Forward-Looking Exporters and Exchange Rate Pass-Through*

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Abstract

This paper shows that the pricing behavior of exporters exhibits a "forward-looking" nature due to the existence of sticky prices. It offers a channel by which the expectations of future exchange rates can affect current export prices at both the firm and product level. By exploring bilateral trade data between the United States and China that are reported by both countries, combined with forward exchange rates, we find that export prices significantly respond to forward premiums at the firm-product level. At the product level, not only current (and past) exchange rate fluctuations but also future exchange rate changes are found to pass-through into import prices. These findings provide a new perspective that reveals the "micro-foundation" for the explanation of the phenomenon of partial 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 (2013)). Previous studies have documented the well-known phenomenon of incomplete exchange rate pass-through into import prices. 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. This incomplete pass-through phenomenon has attracted greater attention due to the finding of a declining pattern at the aggregate level in recent decades. For instance, in Marazzi and Sheets (2007), the pass-through coefficient declined from 0.5 during the 1970s and 1980s to approximately 0.2 over the last decade in the US, and Ceglowski (2010) finds a similar pattern using an alternative data set on US imports.

Consequently, many studies have endeavored to provide potential explanations for the small and declining exchange rate pass-through coefficients. At the aggregate level, various macroeconomic variables, including the stability or volatility of monetary policy (Devereux, Engel and Storgaard, 2004) and exchange rate volatility (Campa and Goldberg, 2005), affect the price response to exchange rate changes.[1] In particular, Devereux and Yetman (2010) argues that the existence of sticky prices represents a key determinant of exchange rate pass-through. However, the micro-level evidence for those macroeconomic determinants of exchange rate pass-through remains under-studied. This paper attempts to fill this gap in the literature by applying a novel perspective of firms' forward-looking behavior to provide micro-level evidence (at both the disaggregate product and firm level) that justifies sticky prices and their impact on exchange rate pass-through.

This paper explores the firm's pricing behavior under a price rigidity framework that incorporates expectations of future exchange rate movements. It shows that future expectations significantly affect firms' current pricing decisions, which consequently leads to a "pass-through" into the observed price at the product level. In this regard, firms' expectations of future exchange rate fluctuations play an important role in current price adjustments in the presence of price rigidity.

We first use a simple model to present the mechanism. When exporters (sellers) make contracts with partners (buyers), it is highly unlikely that prices could be changed frequently

[1] Other factors are also found to be relevant, such as the stickiness of prices, the frequency of price adjustments, and the choice of invoice currency. For example, Choudhri and Hakura (2012) and Choudhri and Hakura (2015) offer evidence based on the presence of between-producer and local currency pricing that the choice of the invoice currency is a significant factor in determining the pass-through magnitude.

in accordance with bilateral exchange rate fluctuations. Due to the "infrequency" of price adjustment, exporters take future exchange rate changes into consideration when they set current export prices. Thus, at the micro-level, an individual firm's pricing decision responds to future exchange rate fluctuations. The less frequently that exporters can adjust the contract, the more weight exporters will place on future exchange rate changes based on their expectations. 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 future exchange rates "pass-through" to current prices.

Empirically, using data on US imports from China collected by the US Census Bureau, we examine the pass-through of forward exchange rates into import prices. 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. Therefore, the reform provides an ideal setting to test the role of forward expectations of exchange rates in determining prices. We use various forward rates in the foreign exchange market as proxies for the market's expectation of future exchange rate movements.

We employ the unit value prices of highly disaggregated imported products from China to the US (reported by the US Census Bureau) and explore the role of future exchange rates at the product level (HS-10) in determining import prices. We use forward exchange rates on the exchange market between the US and China to assess the effect of expectations of future exchange rates. Our estimation shows that, among imports from China, future exchange rate fluctuations account for approximately 26% of the total exchange rate elasticity. In other words, using only past and current exchange rates to compute the pass-through elasticity, a typical practice in the literature, would fail to capture approximately one-fourth of the price responses to exchange rate fluctuations resulting from firms' pre-reactions to expectations of future 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. In a robustness check, we find that for firms operating under different trade regimes, including both ordinary and processing trade, future exchange rate changes can also pass through into current prices.

