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Margins of imports, forward-looking firms, and exchange rate movements ☆

Haichao Fan [a], Yao Amber Li [b], Chen Carol Zhao [b,*]

[a] Institute of World Economy, School of Economics, Fudan University, Shanghai, China
[b] Department of Economics, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

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ABSTRACT

This paper presents theory and evidence on firms' import responses to *current* and *future* exchange rates along both intensive and extensive margins. The paper first builds a dynamic heterogeneous-firm model to study how firms adjust their import decision by taking into account both current and future exchange rates. In the model, individual firms pay a fixed sunk cost and face a probability of failure when searching for foreign intermediate suppliers. The impact of future exchange rate on import is different from that of current exchange rate: spot exchange rate appreciation would increase both the intensive margin (import value of individual firm) and the extensive margin (the number of importing firms), while future exchange rate appreciation increases the extensive margin rather than the intensive margin of imports. The model predictions are strongly supported by an empirical analysis using disaggregated data on China's imports from the United States and forward rates between US Dollar (USD) and Chinese Yuan (CNY) on the non-deliverable exchange market.

1. Introduction

Recent development of the literature has witnessed a surge of studies exploring firm-level trade response to contemporaneous exchange rate fluctuations (e.g., Berman et al., 2012; Amiti et al., 2014). However, the role of expected future exchange rate movements has been largely overlooked. Do firms also react to future exchange rate when making import/export decisions? Do they respond differently along the intensive and extensive margins when facing contemporaneous and future exchange rate movements? Yet, existing studies remain silent on these questions.

In this paper, we examine the heterogeneous response of importers to spot and forward exchange rate movements using disaggregated data on China's imports from the United States. We restrict our empirical investigation based on the China-US context for several reasons. In general, certainly the large volume of China-US trade makes the US as one of the most

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* Corresponding author.
E-mail addresses: fan_haichao@fudan.edu.cn (H. Fan), yaoli@ust.hk (Y.A. Li), zhaochen@connect.ust.hk (C.C. Zhao).

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paramount trade partner countries of China.[1] More importantly, by focusing on the exchange rates between US dollar (USD) and Chinese Yuan (CNY), we are able to overcome difficulties in measuring market expectations for future currency fluctuation, and in isolating influences of domestic financial conditions linked with exchange rates which could also exert impact on trade decisions (Li and Zhao, 2016).

More specifically, the China-US context has at least three distinctive features. First, under a fixed exchange rate regime and a subsequent managed floating one, the previous anticipation of future appreciation of CNY against USD was indeed supported by the follow-up realized appreciation. China officially switched from a fixed exchange rate regime that pegged CNY to USD to a managed floating regime in July 2005, and the nominal exchange rate of CNY/USD started appreciating afterwards. Since July 2005 both forward rates and spot rates present substantial changes. But there also exists a substantial period during the transition from the fixed exchange rate regime to the floating regime with only changes in forward rates but nearly no changes in spot rates since market expectation on appreciation of CNY came as early as 2003. There are clear and substantial movements in USD/CNY forward premiums based on fundamentals over time.[2] This distinguishes China-US context from the countries with floating exchange rates that are characterized by random walk expectations.

Second, Chinese firms were once forbidden to engage in direct trade of foreign exchange rate derivatives. In other words, quite few manufacturing producers in China could hedge future exchange rate risks using future derivatives (e.g. non-deliverable forward contract). As a result, firms rely on adjusting their trading behavior in advance as response to foreign currency fluctuations. Also, due to the strict capital control in China which constituted a credible fixed exchange rate regime, the changes in Chinese exchange rates are hardly attributable to domestic financial conditions. Third, since most Chinese imported goods from the United States are invoiced in USD, the concern on disturbance of multiple invoice currency issues could be substantially attenuated when focusing on China-US trade.[3]

To analyze firm's import response to spot and forward exchange rate changes along both the extensive and intensive margins, we build a dynamic heterogeneous-firm model allowing for individual firm to adjust import decision by taking into account of future exchange rate movements. Following Chaney (2008), we define extensive margin as the number of importing firms and intensive margin as import value of each firm.[4] In the model, we assume that a firm needs to pay a fixed sunk cost and faces a probability of failure when searching for foreign intermediate good suppliers. Our model shows that firms facing future expectations of exchange rate appreciation would increase the extensive margin rather than the intensive margin of imports, while firms facing appreciation of spot exchange rates tend to expand both the intensive margin and the extensive margin of imports.

At the intensive margin, firms facing appreciation of current exchange rates tend to expand their import due to decreased price of imported intermediate goods. Future exchange rates however only affect price of imported intermediate goods and hence the import value of the firm in the future. Thus we can argue that decisions on import values made by existing importers are affected by current rather than expected future exchange rate changes.

At the extensive margin, apparently there exists a different scenario. Expected cumulative profit of import increases along with domestic currency appreciation in the future. When expected benefits surpass sunk costs of import, firms will choose to import. More importantly, due to a probability of failure, firms enter the importing market in advance to capture the opportunity to increase profitability stemming from expected appreciation of currency. Therefore, firms adjust extensive margin of imports as response to both current and future expected exchange rate shocks.[5]

In the empirical investigation, we utilize the undeliverable forward exchange rates between USD and CNY to measure market expectation on future exchange rate movements, and USD/CNY spot rates to measure current exchange rate changes. Our empirical tests are mainly conducted at monthly frequency (2000–2006) using the firm-HS6 product-country level import data extracted from the Chinese customs transaction-level database.[6] To test the import probability of non-importing firm, we also use the annual survey data of Chinese manufacturing firms collected by the National Bureau of Statistics in China (NBSC) in order to track the non-importer group.

[1] The importance of the US-China bilateral trade can be also seen from the following statistics: Taking export and import value together, the US is the largest partner country for China, which contributes 14.1% of total trade value of China in 2016. According to the latest data released by Chinese customs office, in 2016 China imports 888.7 billion RMB from the US, occupying 8.5% of total imports of China, which ranks the fifth among all the countries and regions (after EU, ASEAN (the Association of Southeast Asian Nations), Korea and Japan); China also exports 2542 billion RMB to the US (about 18.4% of total export of China), making the US as top one trade partner of China among all the countries and regions.

[2] The typical fundamentals include monetary policy and real output that are usually believed to help shaping exchange rate movements in the previous literature, e.g., Groen (2005), Wang and Wu (2015), Mark and Sul (2001) and Mark (1995). Those fundamental variables are also found to be relevant for estimating the equilibrium value of Chinese currency, and the prior studies show that, based on those fundamentals, spot exchange rate of CNY had been undervalued (e.g., Coudert and Couharde, 2005; Frankel, 2005; Michael and Rahn, 2005; Zhang, 2001; Garton and Chang, 2005). The undervalue of CNY in turn constitutes the driving force behind the expectation of CNY appreciation and the associated changes in forward premiums.

