the exchange rate regime affect the average size of price changes? Are Chinese and US exporters going to choose Chinese

Yuan to price their products more often than before? In addition, there are several different channels for firms to change their prices. For instance, they can vary the discounts offered to buyers. They can replace existing products with modified ones and charge a different price. Of course, they can also change listing prices directly. Will the change in the exchange rate regime affect which channel exporting firms will use to adjust their prices?

The micro price data from the BLS contain information to answer the above questions. With time series data, we can also investigate how the varieties of products traded between Chinese and the US change over time. For instance, do the varieties increase over time, and how much? How does this compare to other countries? What is the distribution of these varieties across different sectors and does this distribution vary over time? Answers to such questions will help us better understand China - US trade.

A second issue of interest is ERPT, which is measured as the percentage change in prices following a one percent change in the exchange rate. This variable is crucial for several important policy-related issues, such as the transmission of inflation shocks from one country to another. Not surprisingly, there is a huge body of literature studying ERPT both empirically and theoretically. ERPT is especially important with regard to China for another reason: the magnitude of ERPT is crucial in determining the effect of exchange rate movements on the trade balance. China's huge current account surplus with the US is often viewed as a result of its deliberate currency undervaluation. Several prominent foreign policymakers and economic researchers have pressed China to revalue its currency in order to rebalance the global economy. A fundamental assumption of this argument is that a large portion of China's currency appreciation will be passed on to its import and export prices. Studies on the extent of exchange rate pass through for China can evaluate this assumption and shed light on the effectiveness of RMB appreciation in reducing China's trade surplus with the US.

Several recent studies empirically investigate the effect of RMB appreciation on China's import and export prices and/or its trade account imbalance. For instance, see Auer (2011), Cui, Shu, and Chang (2009), Shu, Su, and Chow (2008), and Groenewold and He (2007). Our paper differs from the above studies in a very important way: we use goods-level micro data of import and export prices rather than the aggregate price indexes that are used in previous studies. Our choice of goods-level price data is motivated by important recent studies of ERPT. Nakamura and Steinsson (2010) find that many price changes take the form of product replacements rather than changing prices of existing products. For a lot of export products, their prices never change until they are replaced by some similar products. Price changes under product replacements are usually not included in aggregate price indexes. As a result, the exchange rate pass-through estimated from the aggregate price indexes is seriously downward biased.

The data allow us to estimate ERPT both at the goods level and the aggregate level. In this way, we can investigate: (1) ERPT at varying goods levels and whether they change substantially across different products; (2) if the ERPT changes across goods, what are potential reasons for this heterogeneity; (3) the difference between the ERPTs estimated from micro data and the one estimated from the aggregated price index. This may give us some idea about how large the aggregation bias could be when estimating the ERPT with the aggregate price index. In addition, the data set contains information about product replacement. We can investigate the size of the replacement bias discussed in Nakamura and Steinsson (2010) in China-US import and export price indexes.

We document several interesting empirical findings for US-China trade prices. First, the share of Chinese products in the BLS International Price Program (IPP) survey have increased substantially since 2001. By March 2011 (end of our sample), imports from China account for more than one third of goods in the survey. Under the probability sampling used by the BLS, the chance of a good being included in the sample depends on the value and frequency that good is traded. The rising share of import prices from China in the BLS survey reflects the sharp increase of US-China trade since China gained its WTO membership. The increase in the number of goods in our sample also suggests that China started to export goods that it had not exported before (extensive margin). Kehoe and Ruhl (2009) investigate the idea of extensive margin using disaggregate (four-digit SITC code) trade data. They document that China's WTO membership in 2001 has a big effect on the extensive margin for US-China trade. Our finding is consistent with Kehoe and Ruhl (2009), but we show strong evidence of the extensive margin at a much more disaggregate level (goods level).

Second, we document that almost all US imports from and exports to China are priced in the dollar. More than 97% of US imports from China are priced in the dollar. There has been a decline of non-US-dollar currency in pricing US imports from China mainly reflecting the abandoning of the Hong Kong dollar in pricing China's exports in the early 2000. The US dollar is the only invoicing currency for US exports to China until 2009 when the euro started to be used as an invoicing currency for US exports to China. The usage of the euro remains low: only about 1% of US export prices to China are priced in the euro. The Chinese yuan is rarely used as a pricing currency in China's trade with the US even if the Chinese government has been promoting to broaden the use of the Chinese yuan in the international trade.¹ Less than 0.5% of US import prices from China are set in the Chinese yuan after China adopted a relatively more flexible exchange rate regime in 2005. No US export price is set in the Chinese yuan so far. It would be interesting to see if the Chinese yuan becomes more active as an invoicing currency in the future.

Third, we find that significant price stickiness exists for US imports from China. The mean duration of

¹For instance, see "Beijing looks to broaden renminbi use," *Financial Times*, August 27, 2010.

prices is about 11 months, though the extent of price stickiness varies by sectors. The prices of US exports to China are less sticky: the mean duration is about 7 months. We split our sample period into two subsamples: before and after June 2005. The price stickiness declined in the second subsample for both US imports from and exports to China. The price duration on average becomes shorter after June 2005. Accordingly, the share of prices that adjust in each month increased after June 2005. We document this difference at both the aggregate and disaggregate levels. This suggest that the change in price stickiness is not likely to be caused by the composition effect (shifting from products with high price stickiness to low price stickiness). It is more likely to reflect changes in the macroeconomic environment such as the change in the exchange rate regime or the expectation on future inflation.

Fourth, we estimate the exchange rate pass-through into import prices with goods-level data. We find that short-run pass-through is low at about 20% and the long-run pass-through is around 80%. This result is very close to Auer's (2010) finding. Using the sectoral data, Auer (2010) estimated the pass-through of the appreciation of the yuan against dollar into US import and producer price indexes of tradable goods. He finds that exchange rate movements of other US trading partners have much smaller pass-through than the Chinese yuan. Our goods-level estimate of the pass-through has almost the same magnitude as that in Auer (2010).

In addition, we find that the exchange rate pass-through is much higher after excluding goods that never change their prices. More than a third of goods never change prices in the US imported prices from China. It is likely that some price changes take other forms such as product replacement or changes in discount. Including goods with no price adjustment may introduce downward bias to the estimate of the exchange rate pass-through. Nakamura and Steinsson (2010) find that the product replacement bias can underestimate the exchange rate pass-through in the aggregate price index by nearly a factor of two. We find much bigger pass-through after excluding prices that never change. It indicates that aggregate price indexes could tremendously underestimate the exchange rate pass-through.

2 Data Description

In this section, we describe the data that are used in our study and report some summary statistics. Our main dataset contains unpublished micro-level US import and export prices data collected by the Bureau of Labor Statistics (BLS). The International Price Program (IPP) of the BLS conducts survey to collect US import and export prices each month. The sampling of the survey is undertaken at the entry level items (ELIs) level, which in most cases corresponds to a 10-digit Harmonized System (HS) classification code. The

BLS currently selects companies, ELIs, and individual goods through the probability sampling. Before the sampling process begins, the BLS first obtains data from the Census Bureau or Customs Service on the value and frequency of trade of US companies involved in exporting or importing goods. Such data are consolidated by company and by ELI within each company. Next, the BLS determines the number of goods to request for company/ELI combinations based on a probability proportionate to the amount that a particular firm imports or exports in that ELI. Firms that imports/exports more good x have a higher probability of being sampled for the price of good x . The last stage is to select goods within chosen company/ELI combinations. The chance of an individual item being selected is proportionate to its share of trade within company/ELI combinations. Prices of chosen goods are recorded in each month and these prices are then used to construct import price indexes for the US. These micro data are also used in several previous studies, such as Clausing (2001), Gopinath and Rigobon (2008), Gopinath, Itskhoki, and Rigobon (2010), Gopinath and Itskhoki (2010), Berger et al. (2009), Nakamura and Steinsson (2010) and Neiman (2010). Gopinath and Rigobon (2008) have a detailed description of the collection process of the data and discussion on the main features of the data.

In this paper, we focus on the import goods prices from China to the U.S. and export goods prices from the U.S. to China. Our focus on China and US trade prices is motivated by two facts. First, China switched from a fixed exchange rate regime to a managed floating one in June 2005. It provides an excellent opportunity to study the effects of switching exchange rate regimes on exporting firms' pricing behavior. Second, China has become a very important trade partner of the US during the last two decades. Trade prices between China and the US are one of the most important elements in understanding the US trade and prices.

