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Forward-Looking Exporters and Exchange Rate Pass-Through: A Micro-Level Investigation*

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Abstract

This paper shows that the pricing behavior of exporting firms exhibits a "forward-looking" nature in the presence of sticky prices. It offers a channel by which the expectations of future exchange rates affect current prices at both the product and firm level. To seek the micro-level evidence, we first adopt detailed product-level import data of the United States combined with forward exchange rates to study the exchange rate pass-through into import prices. We find that not only current (and past) exchange rate fluctuations but also anticipated future exchange rate changes effectively pass through into import prices at product level. Moreover, we use disaggregated firm-product-level data on China's exports to the United States and verify that firms significantly adjust prices in response to expected future exchange rate movements. These findings reveal a previously overlooked micro-level pass-through effect of future exchange rates, and suggest a potentially important factor in help explaining incomplete exchange rate pass-through.

JEL: F31, F14, F4

Keywords: Forward-looking; Price adjustment; Exchange rate pass-through; Sticky price

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1 Introduction

Price responses to exchange rate movements are one of the central topics in international macroeconomics (see the comprehensive literature review by Burstein and Gopinath (2014)). Previous studies have documented the well-known phenomenon of incomplete exchange rate pass-through into import prices.[1] Consequently, many studies have endeavored to provide potential explanations for the low exchange rate pass-through coefficients. Various macroeconomic variables, including the stability of monetary policy, exchange rate volatility and currency choice, have been found to affect the aggregate price response to exchange rate changes.[2] In particular, at aggregate level sticky prices play a central role in lowering the responsiveness of prices to exchange rates (e.g., Engel, 2003). Devereux and Yetman (2010) also argue that the existence of sticky prices represents a key determinant of exchange rate pass-through. Yet, the micro-level evidence for those macroeconomic determinants of exchange rate pass-through remains understudied, though the recent development of the literature has witnessed emerging studies that examine firm-level responses to *current* exchange rate fluctuations (e.g., Berman, Martin and Mayer, 2012; Amiti, Itskhoki and Konings, 2014). This paper fills a gap in the literature by exploring firms' forward-looking behavior in the presence of sticky prices to provide micro-level evidence that shows how firms adjust prices in response to not only *current* but also future *expected* exchange rate movements.

The paper first uses a simple framework with price rigidity to explore the firm's pricing behavior in response to expectations of future exchange rate movements. In this parsimonious model, we show that exporting firms (sellers) take anticipated future exchange rate changes into consideration when they cannot adjust prices frequently under price rigidity. Thus, at the micro-level, an individual firm's pricing decision responds to expected future exchange rate

[1] For example, Campa and Goldberg (2005), Goldberg and Campa (2010), and Parsons and Sato (2006) find a partial pass-through of exchange rates into import prices when considering cross-country and cross-product perspectives.

[2] For example, see Devereux, Engel and Storgaard (2004) for the importance of the stability of monetary policy, Campa and Goldberg (2005) for exchange rate volatility, and Choudhri and Hakura (2015) for the choice of invoicing currency.

fluctuations. Consequently, from the perspective of importing countries, the observed prices of imported products reflect both current (and past) and future exchange rate fluctuations. This provides the channel by which expected future exchange rate fluctuations "pass-through" into current prices at the product level.

Empirically the paper confirms the testable predictions of our simple yet intuitive model that prices positively respond to future expected exchange rate fluctuations, at both the product level and the firm level. In the main tests we use US imports from China (at the HS-10 product-level) and China's exports to the United States (at the firm-product-level) to estimate exchange rate pass-through, from both import and export perspectives. We use various forward exchange rates between US dollars (USD) and Chinese Yuan (Renminbi, in short, RMB) as proxies for the market's expectation of future exchange rate movements and compute annualized forward premiums. In our context, the forward premium is a well-performed indicator for the future exchange rate movements, and forward exchange rates are also highly correlated to professional forecast of exchange rates (see data description in Section 4 for more details).

We restrict our main tests using trade data between the United States and China because the reform of China's exchange rate provides an ideal setting to test the role of forward expectations of exchange rates in determining prices.[3] First, the exchange rate reform was preceded by widespread expectation of future appreciation of RMB, and the anticipation was subsequently supported by the realized appreciation. This distinguishes China from many cases in which floating exchange rates are characterized by random walk expectations, given the fact that China had clear and substantial movements in her forward premiums based on fundamentals over time. Unlike most non-credible fixed exchange rate regimes, the market's expectations of RMB appreciation were not driven by other crisis or uncertainties. Second, since China had implemented capital control during the sample period, the link between forward premiums and interest rate differentials is broken down. Thus, the forward premium change had little correla-

[3]our sample period covers an important reform in which China's exchange rate regime switched from a fixed regime (pegged to the USD) to a managed floating one. Within the sample period, nominal spot exchange rates were initially fixed but market expectations of exchange rates began fluctuating even before the change in regime.

tion with domestic financial conditions relative to its impact on traded goods competitiveness that alleviates the concern resulting from interest rate movement.

We find that at detailed product level not only current (and past) exchange rate fluctuations but also anticipated future exchange rate changes effectively pass through into import prices. The price response to expected future exchange rate changes accounts for approximately over one-third of the total "pass-through" coefficient. In other words, using only past and current exchange rates to compute the pass-through elasticity, a typical practice in the literature, would overlook a significant proportion of the price responses to exchange rate fluctuations. In this sense, when accounting for price responses to future exchange rate fluctuations, we find larger pass-through coefficients on import prices, which serves as an explanation for incomplete exchange rate pass-through into import prices. From exporters' perspective, our finding is supported by firm(-product)-level data when using exports of China to the United States: exporting firms indeed adjust their prices in response to expected future exchange rate movements.

We also conduct some further tests to address heterogeneity across product, country, and trade regimes. First, we distinguish exchange rate pass-through by product heterogeneity using the Rauch's product classification (Rauch, 1999) and find that future exchange rate changes influence current prices more significantly for heterogeneous than for homogeneous products. Second, we extend the product-level analysis to US imports from other major trading parters of the United States. We find that Germany, France, South Korea and Japan exhibit significantly positive pass-through of forward exchange rates, and the coefficients are particularly high in South Korea and Japan. In contrast, forward exchange rates have little effect on import prices for US imports from Australia, Canada and the United Kingdom. We discuss several potential explanations for the heterogeneity across countries, including the choice of invoicing currency, exchange rate regimes, and existence of free trade agreements. Lastly, we use firms operating under different trade regimes, including both ordinary trade and processing trade, to check the robustness of our results. For both types of trade regimes, future exchange rate changes can

effectively pass through into current prices.

This paper relates to several branches of the literature. First, it is related to a large body of literature seeking various explanations for the incomplete exchange rate pass-through elasticity.[4] These studies explore the disconnect between exchange rates and prices from either the macro (aggregate level) or micro perspective (disaggregate level). Among these studies, our paper is closely related to those exploring the role of price rigidity (Choudhri and Hakura (2015), Devereux, Engel and Storgaard (2004)) and frequency of price adjustment (Gopinath and Itskhoki (2010)) in determining the "incomplete" pass-through coefficients. But none of these discussed forward-looking behavior from firms' perspective.

Within this literature, our paper is in line with the emerging studies that explore micro-level evidence to study firms' responses to exchange rate movements (Amiti, Itskhoki and Konings, 2014; Berman, Martin and Mayer, 2012).[5] Our paper contributes to this literature in twofold: (i) at the product level, this paper verifies that expectations of future exchange rate movements would pass through into the current prices of imported goods; (ii) at a more micro level using firm-product export data, this paper confirms that exporting firms' pricing behavior indeed responds to future exchange rate fluctuations. To sum up, our paper reveals a previously overlooked micro-level pass-through effect of future exchange rates, and suggests a potentially important factor in help explaining incomplete exchange rate pass-through.