[3] When Chinese firms import from Japan they may use either JPY or USD as invoicing currency. In such cases, whether the imports use USD as vehicle currency and to what extent they use USD as vehicle currency are not observed in the Chinese customs data which makes the problem more complicated. By focusing our study on trade between the US and China, this concern is alleviated. See Li et al. (in press) for more related discussion.

[4] Chaney (2008) define the intensive margin as the size of exports by each exporter and the extensive margin as the set of exporters. Here, we adopt his definition for imports. Specifically, we define the intensive margin as the size of imports by each importer and the extensive margin as the set of imports.

[5] Fan et al. (2016) explains the extent to which news about the future could explain changes in net firm entry.

[6] The Chinese customs database available to us contains the monthly information between 2000 and 2006, but no month information during 2007–2009. To test the import probability of non importing firms, we merged the yearly customs data with the annual survey data of Chinese manufacturing firms collected from National Bureau of Statistics in China from 2000 to 2009 to track the non-importer group.

We employ two econometric specifications to study firm reactions to domestic currency appreciation at the extensive margin. First, we study the effect of exchange rate fluctuations on the growth rate of the number of importers within each HS6 product category. Second, after controlling current (spot) exchange rate changes, the effect of forward premium on the change in firms' entry probability is estimated using logit and linear probability models. Both econometric models present a significant response in firm's importing decision to realized and anticipated exchange rate changes along the extensive margin. We also find that the magnitude of firm's response to realized exchange rates is larger than that to expected future exchange rates. Along the intensive margin, we find that, reaction of existing importers by significantly adjusting the import value comes from the impact of realized spot exchange rates in lieu of future exchange rates. In other words, existing importers display "inertia response" to expectation of future exchange rate shocks.

We conduct several robustness checks. First, we test our results using subsample of ordinary trade instead of full sample, and find that our results are robust to ordinary trade sample. Second, we conduct a robustness check using subsample of observations after 2003 with the commencement of substantial variation in market expectations in exchange rate movements. Our results are not sensitive to the period after 2003 along both margins. Lastly, in addition to the specification with the changes in import responses as dependent variable, we also examine the effect of currency appreciation on import levels along both extensive and intensive margins and obtain similar results.

Our study is related to several strands of the literature. First, this paper is closely related to the studies exploring explanations for trade responses to exchange rate fluctuations. This branch of literature can be divided into two groups at the macro level and the micro level, respectively.

The macro-level studies investigate "in-elasticity" adjustment to the realized exchange rate fluctuations at the aggregate level, mostly using sectoral data (e.g., Campa and Goldberg, 2005; Chinn, 2004; Cheung et al., 2012; Dong, 2012; Devereux and Engel, 2002). They find that aggregate-level import (or export) price and value, display a lack of sensitivity to current (and past) exchange rate fluctuations.[7] Previous literature also aims to explain the reason for the incomplete pass-through, and some prior studies find that firms' pricing strategy and the behavior of "price into market" phenomena could explain the in-responsiveness to exchange rate fluctuations (e.g., Goldberg and Knetter, 1996; Knetter, 1989; Marston, 1990).

The recent micro-level literature focuses on seeking micro-foundations with heterogeneous firms to explain trade response (mainly on export side) to exchange rates fluctuations (e.g., Berman et al., 2012; Amiti et al., 2014; Gopinath et al., 2012). Berman et al. (2012) uses French firm data to show the heterogeneous response to exchange rate changes among producers with different productivity. Amiti et al. (2014) finds that exporters with various import intensity and market share present different magnitude in exchange rate pass-through. The empirical analysis of firms' export response to exchange rate fluctuations using China's customs data includes Tang and Zhang (2012) and Li et al. (2015).[8]

Recently, a new branch of literature examines whether firm response to exchange rate fluctuations is governed by economic shocks, such as monetary shocks and demand shocks. Producers also react differently to exchange rate movements trigged by various shocks. Thus, exchange rate pass through is endogenous in nature. For example, Forbes et al. (2015), and Comunale and Kunovac (2017) build the channel through which firms' price decisions in response to exchange rate movements depend on external shocks or monetary policy, and show empirical evidence that exchange rate pass through could be disentangled into movements of those factors.

Most of the aforementioned studies, especially at the micro-level, focus on the trade response to the realized exchange rates, rather than the expected future exchange rate movements. Evidence on firm response to expectation of future exchange rate movement is rarely explored. To our knowledge, the only recent relevant study is Li and Zhao (2016) that presents evidence for future exchange rate fluctuations to pass-through into current prices based on the US-China bilateral trade.

Our paper is also related to models addressing firms' import decisions in production and the mechanism of import changes under external shocks, e.g., Gopinath and Neiman (2014), Halpern et al. (2015), Amiti and Konings (2007) and Broda and Weinstein (2004). Gopinath and Neiman (2014) develops a heterogeneous trade model with intermediate inputs, and explore the effect of import price shock on productivity. Amiti and Konings (2007) estimates the effects on productivity through the shift of firm's intermediate input decision after tariff reduction. Our model follows the set-up in those production framework with imported intermediate inputs, and adds both the realized and future exchange rates into a firm's profit flows, through which to influence the import decision of the firm.

The remainder of this paper is organized as follows. Section 2 builds a model to capture import responses to current and future exchange rate fluctuations. Section 3 describes the data and measurements and offers a short description of changes in bilateral imports between China and the United States. Section 4 presents the empirical findings along the extensive and intensive margins. Section 5 provides some robustness checks and Section 6 concludes.

[7] For example, Chinn (2004) shows that US import elasticity to exchange rate changes is not statistically significant; Campa and Goldberg (2005) and Hooper et al. (1998) document a partial pass-through of exchange rates to import prices for major developed countries; Marazzi and Sheets (2007) find that the pass-through coefficient has declined during the past decade.

[8] There is also a large body of the literature exploring trade response to exchange rate volatility, e.g., Viaene and de Vries (1992), Hooper and Kohlhagen (1978), Cushman (1988) and Wong et al. (2012).

2. Model

In this section, we provide a simple, dynamic heterogeneous-firm trade model to examine the firm's import responses to realized and expected future exchange rate fluctuations at both the extensive and intensive margins.

