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The Yuan's Exchange Rates and
Pass-through Effects on the Prices
of Japanese and US Imports

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Abstract: This paper estimated the pass-through effects of yuan's exchange rates on prices of the US and Japanese imports from the People's Republic of China (PRC). Empirical results show that, a 1% nominal appreciation of the yuan would result in a 0.23% increase in prices of the US imports in the short run and 0.47% in the long run. Japanese import prices were relatively more responsive to changes of the bilateral exchange rates between the yuan and the yen. For a 1% nominal appreciation of the yuan against the yen, Japanese import prices would be expected to rise 0.55% in the short run and 0.99%, a complete pass-through, in the long run. The high degree of pass-through effects were also found at the disaggregated sectoral level: food, raw materials, apparel, manufacturing, and machinery. However, further analysis indicated that the high pass-through effects in the case of Japan were mainly attributed to the PRC's policy to peg the yuan to the United States (US) dollar, and that the dollar is used as a dominant invoicing currency for the PRC's exports to Japan. After controlling the currency invoicing factor, I found no evidence that the yuan's cumulative appreciation since July 2005 was passed on to prices of Japanese imports at either the aggregate or disaggregated levels. The estimated low pass-through effects of the yuan's appreciation suggest that a moderate appreciation of the yuan would have very little impact on the PRC's trade surplus.

JEL Classification: F31, F32

Contents

1. INTRODUCTION

The exchange rate regime of the People's Republic of China (PRC) has been the focal point of the global community, either in the context of global imbalances, or the bilateral trade deficit between PRC and the United States (US). With a US$370 billion current account surplus, the PRC's de facto peg to the dollar policy has attracted widespread international criticism, which argues that the inflexible exchange rate regime artificially suppresses the value of the yuan and unfairly enhances the competitiveness of PRC exports. The "undervalued yuan" has been perceived as a major factor widening the US trade deficit with the PRC and driving global imbalances.

A substantial revaluation of the yuan has been called for in order to fix the PRC-US trade imbalance. Letting the yuan appreciate against the dollar has been prescribed as an effective solution (e.g, Lim, Spence, and Hausman [2006]; Goldstein [2007]; Obstfeld [2006]; Krugman [2010]). The logic of the argument is straightforward. The yuan's revaluation would raise prices of PRC exports and also lower import prices of foreign goods and services. Following the presumed price changes, demand for PRC exports would decrease, but PRC consumers' demand for imports would increase. As a consequence, the PRC's trade surplus would shrink while the deficit of its counterparts, for instance the US, would decrease. Numerous empirical studies (e.g., Thorbecke and Smith [2010]; Garcia-Herrero and Koivu [2007]) estimated the PRC's export elasticity to real exchange rates and concluded that the yuan's appreciation would give rise to a significant decrease in the PRC's exports, thus reducing the PRC's trade surplus substantially.

As a matter of fact, the effectiveness of the yuan's revaluation on the PRC's trade balance largely depends on the extent the appreciation could be passed on to the import prices of the PRC's trading partners. If the PRC producers are unable to pass rising costs induced by the yuan's appreciation to foreign importers because of market competition, but are instead compelled to absorb most of the rising cost with profit margin adjustments and efficiency improvements, then the prices of PRC exports may change very little. In other words, the transmission mechanism of the yuan's revaluation on the trade balance depends on exchange rate pass-through effects. Without passing on the appreciation to prices of exports, the expected changes on import demand and the bilateral trade balance would not materialize and the yuan's appreciation might have very limited impact on PRC-US trade deficits as well as the global imbalance.

In addition, real exchange rates are a combination of nominal exchange rates and relative prices. The estimated export elasticity in the empirical literature basically uncovered how responsive PRC's exports are to price changes rather than to nominal exchange rate changes, unless relative prices are assumed constant. All arguments for the yuan's appreciation primarily emphasize changes of nominal exchange rates of the yuan and their impact on exports and assume a complete pass-through, which is actually not true. Pass-through effects represent the first step in the process of chain reactions from nominal exchange rate adjustments to eventual changes in exports and trade balance.

In July 2005, the People's Bank of China (PBC) switched its policy from the peg to the dollar to a basket of major currencies. The regime change opened the gate to the yuan's nominal appreciation. Since then, nominal exchange rates of the yuan against the dollar gradually dropped to 6.8 yuan per US dollar from 8.3 yuan per US dollar, implying about 21% cumulative appreciation. The substantial appreciation provides opportunities to examine the relation between the yuan's nominal exchange rates and price adjustments of PRC exports. Empirical exercises on the relation are necessary and imperative for assessing the effectiveness of the yuan's appreciation on the PRC-US trade imbalance as well as the PRC's current account surplus. Given the cumulative appreciation of more than 20%, important empirical questions are whether prices of the PRC's exports have been raised

correspondingly, and to what extent the appreciation has been passed on to prices of foreign imports.