Second, this paper is inspired by the theoretical framework on sticky prices in international macroeconomics, e.g., Fuhrer and Moore (1995*a*), Fuhrer and Moore (1995*b*), Fuhrer (1997), Chari, Kehoe and McGrattan (2000) and Calvo (1983). Our model builds upon the sticky price models (Chari, Kehoe and McGrattan, 2000; Calvo, 1983, among others) that show the "backward and forward looking" effects of macroeconomic shocks (such as money supply shocks)

[4]For example, see Amiti, Itskhoki and Konings (2014), Choudhri and Hakura (2015), Gust, Leduc and Vigfusson (2010), Daniels and VanHoose (2013), Wang (2007), Strasser (2013), Gopinath, Itskhoki and Rigobon (2010), Devereux, Engel and Storgaard (2004), and Gopinath and Itskhoki (2010).

[5]Berman, Martin and Mayer (2012) links exchange rate fluctuations to firm characteristics such as productivity and shows that firms may vary mark-ups in response to exchange rate shocks. Moreover, firms with higher import intensity and larger market shares exhibit greater incomplete pass-through (see Amiti, Itskhoki and Konings, 2014).

on firms' pricing behavior. Our paper links the "forward-looking" nature of exporting firms to exchange rate fluctuations with micro-level empirical evidence.

Lastly, this paper is related to the literature exploring the relationship between exchange rate movements or volatility and trade flows using disaggregated customs data.[6] Our paper differs from those studies by introducing expectations of future exchange rate movements.

The remainder of the paper is organized as follows. Section 2 presents a simple model that incorporates forward-looking behavior into firms' pricing decisions. Section 3 introduces the context of China's exchange rate reform and Section 4 describes the data and measurement issues. Section 5 presents the econometric specifications. Sections 6 and 7 report empirical results from the perspectives of product-level imports of the United States and of firm-product-level exports of China, respectively. The last section concludes.

2 Exporter's Pricing Decision

We use a simple model in line with Chari, Kehoe and McGrattan (2000) and Calvo (1983) to describe an incumbent exporting firm's pricing decision under price rigidity. By assumption, $1-\beta$ proportion of firms can adjust prices in every period. In other words, the sticky price parameter is β; if there is no price rigidity, we have $\beta = 0$. We also assume that exporting firms use local currency pricing (e.g., Chinese exporters use the US dollar to denote their selling prices).[7] e_t is the current exchange rate of the domestic currency with a foreign currency, and thus, an increase in e_t denotes domestic currency appreciation.

Firms engage in monopolistic competition within a sector. The foreign demand equation follows $Q_i = op_i^{-\rho}P_t^{\rho-\eta}$, where p_i is the price charged by a representative firm i, P_t denotes the aggregate price level at time t, ρ and η ($\rho > \eta > 1$) represent the elasticities of substitution of varieties within the sector and across sectors, respectively, and o is a constant.

[6] For example, see Berman, Martin and Mayer (2012), Li et al. (2012), Tang and Zhang (2012), Grier and Smallwood (2013), Viaene and de Vries (1992), Cushman (1988) and Wong, Ho and Dollery (2012).

[7] The assumption of local-currency pricing is reasonable because, in reality, the majority of Chinese exporters use USD to price products when exporting to the United States market.

The optimal price $\bar{p}_t$, chosen by firm i in period t to maximize profits, is denominated in the currency of the buyer (i.e., the destination country's currency) and solves the following optimization problem:

$$\max_{\bar{p}_t} E_t\{\sum_{j=0}^{n} \beta^j e_{t+j}^{-1}(\bar{p}_t - c_{t+j}) \left[o\bar{p}_t{}^{-\rho} P_{t+j}^{\rho-\eta}\right]\} \tag{1}$$

where c_{t+j} is the unit cost of production (also denominated in the destination country's currency) and j is the forward horizon (from 0 to a limited period n). Solving this optimization problem yields:

$$\bar{p}_t = \frac{\rho}{\rho - 1} E_t \frac{\sum_{j=0}^{n} \beta^j e_{t+j}^{-1} c_{t+j} P_{t+j}^{\rho-\eta}}{\sum_{j=0}^{n} \beta^j e_{t+j}^{-1} P_{t+j}^{\rho-\eta}} \tag{2}$$

With the presence of sticky prices ($\beta > 0$), the optimal price set by firm i is a function of not only cost c_t and current exchange rate e_t but also expected future cost $E_t c_{t+j}$ and expected future bilateral exchange rate $E_t e_{t+j}$. If there is no price rigidity ($\beta = 0$), the optimal price equals $\frac{\rho}{\rho-1} c_t$, which is the typical case of constant mark-up under monopolistic competition.

After log-linearizing the optimal price $\bar{p}_t$ around its steady state, we find that export price fluctuation $\tilde{p}_t$ (hereafter, $\tilde{x}$ denotes the change in x) depends on fluctuations of both current and future production costs, $\sum_{j=0}^{n} E_t \tilde{c}_{t+j}$, where $\tilde{c}_{t+j}$ is also denominated in the foreign currency:

$$\tilde{p}_t = (1 - \beta) \sum_{j=0}^{n} E_t \beta^j \tilde{c}_{t+j} \tag{3}$$

In this sense, price fluctuation depends on the production cost denominated in the destination country's currency. In a simple case in which a firm uses only domestic intermediate inputs, the production cost in terms of the foreign currency follows $c_t = e_t P_t v_d$, where v_d is an input bundle, P_t is the domestic aggregate price level. Thus, the cost fluctuation function follows $\tilde{c}_t = \tilde{P}_t + \tilde{v}_d + \tilde{e}_t$. Then, the fluctuation in the exporter's price denominated in the foreign currency generally follows $\tilde{p}_t = (1 - \beta) \sum_{j=0}^{n} E_t \beta^j (\tilde{P}_{t+j} + \tilde{v}_d + \tilde{e}_{t+j})$. When we suppress the

changes in intermediate input costs $\tilde{v}_d$ and in the domestic aggregate price level $\tilde{P}_{t+j}$,[8] then export price fluctuations depend on current and anticipated future exchange rate fluctuations, as follows:

$$\tilde{p}_t = (1-\beta)\sum_{j=0}^{n} E_t \beta^j \tilde{e}_{t+j}. \tag{4}$$

Proposition 1. *In the presence of sticky prices, firms adjust current export prices according to both current exchange rate fluctuations $\tilde{e}_t$ and expectations of future exchange rate fluctuations $E_t\tilde{e}_{t+j}$.*

At the aggregate level, only a proportion of firms $(1-\beta)$ adjust prices, while the other proportion of firms (β) remains at the previous price level. Assuming that firms are producing and exporting a certain product h, the aggregate price level of the exported product h, P_t^h, follows $P_t^h = (1-\beta)\bar{p}_t + \beta P_{t-1}^h$. Then, the aggregate price fluctuations follow $\tilde{P}_t^h = (1-\beta)\tilde{\bar{p}}_t + \beta\tilde{P}_{t-1}^h$. Iterating it over time yields

$$\tilde{P}_t^h = (1-\beta)^2 \sum_{i=0}^{n} \beta^i \sum_{j=0}^{n} \beta^j E_t \tilde{e}_{t+j-i} \tag{5}$$

Proposition 2. *Price fluctuations at the aggregate level (product level) reflect past, current and expected future exchange rate changes, i.e., $\tilde{e}_{t-j}$, $\tilde{e}_t$ and $E_t\tilde{e}_{t+j}$.*

3 Exchange Rate Reform in China

Our main tests are based on bilateral trade between China and the US during the period from 2000 to 2008. The sample period features a change in the Chinese exchange rate regime. In July 2005, China officially announced and adopted a managed floating exchange rate regime to replace the previous peg to the US dollar. As a result, the spot rate between the USD and RMB has appreciated since July 2005. However, examining global forward markets reveals

[8] Since our focus here is the impact of exchange rate fluctuations, we suppress $\tilde{P}_t$ for simplicity but will incorporate the change in domestic inflation rates into regressions in later empirical analysis to capture the effect of $\tilde{P}_t$ due to inflation.

that the forward exchange rates moved substantially before the announcement of the reform in July 2005. As early as 2003, the one-year forward and six-month forward RMB/USD exchange rates had begun to appreciate. This shows that the market had anticipated the long-run future appreciation of the RMB. Since 2003, there had been widespread debate and discussions on the necessity and feasibility of exchange rate reform, and the Chinese government faced increasing pressure to raise the value of the RMB.