2.1. Preference and demand

We consider the following preferences:

$$U = \left[\int_{\omega\in\Omega} x(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where $x(\omega)$ is the quantity of variety ω consumed, $\sigma > 1$ is the elasticity of substitution across varieties and Ω is the set of varieties available. The utility function implies that in a market with the aggregate expenditure E, the demand for the variety ω satisfies the following equation:

$$x(\omega) = p(\omega)^{-\sigma} P^{\sigma-1} E \tag{2}$$

where $p(\omega)$ is the price of variety ω consumer face; and $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$ is the aggregate price index exogenously determined from the perspective of the firm.

2.2. Production

2.2.1. Production

Firms are heterogeneous in productivity ϕ which is drawn from the distribution $G(\phi)$. Firm with productivity ϕ produces output according to the following production function:

$$Y = \phi L^{1-\mu} M^{\mu} \tag{3}$$

where Y is the output, L is the labor inputs, and M is the intermediate inputs bundle, respectively. The intermediate input bundle M is assembled from a continuum of intermediates inputs each indexed by z, according to the following function:[9]

$$M = \left(\int_0^1 m(z)^{\frac{\eta-1}{\eta}} dz\right)^{\frac{\eta}{\eta-1}} \tag{4}$$

where $m(z)$ is the quantity of intermediate input z. For a cost minimizing firm, the total cost of one unit of the composite intermediate is given by $P_M = \left(\int_0^1 p_m(z)^{1-\eta} dz\right)^{\frac{1}{1-\eta}}$, where $p_m(z)$ is the lowest cost of input variety z available to the firm.

The cost of the intermediate input variety z depends on whether it is purchased from a domestic supplier or from a foreign supplier. If the firm purchases intermediate z in domestic market, it pays w/a_H in term of domestic currency, where a_H is the realized domestic productivity to produce intermediate variety z and w is the wage for a domestic worker. If the firm imports the intermediate z from abroad, it pays w_F/a_F in term of the foreign currency to obtain one unit product, where a_F is the realized foreign productivity to produce intermediate variety z and w_F is the wage for a foreign worker.[10]

We can now introduce exchange rates into the model. Exchange rate e is defined as the price of domestic currency in term of foreign currency. A rising e corresponds to the appreciation of the domestic currency. The cost of imported intermediate input z in term of the domestic currency is given by $w_F/(ea_F)$. Thus the appreciation of domestic currency reduces the cost of imported intermediate input z.

Following Eaton and Kortum (2002) and Antràs et al. (2016), we assume that a country's efficiency to produce the intermediate goods follows the Frechet distribution.

$$\Pr(a_l(z) \leqslant a) = e^{-T_l a^{-\theta}}, \quad \text{with } T_l > 0 \tag{5}$$

T_l governs the state of technology in domestic country ($l = H$) and the state of technology in foreign country ($l = F$), while θ determines the variability of productivity draws across inputs. The cost of the intermediates input bundle is given by:

$$P_M = \zeta\left[\left(T_H w^{-\theta} + T_F \frac{w_F}{e}\right)^{-\theta}\right]^{-1/\theta} \tag{6}$$

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[9] China's imports are dominated by intermediate inputs instead of final consumption goods. Specifically, the universe of Chinese customs data shows that intermediate goods and capital goods account for 74% and 19%, and final goods account for only 4%, of total import values during 2000–2006. A fourth "uncertain" category accounts for approximately 3%. If we view capital goods also as "intermediates", then intermediate goods account for 93% of total imports. Hence, our model assume that firm's imports are used to production.

[10] In the model, we assume it is producer currency pricing, which is corresponding to the reality that most of China's imports from US are invoiced in USD. Thus appreciation of CNY directly pass-through to import price for Chinese producers.

where $\zeta = \left[\Gamma\left(\frac{\theta+1-\eta}{\theta}\right)\right]^{1/(1-\eta)}$ and Γ is the gamma distribution function.

Given the domestic rental rate r, the domestic wage of w and foreign wage of w_F, firm chooses labor input L and the amount of domestic intermediate inputs $z \in [0,1]$ to minimize its production cost under the exchange rate e. The cost function $C(\phi, e)$ is given by:

$$C(\phi, e) = \frac{B_e^{\mu}}{\phi} \frac{\zeta^{\mu} w}{T_H^{\mu/\theta} \mu^{\mu} (1-\mu)^{1-\mu}} \tag{7}$$

where $B_e = \left[1 + \frac{T_F}{T_H}\left(\frac{w_F}{we}\right)^{-\theta}\right]^{\frac{-1}{\theta}}$ denotes the cost of intermediate inputs. Note B_e is a cost-reduction factor because $B_e \leqslant 1$ reflects a cost reduction due to the use of imported inputs. Since rental cost and wage are exogenously given, the item $\frac{\zeta^{\mu} w}{T_H^{\mu/\theta} \mu^{\mu}(1-\mu)^{1-\mu}}$ is a constant and identical for all firms. An appreciation of the local currency represents for a decrease in the cost of imported intermediate inputs, hence decreases the cost-reduction factor B_e, i.e.,

$$\frac{\partial B_e}{\partial e} < 0 \tag{8}$$

2.2.2. Market structure

Producers engage in monopolistic competition, and the total number of producers in equilibrium is N. In order to import the foreign intermediate inputs, the firms who do not import at the initial period need to pay a fixed entry cost F in order to search for their foreign intermediate goods supplier.[11] After paying the fixed cost of entry F, we assume that the firms have a probability of $\lambda \in (0,1)$ that would not match with a supplier of the foreign intermediate goods.[12] In other words, the potential importer, after paying a fixed cost F, takes a probability of $1-\lambda$ to change the status from non-importing to importing. At the initial period, the number of firms importing the foreign intermediate goods is given by $(1 - G(\phi^*))N$, where ϕ^* is the import productivity cutoff.

2.3. Firm's decision

We examine the decision of importing firms and non-importing firms separately. Importing firms choose the optimal price to maximize its profit at each period according to the following equation:[13]

$$\pi_{imp}(\phi, e) = (p - C(\phi, e))x, \quad \text{where } C(\phi, e) = \frac{B_e^{\mu}}{\phi} \frac{\zeta^{\mu} w}{T_H^{\mu/\theta} \mu^{\mu}(1-\mu)^{1-\mu}} \tag{9}$$

where the demand x is given by demand Eq. (2) and marginal cost $C(\phi, e)$ is given by the production cost function (7).