There is a plethora of theoretical and empirical literature on exchange rate pass-through. Most of these studies focus on the experiences of industrialized countries such as the US, Japan, and Germany. Studies on the PRC, the second largest trading country, are scant. An exception is Jabara (2009), which estimated pass-through effects of the yuan's appreciation to import prices of the US from 2005 to 2008. This paper studied pass-through effects of the yuan's appreciation on import prices of the PRC's major trading partners the US and Japan. In the case of the US, pass-through effects were examined on general import prices of all commodities imported from PRC. In the case of Japan, not only was the pass-through on general import prices analyzed, but also the pass-through on prices of various commodity groups.

The peg to the dollar policy limits variations of the bilateral exchange rates between the dollar and the yuan. The relatively short period of the yuan's appreciation from July 2005 to July 2008 may not reveal full information on the pricing behaviors of PRC exporters coping with the yuan's appreciation. On the other hand, under the peg regime, the bilateral exchange rates between the Japanese yen and the yuan fluctuated in accord with exchange rate fluctuations between the yen and the dollar. Hence, in the case of Japan, we are able to study the issue over a relatively long time horizon, from 1998 to 2008. In addition, currency invoicing and market competitiveness affect degrees of pass-through (Gopinath, Itskhoki, and Rigobon [2009]; Golderg and Engel [2006]). By comparing pass-through effects between the US and Japan, one could understand to what extent pass-through effects of the yuan's appreciation was affected by currency invoicing and destination markets.

Based on the monthly data from 2004 to 2008, I found that in the short run, 23% of the yuan's appreciation against the dollar would be passed on to import prices of the US, compared with 47% in the long run. For the case of Japan, the empirical results suggest that, in the short run 55% of the yen/yuan exchange rate variations were passed on to Japanese import prices while close to 100%, a complete pass-through, occurred in the long run. The exceptionally high degrees of pass-through are also found in the disaggregated sectoral analysis. In food, raw materials, apparel, manufacturing, and machinery, a 1% nominal appreciation of the yuan to the yen led import prices in these categories to rise 0.38% to 0.62% in the short-run and an increase from 0.71% to 1.10% in the long run.

The high degree of pass-through into Japanese import prices, however, does not imply that PRC exporters have pricing power for their exports to Japan. Further analysis indicates that, the pass-through ability is basically ascribed to the PRC's peg to the dollar policy and the fact that the dollar is used as an invoicing currency for the PRC's exports to Japan. After controlling the currency invoicing factor, I found no significant evidence that the yuan's cumulative appreciation from July 2005 to July 2008 was passed on to Japanese import prices either in the short run or in the long run.

2. LITERATURE REVIEW

Exchange rate pass-through is defined as the percentage change in local currency import prices due to a 1% change in the exchange rate between exporting and importing countries. If import prices respond to exchange rate variation one for one, the pass-through is complete. Constant marginal costs and constant markups of prices over the cost are required conditions to warrant complete pass-through (Goldberg and Knetter [1997]). However, there is no empirical evidence to support a complete pass-through hypothesis. When import prices partially reflect changes in exchange rates, it is referred to in the literature as incomplete exchange rate pass-through.

Theoretical studies on exchange rate pass-through phenomena have been based on models of industrial organizations and emphasized market structures and firms pricing behaviors. Assuming that exchange rate shocks are exogenous, Dornbusch (1987) showed that, in a Cournot model the pass-through effect is larger the more competitive the industry and the larger the share of imports in total sales. Yang (1995) applied an adapted Dixit-Stiglitz model to address the role of product differentiations in pass-through behaviors. The analysis suggested that, exchange rate pass-through is higher in industries with a higher degree of product differentiation and a lower elasticity of marginal cost.

Froot and Klemperer (1989) linked the exchange rate pass-through with foreign firms market shares in a dynamic model. They examined pricing behaviors of export firms under temporary and permanent exchange shock scenarios. Export firms tend to transmit less exchange rates shocks to prices if they perceive that the exchange rate changes are temporary. On the other hand, permanent exchange rate variations will encourage export firms to lower their prices when the local currency appreciates in order to maintain their market shares.

There is a plethora of empirical research estimating pass-through effects, most of which focus on industrialized countries. Campa and Goldberg (2003) investigated the effect of exchange rate pass-through on the import prices of 23 Organisation of Economic Co-operation and Development (OECD) countries. They reported that the unweighted average of pass-through elasticities across OECD countries was approximately 46% over one quarter, and 64% over the longer-term. The US has the lowest pass-through rates in the OECD, at approximately 25% in the short run and 40% in the long run.

Strategic behaviors of export firms also play critical roles in determining degrees of exchange rate pass-through. To maintain price stability, export firms may absorb exchange rate shocks by adjusting their markups. Destination-specific adjustment of markups in response to exchange rate changes is a practice used by export firms which engage in price discrimination across export destinations. It is referred as "pricing-to-market" (PTM) in the literature. PTM works as the following: if exporters' currency appreciates against that of the importers, they reduce their markups of price over marginal cost so as to stabilize prices in the local currency of importers (Knetter 1993). Market competition and elastic demand compel exporters to discipline their price behaviors and limit their ability to pass on rising costs due to exchange rate fluctuations. Gagnon and Knetter (1991) found that Japanese auto exporters offset approximately 70% of the effect of exchange rate changes on buyers' prices through markup adjustment.