Figure 1 displays the pattern of the RMB/USD nominal exchange rate. Note that the nominal exchange rate (the first graph) was flat before July 2005 and appreciated gradually thereafter. However, the forward exchange rates for the RMB (including the three-, six-, nine- and twelve-month forward) appreciated as early as late 2003, especially for the nine-month and twelve-month forward exchange rates. This represents a substantial increase in the expected value of the RMB during the period of exchange rate reform.

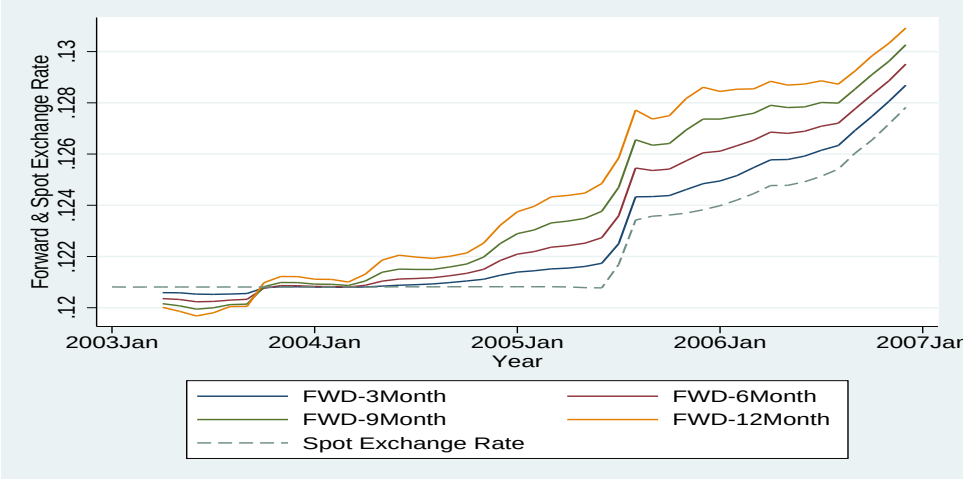

Figure 1: Forward & Spot Exchange Rate Fluctuations Between RMB and USD

The reform of China's exchange rate represents a unique setting to explore firms' pricing behavior under the expectation of future exchange rate fluctuations. In general, because China had implemented capital control during this period, the link between forward premiums and interest rate differentials is broken down. Thus, the forward premiums on exchange rates had little correlation with domestic financial conditions.[9] Due to trend in China's growth, the

[9] Ma and McCauley (2008) provided evidence that China had effective capital control over the sample period,

announcement of the exchange rate reform was preceded by widespread anticipation of future currency reform and the appreciation of the RMB. Therefore, unlike many cases in which floating exchange rates are characterized by random walk expectations, China had clear and substantial, albeit time-varying, movements in its forward premiums based on fundamentals. The expectation of RMB appreciation were subsequently supported by the realized appreciation in the latter half of the decade. Unlike most non-credible fixed exchange rate regimes, China's forward premiums during this period were not driven by the probability of a currency or other type of crisis.

By restricting our data to bilateral trade between the United States and China in the main tests, we can better avoid the invoicing currency issue because the majority of trade transactions between the United States and China use the USD as the invoicing currency.[10] When the USD is used as the invoicing currency, fluctuations in the exporting country's domestic currency (RMB) directly affect exporters' revenue, and thus, exporting firms will have an incentive to adjust export prices. In the later cross-country analysis, we extend our pass-through tests to other major trading partner countries of the United States. The results indicate that expected future exchange rate pass-through varies across countries.

4 Data and Measurement

We compile three sources of data to conduct our empirical analysis, including exchange rate data, product-level import data of the United States, and firm-product-level export data of China. We describe each as follows.

First, the data on exchange rates include both spot exchange rates and forward exchange rates which are obtained from Bloomberg. Forward exchange rates are non-deliverable forward

and Mehl and Cappiello (2009) proved that uncovered interest rate parity condition does not hold between US dollar and other currencies in emerging market economies.

[10] In previous literature, the choice of an invoicing currency is considered to influence pass-through elasticity, e.g., Gopinath, Itskhoki and Rigobon (2010), Parsons and Sato (2006),Goldberg and Tille (2009) and Choudhri and Hakura (2015).

(NDF) rates between USD and RMB in the foreign exchange market as proxy for expected future exchange rates. Forward rates in our tests cover three-, six-, and twelve-month forwards and indicate the trend in market expectations of exchange rate fluctuations.

One might concern whether forward rates adopted in this paper serve as valid measurements for the expected future exchange rates (Fama, 1984). But our data shows that between RMB and USD the forward exchange rate FWD_t is a strong predictor of future spot exchange rate S_{t+1} (for example, see Figure 1 for strong co-movements between the two). The correlation between forward rates FWD_t and future spot rates S_{t+1} ranges from 0.88 to 0.98. The high correlation suggests that the forward exchange rate here is a valid measurement for the realized future spot exchange rate. Also, the forward premium ($\Delta fwd_t \equiv logFWD_t - logS_t$) between RMB and USD is positively correlated with realized future exchange rate movement ($\Delta exr_{t+1} \equiv logS_{t+1} - logS_t$), indicating that the forward premium is a well-performed indicator for the future realized exchange rate movements.[11]

It might be interesting to find alternative proxies for expected future exchange rates, for example, some professional forecast data of exchange rates. We thus collect the quarterly FXFC Foreign Exchange Forecast Index released by Bloomberg, which is based on the survey of forecast of foreign exchange rates from 26 individual forecast providers. Bloomberg reports a very high correlation (above 0.94) between forward exchange rates and the FXFC Index of USD-RMB. This suggests that the forward rates are indeed an accurate proxy for expected future exchange rates.[12]

In later analysis, we extend our study to other trading partner countries of the United States (e.g., the United Kingdom, Japan, South Korea, Australia, Canada, Germany and France). We also use bilateral current and forward exchange rates between USD and US trading partners' currencies, including GBP, JPY, KRW, AUD, CAD, and EUR.

[11] The slope coefficient of the regression as in Froot and Frankel (1989) where we regress Δfwd_t on Δexr_{t+1} is significantly positive and as high as 0.84 for six-month forward rates. This suggests that it is safe to avoid the concern of forward premium puzzle based on our data.

[12] As the FXFC Index is only available after June 2006 while our test is for 2000-2008 at yearly basis, we cannot use it as alternative measure of expected future exchange rates in our robustness check.

The second data source for examining the exchange rate pass-through into product prices is the product-level import data provided by the US Census Bureau.[13] This database documents imported products of the United States at detailed HS-10 digit level on a yearly basis. This sample includes import information, such as import value (excluding tariff and other charges), quantity, and origin country, and spans from 2000 to 2008. Then we calculate unit value import prices at HS-10 product level. As the HS-10 is a highly detailed product categorization scheme, the unit value is an accurate proxy for price in our estimations.

Lastly, the Chinese customs data (2000-2008) on firm-product-level exports to the United States are used to test exporting firms' pricing behavior under exchange rate fluctuations. The Chinese customs data is a transaction-level database that contains monthly records on each firm's export value, quantity, product category (HS-8), destination country and trade regimes (processing trade or ordinary trade). It is the most comprehensive high-frequency trade database in China that captures the universe of all export transactions through Chinese Customs.[14] Because we can observe changes in the export value and quantity of all products exported by each firm, we are able to compute firm-product unit value export prices to investigate price responses to exchange rate movements.