Some further tests are also conducted. First, there is difference in the pass-through of forward exchange rates between heterogeneous and homogeneous products. According to the

Rauch index (Rauch, 1999), we categorize HS-10 imported products into homogeneous products, reference-priced products and heterogeneous products and assess the exchange rate pass-through for each. We find that future exchange rate changes influence current import prices more significantly for heterogeneous products than for homogeneous and reference-price products.

Second, we test the pattern through a cross-country analysis. In addition to the analysis based on US import records, we examine the pass-through of forward exchange rates for other countries, such as the United Kingdom, Japan, South Korea, Australia, Canada, Germany and France, which are major exporters to the US. According to the results, forward exchange rates exhibit different degrees of pass-through into import prices. For example, Germany , France, South Korea and Japan exhibit significant 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 in Australia, Canada and the United Kingdom. There are several potential explanations for the heterogeneity across countries, such as the choice of invoice currency, exchange rate regimes, and existence of free trade agreements.

In addition, through a firm-level analysis, we obtain direct evidence from the perspective of exporting firms and capture the individual firms' pricing behavior. This analysis is based on another data source: Chinese Customs data (reported by China's General Administration of Customs), which records firm-product level trade data on China's exports to the US. We use forward exchange rates as a proxy for market expectations of future exchange rates; we test the model's predictions and find that exporting prices at the firm level significantly respond to future exchange rate fluctuations. The result is robust to both single-product firms and multi-product firms. Moreover, our test is robust to different trade regimes, in terms of both ordinary and processing trade (a firm simultaneously exports and imports). Chinese exporters engaging in ordinary production, as well as those engaging in assembling and processing, consider all future exchange rate fluctuations and respond significantly in expectation of future exchange rate movements.

This paper relates to several branches of the literature. First, it is related to papers seeking various explanations for the incomplete (declining) exchange rate pass-through elasticity, including 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). 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 especially 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. Our paper is also in line with the emerging literature that explores micro-level evidence to study firms' responses to exchange rate movements (Amiti, Itskhoki and Konings, 2014; Berman, Martin and Mayer, 2009).[2] Our paper's contribution to this literature is twofold: First, from the macro perspective, this paper verifies that expectations of future exchange rate movements would pass through into the current prices at the product level. Second, from the micro perspective, this paper confirms that firms' pricing behavior responds to future exchange rate fluctuations.

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

Third, this paper is related to the literature exploring the relationship between exchange rate movements or volatility and trade flows using disaggregated customs data, e.g., Berman, Martin and Mayer (2009), 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). 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 briefly discusses a model that incorporates forward-looking behavior into firms' pricing decisions. Section 3 describes the data and measurements, and Section 4 introduces the context of China's exchange rate reform. Section 5 presents the empirical results on exchange rate pass-through into import prices at the product level. Section 6 describes the results of a firm-level analysis. The last section concludes.

[2]Berman, Martin and Mayer (2009) 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).

2 Exporter's Pricing Decision

We use a simple model in line with Chari, Kehoe and McGrattan (2000) and Calvo (1983) to describe a firm's pricing decision under price rigidity. By assumption, a portion of firms equal to $1-\beta$ 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).[3] e_t is the current exchange rate of the domestic currency with a foreign currency, and thus, an increase in e denotes domestic currency appreciation.

Firms engage in monopolistic competition within a sector. The foreign demand equation follows $Q_i = op_i^{-\rho}P^{\rho-\eta}$, where p_i is the price charged by a representative firm i, P denotes the aggregate price level, 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.

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 marginal 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:

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

Due to 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_tC_{t+j} and expected future bilateral exchange rate E_te_{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

[3]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 US market.

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 only 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, and e_t is the current exchange rate for the domestic currency. 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 $\tilde{p_t} = (1-\beta) \sum_{j=0}^{n} E_t \beta^j (\tilde{P}_{t+j} + \tilde{V_d} + \tilde{e}_{t+j})$. If we suppress the changes in intermediate input costs $\tilde{V_d}$ and in the domestic aggregate price level $\tilde{P}_{t+j}$, then export price fluctuations only depend on current and 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 Data and Empirical Strategy

The main data source for examining the exchange rate pass-through into product prices is the (product-level) import data provided by the US Census Bureau.[4] This database documents the US's imported products at a detailed HS-10 digit level on a yearly basis. Our sample includes imports to the US from 2000 to 2008. It also records import information, such as country of origin, tariffs and so forth. The import price is calculated as a unit value, excluding tariffs and other charges, at each 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. We first conduct a baseline test on US imports from China, and in the following section, we extend this analysis to other major countries (the US's top trading partners).