Besides the declining "pricing power," Taylor (2000) argued that, the decline in inflation in many countries contributed to low pass-through rates. A low inflation environment lessens the expected persistence of cost and price changes, resulting in low pass-through. By examining export prices denominated in exporters' currencies, Vigfusson, Sheets, and Ganon (2007) showed that prices of exports to the US are more responsive to exchange rate changes than that of exports to other markets, and country and region-specific factors affected degrees of pass-through.

3. THEORETICAL FRAMEWORK

Pass-through effects can only be achieved in a non-competitive market. In a perfectly competitive market, exporters face a perfectly elastic demand curve and have no pricing powers. It is impossible for exporters to transfer any part of rising costs due to home currency appreciations. Monopolistic powers associated with imperfect competition allow exporters to adjust prices following variations of exchange rates. Further, firms with pricing power earn a markup over marginal costs. The phenomenon of exchange rate pass-through is generally analyzed with standard markup models.

Assume that the marginal cost of PRC exporters is MC measured in yuan and with markup rate Δ, their export price in terms of terms can be defined as

$$P^{ex} = (1+\Delta)MC$$

Import prices of foreign buyers are a transformation of the export price with exchange rates. Let E be the nominal exchange rate, the yuan's unit value measured in foreign currencies, the import price in terms of foreign currencies can be expressed as

$$P^{im} = E(1+\Delta)MC \qquad (1)$$

Taking logarithm on both sides of equation (1) yields

$$\ln P^{im} = \ln E + \ln(1+\Delta) + \ln MC \qquad (2)$$

Let lower cases of the corresponding variables denote their values in logarithm, the above equation can be simplified as

$$p^{im} = e + \delta + mc \qquad (3)$$

Based on equation (3), a simple econometric model used for testing pass-through can be derived as

$$p_t^{im} = \alpha + \beta e_t + \gamma mc_t + \varepsilon_t \qquad (4).$$

The coefficient of e_t measures the responsiveness of import prices to exchange rate variations. If β is equal to one, pass-through is complete; if β is less than one, pass-through is incomplete.

For capturing gradual adjustment of import prices and controlling non-stationarity of all underlying variables, model (4) was transformed into first difference with lagged marginal costs and nominal exchange rates as

$$\Delta p_t^{im} = \alpha + \sum_{i=0}^{m} \beta_i \Delta e_{t-i} + \sum_{i=0}^{k} \gamma_i \Delta mc_{t-i} + \varepsilon_t \qquad (5).$$

In the above dynamic model, β_0 measures the short run elasticity of import prices to exchange rates, and the sum of the coefficients on the contemporaneous exchange rate and lags of exchange rates $\sum_{i=0}^{m} \beta_i$ indicates the long run elasticity. We first estimated equation (5) for both the US and Japan to examine pass-through effects of the yuan's appreciation.

The data used in estimations are collected from various sources. The US Bureau of Labor Statistics has compiled monthly price indexes of imports from the PRC from 2004. Nominal exchange rates of the yuan against the dollar and Japanese yen were retrieved from PACIFIC Exchange Rate Service. There is no direct measurement on marginal costs of PRC exporters. It was suggested to use unit labor cost as a proxy for marginal costs of PRC exports. However, the unit labor cost data were not available. Instead, monthly producer price indexes (PPI) of the PRC were used as a proxy of the marginal cost. In the macroeconomic literature (e.g., Monacelli [2005]), prices paid by importers are defined as marginal costs of the importers. In the empirical literature on pass-through effects, PPI or the consumer price index (CPI) are used as an acceptable proxy for marginal costs (e.g., Vigfusson, Sheets, and Gagnon [2007]; Gopinath, Itskhoki, and Rigobon [2008]). PPI data were downloaded from the CEIC data base. The Japanese Ministry of Finance compiles not only aggregated price indexes of all imports from the PRC, but also the price indexes of different commodity groups. In the case of Japan, the regression model was estimated for all

imports as well as imports in food, raw materials, apparel, manufacturing and machinery. Moreover, sectoral PPI were used for each corresponding sectors and the monthly time series data range from 1998 to 2008.

4. SOME STYLIZED FACTS AND EMPIRICAL RESULTS

The large appreciation of the yuan occurred after PBC switched from the peg to the dollar to a basket of major currencies in July 2005. Before the change, the yuan's nominal exchange rates against the dollar were virtually kept constant. The policy shift opened the door to the yuan's exchange rate variations following market forces. Figure 1 shows monthly yuan exchange rates against the dollar from 2004 to 2008, along with prices of the US imports from PRC. Both are measured in indexes with the first month of 2004 as the base month. Prior to July 2005, the exchange rates of the yuan to the dollar remained constant. Then, the yuan appreciated steadily until July 2008. The cumulative appreciation added up to 21%. During this period, the price of the US imports from PRC, however, initially decreased. The decline was reversed in May 2007, after that the import prices rose about 5% by the end of 2008. The pattern of the import price movements appears less responsive to the yuan's appreciation.