The first-order condition implies that optimal price follows $p(\phi, e) = \frac{\sigma}{\sigma-1} C(\phi, e)$ and hence firm's profit $\pi_{imp}(\phi, e)$ satisfies the following equation:

$$\pi_{imp}(\phi, e) = \left(\frac{B_e^{\mu}}{\phi}\right)^{1-\sigma} A \tag{10}$$

where $A = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1} \frac{\zeta^{\mu} w}{T_H^{\mu/\theta} \mu^{\mu}(1-\mu)^{1-\mu}}\right)^{1-\sigma} P^{\sigma-1} E$ is identical for all firms. For non-importing firms, $B_e = 1$ and their profit becomes:

$$\pi_{non}(\phi) = \left(\frac{1}{\phi}\right)^{1-\sigma} A \tag{11}$$

To be simplified, we set time 0 to be the current period. At time 0, the firm faces the current and future exchange rates, $(e_0, \bar{e}_0)$, where e_0 denotes the current exchange rate, $\bar{e}_0 = (e_1, e_2, \ldots)$ denotes the expected future exchange rate for times $1, 2$ and so on. The value function for importing firms and non-importing firms are $V_{imp}(\phi, e_0, \bar{e}_0)$ and $V_{non}(\phi, e_0, \bar{e}_0)$, respectively. According to the initial import status, the value functions for these two groups follow (12) and (13), respectively.

$$V_{imp}(\phi, e_0, \bar{e}_0) = \max_{\text{import or not}} \{\pi_{imp}(\phi, e_0) + \beta E V_{imp}(\phi, \bar{e}_0), \pi_{non}(\phi) + \beta E V_{non}(\phi, \bar{e}_0)\} \tag{12}$$

$$\begin{aligned} V_{non}(\phi, e_0, \bar{e}_0) = \max_{\text{import or not}} & \{(1-\lambda)[\pi_{imp}(\phi, e_0) + \beta E V_{imp}(\phi, \bar{e}_0)] \\ & + \lambda[\pi_{non}(\phi) + \beta E V_{non}(\phi, \bar{e}_0)] - F, \pi_{non}(\phi) + \beta E V_{non}(\phi, \bar{e}_0)\} \end{aligned} \tag{13}$$

[11] See Antràs et al. (2016), Halpern et al. (2015) and Gopinath and Neiman (2014) introduce the same assumptions.

[12] Previous literature provide empirical evidence on the export/import failure rate, e.g., Cadot et al. (2013) and Besedes and Prusa (2006). Dixit (1989b) and Dixit (1989a) rationalize the uncertainty that faced by exporters when they make trade decision.

[13] In our model, maximizing its discount profit flow is equivalent to maximizing its profit in each period since we ignore the dynamic inputs of production which would affect the next period profit.

where $\beta = \frac{1}{1+r}$, and r is interest rate.[14] The future profit flow is discounted by $\beta \in (0,1)$. Due to the strict capital control in China, the interest parity does not hold for China. This implies that the interest rate r is unrelated with the exchange rate e.[15]

By comparing importing and non-import status for importers, we have the following Lemma.[16]

Lemma 1. *Importing is always a dominant strategy for existing importers.*

See Appendix B for the proof of Lemma 1.

It implies that the importing firms always choose to import in subsequent periods. Hence, the value function for importers is given by $V_{imp}(\phi, e_0, \bar{e}_0) = \sum_{m=0}^{\infty} \beta^m \pi_{imp}(\phi, e_m)$, where $\beta = \frac{1}{1+r}$ represents the discount rate.

For non-importing firms, they decide whether to start importing by comparing profit flows between these two status according to Eq. (13). There exist a cut-off productivity ϕ_0^* at period 0 as implicitly defined by:

$$(1-\lambda)\left[\pi_{gap}(\phi_0^*, e_0) + \beta\left[EV_{imp}(\phi_0^*, \bar{e}_0) - EV_{non}(\phi_0^*, \bar{e}_0)\right]\right] = F \tag{14}$$

where $\pi_{gap}(\phi_0^*, e_0) = \pi_{imp}(\phi_0^*, e_0) - \pi_{non}(\phi_0^*) = \left[B_e^{\mu(1-\sigma)} - 1\right] A\phi^{\sigma-1}$ reflects the profit gap between importing and non-importing. It is a increasing function in both exchange rate e and the productivity ϕ.

Since the marginal firm with productivity ϕ_0^* is indifferent with regard to either importing or non-importing at period 0, for the purpose of simplicity in derivation, without the loss of generality, we treat that firm as non-importer. In other words, we assume that such a firm would not search the supplier of foreign intermediate goods at period 0. This non-importing firm with productivity ϕ_0^* would only search the supplier of foreign intermediate goods at the period $m > 0$, when ϕ_0^* exceeds the import productivity cutoff at period m, ϕ_m^*. However, this search has a probability λ to fail, i.e., the probability for this firm to successfully become an importer at period m is $1-\lambda$. Given the expected exchange rate trends $(e_0, e_1, e_2, \ldots)$, we assume that the expected import productivity cutoff at the periods $(d_1, d_2, \ldots d_j, \ldots)$ would be lower than ϕ_0^* and thus, the firm would attempt to enter importing market at the periods $(d_1, d_2, \ldots, d_j, \ldots)$. In other words, d_j corresponds to the period of the firm's jth attempt to become an importer.[17]

Since at any time d_j, the non-importing firms with productivity cutoff ϕ_0^* would choose to import, it has the probability λ^j to fail. Thus the difference value between importing and non-importing becomes:

$$EV_{imp}(\phi_0^*, \bar{e}_0) - EV_{non}(\phi_0^*, \bar{e}_0) = \sum_{j=0}^{\infty} \sum_{m=d_j}^{d_{j+1}-1} \lambda^j \beta^m \pi_{gap}(\phi_0^*, e_m) + \sum_{j=0}^{\infty} \lambda^j \beta^{d_{j+1}} F \tag{15}$$

where $d_0 = 0$ and $\beta^0 = \lambda^0 = 1$. In Eq. (15), the term $\sum_{j=0}^{\infty} \sum_{m=d_j}^{d_{j+1}-1} \lambda^j \beta^m \pi_{gap}(\phi_0^*, e_m)$ reflects the discounted profit gap between importing firms and non-importing firms; the term $\sum_{j=0}^{\infty} \lambda^j \beta^{d_{j+1}} F$ reflects the discounted total payment for fixed import cost when non-importing firms try to import at the periods $(d_1, d_2, \ldots d_j, \ldots)$.[18]

The previous equation implies:

$$\pi_{gap}(\phi_0^*, e_0) + \beta[EV_{imp}(\phi_0^*, \bar{e}_0) - EV_{non}(\phi_0^*, e_0)] = \sum_{j=0}^{\infty} \sum_{m=d_j}^{d_{j+1}} \lambda^j \beta^m \pi_{gap}(\phi_0^*, e_m) + \sum_{j=0}^{\infty} \lambda^j \beta^{d_{j+1}+1} F \tag{16}$$

As a result, the previous equation together with Eq. (14) imply:

$$(1-\lambda)\left[\sum_{j=0}^{\infty} \sum_{m=d_j}^{d_{j+1}} \lambda^j \beta^m \pi_{gap}(\phi_0^*, e_m) + \sum_{j=0}^{\infty} \lambda^j \beta^{d_{j+1}+1} F\right] = F \tag{17}$$

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[14] For non-importing firm, its value becomes $(1-\lambda)[\pi_{imp}(\phi, e_0) + \beta EV_{imp}(\phi, \bar{e}_0)] + \lambda[\pi_{non}(\phi) + \beta EV_{non}(\phi, \bar{e}_0)] - F$ if it choose to import by paying the fixed cost F; its value is $\pi_{non}(\phi) + \beta EV_{non}(\phi, \bar{e}_0)$ if it does not choose to import.