Prices of intra-firm transactions are excluded from our sample, following Gopinath, Itskhoki, and Rigobon (2010) and Nakamura and Steinsson (2010). Neiman (2010) finds that intra-firm prices are characterized by less stickiness, less synchronization, and greater exchange rate pass-through. These characteristics may just reflect the transfer price strategy to minimize tax payment of multinational firms. As a result, we exclude these accounting prices in our main analysis. Figure 1 shows the share of intra-firm prices in US import prices from China in our sample. The share of intra-firm prices rises over time, but remains below 20% for most of the time. In contrast, currently about 48% of price quotes for US imports are intra-firm, which is much higher than imports from China. This difference could reflect China's restrictions on FDI. It may also result from firms endogenously choosing arm's length trade based on the types of goods that China exports. We think it may be an interesting topic for future research.

We consider two types of prices: reported prices and net prices. Reported prices are prices that are

reported by importing firms in survey forms. They can either be list prices, transaction prices, or estimated prices. List prices are sticker prices that sellers ask for. Transaction prices are the actual prices paid by importers. When no actual transaction occurs during the survey period, firms are also allowed to provide an estimated price. Actual transaction prices provide the most accurate reflection of prices faced by buyers and sellers in item markets. Estimated and list prices can differ substantially from actual transaction prices. For instance, list prices can be much higher than actual transaction prices when discounts and/or rebates are granted to buyers. To reflect actual transaction prices as much as possible, the BLS constructs net prices, which are the prices used to calculate import and export price indexes. These net prices include actual transaction prices, as well as estimated prices or prices imputed by the BLS. For instance, when reporters fail to provide a transaction price, but the BLS knows that trades occur during that period, the BLS will use the reported prices and the discount structure information of the product to estimate a transaction price. Exchange rate changes and tariffs are also adjusted in net prices by the BLS when such information is available. Although net prices may better reflect the market prices, it can also potentially introduce spurious price changes. For instance, when prices are set in the foreign currency, the adjustment of the prices for exchange rate changes by the BLS will show price changes even if they do not. To avoid this problem, we also construct a series of net prices where prices imputed by the BLS are excluded. Missing values is a common problem faced by studies using micro price data. We pull forward the last observation to close the gap between observations in our sample, following the standard treatment in the literature.²

Our monthly data start in September 1993 and end in March 2011. For US imports from China, there are 323,805 price quotes (net prices exclusive) for 14,534 goods.³ So on average, there are 1,513 price quotes each month and 22.3 price quotes for each good. The US exports a much smaller number of goods to China than it imports. For net prices, there are only 1,047 goods with 23,638 price quotes. On average, there are 22.6 price quotes for each good, which is similar to that of US imports from China. Figure 2 shows the number of price quotes for US imports from China as well as that for US total imports. We only present results for net prices since reported prices have almost identical results. In Figure 2(a), missing values are filled by pulling the last observation forward. In this case, we have about 7,500 price quotes in each month for US total imports. Price quotes for US imports from China tripled during the sample period, increasing from less than 1,000 to about 3,000. As a result, the share of Chinese import prices increased substantially (from less than 10% to more than 35%) in our sample period.

Under the probability sampling used by the BLS, the chance of a good being included in the sample

²For instance, see Nakamura and Steinsson (2010). This is also a standard practice at the BLS when calculating price indexes.

³Among 323,805 net prices, there are 88,377 missing values that are filled by pulling the last observation forward.

depends on the value and frequency that the good is traded. The higher value or frequency a good is traded, the more likely it is included in the sample. The increasing share of import prices from China in US total imports reflects the sharp rise in US - China trade. The increase in the number of goods in our sample also suggests that China started to export goods that it had not exported before (extensive margin). Recent research in international trade has focused on the role of the extensive margin in driving trade patterns. For instance, Yi (2003) uses the extensive margin to explain the growth in global trade following trade liberalization. Ruhl (2008) argues that the extensive margin is important to understand high trade elasticity following a permanent shock. Nakano(2008) shows that the extensive margin may also help explain the real exchange rate volatility in macroeconomic models. Kehoe and Ruhl (2009) investigate the extensive margin using disaggregate (four-digit SITC code) trade data. They find significant evidence of growth in the extensive margin following a decrease of trade barriers. In particular, they document that China's WTO membership in 2001 has a big effect on the extensive margin for US-China trade. Figure 2(b) presents the number of US imports from China in different sectors. The number of goods that the US imports from China exhibits a sharp increase after 2001 in most sectors. Similar results exist at more disaggregate levels, such as the HS10 digit level. These findings are consistent with Kehoe and Ruhl (2009), but we show that the effect of the extensive margin is strong even at more disaggregate levels.

Figure 3 displays the number of price quotes in countries/region that have a declining number of goods in the BLS price survey. These countries/region mainly include East Asian countries/region and Germany. The decline in the number of US imported goods from East Asian countries reflects increasing vertical specialization in international trade among these countries/region and China. In the last two decades, China has become the hub of assembling final products for international trade due to its low labor costs.

Figure 4 shows the number of US export prices to China and the number of total export prices. There are on average about 7,500 price quotes in each month. Exports to China account for only a very small fraction of US total export prices in the IPP survey, though the share has increased over time in our sample. At its peak, the share of export prices to China in total US export prices is less than 4%. This contrasts sharply with the import price data, where US import prices from China account for more than 35% of total import prices.

3 Price Stickiness

In this section, we report our results on the stickiness of US import and export prices with China. A question that is highly related to price stickiness in international trade is the currency in which imports/exports are priced (invoicing currency). The choice of invoicing currency has important implications for optimal

monetary and exchange rate policy. For instance, when prices are sticky and set in the producer's currency (producer currency pricing or PCP), all exchange rate changes will be passed on to importing country's prices (100 percent exchange rate pass-through). In contrast, when prices are set in the importer's currency (local currency pricing, or LCP), the short-run exchange rate pass-through is zero. Devereux and Engel (2003) find that the optimal exchange rate policy is different under PCP and LCP. Engel (forthcoming) studies the optimal monetary policy under LCP.

In our sample, more than 97% US import prices from China and almost 100% US export prices to China are in the US dollar. This is consistent with Gopinath and Rigobon's (2008) finding that more than 90% US imported goods are priced in dollars. Figure 5 shows the fraction of non-dollar prices in US imports from China. Non-US-dollar currencies that are used to price Chinese imports include the Japanese yen, Taiwanese dollar, Hong Kong dollar, Chinese yuan, Deutsche mark, and euro. Before 2004, most non-dollar transactions for imports from China are in Hong Kong dollars. Since then, the share of prices in Hong Kong dollars has declined substantially. The currency index has become the most prominent invoicing currency. In this case, the good is priced based on a basket of currencies which are not disclosed to the BLS. The Japanese yen and Chinese yuan have also been used as invoice currency since 2006. For US exports to China, the US dollar was the only invoicing currency until 2009. Since 2009, the euro has also been used as an invoicing currency for US exports to China. However, the use of the euro remains low: only about 1% of US export prices to China are in euros. Although China switched from the fixed exchange rate regime in June 2005 to a managed floating one, it seems that the regime switching has not affected the exporting firm's choice of invoicing currency. Overall the US dollar is still the dominant invoicing currency for trade between the US and China.

Table 1 reports some summary statistics on the price stickiness in our sample. For reported prices of US imports from China, there are 311,696 prices reported for 14,543 goods. On average, a good lasts for 22.22 months before it is discontinued or replaced by a new product. This is much shorter than the mean life of a good in US total imports, which is 37.5 months as reported in Gopinath and Rigobon (2008). There is substantial heterogeneity in duration across goods. Some exist for only one month and the longest duration is as long as 125 months, or ten years and 5 months. The average number of price changes for each good is 1.85. There is substantial difference in the number of price changes across goods. A large share of goods (about 35%) never change prices during their lifetime. In contrast, some goods have more than 50 pricechanges. Net prices that exclude prices imputed by the BLS behave similarly to reported prices in the above statistics.

Analogous summary statistics are also reported for US exports to China. A significant difference between

US import prices from and export prices to China is with regard to price stickiness. On average, US exports to China have more than 5 price changes for each good, while imports from China have less than 2 price changes for each good. Table 1 shows that the duration of goods is about the same for US imports from and exports to China. This suggests that US export prices to China change more frequently than US import prices from China.