5 Estimation of Exchange Rate Pass-Through Elasticity

Since the model has predictions at both product level (see Proposition 2) and firm level (see Proposition 1), we will use data to test the price responses to current and future exchange rate movements. In this section, we introduce our estimation approach of exchange rate pass-through elasticity.

Following the conventional practice in the exchange rate pass-through literature, the change

[13]The data are downloaded from the Trade Data and Concordances at Schott's International Economics Resource Page, available at http://faculty.som.yale.edu/peterschott/sub_international.htm. Please see Schott (2008) for detailed data descriptions.

[14]This dataset has been used in many previous studies, especially those that focus on firm-level analysis of exports/imports, e.g., Khandelwal, Schott and Wei (2013) , Fan, Li and Yeaple (forthcoming) Lu, Tao and Zhang (2013), Li et al. (2012).

in the logarithm of prices is calculated as the dependent variable, and the change in the logarithm of spot exchange rates is the main explanatory variable. Beyond that, we add future exchange rate changes as another important explanatory variable. For example, in the product-level analysis, we regress the US import price on exchange rate changes, including both current and anticipated future exchange rates (see equation (8) in Section 6.1). The aim of this analysis is to measure the pass-through of expected future exchange rate fluctuations into import prices at the product level. According to our model predictions, positive coefficients for both current and forward exchange rates are expected. In further tests, we check the pass-through elasticity of expected future exchange rates into import prices for homogeneous and heterogeneous products to capture the importance of product homogeneity. We also conduct the product-level analysis for US imports from other trading partners (based on major currencies) to examine the heterogeneity in the pass-through coefficients of expected future exchange rates across countries.

We next investigate the export price response to exchange rate changes, especially to anticipated future exchange rate movements, from each individual exporting firm's perspective. This exercise aims to seek a micro-foundation for the pass-through effect observed in the product-level analysis. In this exercise, we define disaggregated (firm-product) prices in two aspects: one is the export price charged by an exporting firm for each specific product, and the other is a constructed firm-level price index.

Now we use a simplified econometric model (with a representative product) to illustrate our estimation approach. Note that the product index will be suppressed in this section for simplicity. In the typical practice of the literature, the pass-through elasticity can be obtained from the following estimation:

$$\Delta p_t = \beta \Delta exr_t + \eta_t \tag{6}$$

where $\Delta p_t \equiv p_t - p_{t-1}$ is log price changes, Δexr_t is the realized exchange rate changes at time t, and η_t is error term. This is the simplified version of pass-through estimation, and more control variables can be added when necessary. Now, by incorporating the price response to

the expected future exchange rate into the pass-through estimation, our approach follows

$$\Delta p_t = \beta_1 \Delta exr_t + \beta_2 \Delta fwd_t + \mu_t \tag{7}$$

where forward premium Δfwd_t is included as explanatory variable, and μ_t is error term. We do not add other lagged terms to capture the past exchange rate fluctuations because one-year difference already incorporates price adjustments to both past and current exchange rate changes when using yearly data.[15]

According to Proposition 2 of our model, we expect to see $\beta_1 > 0$ and $\beta_2 > 0$ because price changes at aggregate product level always reflect both current and expected future exchange rate changes. This suggests that not only current (and past exchange rates) but also expected future exchange rates can effectively pass through into import price changes. Including the term of expected exchange rate changes would improve the estimates of exchange rate pass-through elasticity ($\hat{\beta}$) in equation (7) since it would alleviate the omitted variable issue in the conventional estimation as in equation (6).

6 Exchange Rate Pass-Through into US Import Prices

The two propositions in our model will guide our empirical analysis. We start with Proposition 2 to test the price responses to current and future exchange rate movements at product level. In this section we will use highly detailed HS-10 product-level import data from US Census Bureau to estimate exchange rate pass-through into import prices. In the first two parts of the product-level analysis, we use imports of the United States from China, covering all goods, differentiated goods and homogeneous goods (by product heterogeneity). In the last part, to examine the heterogeneity of the current and expected exchange rate pass-through elasticities across countries, we conduct the product-level analysis for US imports from other trading

[15]The literature indicates that exchange rates almost completely pass through into prices within one or two years (e.g., Campa and Goldberg, 2005).

partners.

6.1 US Import Prices and Expectation of Future Exchange Rates

Using the imports of the United States from China, we estimate the elasticity of the pass-through of current and expected future exchange rates into HS-10 product import prices. The baseline specification is as follows:

$$\Delta p_{ht} = \beta_1 \Delta exr_t + \beta_2 \Delta fwd_t + \beta_3 \pi_t + F_h + \varepsilon_{ht} \tag{8}$$

The log price difference (Δp_{ht}) for product h in year t is the dependent variable; current exchange rate changes Δexr_t and forward exchange rate fluctuations Δfwd_t are the main explanatory variables. To control for the inflation rate π_t, we use the exporting country's domestic CPI-based inflation index. Product fixed effects F_h are also included in the regression to capture the time-invariant product heterogeneity in exchange rate pass-through elasticity. Thus, standard errors are also clustered at the product level.

As the import data are annual data, both price changes and current exchange rate fluctuations are calculated on a yearly basis. For the dependent variable Δp_{ht}, i.e., product-level price changes, we include both unweighted and weighted (by quantity) average unit values as the price for each product. We adopt the weighted unit value price because there may be multiple transaction records of a single HS-10 product in the original data even for the same trading partner country of the United States. For the main independent variable, forward rate fluctuations Δfwd_t, we employ two measures: an annualized forward $\Delta fwd1$ based on three-month forward exchange rates and the one-year forward exchange rate $\Delta fwd2$. Current exchange rate fluctuations Δexr_t are also included in the regression to capture the price response to the realized exchange rate movements, following the standard estimation of pass-through elasticity in the literature.

Table 1: Exchange Rate Pass-Through to Import Price: U.S. Imports From China

	Unweighted Price			Weighted Price		
	(1)	(2)	(3)	(4)	(5)	(6)
Δexr	0.426**	0.475**	0.445**	0.426**	0.473**	0.444**
	(0.185)	(0.187)	(0.187)	(0.185)	(0.187)	(0.187)
$\Delta fwd1$		0.328*			0.326*	
		(0.191)			(0.191)	
$\Delta fwd2$			0.249			0.248
			(0.220)			(0.220)
Inflation	1.957***	1.709***	1.746***	1.955***	1.709***	1.745***
	(0.292)	(0.339)	(0.369)	(0.292)	(0.339)	(0.369)
Product Fixed Effects	yes	yes	yes	yes	yes	yes
Observations	74606	74606	74606	74606	74606	74606
Adjusted R^2	0.053	0.053	0.053	0.053	0.053	0.053

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by product. Prices and exchange rates are in logarithm. A constant term is included in all regressions.

Table 1 reports the baseline results. The left panel presents the results of unweighted price regressions, and the right panel presents the weighted results. We find that the current exchange rate pass-through coefficients are quite stable across different specifications, ranging from approximately 0.4 to 0.5 for both the weighted import price and the unweighted import price. Annualized three-month forward exchange rate changes have a pass-through elasticity of approximately 0.3 into import prices, and one-year forward changes also obtain positive coefficients of approximately 0.25. Thus, expected future exchange rates, especially short-run forward expectations $\Delta fwd1$, significantly pass through into price changes of imported products.

If we regard the pass-through of exchange rates into prices as a combination of both current and expected future exchange rate changes, the current price adjustment to future changes adds approximately 0.3 to the conventional pass-through coefficients. Summing the coefficients for $\Delta fwd1$ and Δexr, we obtain a larger coefficient for the pass-through elasticity. By accounting for the price responses to expected future exchange rate fluctuations, we find larger pass-through coefficients into import prices. This provides a potential explanation for the incomplete exchange rate pass-through observed in previous studies.