The second data source, i.e., on exchange rates, includes both spot exchange rates and forward exchange rates, which are obtained from Bloomberg. Forward exchange rates are the NDF (non-deliverable forward) rates between US and China in the foreign exchange market. Forward exchange rates in our tests cover one-, three-, six-, nine-, and twelve-month forwards and indicate the trend in market expectations of exchange rate fluctuations. In robustness checks, we extend our study to other countries other than China (e.g., the United Kingdom, Japan, South Korea, Australia, Canada, Germany and France). We also use current and forward exchange rates between those countries (e.g., GBP, JPY, KRW, AUD, CAD, EURO) and US dollars as bilateral exchange rates. The inflation rates for the exporting countries are yearly CPI-based inflation rates obtained from the World Bank.

Following the conventional practice in the exchange rate pass-through literature, the change in the logarithm of prices is calculated as the dependent variable, and the change in the logarithm of exchange rates is the main explanatory variables. In the baseline estimation, we regress the import price at the HS-10 product level on exchange rate changes, including both current and future exchange rates. The aim of this analysis is to verify and measure the pass-through of future exchange rate fluctuations into import prices at the product level (HS-10). According to our model predictions, positive coefficients for both current and forward exchange rates are expected. In further tests, we check the pass-through of future exchange rates into import prices for homogeneous and heterogeneous products to capture the importance of product homogeneity. Moreover, we conduct a cross-country analysis (based on major currencies) to examine the heterogeneity in the pass-through of future exchange rates across countries.

[4]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.

As a further check, we conduct a firm-level analysis based on Chinese exports to the US. The firm-level exporting data are extracted from the Chinese Customs Database (2000-2006), which 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. This dataset has been used in many previous studies, especially those that focus on firm-level analysis of filed Chinese exports/imports, e.g., Khandelwal, Schott and Wei (2013) , Lu, Tao and Zhang (2013), Tang and Zhang (2012) and Li et al. (2012). We utilize this dataset to capture Chinese exporters' pricing behavior under exchange rate fluctuations. Because we can observe changes in the export price charged by each firm for a specific product, we then use the value and quantity to compute unit values as a proxy for prices in our tests.

The previous product-level analysis serves as the baseline for the analysis of exchange rate pass-through into import prices at the aggregate level (product level). In the firm-level analysis, we define disaggregate (firm-product) prices from two perspectives: one is the price charged by a firm for each specific product, and the other is a constructed firm-level price index. We investigate the response of disaggregate prices to exchange rate changes, especially to future exchange rates. This test serves as a micro-foundation for the pass-through effect observed in the previous analysis at the product level.

4 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 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 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.