[15] The uncovered interest parity implies that $r_t^* = r_t + \frac{\bar{e}_t - e_t}{e_t}$, where $\bar{e}_t$ is the expected exchange rate. If capital is perfectly mobile internationally, domestic and foreign interest rates will be related to future appreciation according to uncovered interest parity. Note that the relation between interest rates and exchange rates might also depend on the exchange rate regime. Under the fixed exchange rate regime, UIP is unlikely to hold due to the pegging of RMB to USD. However, when it moves to the "managed floating" regime, the Chinese government still imposes a strict capital control in setting a guidance range for exchange rate movements. Under such situation, the UIP condition is still unlikely to hold. Nonetheless, we could not completely deny the possibility of the potential relationship with UIP condition in China during the latter regime. The forward premium might be weakly related to interest rates in the managed floating regime. In case of the potential existence of UIP condition, we add interest rate into our empirical specifications to control for the potential confounding effect from interest rates.

[16] To be simplified, we ignore the probability of importing firms to become non-importing in our model. If we assume that all importing firms faces a constant probability in every period of a bad shock that would force them to become non-importing, our propositions still hold.

[17] For example, when the expected productivity cutoff at period 1, 3 and 4 is higher than ϕ_0^* and at period 2, 5 and 6 is lower than ϕ_0^*, then $d_1 = 2, d_2 = 5, d_3 = 6$.

[18] Specifically, the term $\lambda^j \beta^m \pi_{gap}(\phi_0^*, e_m)$ reflects the discounted profit gap between importing firms and non-importing firms with productivity ϕ_0^* at time m, where $\pi_{gap}(\phi_0^*, e_m)$ denotes the profit gap between importing and non-importing at time m; λ^j denotes the probability of successive fail for j times; β^m denotes the discount rate at time m.

2.4. Implications

We now turn to the scenario with expected future exchange rate shock, where the market has anticipated the domestic currency to appreciate in the future. Considering the case where exchange rate appreciates from $(e_0, e_1, e_2, \ldots)$ to $(e'_0, e'_1, e'_2, \ldots)$. Now, importing productivity cutoff ϕ_0^* becomes $\widetilde{\phi}_0^*$; d_j becomes d'_j. Now, according to Eq. (17), we have:[19]

$$\sum_{j=0}^{\infty}\sum_{m=d'_j}^{d'_{j+1}}\lambda^j\beta^m\pi_{gap}(\widetilde{\phi}_0^*, e'_m) + \sum_{j=0}^{\infty}\lambda^j\beta^{d'_{j+1}+1}F = \sum_{j=0}^{\infty}\sum_{m=d_j}^{d_{j+1}}\lambda^j\beta^m\pi_{gap}(\phi_0^*, e_m) + \sum_{j=0}^{\infty}\lambda^j\beta^{d_{j+1}+1}F \tag{18}$$

Given the expected distribution of the exchange rate $(e_0, e_1, e_2, \ldots)$, the expected import productivity cutoff would be lower than ϕ_0^* during the periods $(d_1, d_2, \ldots d_j, \ldots)$. As a results, choosing to start importing at periods d_j, for all j, would generate the maximum profits for non-importing firms with productivity ϕ_0^*. In other words, $EV_{non}(\phi_0^*, \bar{e}_0)$ is maximized when choosing to import for the periods $(d_1, d_2, \ldots d_j, \ldots)$. Correspondingly, the value of $EV_{imp}(\phi_0^*, \bar{e}_0) - EV_{non}(\phi_0^*, \bar{e}_0)$ is minimal when choosing to import at the periods $(d_1, d_2, \ldots d_j, \ldots)$. According to Eq. (15), we have the following:

$$\sum_{j=0}^{\infty}\sum_{m=d_j}^{d_{j+1}}\lambda^j\beta^m\pi_{gap}(\phi_0^*, e_m) + \sum_{j=0}^{\infty}\lambda^j\beta^{d_{j+1}+1}F \leqslant \sum_{j=0}^{\infty}\sum_{m=d'_j}^{d'_{j+1}}\lambda^j\beta^m\pi_{gap}(\phi_0^*, e_m) + \sum_{j=0}^{\infty}\lambda^j\beta^{d'_{j+1}+1}F \tag{19}$$

The previous two Eqs. (18) and (19) imply that (see detailed derivations for Eq. (20) in Appendix C):

$$\sum_{j=0}^{\infty}\sum_{m=d'_j}^{d'_{j+1}}\lambda^j\beta^m\pi_{gap}(\widetilde{\phi}_0^*, e'_m) - \sum_{j=0}^{\infty}\sum_{m=d'_j}^{d'_{j+1}}\lambda^j\beta^m\pi_{gap}(\phi_0^*, e_m) \leq 0. \tag{20}$$

Then we have:

$$\widetilde{\phi}_0^* \leqslant \left[\frac{\sum_{j=0}^{\infty}\sum_{m=d'_j}^{d'_{j+1}}\lambda^j\beta^m\left[(B(e_m))^{\mu(1-\sigma)} - 1\right]}{\sum_{j=0}^{\infty}\sum_{m=d'_j}^{d'_{j+1}}\lambda^j\beta^m\left[(B(e'_m))^{\mu(1-\sigma)} - 1\right]}\right]^{\frac{1}{\sigma-1}}\phi_0^* \tag{21}$$

As the exchange rate e_m appreciates to e'_m, the item $(B(e_m))^{\mu(1-\sigma)}$ would increase to $(B(e'_m))^{\mu(1-\sigma)}$. If both β and λ are larger than zero, $\widetilde{\phi}_0^*$ is less than ϕ_0^* as e_m appreciates into e'_m for any time m since new import productivity cut-off $\widetilde{\phi}_0^*$ is smaller than the right term of Eq. (21) and the item within the large bracket in right-hand side of Eq. (21) is less than one. The more exchange rate appreciates (i.e. e_m appreciates into a higher e'_m) for any m, the smaller the cut-off productivity becomes (i.e. ϕ_0^* decreases into a lower $\widetilde{\phi}_0^*$). As a result, more firms would start to import as current or future domestic currency appreciates. Moreover, the impact of the change in expected exchange rate e_m is weaker than the impact of spot exchange rate fluctuations since both λ^j and β^m are less than one. In other words, spot exchange rate change always have significant effect on current import decision.