Figure 1: US Dollar/Yuan Exchange Rates and the Prices of US Imports from the PRC
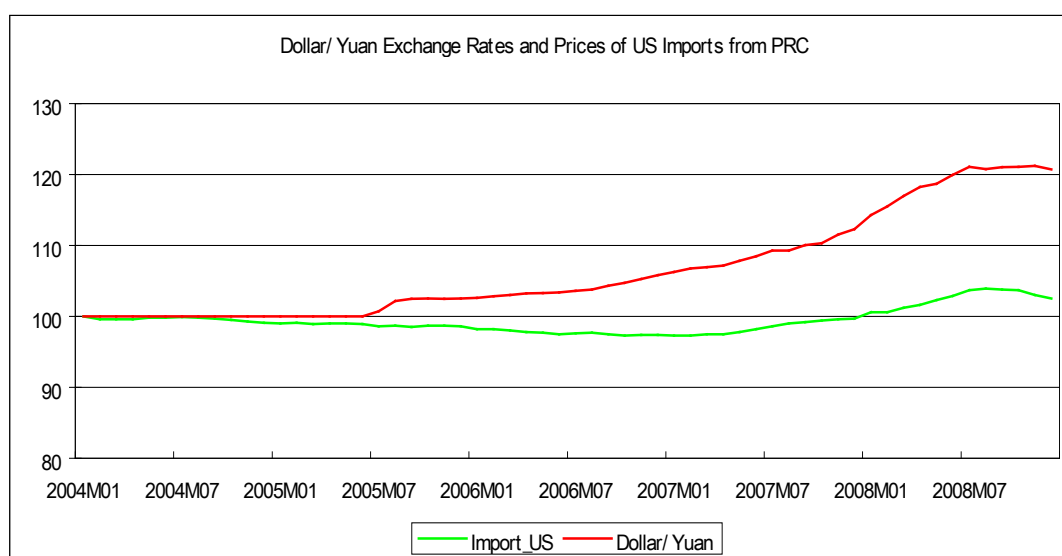

Sources: the US Labor Department database, Pacific Exchange Rate Services database, and the author's calculations.

Figure 2 illustrates movements of the bilateral exchange rates between the yuan and the yen and aggregated price indexes of all imports as well as prices indexes of manufacturing imports from the PRC. Swings of the bilateral exchange rates mainly reflect movements of the yen's exchange rate against the dollar before July 2005. The volatility of the exchange rates was very high. From August 1998 to December 1999, the yuan depreciated against the yen and the yen/yuan exchange rate fell to 12.4 from 15.6; then, the yuan started to appreciate against the yen and the yen/yuan exchange rate reached the level of 16.1 in February 2002. After that, the yuan trended downward again until January 2005, when the yen/yuan exchange rate was 12.5. A new appreciation cycle ended when the global financial crisis erupted in September 2008 and the PRC government reverted to the rigid peg to the dollar policy. Despite the high volatility, prices of Japanese imports seemed to track closely movements of the bilateral exchange rates between the yuan and yen. The correlation coefficients are surprisingly high, 0.56 between the aggregated import price and the exchange rate, and 0.71 between manufacturing import price and the exchange rate. The

high correlations suggest that, Japanese import prices had been adjusted to reflect the exchange rate variation.

Figure 2: JPY/CNY Exchange Rates and Prices of Japanese Imports from PRC
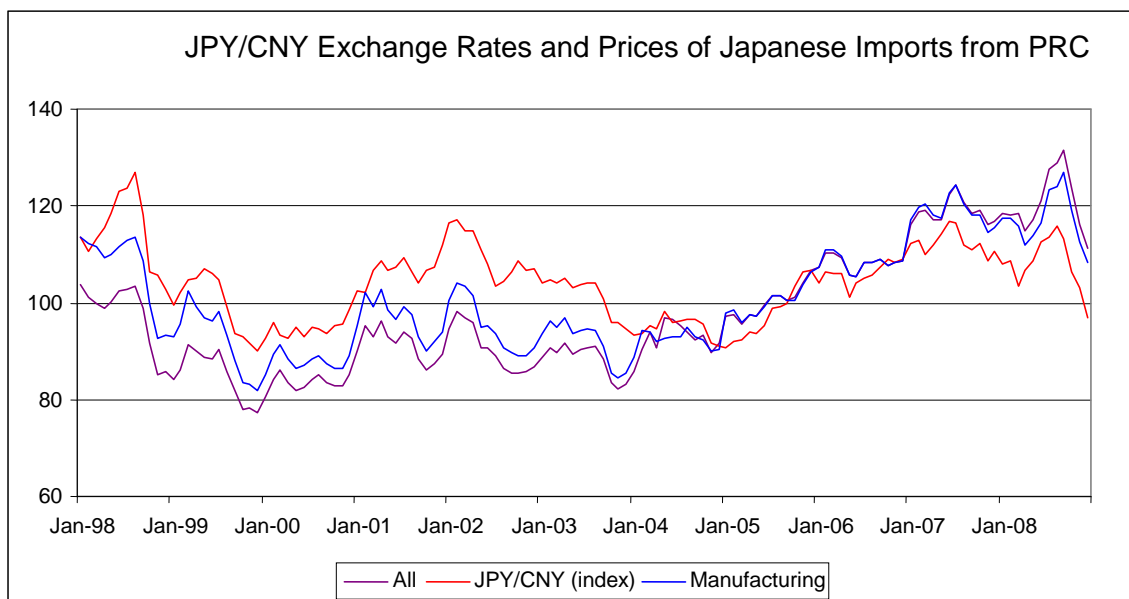
Sources: the Japanese Ministry of Finance, Pacific Exchange Rate Services, and the author's calculation.