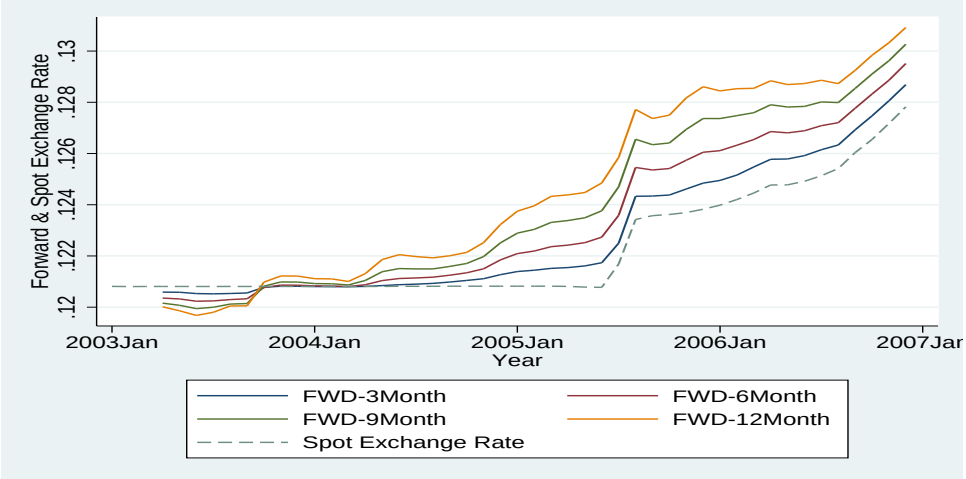

Figure 1: Forward & Spot Exchange Rate Fluctuations Between RMB and USD

The reform of China's exchange rate represents a unique setting to explore firms' price behavior under the expectation of future fluctuations. Due to trend in China's growth, the announcement was preceded by widespread anticipation of future currency reform and the appreciation of the RMB. Thus, 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 (which 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. In general, because China had a closed capital account during this period, the forward premiums on exchange rates had little impact on domestic financial conditions relative to their impact on the competitiveness of traded goods.

In addition, as our study is based on the US-China bilateral trade context, we believe that this, to some extent, avoid concerns related to the invoice currency issue. In previous literature, the choice of an invoice 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). By restricting our data to bilateral trade between the US and China, we can better avoid the invoice currency issue because the majority of trade transactions between the US and China use the USD as the invoicing currency. When the USD

is used as the invoicing currency, fluctuations in the domestic currency (RMB) directly affect exporters' revenue, and thus, exporting firms will have an incentive to adjust export prices.

In the subsequent cross-country analysis, we extend our pass-through tests to other major countries. However, those countries do not necessarily use the USD as their major invoicing currency. The results indicate that future exchange rate pass-through varies across countries.

5 Results

5.1 Product-Level Import Price Response to Future Exchange Rates

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

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

The log price difference (Δp_{ht}) is the dependent variable, and 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 regressions. Standard errors are clustered at the product level.

As the US 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 use weighted unit value prices because there may be multiple transaction records for a single HS-10 product. For the main independent variable, forward rate fluctuations Δfwd_t, we employ two measures: an annualized one-year forward $\Delta fwd1$ based on three-month forward exchange rates and the one-year forward exchange rate $\Delta fwd2$. Current exchange rate fluctuations exr_t are also included in the regression, which capture the price adjustment to the realized exchange rate movements, following the standard pass-through estimates in the literature.

Table 1: Pass Through to Import Price: US Import 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. Constants are 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 approximately 0.4 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, 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 future exchange rate changes, the current price adjustment to future changes adds approximately 0.3 to the 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 future exchange rate fluctuations, we find larger "pass-through" coefficients into import prices that provide an 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, e.g., if we compare pass-through coefficients for current exchange rates Δexr in regressions that include forward exchange rates in columns (2), (3), (5) and (6) with those coefficients for current exchange rates in columns (1) and (4). This indicates that the pass-through of realized exchange rate fluctuations is strengthened after controlling for price responses to future expectations.

5.2 Heterogeneous Products and Homogeneous Products

Firms' pricing decisions are affected by the nature of the products that they sell; i.e., exporters' pricing power varies across products with different levels of homogeneity. Intuitively, for heterogeneous products, exporting firms absorb exchange rate changes by adjusting markups or product quality, which affects the degree of exchange rate pass-through. Thus, we conjecture that the exchange rate pass-through, especially for future rates, could be quite different between homogeneous goods and heterogeneous goods.

Using the dataset on US imports from China, we assess the pass-through of exchange rates for two subsamples: one with heterogeneous and one with homogeneous products. According to the Rauch index, products are categorized into "homogeneous", "reference price" and "heterogeneous"; we include both "homogeneous " and "reference price" products, according to the Rauch index, in a single group labeled "homogeneous". In Table 2, we list the summary statistics of the number of products imported by the US from China at the HS-10 digit level in different years in our sample. The heterogeneous products accounts for 70% of total US imports, reference-price products account for less than 30% of the total, and homogeneous products represent a very small percentage of the total.

Table 2: Summary Statistics: Number of Produts (HS-10) US 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
Referred Price	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

The results for pass-through are listed in Table 3. The left-hand panel reports the results for the heterogeneous subsample, and the right-hand panel reports the results for the homogeneous subsample. 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 result reflects the difference in exchange rate pass-through into import price resulting from the heterogeneity of export products. Exchange rate fluctuations are more likely to be reflected in the export prices of heterogeneous products. A potential explanation for the pattern is as follows: producers of heterogeneous products enjoy greater pricing power; however, there is typically a universal market price in USD for the "homogeneous" and "reference price" product categories. Thus, when firms export "homogeneous" and "reference-priced" products, they may have little flexibility in adjusting their export prices in USD. In addition, for bilateral trade

between the US and China, it is likely that Chinese firms exporting homogeneous products have less pricing power than heterogeneous goods exporters.