Considering the distribution of firms' productivity, the total number of importing firms (i.e., the firm mass) follows $(1 - G(\phi_0^*))N$. The firm mass represents extensive margin of import, thus satisfies the following proposition:[20]

Proposition 1. *When $\lambda \neq 0$ and $\beta \neq 0$, the appreciation of the exchange rate e_t would increase the number of importing firms (i.e., extensive margin). Both future exchange rate e_t (for $m > 0$) fluctuations and spot exchange rate e_0 rate fluctuations play a role in determining the extensive margin of imports. Potential importers' response to spot exchange rate changes is stronger than to future exchange rate changes.*

From the proposition, we see that both spot and expected exchange rate appreciation would increase the extensive margin. Moreover, the response to changes in spot exchange rate is larger than to the changes in future exchange rate. After exploring the extensive margin response to the spot and expected future exchange rate changes, we move forward to check the response of intensive margin in import. In our model, maximizing its discount profit flow is equivalent to maximizing its

[19] Here, we would not make constraints on the exchange rate appreciation, i.e., the exchange rate could appreciate infinitely. Should we assume that there is an upper bound for the exchange rate appreciation, the following derivations and Proposition 1 and 2 would not be affected. This can be seen from the cutoff equation, Eq. (21): as long as the exchange rate e_m appreciates to e'_m, even just with an infinitesimal change, the term inside brackets is always less than 1. As a result, new import productivity cutoff $\widetilde{\phi}_0^*$ is always less than ϕ_0^*.

[20] The number of importing firms would not change during the depreciation of the exchange rate. As the exchange rate depreciates (i.e., e_m depreciates into e'_m), the import cutoff increases. However, given that domestic exchange rates do not depreciate too much, the existing importers would not exit import market since importing is always a dominant strategy for existing importers according to Lemma 1. If we assume that there is an additional fixed cost needed to be paid in each period, the importers are possible to exit when the exchange rate depreciates. This is because the net profit excluding the fixed costs for existing importers could be negative as the exchange rates depreciate when there is an additional fixed cost in each period. In order to simplify our derivations, we ignore this possibility.

profit in each period since the profit at time t only depends on the corresponding input at time t. For existing importers, the ideal intermediate input equals the static optimized one. The importer's import value as $R_{imp}(\phi, e)$ satisfies:

$$R_{imp}(\phi,e) = \frac{T_F\left(\frac{w_F}{e}\right)^{-\theta}}{T_H w^{-\theta} + T_F\left(\frac{w_F}{e}\right)^{-\theta}} \mu C(\phi,e) x = \frac{T_F\left(\frac{w_F}{e}\right)^{-\theta}(\sigma-1)}{T_H w^{-\theta} + T_F\left(\frac{w_F}{e}\right)^{-\theta}} \mu \left(\frac{B_e^{\mu}}{\phi}\right)^{1-\sigma} A \tag{22}$$

where the import share $\frac{T_F\left(\frac{w_F}{e}\right)^{-\theta}}{T_H w^{-\theta}+T_F\left(\frac{w_F}{e}\right)^{-\theta}}$ and $(B(e))^{\mu(1-\sigma)}$ are both increasing function of e. As a result, an increase in the spot exchange rate e raises individual firm's import value, i.e., the intensive margin of imports.[21] However, the firm's import value is not affected by the expected future exchange rate movements e_t. Hence, we have the following proposition:

Proposition 2. *Unlike extensive margin, import value of firms (i.e. intensive margin) positively responds to spot exchange rate appreciations but does not respond to future exchange rate fluctuations.*

From Propositions 1 and 2, the response in aggregate import value change to spot exchange rate stems from both the extensive margin and the intensive margin. However, the aggregate import value change to expected exchange rate changes mainly comes through adjustment along the extensive margin rather than intensive margin. In Appendix D, we further discuss that there even exist negative responses of the intensive margin to the expected future exchange rate. This would amplify the difference between the impact of spot rates and that of future rates in terms of the intensive margin response.

3. Data, measurements, and empirical strategy

This section describes our data and measurements of key variables, and discusses the reason of taking US-China trade data for the empirical investigation. We also present some statistical patterns based on the data of China's imports from the United States.

3.1. Data and measurements

Our data sources are threefold: (1) firm-HS6 product-country level import data from China's General Administration of Customs; (2) Chinese firm annual survey data from the National Bureau of Statistics of China (NBSC), and (3) historical data on spot exchange rates and forward exchange rates from Blomberg as well as other macro economics variables from World Bank.

The customs data record detailed information of all China's international trade transactions from year 2000 to 2009. It does not provide month information after 2006. Since monthly information is missing from 2007 to 2009, our monthly empirical tests only cover the time length from Jan 2000 to Dec 2006. For each transaction, the dataset provides source and destination country of shipment, import and export value, product classification in HS-8 code, firm's contact information (e.g., company name, telephone, zip code and contact person), types of firm (e.g., state owned, domestic private firms, foreign invested and joint ventures) and customs regime (e.g., "Processing and Assembling", "Processing with Imported Materials", and "ordinary trade"). We then employ a number of procedures to clean the customs data and document import behavior of firms. We drop observations with missing import value, quantity or source country, and convert HS product codes after 2002 into HS 1996 codes at HS-6 digit level to keep consistency over time.[22]

We plot the time trend of monthly import data in Fig. A.1 in Appendix, where Fig. A.1(a) and (b) presents the aggregate import value and the number of importers, respectively. Both show a steady increasing trend over time though fluctuations also present. Fig. A.1(c) and (d) displays the mean and median import value per firm (i.e., the intensive margin), and show a slight and weak upward trend.[23] For robustness, a subsample that contains only continuing importers is examined and displays a similar pattern of the mean/median import value per firm as in the full sample (see Figs. A.2(a) and (b) in Appendix). Those graphs suggest that, rather than the increase in the intensive margin, the surge of new entrants at the extensive margin is the main driving force for the surge in China's aggregate import value from the United States.

Following the approach in Bernard et al. (2009), we further conduct a decomposition exercise and obtain the contribution of each margin to aggregate import growth (see Table A.1 in Appendix). We find that the majority of total import growth comes from the entry of new firms (on average 73% contribution), while the changes in import value of existing importers only contribute a small proportion of approximately 27%.[24] If comparing China's import margins with the United States in Bernard et al. (2009), the weight contributed by the extensive margin in China (73%) is larger than that in the United States

[21] The import value of firm decreases as spot exchange rate e depreciates.