The BLS adjusts reported prices with exchange rate changes, discounts, and other corrections. As argued by Gopinath and Rigobon (2008) and Nakamura and Steinsson (2010), such adjustments may introduce spurious price changes. Note in Table 1 that the characteristics of the dataset of net prices excluding prices imputed by the BLS is similar to that of the reported prices, and so we focus on reported prices, given the above criticism, when presenting our results for price stickiness. We use price durations as our measure of price stickiness. For each good, we calculate the shortest, the longest, and mean duration of its prices. As shown in Table 2, across goods in the full sample, the shortest duration of US import prices from China ranges from 1 month to 85 months with a mean of 7.29 months. The longest duration also ranges from 1 month to 85 months with a mean duration of 14.21 months. The mean duration ranges from 1 month to 85 months with a mean of 10.29 months.⁴ The average duration for US exports to China is 7.03 months, indicating more flexible prices for US exports to China than its imports from China.

We also split our sample into two sub-samples: pre- and post- June 2005. Since China began appreciating its currency in June 2005, we want to compare if price stickiness differs in these two periods. There are 7,418 prices in our pre- June 2005 sub-sample and 9,548 prices in the post- June 2005 sub-sample for US imports from China. The mean price duration in the pre- June 2005 sub-sample is 8.10 months. It is much smaller, at 5.11 months in the second sub-sample. Similar results are also found in US exports to China. The mean duration for US export prices to China is 4.65 months in the pre- June 2005 sub-sample and 3.34 months in the post- June 2005 sub-sample. Note that we have only 68 periods in the post- June 2005 sub-sample, so the maximum duration is capped at 68 months. This may generate spurious shorter price durations in our post- June 2005 sub-sample. To address this problem, we also investigate the cross-sectional evidence of price stickiness. Figure 6 presents the fraction of price that change in each month for US trade with China. An increase in the fraction of prices changes indicates an increase in price flexibility, or a decline in price stickiness.

Figure 6(a) shows the fraction of US export prices to China that change in each month. The fraction of price changes increased substantially in 2005, which suggests a decline of price stickiness. A similar decline of price stickiness around 2005 is also shown in Figure 6(b) for US imports from China. Next we

⁴Note that if a good has only one price, the shortest, longest and mean durations are the same.

use structural break tests with an unknown number of breaks and break dates to identify potential breaks in price stickiness.

3.1 Structural Break Tests

The structural break tests are from Bai and Perron (2003). Two specifications are considered in our tests. In the first specification,

$$y_t = a_j + \varepsilon_t \tag{1}$$

for $t = T_{j-1} + 1, \dots, T_j$ and $j = 1, 2, \dots, m + 1$, where y_t is the fraction of price changes in Figure 6, m is the number of breaks, and T_j is the date of the j^{th} structural break. Both the number of breaks and the date of breaks are unknown and will be estimated from the data. In each regime, y_t has a different mean a_j . So we call this the mean model. In the second specification, y_t is allowed to a different mean and different deterministic time trend:

$$y_t = a_j + b_j \times \frac{t}{T} + \varepsilon_t, \tag{2}$$

for $t = T_{j-1} + 1, \dots, T_j$ and $j = 1, 2, \dots, m + 1$.⁵ We call this specification the trend model.

Four tests are used to determine the number of breaks in each model:

1. Test $H_0 : m = 0$ against $H_A : m > 0$;
2. Test $H_0 : m = 0$ against $H_A : m = k$ for pre-specified k ;
3. Test $H_0 : m = k$ against $H_A : m = k + 1$ sequentially for $k = 0, 1, \dots$;
4. BIC.

The first test is used to test the null hypothesis of no break against the alternative that there is at least one break. In the second test, we test the null of no break against the alternative of k breaks for $k = 1, \dots, 5$. We use the third test to find the number of breaks k by testing the null of k breaks against the alternative of $k + 1$ breaks. The test is conducted sequentially for $k = 0, 1, \dots$ until we fail to reject the null hypothesis. The BIC is also used to select the number of breaks.

⁵ T is the number of periods. Time t in equation (2) is expressed as a fraction $\frac{t}{T}$ purely due to technical reasons documented in Bai and Perron (2003).

Results of US Exports to China

In the mean model,

1. The null of no breaks ($H_0 : m = 0$) is strongly rejected;
2. The null of no breaks ($H_0 : m = 0$) is rejected in favor of the alternative of 1, 2, 3, 4 or 5 breaks;
3. The null of $H_0 : m = k$ is rejected in favor of the alternative of $H_A : m = k + 1$ for $k = 0$, but we fail to reject the null for $k = 1$.
4. BIC suggests that there is 1 break with the 2 breaks model being the second best model.

All tests strongly reject the null of no breaks. Tests 3 and 4 suggest that there is one structural break (2 regimes) in the data. Given 1 structural break, the mean model indicates the break date is January 2006. Table 3 presents the results of structural break tests. The coefficient a_j increases from 0.181 in the first regime to 0.235 in the second regime. In other words, 18.1% of prices adjust in each period for the first regime. The share of price adjustment increases to 23.5% in the second regime.

Similar results are found in the trend model. As in the mean model, our tests suggest there is one break in the sample with a break date of May 2005. The share of price adjustment has a downward slope (-0.052) in the first regime, but an upward slope in the second regime. The break date coincides with the date that China starts to appreciate the RMB. Figure 7 displays the share of price adjustment in each month for US exports to China and the fitted values from the mean and trend models. The evidence of regime switching is very strong in these charts. US export prices to China become less sticky (more flexible) after 2005. The most obvious explanation to this regime switching is the change in China's exchange rate policy: when firms face more exchange rate fluctuations that drive their prices out of the optimal price, they will change their prices more frequently to align their prices with the optimal one. A competing explanation to the above finding could come from potential changes in trade composition. Perhaps the US is exporting more products in sectors with less sticky prices after 2005. To address this issue, we also check price stickiness at disaggregated levels. Figure 8 shows the share of price changes in sectors that are aggregated 2-digit HS codes. The decline of price stickiness around 2005 is also evident at the disaggregated level. This finding suggests that the decline in price stickiness of US exports to China is unlikely to be mainly driven by the composition effect.

Results of US Imports from China

In the mean model,

1. The null of no breaks ($H_0 : m = 0$) is strongly rejected;
2. The null of no breaks ($H_0 : m = 0$) is rejected in favor of the alternative of 1, 2, 3, 4 or 5 breaks;
3. The null of $H_0 : m = k$ is rejected in favor of the alternative of $H_A : m = k + 1$ for $k = 0, 1, 2$, but we fail to reject the null for $k = 3$.
4. BIC suggests that there are 2 breaks with the 3 breaks model being the second best model.

Tests 1 and 2 strongly reject the null of no breaks. Test 3 suggest that there are 3 breaks (4 regimes) in the data. The BIC test indicates that the the 2 break model is the best, but the 3 break model also performs well. Based on the results of tests 3 and 4, we choose 3 breaks as our benchmark model. Similar results are also found in the trend model.

The results of the structural break tests for US import prices from China are reported in the lower panel of Table 3. In the mean model, three break dates are identified: July 1999, May 2005, and December 2007. These break dates are closely linked to China’s accession to the WTO, China’s change in its exchange rate policy, and the deterioration of the global financial crisis.

Gopinath and Rigobon (2008) find that the aggregate price stickiness for US imports increased in the 1990s. They further document that the increase is mainly due to the increase of price stickiness at disaggregate levels rather than the composition or country effects of US imports. Gopinath and Rigobon (2008) argue that the increase of US import price stickiness in the 1990s may be responsible for the decline of ERPT into US import prices during this period. We also find a steady increase in price stickiness from the 1990s to the early 2000s for US imports from China. However, we further document that the increase in price stickiness for US imports from China is reversed after 2005. It would be interesting to investigate whether the decline of price stickiness increases ERPT to US import prices.

Figure 6 shows that the price stickiness of US imports from China has declined substantially since the mid 2000s. A similar pattern of price stickiness is also found at disaggregated levels. Table 4 reports the sectoral level mean price duration of US imports from China for the whole sample and two sub-samples of before and after June 2005. The sectors are aggregations of 2-digit HS codes. First, significant heterogeneity exists across sectors. The price duration varies from about 4 months in the Animals and Vegetable Products sector to more than 12 months in several sectors including Textile and Footwear/Headgear. In addition, the post- June 2005 sample has shorter durations than the pre- June 2005 sample in most sectors (10 out of 12 sectors), indicating a decline of price stickiness. Figure 9 shows the ratio of prices that adjusted to total number of prices in each month in different sectors. In all sectors in the figure, the fraction of prices that

adjust in each month display a decline in the 1990s and then, an increase in around 2005. These findings at the sectoral level suggests that the decline of price stickiness of US imports from China after June 2005 is not likely to be caused by the composition effect (a shifting from products with higher price stickiness to those with low price stickiness). It is more likely that the decline of price stickiness reflects changes in the macroeconomic environment, such as a change in exchange rate regime or an expectation of future inflation.