In the estimations, nominal exchange rates between the dollar and the yuan were defined as dollar/yuan; nominal exchange rates between the yen and the yuan were defined as yen/yuan. Therefore, higher values of exchange rates mean that the yuan appreciates against the dollar or the yen. The estimated coefficients of exchange rates Δe_t and its lags are expected to be positive and significant should there exist any pass-through. The regression models with different lagged independent variables were estimated. I applied the Akaike information criterion (AIC) to determine optimal numbers of lags. I started with zero lags and then added lagged variables. Once the value of AIC started to rise, I stopped estimating new models with additional lagged variables. The ordinary least squares method was employed to estimate the regression model.

For the US case, the estimates with one- and two-period lagged variables of Δe_t and one period-lagged variable of Δmc_t were selected. Table 1 summarizes the estimates. The estimated coefficient of Δe_t is 0.23 and statistically significant at 1%, suggesting that, if the yuan appreciates by 1% against the dollar, import prices would be expected to rise 0.23%; the estimated coefficient of Δe_{t-1} is 0.02, but this is insignificant; the estimated coefficient of Δe_{t-2} is 0.24, implying that 24% of the appreciation would be passed on to import prices after two periods. The impact of production cost changes on import prices was very small. There is no price adjustment in the current period for production cost changes as the estimated coefficient of Δmc_t is 0.03 and insignificant. The adjustment occurred one period later, but was only 0.06% of price increase for a 1% increase in marginal cost as suggested by the estimated coefficient of Δmc_{t-1}, which is significant at 5%.

Table 1: Yuan's Appreciation and the Pass-through Effects on Prices of the US Imports from PRC

Independent Variable	$\Delta e_t^{\$/Yuan}$	$\Delta e_{t-1}^{\$/Yuan}$	$\Delta e_{t-2}^{\$/Yuan}$	Δmc_t	Δmc_{t-1}	Adj. R-squared	Sample Size
Estimated Coefficients	0.228*** (0.066)	0.024 (0.126)	0.244*** (0.082)	0.030 (0.023)	0.055** (0.054)	0.481	60

Notes:***, ** and * indicate statistics significance at 1%, 5% and 10% respectively. The numbers in parentheses are standard errors.

Source: The author's estimates.

In summary, the pass-through effect of the yuan's appreciation on prices of the US imports from PRC is about 23% in the short run and 47% in the long run. The low pass-through effect of the yuan's appreciation implies that moderate appreciation of the yuan would have very limited impact on the bilateral trade imbalance between the PRC and the US. Usually export demand elasticity is lower than one. The impact of the yuan's appreciation on PRC exports is determined by the joint impact of the pass-through and export demand elasticity. For example, if the export demand elasticity is 0.5, using the result of this research, we can conclude that a 10% nominal appreciation of the yuan against the dollar, would lead merely 1.15% decrease in PRC exports to the US in the short run, and 2.35% decrease in the long run; a 20% appreciation could only reduce the PRC's exports to the US by 4.7% in the long run, which is negligible compared with the more than US\$260 billion trade deficit the US had with PRC in 2008. The relatively small sample size does undermine the accuracy of the estimated pass-through effects. It is worthwhile to be cautious when one interprets the policy implication of the result.

In the case of Japan, the sample size is much larger compared with the US. We use the monthly data from 1998 to 2008, 11 years including 132 observations. In addition, the exercises were done for not only all imports as a whole but also for imports in five commodity categories. Compared with the case of the US, Japanese import prices were apparently more responsive to variations of the bilateral exchange rates between the yen and the yuan and degrees of pass-through are much higher. Table 2 reports the estimates for all Japanese imports as a whole and imports in food, raw materials, apparel, manufacturing, and machinery. The model with only one-period lag of Δe_t was employed for the estimations. As a reference, we also reported estimates with one-period lag of Δmc_t and two-period lag of Δe_t side by side in the table.