Also note that after including forward expectations, the conventional exchange rate pass-

through coefficients become larger in Table 1, i.e., we can compare pass-through coefficients for current exchange rates Δexr in regressions that include forward exchange rates (see columns 2-3 and 5-6) with those in regressions without expected exchange rates (see columns 1 and 4). This indicates that the pass-through of realized exchange rate fluctuations might be strengthened after controlling for price responses to changes in expectations of future exchange rates, while ignoring expected exchange rate movements may bring the estimation bias of pass-through elasticity due to the potential omitted variable problem.

6.2 Exchange Rate Pass-Through by Product Heterogeneity

Pricing decisions of firms are affected by the nature of the products that they sell. That is to say, firms' pricing power varies across products, perhaps because firms selling different products may face different demand elasticities which leads to various scope of price adjustment. Thus, it is important to examine how product heterogeneity relates to exchange rate pass-through. We conjecture that the exchange rate pass-through, especially for future exchange rates, would vary by product heterogeneity: products that are heterogeneous would respond more pronounced than those that are not.

Table 2: Summary Statistics: Number of HS-10 Produts U.S. Imported from China (by Rauch Index)

year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Heterogeneous	5,663	5,629	5,656	5,743	5,882	6,128	6,221	5,765	5,740
Reference-Priced	1,635	1,684	1,670	1,769	1,904	2,042	2,141	1,934	1,888
Homogeneous	295	305	287	300	309	339	366	330	326

Using the dataset on imports of the United States from China, we assess the pass-through effect of exchange rates for two subsamples: one with heterogeneous and one with homogeneous products. According to Rauch's product classification (Rauch, 1999), products are categorized into "homogeneous", "reference-priced" and "differentiated" where we denote "differentiated" goods as "heterogeneous" products. In Table 2, we list the summary statistics of the number of products imported by the United States from China at the HS-10 digit level in different years

in our sample. The heterogeneous products account for 70% of total number of HS-10 products that the United States import from China, reference-priced products account for less than 30% of the total, and homogeneous products represent only a small fraction. In the following regression analysis, we include both "homogeneous" and "reference-priced" products into a single group labeled "homogeneous" that would be compared with heterogeneous products.

Table 3 presents the differences in exchange rate pass-through into import prices resulting from the product heterogeneity. The left panel reports the results for the subsample of heterogeneous goods, and the right panel reports the results for the homogeneous products. The pass-through coefficients of heterogeneous products, for both current and forward exchange rate changes, are larger and more significant than those of homogeneous products. This suggests that exchange rate fluctuations are more likely to be reflected in the prices of heterogeneous products.

Table 3: Homogeneous Products and Heterogenous Products

	Heterogeneous			Homogeneous		
	(1)	(2)	(3)	(4)	(5)	(6)
Δexr	0.479*	0.597**	0.537**	0.440	0.473	0.468
	(0.255)	(0.257)	(0.257)	(0.404)	(0.406)	(0.407)
$\Delta fwd1$		0.811***			0.208	
		(0.255)			(0.435)	
$\Delta fwd2$			0.777***			0.328
			(0.290)			(0.493)
Inflation	1.464***	0.819*	0.776	2.392***	2.233***	2.110***
	(0.399)	(0.460)	(0.499)	(0.626)	(0.741)	(0.806)
Product Fixed Effects	yes	yes	yes	yes	yes	yes
N	36788	36788	36788	14581	14581	14581
R^2	0.113	0.114	0.114	0.177	0.177	0.177

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by product. Prices and exchange rates are in logarithm. A constant term is included in all regressions.

A potential explanation for this pattern is as follows: producers of heterogeneous products enjoy greater pricing power due to larger scope of quality differentiation; however, there is typically a universal market price in USD for the "homogeneous" and "reference-priced" products. When firms export "homogeneous" and "reference-priced" products, they may have little flexibility in adjusting their prices due to the universal price denominated in USD in the world

market. For bilateral trade between the United States and China, firms exporting homogeneous products have little room to change their prices when they forecast exchange rate movements, while exporters of heterogeneous products have greater pricing power and larger scope of price adjustment. They could adjust price with more flexibility when current and future exchange rates fluctuate. Thus, we observe larger and more significant coefficients of Δexr and Δfwd for heterogeneous products than those for homogeneous products.

In addition, the test using heterogeneous goods preserves two key features of the baseline result as in Table 1. First, the current price changes respond significantly to both current and forward exchange rate movements (see columns 2 and 3 in Table 3). Second, taking into account the expected future exchange rate changes also enlarges the conventional measure of the exchange rate pass-through elasticity, shown by the coefficients of Δexr, when comparing column 1 with columns 2-3.

6.3 Evidence from Other Trading Partners of the United States

So far, our analysis has been based on the US imports from China, and our sample period covers the time when the change in China's exchange rate regime occurred, i.e., China switched from a fixed regime to a managed floating regime. This feature distinguishes China from other countries, especially those with a flexible exchange rate regime. To alleviate the concern that our finding of the importance of expected future exchange rate movements applies to only one particular country, we now extend the analysis to other trading partners of the United States to explore the variation in the pass-through coefficients of forward exchange rate fluctuations across countries.

Besides China, our test covers seven major trading partners of the United States using data on US imports from the United Kingdom, South Korea, Japan, Germany, France, Canada and Australia. All seven countries have available forward exchange rate data. We graph three-, six-, and twelve-month forward exchange rates and the current exchange rate for the major countries in Figure 2 in the Appendix. Then we apply similar econometric specification as

in the baseline estimation of equation (8) and regress import price changes on the changes in exchange rates, including both current and forward exchange rates. The results are reported in Table 4.

Table 4: Results for Other Trading Partners of the United States

	CN	UK	Korea	Japan	Germany	France	Canada	Australia
Panel A: Main Explanatory Variable-Only Current Exchange Rate Change								
Δexr	0.426**	0.316***	0.104	0.388***	0.288***	0.345***	0.139*	0.701***
	(0.185)	(0.119)	(0.110)	(0.067)	(0.069)	(0.111)	(0.083)	(0.184)
Panel B: Main Explanatory Variable-Current Exchange Rate and Annualized 3-Month Forward								
Δexr	0.475**	0.320***	0.459***	0.646***	0.335***	0.425***	0.149*	0.808***
	(0.187)	(0.120)	(0.124)	(0.077)	(0.075)	(0.123)	(0.085)	(0.255)
$\Delta fwd1$	0.328*	0.217	2.185***	2.364***	0.701*	0.836*	0.421	0.988
	(0.191)	(0.603)	(0.295)	(0.396)	(0.361)	(0.434)	(0.562)	(1.515)
Panel C: Main Explanatory Variable-Current Exchange Rate and Annualized 1-Year Forward								
Δexr	0.445**	0.330***	0.351***	0.747***	0.334***	0.416***	0.157*	0.829***
	(0.187)	(0.121)	(0.118)	(0.084)	(0.075)	(0.124)	(0.085)	(0.267)
$\Delta fwd2$	0.249	0.395	3.081***	3.345***	0.665	0.781	0.724	1.153
	(0.220)	(0.650)	(0.432)	(0.518)	(0.408)	(0.499)	(0.618)	(1.632)

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by product. Domestic inflation rate from the exporting country and product fixed effects are included in all regressions. Prices and exchange rates are in logarithm. A constant term is included in all regressions.

Table 4 is separated into three panels. The top panel lists the results for the current exchange rate pass-through into import prices (see Panel A). In contrast, the bottom two panels include both current and forward exchange rate fluctuations in the pass-through tests (see Panels B and C). The difference between the bottom two panels is that Panel B uses "three-month" forward rates to calculate annualized forward fluctuations, $\Delta fwd1$, and Panel C uses "one-year" forward rates, $\Delta fwd2$, to measure future fluctuations. For all countries, adding forward exchange rate fluctuations makes the pass-through coefficients for current exchange rates significantly larger than those without expected future exchange rate fluctuations. For the convenience of comparing the results of other countries with those of China, we also list the result of the US imports from China from the baseline results in Table 1 in the first column of Table 4.