[22] China changed HS-8 codes in 2002 and 2007. Since we have the concordances among HS codes only available at HS-6 instead of HS-8 digit level, we use the concordance table from the United Nations Comtrade to convert HS product codes over time.

[23] The yearly import data from 2000 to 2009 also show similar pattern as the monthly data. To save space, the graphs based on yearly data are not reported in the paper but available upon request.

[24] The contribution of the extensive margin represents the aggregate import changes contributed by the change of total number of importers, while that of the intensive margin represents the one contributed by the change in average import value per firm.

(58%). Thus, it is safe to conclude that, the extensive margin, rather than the intensive margin, is the dominant factor in explaining the substantial growth of China's aggregate imports from year 2000 to 2009.

One key indicator in our study is the probability of firm to import, which is specified by comparison between firms imports and firms do not import. As the unavailability of non-importing firms in Customs data, we turn to data from Annual Survey Data of Chinese Manufacturing Firms collected by the NBSC.[25] It is the most comprehensive Chinese dataset covering all state-owned enterprises (SOEs) and non-state-owned enterprises with annual sales of at least five million CNY (Chinese currency) from 2000 to 2009, within which firms' production information (e.g. employment, capital stock, gross output, value added), firm's identification information (e.g., company name, telephone number, zip code, contact person, etc.), and information on major accounting statements are provided. We merge firm-product-level transaction custom data with NBSC Database by matching firms' contact information firstly with company name, then with both zip code and telephone number, and finally with telephone number and contact person's name.[26] After matching, information about whether a firm imports is obtained consequently. Compared with the importing firms recorded by the Custom Database, the merged sample covers about 46% of total import value in the Custom Database. When we use the merged sample to do the empirical tests, we use yearly data with a longer time span from 2000 to 2009.[27]

Both the current (spot) and non-deliverable forward exchange rates are obtained from Blomberg.[28] Forward rates with various maturity, e.g. three-month, six-month, nine-month and twelve-month, are adopted as proxy for market's expectation of future exchange rate. In the empirical tests, we compute an annualized forward premiums based on the forward exchange rates with different maturity to measure the changes of expected future fluctuations. Specifically, we calculate a series of k-month forward premiums between USD and CNY as $\Delta fwd_{t,k} = \ln[FXR_{t+k}/EXR_t]$, where FXR_{t+k} is forward rate with k-month maturity at month t and EXR_t is contemporaneous (spot) exchange rate at period t.[29] To make forward premium with different maturity comparable, we further calculate an annualized forward premium $\Delta fwd^{ann}_{t,k}$ based on various k-month forward rates, according to $\Delta fwd^{ann}_{t,k} = \frac{12}{k}\Delta fwd_{t,k}$.

3.2. Exchange rate policy reform and expected CNY appreciation

Our dataset is from 2000 to 2009 in the context of China's exchange rate policy reform. In July 2005, China declared to abandon its fixed exchange rate to the U.S. dollar, the spot exchange rate of Chinese Yuan against U.S. Dollars began, as a result, to appreciate since then. However, market estimation on appreciation of Chinese currency came, as a matter of fact much earlier than the official announcement. It can be traced to early 2003 when Japan firstly made a proposal pushing China to reform its exchange rate regime in G7 meeting of that year. The Chinese government faced increasing pressure involving its currency reform.[30] In late 2003, the USD/CNY forward exchange rates started to increase due to the expected appreciation of Chinese Yuan.

Fig. 1 captures the fluctuations of both spot and future exchange rates between CNY and USD from 2000 to 2009. Note that the nominal exchange rate of CNY against USD (the first graph) kept flat before the middle of 2005 and appreciated gradually afterwards. The forward exchange rates of CNY (including three-, six-, nine- and twelve-month forward) appreciated in the late 2003, especially for the nine-month and twelve-month maturities. Those reported forward rates are available from off-shore foreign exchange market such as Hong Kong or Singapore.

The fluctuation of USD/CNY exchange rate provides an ideal setting to test our theoretical predictions for the following reasons. First, both spot and forward exchange rates of CNY against USD appreciate for a substantially long term. This gradual and steady appreciation is seldom observed in the exchange rates of CNY against other currencies whose movements usually follow random walk (see related discussion in Li and Zhao (2016)). Second, engaging in direct trade of foreign exchange rate derivatives was forbidden for Chinese firms in the past, manufacturing producers were incapable to hedge future exchange rate risks by using future derivatives (e.g. non-deliverable forward contract). As a result, firms only reacted to foreign currency fluctuations by adjusting their import decisions in advance. Third, owing to strict capital control in China, exchange rate movements hardly influence domestic financial conditions, which facilitates focusing on trade under exchange rate changes without the need of addressing the liquidity status in the general equilibrium.[31]

The forward exchange rate reported in the foreign exchange market may be the most accurate and available forecast of future exchange rate for domestic producers. In order to further justify that US-China bilateral forward exchange rates play as a valid proxy for predicting future exchange rates, we adopt a simple OLS regression to test the predictive power of the forward rates between CNY and major currencies (including AUD, CAD, EUR, JPY, GBP, KRW and USD). The exchange rate

[25] The Customs data only contain all exporting firms and importing firms. Thus, if a firm neither imports nor exports, it would not appear in the Customs data.

[26] See detail descriptions in Fan et al. (2015) and Fan et al. (2015).

[27] There is no month information in NBSC firm-level data. As a result, we should do the yearly empirical tests when we use the merged data. Moreover, using the sample of 2000–2006 to conduct the yearly empirical tests would not affect our results.

[28] These data represent non-deliverable forward data in an off-shore exchange rate market outside mainland China.

[29] The k-month expected exchange rate equals $\Delta fwd_{t,k} * (1 + r^f)/(1 + r)$, where r^f and r are the interest rates in foreign and domestic countries, respectively. Since interest rates change less frequently than exchange rates, the effect is absorbed in the year dummies in regressions. So we use the forward exchange rates to directly measure the market's expectation for future exchange rates.

[30] In the G7 meetings of 2004, more countries and global institutions including the IMF started to urge China to reform its foreign exchange rate policy.

[31] We still control for interest rate in our empirical study.