Table 2: Yen/Yuan Exchange Rates and the Pass-through Effects on Prices of Japanese Imports from PRC

Independent variables	All		Food		Raw Materials		Apparel		Manufacturing		Machinery	
$\Delta e_t^{yen/yuan}$	0.546*** (0.066)	0.554*** (0.066)	0.384*** (0.084)	0.383*** (0.085)	0.616*** (0.121)	0.631*** (0.126)	0.498*** (0.127)	0.508*** (0.120)	0.502*** (0.059)	0.510*** (0.060)	0.364*** (0.096)	0.400*** (0.100)
$\Delta e_{t-1}^{yen/yuan}$	0.440*** (0.077)	0.451*** (0.081)	0.449*** (0.085)	0.459*** (0.094)	0.264*** (0.107)	0.261*** (0.126)	0.573*** (0.123)	0.640*** (0.132)	0.491*** (0.081)	0.513*** (0.084)	0.346*** (0.107)	0.331** (0.117)
$\Delta e_{t-2}^{yen/yuan}$		-0.072 (0.072)		-0.023 (0.073)		0.005 (0.205)		-0.251* (0.142)		-0.097 (0.082)		-0.047 (0.095)
Δmc_t	0.417*** (0.149)	0.404** (0.147)	0.178** (0.073)	0.180** (0.075)	0.914** (0.408)	0.927** (0.419)	0.186** (0.076)	0.094 (0.106)	0.511*** (0.135)	0.517*** (0.130)	0.204 (0.209)	0.195 (0.225)
Δmc_{t-1}		-0.003 (0.157)		-0.052 (0.067)		-0.278 (0.512)		-0.161 (0.135)		-0.093 (0.145)		-0.283 (0.194)
Adj. R-squared	0.514	0.499	0.387	0.380	0.144	0.136	0.209	0.219	0.465	0.463	0.183	0.187
Sample size	130	129	130	129	130	129	130	129	130	129	130	129

Notes:***, ** and * indicate statistic significances at 1%, 5% and 10% respectively. The numbers in parentheses are standard errors.

Source: The author's estimates.

For all Japanese imports from the PRC, the estimated coefficient of Δe_t is 0.55 and statistically significant at 1% and that of Δe_{t-1} is 0.44, also significant at 1%. The estimates indicate that, for a 1% change in yen/yuan exchange rates, 0.54% would be expected to be transmitted into import prices in the current period and 0.44% in the second period. In other words, the pass-through effect of yen/yuan exchange rates on Japanese import prices is 55% in the short run and 99%, an almost complete pass-through in the long run. Moreover, changes in production costs also affected import prices significantly. The estimated coefficient of Δmc_t is 0.42 and significant at 1%, suggesting that 42% of marginal cost increase in PRC exports would be expected to be passed on to Japanese importers.

The substantially high pass-through in the short run and a near complete pass-through in the long run were also found in sectoral analysis. In manufacturing, the short run elasticity of import prices to yen/yuan exchange rates was 0.50 while the long run was 0.99; in food, 0.38 in the short run and 0.83 in the long run; in machinery, 0.36 in the short run and 0.71 in the long run; in apparel, 0.50 in the short run and 1.10 in the long; and in raw materials, 0.62 in the short run and 0.87 in the long run. All of these estimates are statistically significant at 1%. The empirical results imply a very high pass-through effect of the yuan's appreciation on prices of Japanese imports from the PRC. However, since the yuan has been pegged to the dollar, which is also used as a major invoicing currency, the role of the dollar should be an important factor in determining the pass-through effects. It is imperative to control the impact of the dollar and the currency invoicing factor when evaluating actual pass-through effects of the yuan's appreciation on prices of Japanese imports.

5. CURRENCY INVOICING AND PASS-THROUGH EFFECTS

The empirical analysis shows that pass-through effects between Japan and the US differ significantly. In the long run, it is less than 50% for import prices of the US, but close to 100% for that of Japan. The difference could be intuitively explained by currency invoicing practices. In trade, exporters can set prices in their own currencies, referred as producer currency pricing (PCP) in the literature, in currencies of destination markets—local currency pricing (LCP), or in vehicle currencies. Currency invoicing choices affect the degree of pass-through effects (Goldberg and Tille [2004]). Theoretically speaking, if exporters choose PCP, then exchange rate variations will be fully transmitted into import prices. On the other hand, with LCP, import prices will be independent of exchange rate movement at least in the short run (Engle [2006]).

The PRC yuan is not convertible and the use of the yuan as an invoicing currency to settle the PRC's trade is very limited. PRC's exports to the US are mainly priced in dollars, the local currency of the US importers. Therefore, LCP practice limited the ability of PRC exporter to pass the yuan's appreciations into import prices of the US. When exporting to Japan, PRC exporters also use the dollar rather than the yen as a major invoicing currency to settle the transactions, despite of the fact that the yen is a fully convertible international currency. For instance, in 2009 more than 78% of PRC's exports to Japan were invoiced in US dollars, while only 18% were settled in yen and 3.5% in other currencies including the Euro, Swiss franc, Canadian dollar, and the yuan, etc. (Figure 3).