By comparing the results across countries, we find that anticipated future exchange rate changes, measured by both $\Delta fwd1$ or $\Delta fwd2$, have significantly positive pass-through into import prices in countries such as South Korea and Japan. For China, Germany and France, the short-run three-month forward changes $\Delta fwd1$ have a clear, significant effect on import prices, since short-run expectations would be more precise than the expectation in a longer horizon. However, for the United Kingdom, Canada and Australia, neither $\Delta fwd1$ nor $\Delta fwd2$ affects the current prices of imported products. Regarding the magnitude of the coefficients, we find that forward rates coefficients are larger for South Korea and Japan than they are for other countries.

There are several potential explanations for the variations in the pass-through coefficients for expected future exchange rates across countries. We briefly discuss some of these explanations as follows.

First, the variations may come from the choice of invoicing currency. Among the countries exporting to the US, when firms invoice exports in USD, i.e., the currency of the recipient country, we observe significant forward exchange rate pass-through effects. As producers must bear the foreign currency risk, they are more sensitive to exchange rate changes, especially to future exchange rate movements. If the price of an exported product is invoiced in the producer's own currency, it has little incentive to adjust the price, and the pass-through of exchange rate fluctuations is expected to be smaller. This explanation may apply to China, Japan, and South Korea. For example, the majority of exports from these three countries to the United States are invoiced in USD rather than in their own currencies, and thus we observe significantly positive pass-through coefficients. However, for countries such as the United Kingdom, Canada and Australia, the invoicing currency is not apparent and thus we observe little effect of future exchange rate pass-through on import prices.

Second, various exchange rate regimes may explain part of the variations. For those countries (such as the United Kingdom and Australia) that operate under a floating exchange rate regime, the fluctuations in forward exchange rates may generally follow a random walk because the

market anticipates a stochastic process regarding the changes in currency value in the long run. Anticipated future exchange rate fluctuations thus play little role in a firm's current price decision. This could be a potential reason for the insignificant pass-through coefficients of the forward exchange rates in those countries.

Third, the variations may stem from the existence of Free Trade Agreement (FTA). For example, the United States and Canada have formed a free trade zone through the NAFTA (North American Free Trade Agreement), in which trade activities are very frequent. Then, price adjustments may be more flexible and more frequent with the support of mutual trade agreement. With the potentially high-frequency price adjustments, it is not surprising to see little effect of future exchange rate expectations on current prices for US imports from Canada.

7 Micro Evidence from Exporting Firms

Now we turn to exporters' perspective to display direct evidence from Chinese exporting firms to justify that firms take expected future exchange rate movements into consideration when making decisions on current prices. Using Customs data on Chinese exports to the United States, we are able to observe the prices that exporting firms charge for each product and the price movements with respect to exchange rates (including forward exchange rates). This exporting-firm analysis corroborates the previous product-level analysis since it presents micro-level evidence from the exporting firms' perspective and helps explain the pass-through effect at the product level observed from US imports. In this section, we report export price adjustment at both firm level and firm-product level.

7.1 Exporters' Perspective (I): Price Adjustment at Firm Level

To capture exporters' price adjustments, we take the difference of the (log) export price of Chinese firm i between time t and $t-1$, Δp_{it}, as dependent variable.[16] The explanatory variables include the log annualized forward premium based on k-month forward rates between RMB and USD, denoted by Δfwd_{t+k} (where $k = 3, 6, 12$) to reflect future exchange rate expectations. We also control for the log realized exchange rate changes between t and $t-1$, Δexr_t. The domestic inflation rate π_t is added to control for price changes due to inflation. The firm fixed effects F_i is also included to capture the time-invariant firm characteristics that may affect its pricing behavior. The robust standard errors are clustered at the firm level since the current focus is firm-level price response. The econometric specification is given by:

$$\Delta p_{it} = \beta_1 \Delta exr_t + \beta_2 \Delta fwd_{t+k} + \pi_t + F_i + \varepsilon_{it}.$$

If firms export multiple sub-categories of products within the main categories, it is natural to think of the price adjustments across sub-categories of products. For example, a multi-product exporter may adjust the prices of certain sub-categories but hold constant prices for other product categories in response to exchange rate fluctuations. Thus, the observed price adjustment at the firm level may be confounded by the adjustments across product sub-categories. To solve this issue we adopt two approaches: First, we examine the firm-level price adjustment by focusing on the major product (at the HS-6 digit level)[17] for each individual firm and single-product firms. Second, we construct a weighted average price index at firm level for each multi-product firm. We introduce each in turn.

Firm-level analysis for major product and single product.—Table 5 reports regression results for firms with major product in columns 1-4 and firms with single product in columns 5-8. The top panel does not include product fixed effects, while the bottom panel does.

[16] As this test focuses on the pricing behavior of continuous exporters, we drop those exiting firms or discontinuous exporters.

[17] We pick up the HS-6 product that has the largest export value within each firm as major product.

Table 5: Firm-Level Export Price Adjustment and Forward Premiums

	Dependent Variable: Δp_{it}							
	Firm with Major Product				Firm with Single Product			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: without product fixed effects								
Δexr	0.688***	0.724***	0.739***	0.747***	0.412***	0.466***	0.485***	0.493***
	(0.069)	(0.069)	(0.069)	(0.070)	(0.121)	(0.120)	(0.120)	(0.121)
Δfwd-3month		0.194***				0.408***		
		(0.061)				(0.109)		
Δfwd-6month			0.279***				0.514***	
			(0.073)				(0.128)	
Δfwd-12month				0.353***				0.596***
				(0.082)				(0.143)
Inflation	0.975***	0.810***	0.731***	0.665***	1.018***	0.676***	0.572***	0.492**
	(0.110)	(0.119)	(0.125)	(0.130)	(0.182)	(0.198)	(0.209)	(0.217)
N	180573	180573	180573	180573	57582	57582	57582	57582
R^2	0.006	0.006	0.006	0.006	0.004	0.004	0.004	0.004
Panel B: with product fixed effects								
Δexr	0.748***	0.800***	0.817***	0.825***	0.400***	0.454***	0.472***	0.479***
	(0.071)	(0.071)	(0.071)	(0.072)	(0.127)	(0.126)	(0.126)	(0.126)
Δfwd-3month		0.262***				0.376***		
		(0.062)				(0.111)		
Δfwd-6month			0.360***				0.475***	
			(0.074)				(0.131)	
Δfwd-12month				0.440***				0.555***
				(0.083)				(0.146)
Inflation	0.983***	0.763***	0.673***	0.601***	1.036***	0.727***	0.630***	0.555**
	(0.111)	(0.120)	(0.126)	(0.132)	(0.188)	(0.204)	(0.214)	(0.223)
N	180573	180573	180573	180573	57582	57582	57582	57582
R^2	0.037	0.037	0.037	0.037	0.069	0.069	0.069	0.069

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by firm. Prices and exchange rates are in logarithm. A constant term is included in all regressions.

We include product fixed effects in some specifications to capture the potential time-invariant product heterogeneity in exchange rate pass-through elasticity.[18] Note that here we consider product fixed effects instead of firm fixed effects because the dependent variable Δp_{it} in this exercise is in fact product-specific.

In Table 5, both the current exchange rate Δexr and the forward exchange rate Δfwd show significantly positive effects on firm-level price changes. This means that the current export price set by a firm is positively affected by expectations of future exchange rate movements. Let us take columns 2 and 6 (based on 3-month forward rates) of Panel A in Table 5 as example. For

[18]In Chinese customs data we are able to identify product category for each firm's major product or single product.

firms with major product, the elasticity of future exchange rate fluctuations Δfwd is around 0.19 while that of current exchange rate Δexr is 0.72; for single product firms, the elasticity of Δfwd equals 0.41 and that of Δexr equals 0.47. The price adjustment to the expected future exchange rate fluctuation is stronger for single-product exporters, compared to firms with their major product. One possible explanation is that, compared to single-product firms, multi-product exporters may be better in absorbing the expected future exchange rate shocks when making cross-product adjustment within firm.