4 Exchange Rate Pass-through

The extent of pass-through of the exchange rate into local currency import prices is critical for policy issues such as the international transmission of inflation and the optimal exchange rate policy. The role of China in exchange rate pass-through to US import prices has attracted great interest for both policymakers and academic researchers alike. The standard pass-through regression takes the form:

$$\Delta p_t = \alpha + \gamma \Delta s_t + \delta \Delta c_t^* + \beta \Delta d_t + \varepsilon_t, \quad (3)$$

where p_t is the log import price denominated in importing country's currency, s_t is the log exchange rate, c_t^* is the log production cost of exporters, and d_t is the log import demand.⁶ Coefficient γ measures the percentage change in the import price given one percent change in the exchange rate. Pass-through is usually found incomplete ($\gamma < 1$) and has declined in the last two to three decades for US import prices.

Given the limitations of data, previous studies on the exchange rate pass-through of US imports from China use aggregate price indexes. Nakamura and Steinsson (2010) point out an important caveat about estimating exchange rate pass-through using aggregate price indexes. They note that a large fraction of US imports never change their prices during the lifetime. In the last section, we also show that more than a third of US imported goods from China never change their prices. Nakamura and Steinsson (2010) argue that price adjustments can take the form of product replacement. As a result, some products never change their prices in the data. The product replacement usually cannot be adequately measured in the price index because it is difficult to link a product with its replacement in practice. In this case, including goods that are replaced in aggregate price indexes will make the price indexes very smooth and result in a downward bias in the estimate of exchange rate pass-through. Our paper contributes to the literature by estimating ERPT of US imports from China from goods-level prices. We are able to exclude prices that never change in our estimation of ERPT, and we can investigate how much such prices affect our estimate.

⁶Lags of Δp_t or Δs_t usually are also used in the regression.

We employ two strategies to estimate ERPT. First, we estimate lifelong ERPT following Gopinath, Itskhoki, and Rigobon (2010). In this exercise, we estimate the following regression:

$$\Delta p_i = \gamma \Delta s_i + \beta' z_i + \varepsilon_i, \quad (4)$$

where Δp_i^s is the change of the price of good i during its life. Δs_i is the change of the exchange rate during the same period. The vector z includes corresponding changes in other variables. Following Gopinath, Itskhoki, and Rigobon (2010), we include US CPI growth, China's CPI growth, and US real GDP growth in vector z_i . Our sample begins in July 2005 when the RMB began to appreciate against the US dollar and ends in July 2008 to avoid the effect of the global financial crisis. The RMB also paused its appreciation between July 2008 and May 2010, which makes that period unsuitable in the estimation of ERPT.

Table 5 presents the results of lifelong ERPT. In unweighted ERPT, all goods are treated equally in our regression and each good is weighted by its annual trade weight at the HS10 level when we estimate weighted ERPT. When all prices are included, ERPT is much smaller than one: ranging from 0.2 to 0.6. When we condition our estimate on prices that have at least one change, the estimated ERPT is much higher: it ranges from 1.1 to 2.1. This is about 3 to 5 times larger than the estimate with all prices.

In the second exercise, we estimate the ERPT from a more standard equation that is widely used in the literature:

$$\Delta p_t^i = \alpha + \sum_{j=0}^p \gamma^j \Delta s_{t-j} \Delta s_{t-j} + \beta' z_{t-j} + \varepsilon_t, \quad (5)$$

where Δp_t^i is the change in the log price of good i and Δs_t is the change in the log exchange rate. Following Gopinath and Rigobon (2008), we include the US CPI inflation rate, China's CPI inflation rate, and US GDP growth in vector z_t . Up to 6 lags (half year) of the independent variables are added. Gopinath and Rigobon (2008) and Gopinath, Itskhoki, and Rigobon (2010) use 24 lags (2 years) in their estimation. We choose shorter lags for two reasons. First, China began to appreciate its currency only after June 2005, so we have a shorter sample than Gopinath, Itskhoki, and Rigobon (2010). Adding too many lags would make our sample too small. Second, Gopinath, Itskhoki, and Rigobon (2010) find that pass-through usually takes place within the first 2 quarters. Thus, we believe that 6 lags in our monthly data can capture the dynamics of ERPT sufficiently well. Following Gopinath and Rigobon (2008), we also include fixed effects at the 4-digit HS level to control for the sectoral fixed effect. Standard errors are clustered at this level.

We run pooled regressions at the goods level, where each observation is weighted by its annual trade value

at the HS10 level. The short-run exchange rate pass-through is defined by the contemporaneous response of the import price to the exchange rate γ^0 . The long run exchange rate pass-through is the sum of γ 's at all lags ($\sum_{j=0}^6 \gamma^j$). Table 6 reports the cumulative exchange rate pass-through $\sum_{j=0}^n \gamma^j$ for $j = 0, 1, \dots, 6$ estimated from equation (5). The left panel presents the results for all prices and the right panel reports results conditional price adjustment. That is, we exclude goods that never change their prices from our sample in the right panel. We run regressions for both the reported prices and the net prices excluding prices imputed by the BLS.

When we include all prices in the regression, our results are similar to previous findings in the literature. First, the short-run exchange rate pass-through is low, at 16.3% for reported prices and 20.7% for net prices exclusive. The pass-through continues to rise in the following months. At its maximum level, ERPT into US import prices can be 82% for reported prices and 69.4% for net prices exclusive. This is much higher than the estimate of ERPT into US aggregate import price index during the same period. For instance, Marazzi and Sheets (2007) find that only about 20% of exchange rate changes is passed on to US import price index after the 1990s. However, our estimate is close to Auer's (2011) estimate using sectoral price indexes. He finds that the pass-through of the RMB appreciation to US import prices can be as high as 80%. Our results suggest that the exchange rate pass-through for US imports from China is higher than that of imports from other countries, as emphasized by Auer (2011).

The right panel of Table 6 presents the exchange rate pass-through estimate when goods that never change prices during their lifetime are excluded. Table 1 shows that more than one-third of the goods never change prices for US imports from China. Some price adjustment may take other forms such as product replacement or discount changes. Nakamura and Steinsson (2010) find that the product replacement bias can underestimate ERPT in the aggregate price index by nearly a factor of two. A more accurate measure of pass-through may be the one that exclude prices with no change in their entire lives. The right panel of Table 6 shows that ERPT exclusive of prices that never change can be much higher than when ERPT is estimated with all prices. Our estimate of ERPT is based on a very simple model with limited number of observations. Therefore, we should be cautious in interpreting the level of our estimate. However, an interesting finding is the large difference between the estimate from all prices and that conditional on price adjustment. It deserves further investigation on the sources of this difference and their effects on the estimate of ERPT.

5 Conclusion

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Figure 1: Share of Intra-firm Prices in US Imports from China