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
Adjusted R^2	-0.054	-0.053	-0.053	-0.021	-0.021	-0.021

Notes: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses. Robust standard errors clustered by product. Constants are included in all regressions

5.3 Cross Country Analysis

In the previous section, our analysis was based on the change in China's exchange rate regime. This feature distinguishes China from other countries, especially from other countries with a flexible exchange rate regime. In this section, we extend the analysis to multiple countries to explore the variation in the pass-through of forward exchange rate fluctuations.

We select seven major countries, including imports from the United Kingdom, South Korea, Japan, Germany, France, Canada and Australia in our sample. All of them are major trading partners of the US and have mature forward exchange markets. 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. The econometric methodology is similar to that of the baseline estimation, and we regress import prices on the changes in exchange rates, including both current and forward exchange rates. The results are listed in Table 4.

Table 4: Country by Country Regression

	CN	UK	Korea	Japan	Germany	France	Canada	Australia
	Only Current Exchange Rate							
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)
	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)
	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. Constants are included in all regressions

The table is separated into three panels. The top panel lists the results for the current exchange rate pass-through into import prices. In contrast, the bottom two panels include both current and forward exchange rate fluctuations in the pass-through tests. The difference between the bottom two is that the second panel uses "three-month" forward rates to calculate forward fluctuations, $\Delta Fwd1$, and the third panel 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 future exchange rate fluctuations.

By comparing the results across countries, we find that future exchange rate changes, including both $\Delta Fwd1$ and $\Delta Fwd2$, have significantly positive pass-through into import prices in countries such as China, South Korea, and Japan. For Germany and France, only the 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 term. 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 are significantly 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 future exchange rates across countries. We list several of these explanations below.

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 rate changes. If the price of an export 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 smaller in this case. For example, the majority of exports from China, Japan and South Korea to the US are invoiced in USD rather than in their own currencies, and we observe significantly larger pass-through coefficients. However, for countries such as the UK, Canada and Australia, the invoice currency is not apparent and thus has little effect on exchange rate pass-through.

Second, various exchange rate regimes may explain part of the variations. For those countries, such as the UK 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 stable change in currency value in the long run. Future exchange rate fluctuations play little role in a firm's current price decision. This could be another reason for the insignificant pass-through of the forward exchange rate in those countries.

Third, the variations may stem from the existence of Free Trade Agreement (FTA). For example, the US and Canada have formed a free trade zone, in which trade activities are very frequent. Pricing adjustments may be more flexible and frequent with the support of mutual trade agreement. With a high frequency of price adjustment (trade contracts), future exchange rate expectations have little effect on current prices.

6 Export Prices and Expectation of Future Exchange Rates

6.1 Firm-Product Level Price Adjustment

In this section, to identify the mechanism driving the pass-through of exchange rates into import prices at the product level, we directly explore evidence on firms' price adjustments. Based on Chinese Customs data on exports, we are able to observe the prices that firms charge for each product and their movements with respect to exchange rates (including forward exchange rates). This test differs from the analysis in the previous section in that it presents evidence from the exporter's perspective that explains the pass-through effect at the product level observed in the baseline results.

Following the previous studies (e.g., Berman, Martin and Mayer (2009)), the dependent

variable p_{iht} is the logarithm of the export price of Chinese firm i's product h at time t.[5] In this test, each firm-product bundle is defined as one observation. The product category is defined at the HS-10 digit level. The explanatory variables include the log k-month forward exchange rate between China and the US, labeled as fwd_{t+k}. We include three-, six-, nine-, and twelve-month forward premiums as alternative measures of future exchange rate expectations. We control for current exchange rates, in log form, written as exr_t. The inflation rate is added to control for price changes due to domestic inflation. We also add firm-product fixed effects (F_{ih}) in the regression and include year dummies to control for annual economy-wide macroeconomic trends and other export-related policies. The robust standard errors are clustered at the product level. The econometric specification is as follows:

$$p_{iht} = \beta_1 fwd_{t+k} + \beta_2\ exr_t + F_{ih} + F_t + \varepsilon_{iht}$$