Figure 3: The Distribution of Currency Invoicing: PRC's Exports to Japan in 2009

(in %)
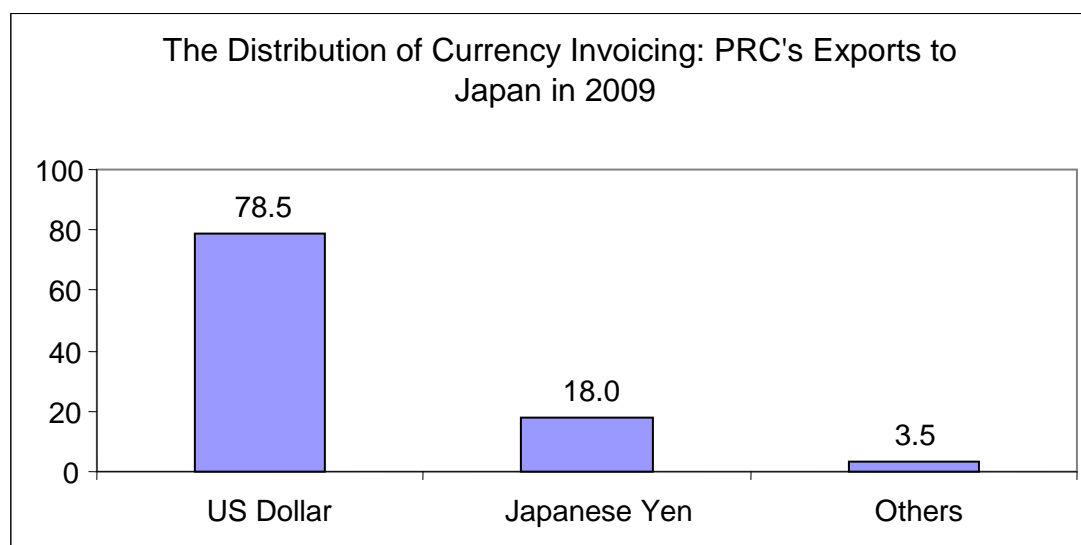
Source: PRC Customs.

Apparently, the dollar functions as a vehicle currency in the bilateral trade between the PRC and Japan. After a few devaluations, the PBC pegged the yuan to the dollar from 1995 until July 2005. When the yuan was pegged to the dollar, using the dollar as an invoicing currency was equivalent to using the yuan. The vehicle currency pricing in PRC's exports to Japan is actually equivalent to PCP. The high pass-through effects, 55% in the short run and 100%, a complete pass-through in the long run, are consistent with a theoretical argument based on PCP assumptions.

On the other hand, from July 2005 to July 2008, the PRC deviated from the rigid peg to the dollar policy by allowing the yuan to appreciate by about 21% against the dollar cumulatively. During this period, using the dollar as a vehicle currency would not be equivalent to using the yuan. Following the yuan's appreciation, if PRC exporters did not adjust their prices dollars when selling to Japanese importers, the estimated pass-through effect would be solely attributed to variations of nominal exchange rates between the yen and the dollar; if they raised their prices invoiced in dollars, part of the estimated pass-through effect should be attributed to the yuan's appreciation. An important question is to what extent the yuan's appreciation since July 2005 was passed on to prices of Japanese imports.

To evaluate the pass-through effects solely attributed to the yuan's appreciation since July 2005, I decomposed yen/yuan nominal exchange rates into two parts:

$$e_t^{Yen/Yuan} = e_t^{Yen/\$} + e_t^{\$/Yuan} \qquad (6)$$

Where $e_t^{Yen/Yuan}$ denotes nominal exchange rates between the yen and the yuan, $e_t^{Yen/\$}$ nominal exchange rates between the yen and the dollar, and $e_t^{\$/Yuan}$ nominal exchange rates between the dollar and the yuan. All three terms are in the logarithm of the corresponding variables. Substituting equation (6) into the regression equation (5) yields

$$\Delta p_t = \alpha + \sum_{i=0}^{m} \beta_i \Delta e_{t-i}^{Yen/\$} + \sum_{i=0}^{m} \lambda_i \Delta e_{t-i}^{\$/Yuan} + \sum_{i=0}^{k} \gamma_i \Delta mc_{t-i} + \varepsilon_t \qquad (7).$$

In the regression equation (6), coefficient β_i measures pass-through effects due to variations of yen/dollar exchange rates and coefficient λ_i indicates pass-through effects

imposed by the yuan's appreciation against the dollar. If λ_i is positive and statistically significant, it means that there exists pass-through.

Using the sample of 2005 to 2008, I estimated regression equations (6) for all Japanese imports from PRC as well as imports in food, apparel, raw materials, manufacturing, and machinery. The number of lagged independent variables was selected following previous estimations. Table 3 reports the estimated results. For all imports, the estimated coefficients of $\Delta e_t^{\$/yuan}$ is 0.75, but this is insignificant, suggesting that the yuan's appreciation was not passed on to the import price. On the other hand, the estimated coefficient of $\Delta e_t^{yen/\$}$ is 0.49 and significant at 1% and that of $\Delta e_{t-1}^{yen/\$}$ is 0.47 and significant at 1%, indicating that 49% of yen/dollar exchange rate variations were passed into the import price in the short run and 96% in the long run, close to a complete pass-through. The empirical results imply that the yuan's appreciation against the dollar from July 2005 to 2008 did not affect the general prices of Japanese imports from the PRC. The estimated pass-through effect during this period was solely due to the fluctuation of yen/dollar exchange rates. Using the dollar as an invoicing currency gives rise to the complete pass-through.