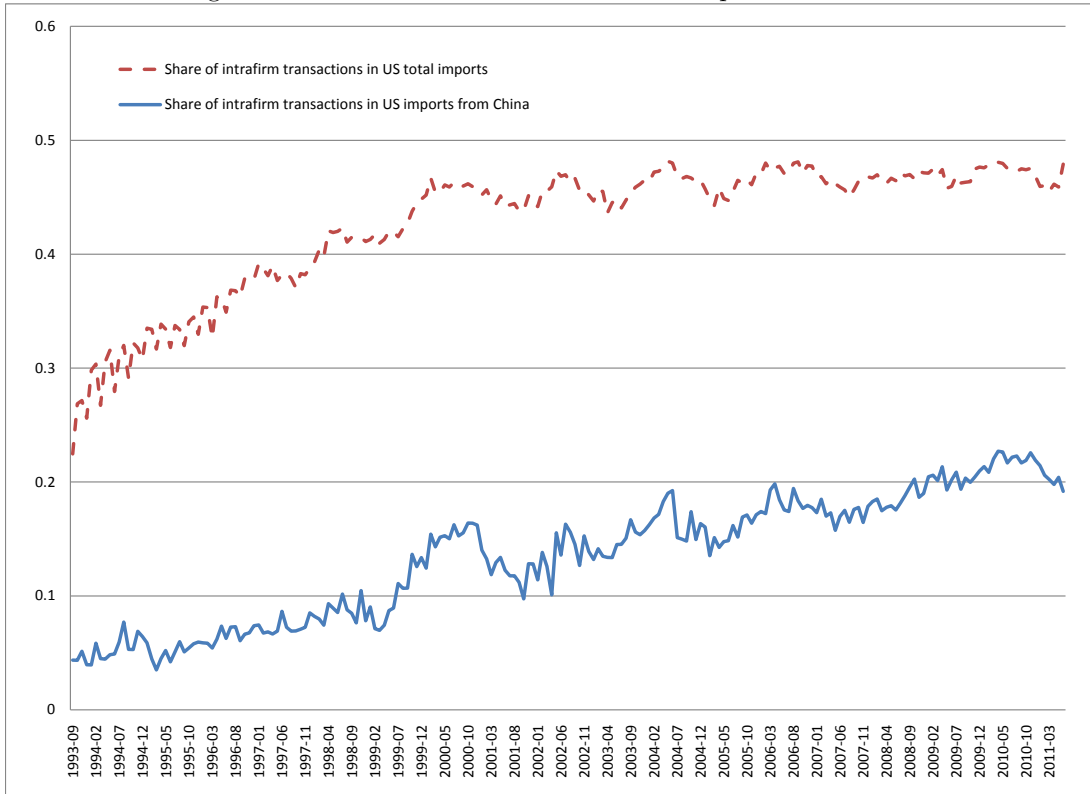
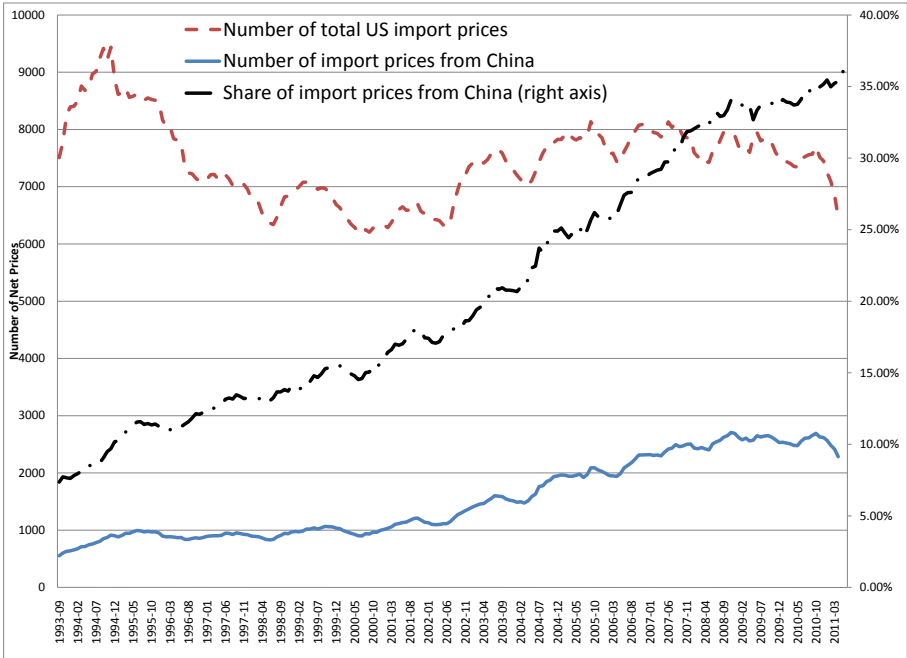
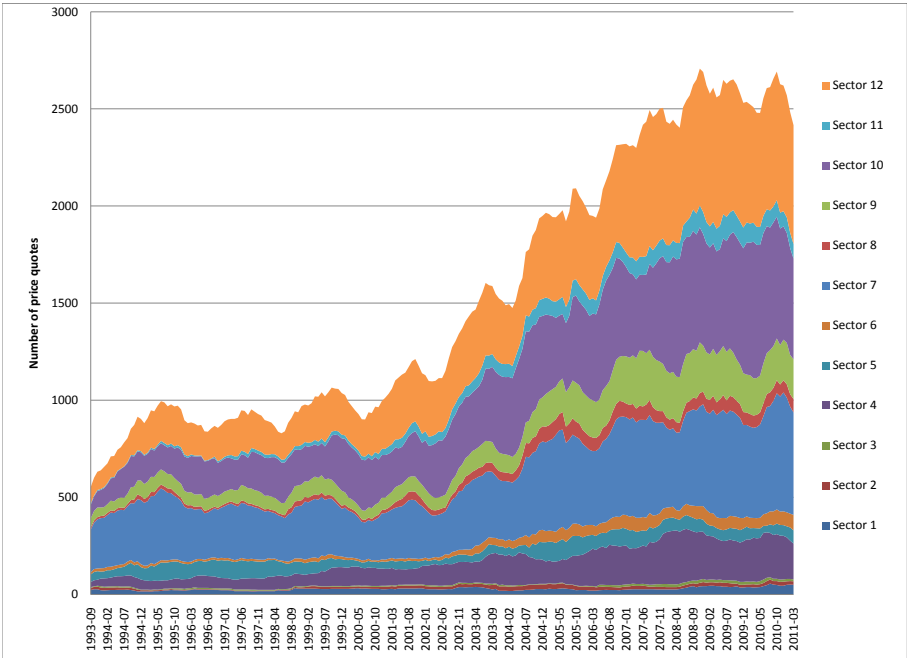


Figure 2: Number of Price Quotes per Month in US Imports (Excluding Intra-Firm Prices)



(a) Net Prices



(b) Number of US Imports from China by Sectors

Figure 3: Countries with A Declining Number of Prices

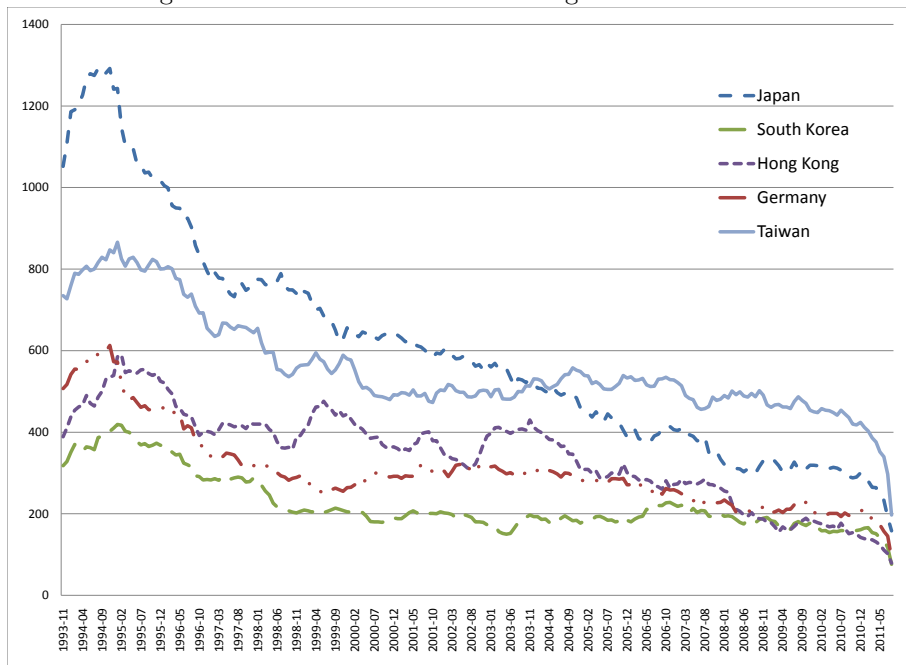


Figure 4: Number of Price Quotes per Month in US Exports (Excluding Intra-Firm Prices)