Table 5: Export Price to US and Forward Exchange Rate Premium

	Full Sample: All Firms			Sub Sample: Single-Product Firms		
	(1)	(2)	(3)	(4)	(5)	(6)
	3-month	6-month	12-month	3-month	6-month	12-month
fwd-3month	0.306***			0.334***		
	(0.0262)			(0.0405)		
fwd-6month		0.356***			0.375***	
		(0.0312)			(0.0474)	
fwd-1year			0.370***			0.383***
			(0.0399)			(0.0606)
exr-3month	0.415***			0.335***		
	(0.0412)			(0.0606)		
exr-6month		0.290***			0.261***	
		(0.0152)			(0.0218)	
exr-1year			0.172***			0.160***
			(0.0064)			(0.0091)
Inflation	5.961***	5.738***	5.664***	7.277***	7.093***	7.053***
	(0.6031)	(0.5923)	(0.5731)	(0.7613)	(0.7544)	(0.7438)
Firm-Product Fixed Effects	yes	yes	yes	yes	yes	yes
Year Fixed Effects	yes	yes	yes	yes	yes	yes
N	6686268	6686268	6686268	1894032	1894032	1894032
adj. R-sq	0.911	0.911	0.911	0.944	0.944	0.944

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. Constants are included in all regressions

Table 5 reports baseline regression results. The left panel reports the results based on the full sample, including all exports from China to the US; the right panel includes firms only exporting a single product. Both the current exchange rate exr and the forward exchange

[5]The log value of price only focuses on the pattern of continuing firms, without considering of extensive margin shifts.

rate fwd have positive effects on the price of a firm-product bundle. All forward premiums have significantly positive coefficients. This means that the current export price set by a firm is positively affected by expectations of future exchange rates. We also find that the three-month forward premium has the largest coefficient among all forward premiums and that the coefficients decline as the forward interval increases. Moreover, by comparing the two panels, we find a similar pattern for both and coefficients are slightly stronger for single-product firms.

Table 6: Robustness: Processing and Ordinary Trade

	3-month		6-month		12-month	
	(1) Process	(2) Ordinary	(3) Process	(4) Ordinary	(5) Process	(6) Ordinar
fwd-3month	0.358***	0.283***				
	(0.0375)	(0.0309)				
fwd-6month			0.429***	0.321***		
			(0.0448)	(0.0379)		
fwd-1year					0.494***	0.309***
					(0.0567)	(0.0493)
exr-3month	0.426***	0.387***				
	(0.0621)	(0.0450)				
exr-6month			0.305***	0.272***		
			(0.0231)	(0.0165)		
exr-12mpnth					0.182***	0.162***
					(0.0095)	(0.0070)
Inflation	10.84***	4.137***	10.49***	3.975***	10.14***	4.037***
	(0.7304)	(0.7500)	(0.7174)	(0.7382)	(0.6847)	(0.7195)
Firm-Product Fixed Effects	yes	yes	yes	yes	yes	yes
Year Fixed Effects	yes	yes	yes	yes	yes	yes
N	1330812	4741727	1330812	4741727	1330812	4741727
Adjusted R^2	0.958	0.899	0.958	0.899	0.958	0.899

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. Constants are included in all regressions

A significant portion, e.g., approximately 30%, of Chinese exports belongs to the processing trade, meaning that producers import intermediate products to assemble or process them into final products in China and then export them abroad. The price decisions of this type of firm might differ from those of a firm engaging in ordinary trade. To identify pricing patterns for both ordinary and processing trading firms, we analyze the two subsamples separately. As a robustness check, we categorize export transactions into ordinary trade and processing trade.[6] For both types of trade regimes, the aforementioned results still hold (see Table 6). Columns 1, 3 and 5 list results for processing trade, whereas Columns 2, 4, and 6 are for ordinary trade. The pass-through coefficients for both current and forward exchange rate fluctuations are larger for processing trade. The results suggests that those firms engaging in processing

[6]Processing trade includes "processing and assembling" and "processing with imported inputs".

trade are sensitive to exchange rate movements and are more likely to adjust their exporting prices.