Comparing the coefficients of $\Delta e_t^{yen/\$}$ and $\Delta e_{t-1}^{yen/\$}$ with that of Δe_t and Δe_{t-1} reported in Table 2, which were estimated with yen/yuan exchange rates from 1998 to 2008, I found that they are very close, further suggesting that currency invoicing is the reason leading to 100% pass-through effects on prices of Japanese imports from the PRC. The estimates on the five commodity groups also show that the yuan's appreciation contributed little to changes of Japanese import prices. The estimated coefficients of $\Delta e_t^{\$/yuan}$ are -0.217 in the food sector, 5.326 in raw materials, 1.825 in apparel, 0.671 in manufacturing, and -0.187 in machinery. All of them are statistically insignificant.

On the other hand, the estimated coefficients of $\Delta e_t^{yen/\$}$ are 0.474 in manufacturing and 0.519 in machinery, both are statistically significant at 1%; the estimated coefficients of $\Delta e_{t-1}^{yen/\$}$ are 0.474 in manufacturing and 0.441 in machinery and are statistically significant at 1%. These sectoral estimates show that, with the decomposition, pass-through effects of the yen/dollar exchange rates remained very high, close to 50% in the short run and 100% in the long run, very similar to the estimates when only yen/yuan exchange rates were included. In the food sector, the pass-through effect of yen/dollar into prices of Japanese imports was relatively weaker than before, about 27% in the short run, but still reached 70% in the long run.

Table 3: Yuan's Appreciation and the Pass-through Effects on Prices of Japanese Imports from the PRC

Independent Variable	All	Food	Raw Materials	Apparel	Manufacturing	Machine
$\Delta e_t^{yen/\$}$	0.488*** (0.010)	0.267* (0.147)	0.525* (0.280)	0.200 (0.256)	0.474*** (0.101)	0.519*** (0.159)
$\Delta e_{t-1}^{yen/\$}$	(0.467)*** (0.103)	0.435*** (0.117)		0.498** (0.161)	0.474*** (0.111)	0.441*** (0.156)
$\Delta e_t^{\$/yuan}$	0.747 (0.488)	-0.217 (0.440)	5.326 (3.506)	1.825 (1.165)	0.671 (0.608)	-0.187 (0.967)
Δmc_t	0.411** (0.180)	-0.077 (0.064)	1.735** (0.782)	0.221 (0.150)	0.303* (0.171)	0.223 (0.339)
Adj. R-squared	0.594	0.376	0.152	0.121	0.519	0.312
Sample size	46	46	47	46	46	47

Notes: :***, ** and * indicate statistic significances at 1%, 5% and 10% respectively. The numbers in parentheses are standard errors.

Source: the Author's estimates.

6. CONCLUDING REMARKS

The yuan cumulatively appreciated against the dollar about 20% since July 2005. The yuan's further appreciation is expected to be an effective solution for reducing bilateral trade imbalances between the PRC and the US. To what extent the yuan's appreciation would be able to lower the PRC's huge trade surplus depends on the pass-through effects of the yuan's appreciation. With the available information, this paper conducted a comprehensive empirical analysis on pass-through effects of the yuan's appreciation on prices of the US and Japanese imports from PRC. In the case of Japan, not only was pass-through estimated for all imports from PRC, but also for five major commodity groups food, raw materials, apparel, manufacturing, and machinery. Empirical results indicate that the pass-through effects of the yuan's appreciations on prices of US imports and that of Japan differ substantially. While pass-through effects on US import prices are relatively weak, about 23% in the short run and less than 47% in the long run, I did not find any evidence that the yuan's appreciation from July 2005 to 2008 was passed into prices of Japanese import from the PRC.

The initial empirical analysis shows that, Japanese import prices were relatively more responsive to changes of the bilateral exchange rates between the yuan and the yen. For a 1% nominal appreciation of the yuan against the yen, Japanese import prices would be expected to rise 0.55% in the short run and 0.99%, a complete pass-through, in the long run. The high degree of pass-through effects were also found at the disaggregated sectoral level: food, raw materials, apparel, manufacturing, and machinery. However, the near complete pass-through effects were not due to the appreciation of the yuan, but due to the PRC's peg to the dollar policy and the fact that the dollar has been used as a dominant invoicing currency for PRC exports to Japan.

After controlling the currency invoicing factor, I found no evidence that the yuan's cumulative appreciation since July 2005 was passed on to prices of Japanese imports at both the aggregate and disaggregated levels. In other words, PRC exporters were not able to transmit the rising cost associated with the yuan's appreciation to Japanese importers. My empirical findings have very important policy implications for current debates on whether the yuan's further appreciation would be effective in mitigating the US trade deficit with the PRC and reducing the PRC's overall trade surplus. The low pass-through on the US import prices and the insignificant contribution of the yuan's appreciation on the complete pass-through phenomenon on Japanese import prices suggest that a moderate appreciation of the yuan would have very limited impact on PRC exports and would not bring substantial changes to the PRC's trade surplus with either the US or the rest of the world. In addition, the experience of Japan since the Plaza Accord shows that productivity growth plays a critical role in maintaining price stability and reducing pass-through effects. The PRC's labor productivity expanded five times from 1987 to 2007 (APO [2010]). The impressive high productivity growth partially explained why little pass-through was found after the yuan's 20% appreciation.

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