Comparing column 1 with columns 2-4, the realized exchange rate pass-through elasticity becomes larger when adding the expected future exchange rate movements Δfwd. All annualized forward premiums, include three-, six- and twelve-month forward premiums, have significantly positive coefficients. It is worth noting that the largest coefficients of Δexr among all specifications appear when controlling for twelve-month forward premium, and the current exchange rate pass-through coefficients increase with the time interval of forward rates.

Weighted firm-level price adjustment.—To complement the above firm-level price analysis, we further construct a firm-level price index to analyze price adjustments to the expected exchange rate fluctuations for exporting firms, especially those multi-product firms. Firm i's export price change in time t, Δp_{it}, is an index calculated as weighted average unit value price change across all HS-6 products (indexed by h) exported by firm i in time t and $t-1$, i.e., $\Delta p_{it} = \sum_h s_{ih,t-1} \Delta p_{iht}$, where $s_{ih,t-1}$ is the share of each HS-6 product h in firm i's total export sales at time $t-1$, and Δp_{iht} is the log price change for firm i's product h from period $t-1$ to period t. Therefore, Δp_{it} is computed as a weighted average change in prices for all the individual products within firm i. This approach of computing firm-level price change index follows the construction of a Tornqvist index as in Smeets and Warzynski (2013).[19] Then the price change across product is aggregated at the firm level to analyze the price adjustment response to exchange rate fluctuations.

The results are reported in Table 6 with two panels, without and with firm fixed effects,

[19]The only difference is that they use the average share between period t and $t-1$ as weight, while we use the initial share as weight. Our results remain qualitatively similar when using the average share.

Table 6: Firm-Level Weighted Export Price Adjustment and Forward Premiums

	Dependent Variable: Weighted firm-level price index Δp_{it}							
	Subsample: Only Ordinary Transactions				Full Sample: All Transactions			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: without firm fixed effects								
Δexr	0.340***	0.352***	0.356***	0.358***	0.334***	0.352***	0.358***	0.359***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.022)	(0.021)	(0.021)	(0.022)
Δfwd-3month		0.073***				0.125***		
		(0.019)				(0.017)		
Δfwd-6month			0.097***				0.150***	
			(0.021)				(0.019)	
Δfwd-12month				0.114***				0.166***
				(0.022)				(0.019)
Inflation	0.412***	0.342***	0.317***	0.298***	0.332***	0.212***	0.182***	0.164***
	(0.036)	(0.039)	(0.041)	(0.042)	(0.032)	(0.035)	(0.037)	(0.038)
N	413843	413843	413843	413843	467715	467715	467715	467715
R^2	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004
Panel B: with firm fixed effects								
Δexr	0.677***	0.703***	0.709***	0.709***	0.623***	0.653***	0.658***	0.658***
	(0.037)	(0.036)	(0.036)	(0.036)	(0.033)	(0.032)	(0.032)	(0.033)
Δfwd-3month		0.115***				0.147***		
		(0.032)				(0.028)		
Δfwd-6month			0.148***				0.176***	
			(0.035)				(0.031)	
Δfwd-12month				0.166***				0.190***
				(0.037)				(0.032)
Inflation	0.501***	0.411***	0.380***	0.362***	0.365***	0.249***	0.219***	0.203***
	(0.054)	(0.058)	(0.061)	(0.062)	(0.047)	(0.051)	(0.053)	(0.054)
N	413843	413843	413843	413843	467715	467715	467715	467715
R^2	0.233	0.233	0.233	0.233	0.235	0.236	0.236	0.236

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by firm. Price and exchange rates are in logarithm. A constant term is included in all regressions.

respectively. Three-, six- and twelve-month annualized forward exchange rate changes Δfwd are employed separately in the regressions. To avoid the potential noise from processing trading firms, we analyze the two samples separately.[20] We first drop the transactions belonging to processing trade and keep only observations of ordinary trade, and show results in the left panel in Table 6. We then keep all transactions and use the full sample to analyze the firm-level price adjustment in the right panel in Table 6.

[20]Processing trade includes "processing and assembling" and "processing with imported inputs". A significant proportion (approximately 30%) of Chinese exports belongs to processing trade, suggesting that Chinese producers import intermediate components to assemble or process them into final products in China and then export them abroad. The price decisions of a processing-trade firm may differ from those of a firm engaging in ordinary trade. Thus, we exclude processing-trade transactions from the firm-level regression in the left panel in Table 6. For the recent development of the literature on processing trade, see, e.g., Yu (forthcoming) and Manova and Yu (2014).

The firm-level price elasticity is around 0.07 for expected future exchange rate movements Δfwd based on three-month forward rates, and 0.35 for the realized exchange rate movements Δexr without firm fixed effects (see column 2 in panel A); when including firm fixed effects, both exchange rate pass-through coefficients become larger (see panel B). Although the majority adjustment in price comes from the realized exchange rate fluctuation, the response to the expected future ones still counts almost one-fourth of the total exchange rate pass-through elasticity (including both current and expected pass-through). There is little difference between the sample of ordinary trade in columns 1-4 and the full sample in columns 5-8.

7.2 Exporters' Perspective (II): Firm-Product Price Adjustment

Now we turn to a more disaggregated (firm-product level) analysis of exchange rate pass-through elasticity. The dependent variable Δp_{iht} is the difference in log export price of Chinese firm i's product h between time t and $t-1$.[21] The product category is defined at the HS-6 digit level since HS-6 is the most disaggregated product classification that is consistent over time for Chinese products and available to us. The econometric specification is given by

$$\Delta p_{iht} = \beta_1 \Delta exr_t + \beta_2 \Delta fwd_{t+k} + \pi_t + F_h + \varepsilon_{iht}$$

where Δfwd_{t+k} stands for the log k-month forward premium between CNY and the USD. Both the realized exchange rate changes Δexr_t and inflation rate π_t are included as explanatory variables.

Table 7 reports firm-product level price adjustment results. Columns 1-4 report the results based on the full sample of firm-product bundles, including all exported goods from China to the United States; columns 5-8 present results using firms only exporting a single product. Both the current exchange rate change Δexr and the forward exchange rate fluctuation Δfwd have positive effects on the firm-product price adjustment. This means that the current export

[21] As we take price difference, we focus on the price adjustment pattern of continuing firm-product bundles.

Table 7: Firm-Product Price Adjustment and Forward Premiums

	Dependent Variable: Δp_{iht}							
	Full Sample				Single Product			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: without product fixed effects								
Δexr	0.724***	0.818***	0.847***	0.854***	0.635***	0.703***	0.723***	0.731***
	(0.041)	(0.041)	(0.041)	(0.042)	(0.118)	(0.118)	(0.118)	(0.119)
Δfwd-3month		0.715***				0.432***		
		(0.037)				(0.108)		
Δfwd-6month			0.867***				0.546***	
			(0.043)				(0.128)	
Δfwd-12month				0.962***				0.637***
				(0.049)				(0.144)
Inflation	0.948***	0.358***	0.207***	0.113	0.937***	0.575***	0.465**	0.379*
	(0.065)	(0.071)	(0.075)	(0.078)	(0.184)	(0.200)	(0.210)	(0.219)
N	1029857	1029857	1029857	1029857	70706	70706	70706	70706
R^2	0.003	0.003	0.003	0.003	0.005	0.005	0.005	0.005
Panel B: with product fixed effects								
Δexr	0.751***	0.858***	0.890***	0.895***	0.680***	0.756***	0.777***	0.784***
	(0.042)	(0.042)	(0.042)	(0.042)	(0.123)	(0.123)	(0.124)	(0.124)
Δfwd-3month		0.783***				0.462***		
		(0.037)				(0.111)		
Δfwd-6month			0.944***				0.577***	
			(0.044)				(0.132)	
Δfwd-12month				1.042***				0.669***
				(0.049)				(0.148)
Inflation	0.961***	0.324***	0.163**	0.066	0.916***	0.536***	0.426**	0.340
	(0.065)	(0.071)	(0.075)	(0.078)	(0.189)	(0.206)	(0.216)	(0.225)
N	1029857	1029857	1029857	1029857	70706	70706	70706	70706
R^2	0.011	0.012	0.012	0.012	0.055	0.055	0.055	0.055