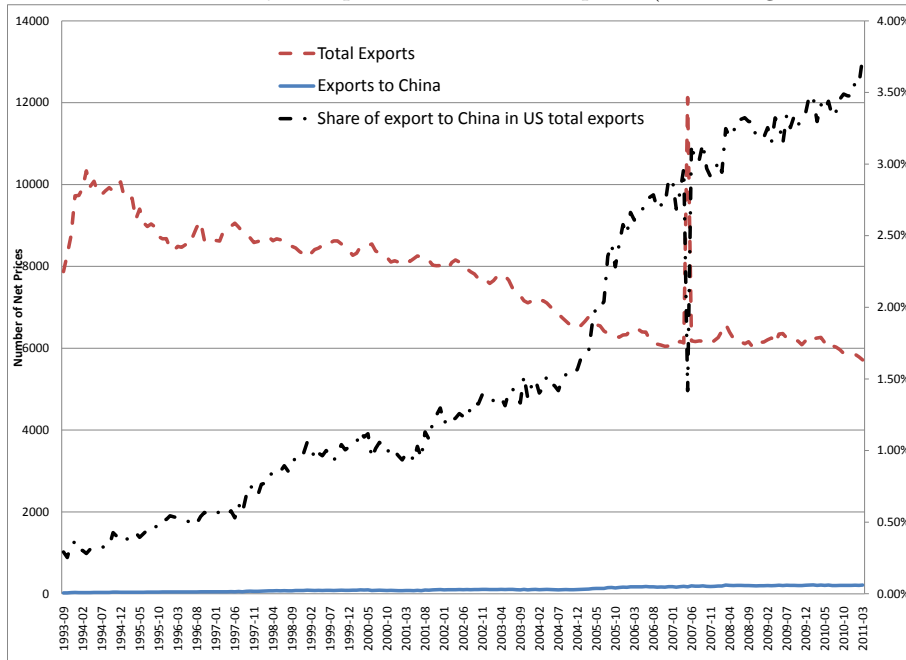


Figure 5: Fraction of non-dollar transactions in US imports from China

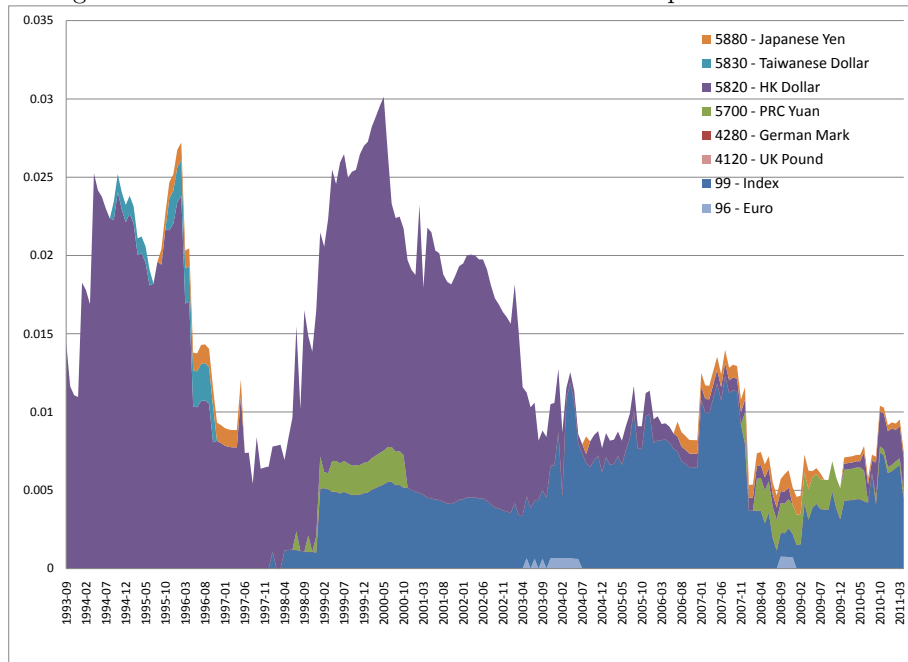
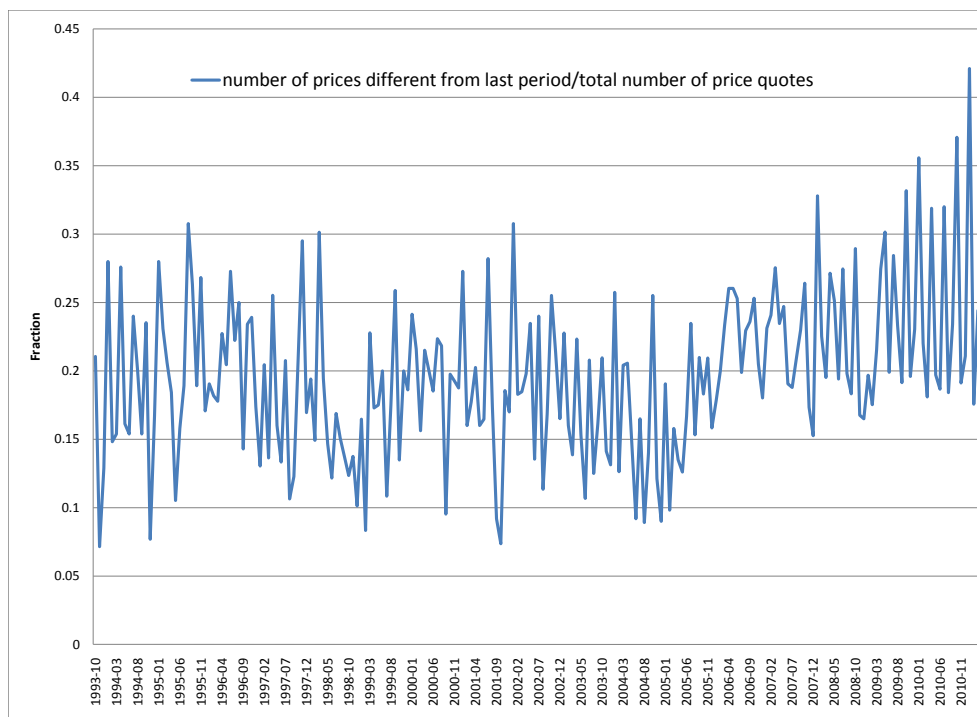
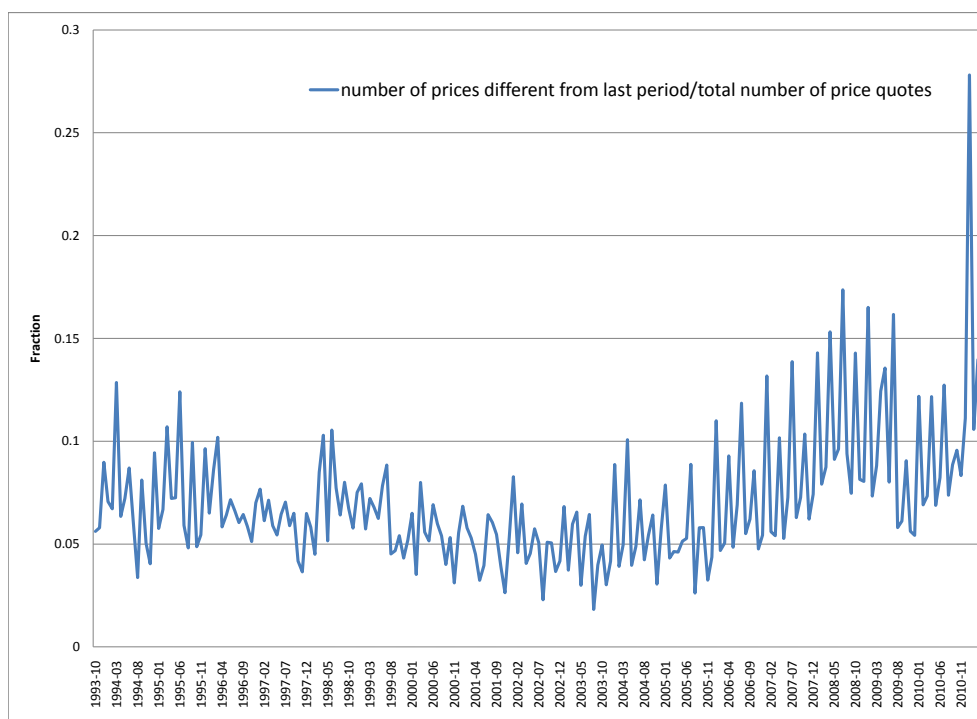