6.2 Firm Level Price Adjustment

To complement the " firm-product" analysis in section 6.1, we construct a firm-level price index to analyze firms' price adjustments to forward exchange rate fluctuations in this section. If firms export numerous sub-categories of products within the main categories, there will typically be a price adjustment in the major category. A firm may adjust its price for a certain sub-category and hold prices constant for others in response to corresponding exchange rate fluctuations.

We first focus on firms exporting a single HS-6 product, allowing firms to export various sub-categories within the HS-6 digit level. If firm exports more than one product at the HS-10 level (but under the same product category according to HS-6), the firm's export price is an index calculated as an average unit price weighted by the quantity of each HS-10 product, i.e., $p_h = \Sigma s_{hs10} p_{hs10}$, where s_{hs10} is the share of each HS-10 product in total exports. Each individual firm represents a single observation in our sample. The largest difference between this test and the previous one is that in the previous section, the observation is defined at the "firm-product" level (a product at the HS-10 digit level), whereas in this section, the price is aggregated at the firm level to analyze the pricing response to exchange rate changes.

The result is displayed in Table 7. Three-, six- and twelve-month annualized forward exchange rates fwd are utilized separately in the regressions. All of them are significantly positive, which suggests that firm-level prices also respond to future exchange rate fluctuations. Of the forward rates, the long-term rate for the one-year forward rate has the largest coefficient. Furthermore, given the positive coefficient of exr, firm-level prices shift following movements in the current exchange rate. If we compare this result with the previous "firm-product" regression results, we find that the firm-level price has larger pass-through coefficients or both current and forward exchange rate fluctuations than is observed at the "firm-product" level. Thus, multi-product firms clearly adjust their sub-category prices.

Table 7: Firm Level Price Regressions

	3-month		6-month		12-month	
	Dependent Variable: Log Firm Price					
fwd-3month	0.631***	0.359***				
	(0.085)	(0.046)				
fwd-6month			0.805***	0.399***		
			(0.102)	(0.055)		
fwd-1year					0.976***	0.419***
					(0.134)	(0.072)
exr-3month	0.508***	0.601***				
	(0.129)	(0.068)				
exr-6month			0.402***	0.402***		
			(0.049)	(0.025)		
exr-12month					0.254***	0.232***
					(0.021)	(0.011)
Inflation	19.592***	9.938***	18.708***	9.767***	17.772***	9.661***
	(1.652)	(0.820)	(1.650)	(0.825)	(1.667)	(0.842)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed	No	Yes	No	Yes	No	Yes
N	1447277	1447277	1447277	1447277	1447277	1447277
adj. R-sq	0.005	0.894	0.005	0.894	0.005	0.894

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. Constants are included in all regressions

7 Conclusion

This paper explores price responses to future exchange rate fluctuations and their effects on exchange rate pass-through into import prices. Due to the presence of sticky prices, firms account for expectations of future exchange rate changes in 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 bilateral trade data between China and the US confirm that expectations of future exchange rate fluctuations indeed pass through into import prices. At a detailed product level, our analysis shows that both current and future exchange rate changes could pass-through into import prices. However, from the firm's perspective, the investigation based on a "firm-level" analysis further verifies that a firm's export price is adjusted substantially in response to anticipated changes in exchange rates.

Our findings reveal 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. Our findings suggest that firms' responses to future ex-

pectations should be considered when considering exchange rate pass-through issues. In this paper, we find that the price response to expected future exchange rate changes accounts for approximately one-fourth of the total "pass-through" coefficient, which is of significant importance.

There are numerous potential avenues for future research in this area. The analysis in our paper is based on a representative firm to document the price adjustment mechanism. One possibility for future research concerns the heterogeneity in responses to future exchange rate expectations. A heterogeneous firm framework could reveal different degrees of response across firms. For example, the responses to forward expectations might be associated with a firm's productivity or import intensity. Analyzing heterogeneous firms at a disaggregate level could further address the puzzle of incomplete exchange rate pass-through.

Future studies could also explore, for example, product switching patterns and the pass-through of future exchange rates. Some firms reshuffle their products, especially multi-product firms facing expected exchange rates. This pattern could diminish the pass-through effect of exchange rate expectations into prices. The product-level pattern may help to further determine the reasons for incomplete "pass-through" coefficients at the disaggregate level and provide a micro-foundation for the observed patterns.