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by product. Price and exchange rates are in logarithm. A constant term is included in all regressions.

price set by a firm is positively affected by both current (and past) and expected exchange rate fluctuations. Also note that the coefficients for Δexr become larger when controlling for the expected future exchange rate changes Δfwd. Compared with the previous firm-level price analysis, the magnitude of forward premium coefficients and the size of current exchange rate pass-through coefficients are larger at firm-product level, suggesting the possibility that firms may reallocate resources across products within firm to better absorb exchange rate shocks. Thus, the observed pass-through elasticities for both current and expected future exchange rates are more incomplete at firm level than at firm-product level. Lastly, as a robustness check, we categorize export transactions into ordinary trade and processing trade. For both

types of trade modes, the aforementioned results still hold (see Table 8).

Table 8: Firm-Product Price Adjustment: Ordinary Trade vs. Processing Trade

	Dependent Variable: Δp_{ipt}							
	Full Sample				Single Product			
	Ordinary	Processing	Ordinary	Processing	Ordinary	Processing	Ordinary	Processing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δexr	0.711***	0.927***	0.814***	1.025***	0.845***	1.068***	0.853***	1.071***
	(0.048)	(0.085)	(0.048)	(0.085)	(0.048)	(0.085)	(0.048)	(0.085)
Δfwd-3month			0.688***	1.224***				
			(0.042)	(0.077)				
Δfwd-6month					0.855***	1.365***		
					(0.050)	(0.088)		
Δfwd-12month							0.970***	1.399***
							(0.057)	(0.095)
Inflation	1.163***	0.211*	0.603***	-0.772***	0.442***	-0.943***	0.332***	-0.998***
	(0.076)	(0.124)	(0.083)	(0.137)	(0.087)	(0.144)	(0.091)	(0.150)
Product fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
N	826358	203499	826358	203499	826358	203499	826358	203499
R^2	0.012	0.026	0.012	0.028	0.012	0.028	0.012	0.027

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by product. Price and exchange rates are in logarithm. A constant term is included in all regressions.

8 Conclusion

This paper explores price responses to future exchange rate fluctuations and their effects on exchange rate pass-through into import prices. In the presence of sticky prices, firms incorporate expectations of future exchange rate changes into their current pricing decisions. Consequently, at the aggregate level, the prices of imported products reflect exchange rate changes, including past, current, and future exchange rate fluctuations. The empirical tests based on US imports from China and other countries at HS-10 product level confirm that expectations of future exchange rate fluctuations indeed pass through into import prices. Moreover, from the exporting firms' perspective, we use highly disaggregated firm-product level customs data on China's exports to the United States and test the exchange rate pass-through. The results verify that exporting firms indeed significantly adjust their export prices in response to anticipated changes in exchange rates.

Our paper reveals a previously overlooked "pass-through" response to future exchange rates,

which results from firms' pre-reactions to expected exchange rate movements. It provides a new perspective to examine how price rigidity plays a role in the low "pass-through" coefficients observed in the literature and suggests a potentially important factor in helping explain incomplete pass-through of exchange rates to prices. Our findings suggest that firms' responses to future expectations should be considered when studying exchange rate pass-through. We find that the price response to expected future exchange rate changes accounts for approximately over one-third of the total "pass-through" coefficient, which is of significant importance.

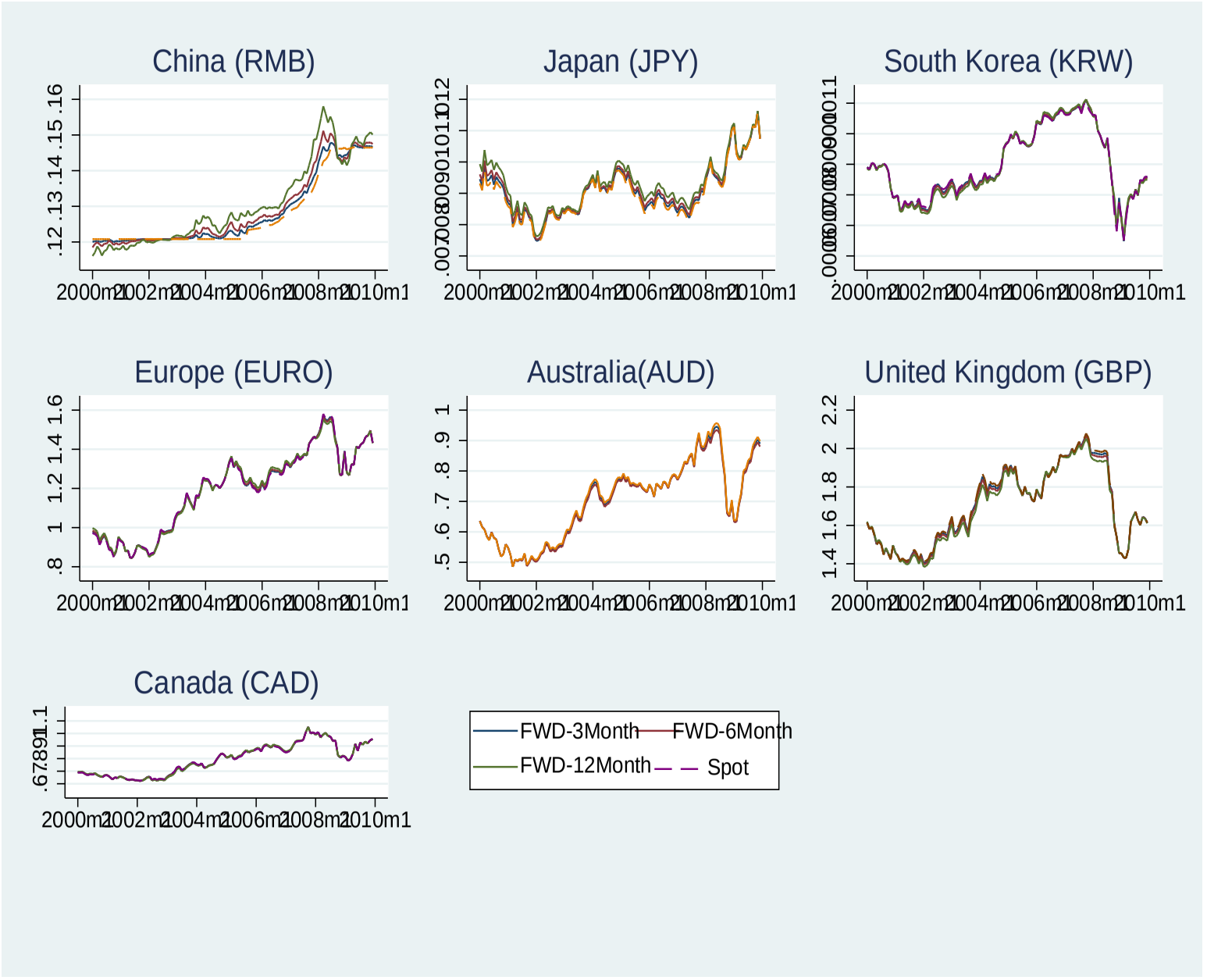

Figure 2: Movement of Exchange Rates across Countries

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