Figure 6: Fraction of Price Changes in Each Month

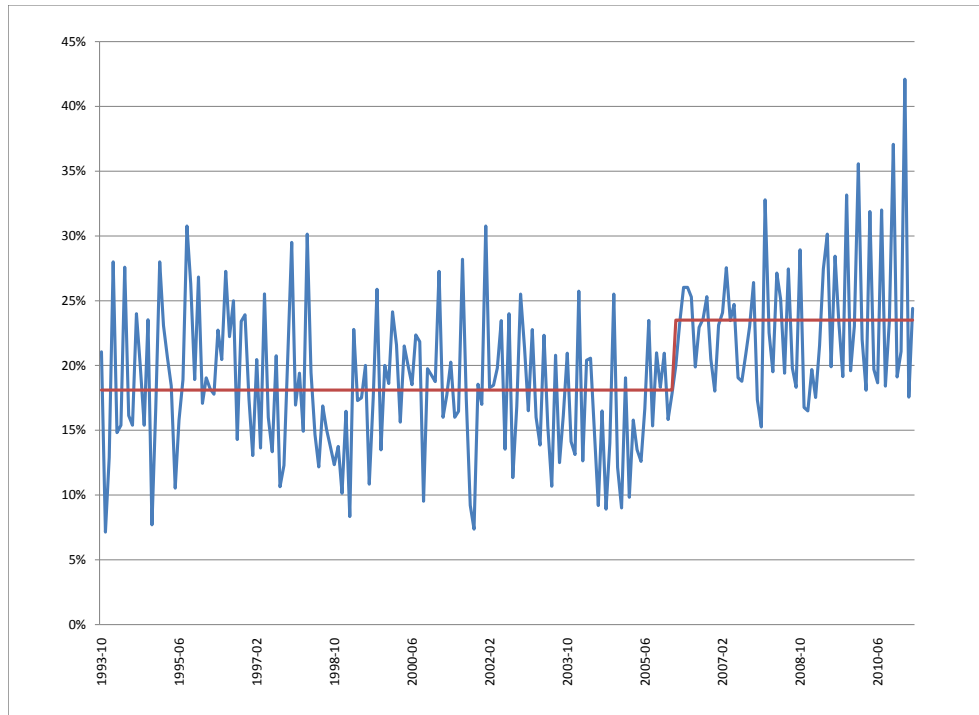


(a) US Exports to China

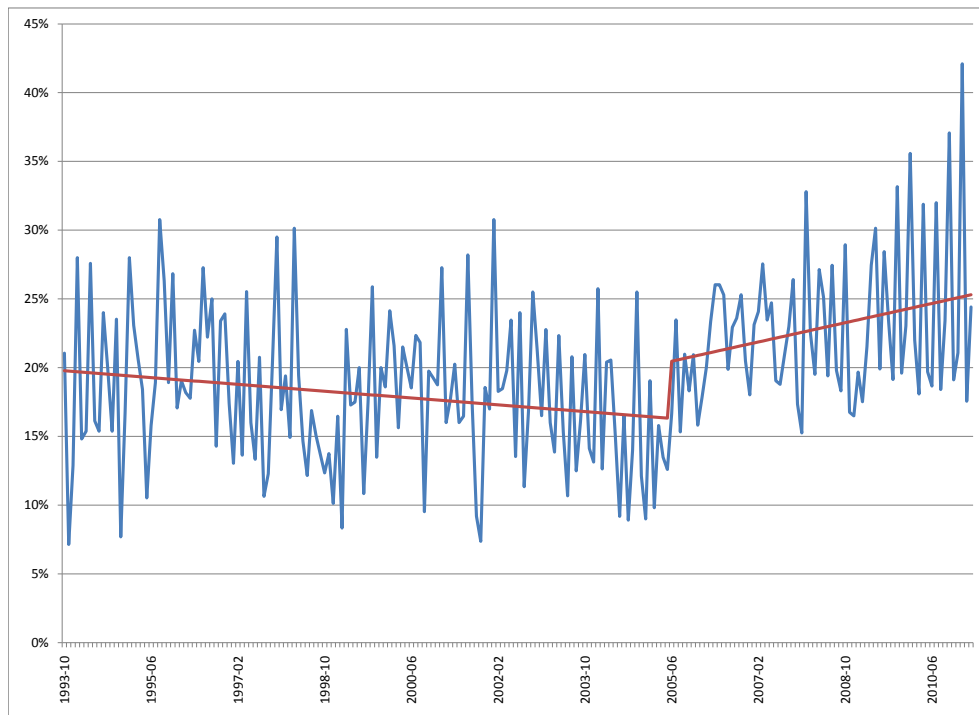


(b) US Imports from China

Figure 7: Fraction of Price Changes in Each Month (US Exports to China)

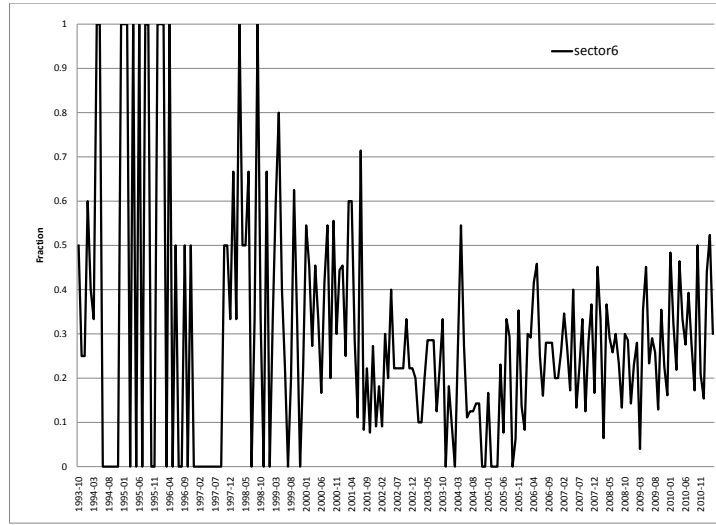


(a) Mean Model

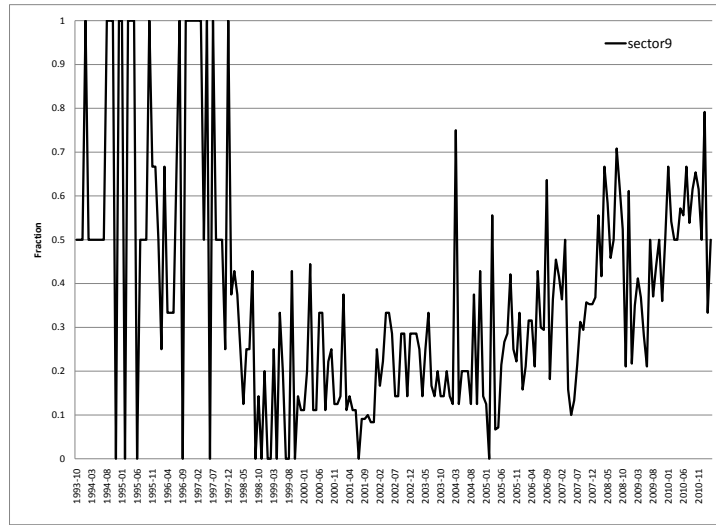


(b) Trend Model

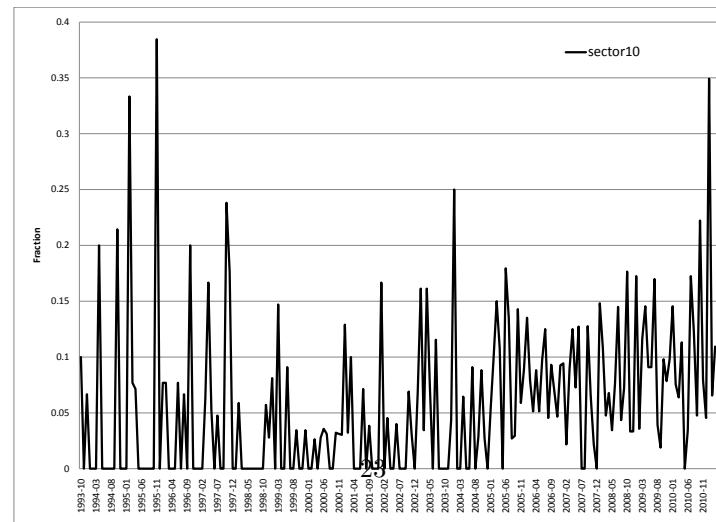
Figure 8: Fraction of Price Changes by Sectors (US Exports to China)