Another interesting direction for further research would be to explore the country-level variation in firms' responses to future exchange rate changes. Moreover, the determinants of the variation in firms' price adjustments across countries could be considered. Even when facing expected exchange rate changes, firms may shift trade partners. Changing partners could also affect pass-through magnitudes.

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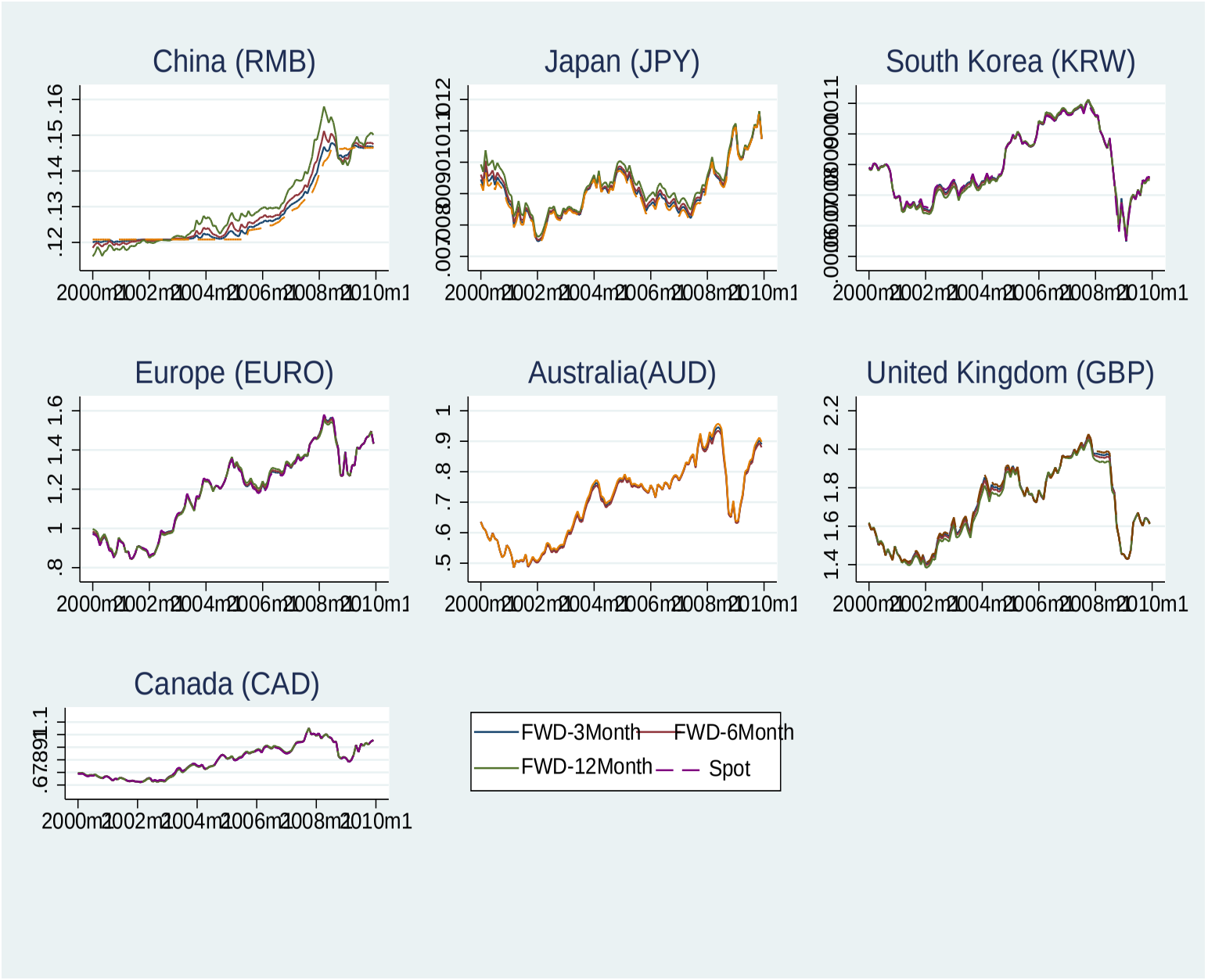

Figure 2: Movement of Exchange Rates across Countries