(a) Sector 6: Wood and Wood Products

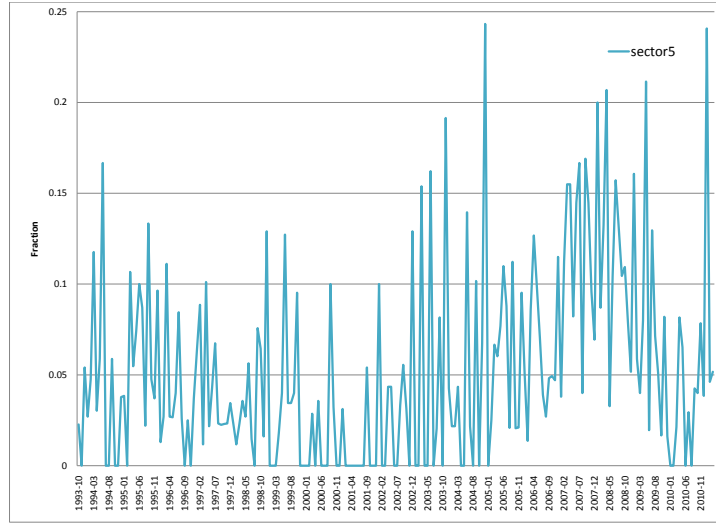


(b) Sector 9: Metals

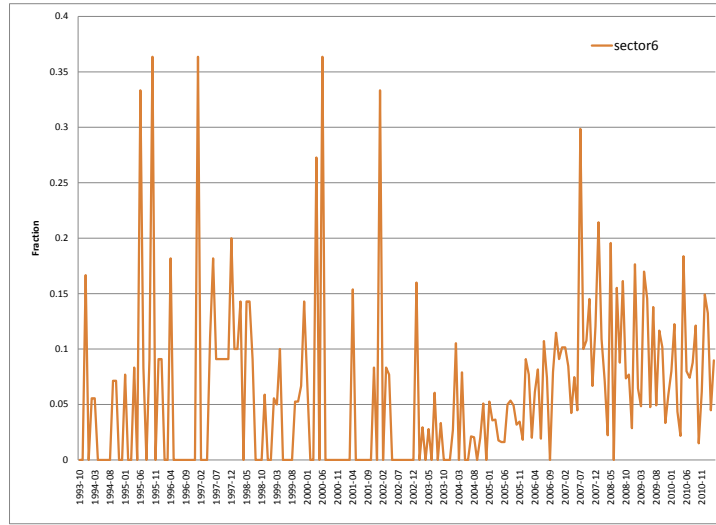


(c) Sector 10: Machinery/Electrical

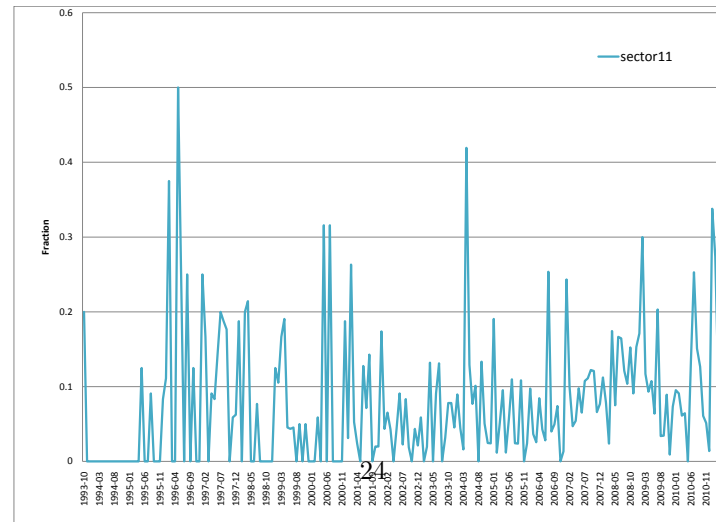
Figure 9: Fraction of Prices that Change in Each Month by Sectors



(a) Sector 5: Chemical and Allied Industries, Plastics, and Rubber



(b) Sector 6: Rawhide, Skins, Leather, and Furs



(c) Sector 11: Machinery/Electrical

Table 1: Summary Statistics

	Number of goods	Number of prices	Goods duration (months)			Price changes for each good			Goods with no price change
			min	max	mean	min	max	mean	
US Imports from China									
Reported	14,543	311,696	1	125	22.22	0	58	1.85	34.90%
Net exclusive	14,534	323,805	1	125	24.63	0	75	1.93	37.10%
US Exports to China									
Reported	1,048	23,043	1	139	23.23	0	79	5.39	23.47%
Net exclusive	1,047	23,638	1	139	23.33	0	80	5.33	24.55%

Note:

- This table reports summary statistics for prices of US imports from and exports to China.
- Reported is the reported prices and net exclusive is the net prices excluding prices imputed by the BLS. See the section on data description for more information on these prices.
- Our data are monthly observations from September 1993 to March 2011.

Table 2: Price Durations (months) of US Import Prices from and Export Prices to China

	Whole Sample			Pre-June-2005			Post-June-2005		
	Shortest duration	Longest duration	Mean duration	Shortest duration	Longest duration	Mean duration	Shortest duration	Longest duration	Mean duration
US Imports from China									
# of goods	14,543			7,418			9,548		
MIN	1	1	1	1	1	1	1	1	1
MAX	85	85	85	79	79	79	68	68	68
MEAN	7.29	14.21	10.29	5.65	14.58	8.10	2.90	10.97	5.11
US Exports to China									
# of goods	1,048			484			739		
MIN	1	1	1	1	1	1	1	1	1
MAX	60	60	60	51	57	51	45	47	45
MEAN	4.68	10.59	7.03	2.11	11.53	4.65	1.65	8.43	3.34

Note:

- This table reports durations of US import/export prices from/to China.
- The statistics are calculated from reported prices.
- The data are monthly observations from September 1993 to June 2011.

Table 3: Results of Structural Break Tests

US Exports to China				
	Regime	Regime Date	a_j	b_j
Mean Model	1	October 93 to January 2006	0.181***	NA
	2	February 2006 to March 2011	0.235***	NA
Trend Model	1	October 93 to May 2005	0.198***	-0.052**
	2	June 2005 to March 2011	0.106*	0.147**
US Imports from China				
	Regime	Regime Date	a_j	b_j
Mean Model	1	October 1993 to June 1999	0.070***	NA
	2	July 1999 to April 2005	0.051***	NA
	3	May 2005 to November 2007	0.070***	NA
	4	December 2007 to March 2011	0.102***	NA
Trend Model	1	October 1993 to January 1998	0.078***	-0.075*
	2	February 1998 to December 2003	0.099***	-0.103***
	3	January 2004 to November 2007	-0.028	0.132*
	4	December 2007 to March 2011	0.147**	-0.050

Note:

- This table reports the results of structural break tests for price stickiness of US trade with China.
- Superscripts *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.

Table 4: Mean Price Durations (months) at Sectoral Level

Sector		Whole Sample	Pre-June-2005	Post- June-2005
1	Animals, Animals and Vegetable Products	3.69	2.74	2.34
2	Prepared Foodstuff	5.49	4.21	2.25
3	Mineral Products	4.37	2.50	2.41
4	Chemical and Allied Industries, Plastics, and Rubber	6.89	3.81	3.38
5	Rawhide, Skins, Leather, and Furs	8.71	3.23	2.33
6	Wood and Wood Products	8.35	5.28	3.04
7	Textile and Footwear/Headgear	8.95	3.54	2.61
8	Stone/Glass	10.14	4.06	3.54
9	Metals	6.77	4.53	3.04
10	Machinery/Electrical	7.77	4.03	2.84
11	Transportation	8.03	4.84	3.74
12	Miscellaneous	9.89	4.67	3.42

Note:

- This table reports sectoral level mean price durations of US imports from China. The sectors are aggregations at the 2-digit level HS codes.
- The statistics are calculated from reported prices.
- The data are monthly observations from September 1993 to November 2009.

Table 5: Lifelong Exchange Rate Pass-Through (ERPT)

All Prices								
	Reported Prices				Net Prices Exclusive			
	ERPT	<i>s.e.</i>	N	Scaled Pearson χ^2	ERPT	<i>s.e.</i>	N	Scaled Pearson χ^2
Unweighted	0.496	(0.379)	4700	1.09	0.615	(0.358)	4927	1.08
Weighted	0.207	(0.326)	3792	1.10	0.381	(0.303)	3975	1.10
Conditional on Price Changes								
	Reported Prices				Net Prices Exclusive			
	ERPT	<i>s.e.</i>	N	Scaled Pearson χ^2	ERPT	<i>s.e.</i>	N	Scaled Pearson χ^2
Unweighted	1.059	(0.750)	2425	1.15	1.117	(0.742)	2442	1.15
Weighted	1.815	(0.616)	1919	1.18	2.097	(0.590)	1940	1.17

Note:

–This table reports lifelong ERPT for US imports from China.

–*s.e.* is the standard error and N is the number of observations.

–The data are monthly observations from June 2005 to July 2008.

–Column All Prices includes all prices in our sample. Column Conditional on Price Changes only includes prices that have at least one change in the lifetime.

Table 6: Exchange Rate Pass-through at Goods Level

lag (<i>j</i>)	All Prices		Conditional on Price Adjustment	
	Reported Prices	Net Prices Exclusive	Reported Prices	Net Prices Exclusive
0	0.163	0.207	0.221	0.287
1	0.494	0.441	0.672	0.604
2	0.820	0.694	1.126	0.954
3	0.442	0.333	0.589	0.447
4	0.204	0.048	0.277	0.071
5	0.499	0.381	0.725	0.561
6	0.802	0.662	1.137	0.941

Note:

–This table reports the accumulative exchange rate pass-through ($\sum_{j=0}^n \gamma^j$ for $j = 0, 1, \dots, 6$) estimated from goods-level US import prices from China.

–Net prices exclusive are net prices that exclude imputed prices by the BLS.

–The data are monthly observations from June 2005 to July 2008.

–The right panel excludes goods that never change prices during their lifetime.