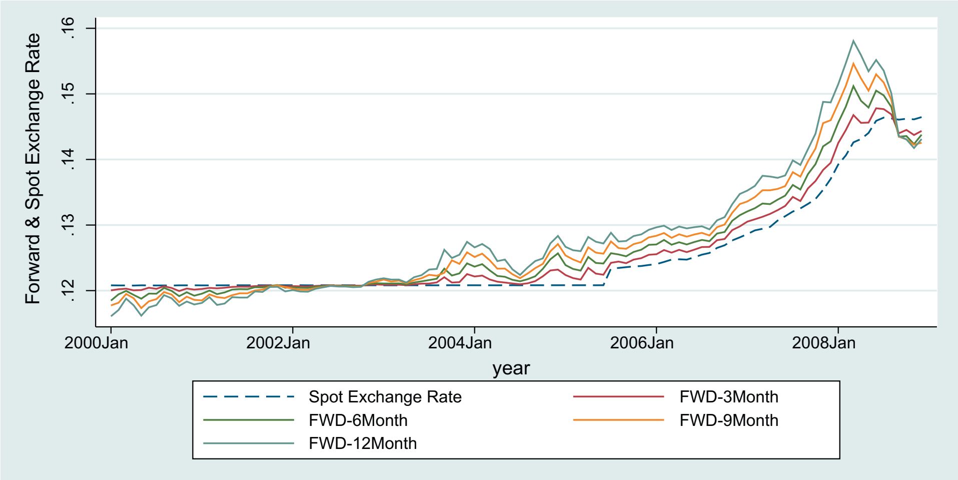

Fig. 1. Forward & spot exchange rate fluctuations between CNY and USD.

series are from January 2000 to September 2010, spanning 129 months. Following the classic approach of testing "forward premium puzzle" in previous literature (e.g., Fama, 1984), we regress 3-month forward premium $FXR_{t+3} - EXR_t$ on the gap between 3-month realized exchange rates EXR_{t+3} and spot rates EXR_t for each currency pairs:

$$FXR_{t+3} - EXR_t = \beta(EXR_{t+3} - EXR_t) + \epsilon_t \tag{23}$$

The statistics is displayed in Table 1. The significantly positive coefficient in column 7 shows that forward exchange rates between CNY and USD have strong power in predicting the actual future changes. Except for CNY/USD, the coefficients of $EXR_{t+3} - EXR_t$ between CNY and other major currencies are all insignificant (see columns 1–6), which implies that the forward rate of CNY against other major currencies could hardly be employed as proxy for predicting future exchange rates.[32]

In addition, we plot the bilateral spot and forward exchange rates between CNY and 7 major currencies (including USD) in Fig. A.3. The patterns displayed in Fig. A.3 show a clear and steady appreciation of spot exchange rate of CNY against USD after exchange rate reform in 2005 whereas the corresponding forward rates started appreciating as early as 2003. The pattern of CNY/USD exchange rate movement is driven by economic fundamentals rather than noise shocks during China's shift of its exchange rate regime from the pegging to USD regime to a managed floating one.[33] Thus the expectation of appreciation of CNY against USD would be generally viewed as long-lasting and steady. However, the similar pattern is seldom observed for exchange rates between CNY and other major currencies which in contrast tend to follow random walk pattern as shown in Fig. A.3. [34] Hence, our empirical investigation is based on data between China and the United States by employing CNY/USD forward rate as future exchange rate predictor. This China-US based empirical investigation can better reflect firms' import responses to expected future exchange rate movements although it sacrifices the potential benefit from cross-country variations.

4. Empirical results

Our model have two main theoretical predictions. First, the number of importers (i.e., extensive margin) responds to both the spot exchange rate fluctuations and the expected future exchange rate fluctuations. Second, the import value for each individual existing importer (i.e., intensive margin) only responds to the spot exchange rate movements but not to the expected future exchange rate movements. In this section, we test these two theoretical predictions on extensive margin and intensive margin, respectively.

4.1. Extensive margin

In the extensive margin test, we focus on the number of importers within the same HS-6 product category to test whether both contemporaneous and future exchange rate appreciations encourage firms to import from abroad. Our major sample

[32] If we use forward premium based longer maturity, i.e., six-,nine-,twelve-month forward, and regress forward premiums $FXR_{t+k} - EXR_t$ on the gap between EXR_{t+k} and EXR_t for the USD/CNY exchange rate (when $k = 6, 9,$ *or* 12 respectively), the coefficients of $EXR_{t+k} - EXR_t$ are still significant positive. Specifically, the coefficients of EXR_{t+k} and EXR_t for $k = 6, 9$, or 12 are 0.664, 0.626, and 0.576, respectively. All of them are significant at 0.1% level.

[33] The previous studies usually include real output, monetary policy, foreign reserve, capital flows, fiscal policy, productivity differential, terms of trade, etc. into economic fundamentals to estimate the equilibrium value of RMB and find that RMB was undervalued before the exchange rate reform (e.g., Coudert and Couharde, 2005; Frankel, 2005; Michael and Rahn, 2005; Zhang, 2001; Garton and Chang, 2005).

[34] The patterns of exchange rates between CNY and other currencies also depend on, the (indirect) exchange rate regime of CNY vis-à-vis the currencies as those currencies may peg or float against USD.

Table 1
Forward rates test for major currencies.

	Dependent variable: $FXR_{t+k} - EXR_t$						
	(1) AUD	(2) CAD	(3) EUR	(4) GBP	(5) JPY	(6) KRW	(7) USD
$EXR_{t+3} - EXR_t$	−0.171	0.172	−0.681	0.0139	0.429	0.162	0.620***
	(0.5771)	(0.415)	(0.449)	(0.458)	(0.407)	(0.460)	(0.060)
Observations	129	129	129	129	129	129	129

*p < 0.10.
**p < 0.05.
*** $p < 0.01$.

covers the monthly import from Jan 2000 to Dec 2006. The baseline empirical specification for extensive margin is written as follows:

$$\Delta \ln Num_{pt} = \beta_1 \Delta fwd^{ann}_{t,k} + \beta_2 \Delta exr_t + \beta_3 \pi_t + \beta_4 i_t + \varphi_p + \varphi_q + \varepsilon_{pt} \tag{24}$$

where the subscript t refers to the month. The dependent variable $\Delta \ln Num_{pt}$ is the change of the (log) number of firms importing the HS6 product p at month t. The independent variables include an annualized forward premium based on k-month forward rate $\Delta fwd^{ann}_{t,k}$ and the logarithm of spot exchange rate changes Δexr_t. To be specific, the annualized forward premiums $\Delta fwd^{ann}_{t,k}$ between USD and CNY are calculated based on forward rates with k-month maturity (see more detailed description in Section 3.1). In order to make spot exchange rate changes comparable to annualized forward premium within one equation, the spot exchange rate changes Δexr_t is also annualized as $12 * ln[EXR_t/EXR_{t-1}]$, where the subscript t refers to the month t. Also, the domestic inflation rate π_t and interest rate i_t at month t are also included into our regression to control for macro-level economic conditions. To control the time trend if any, we include the time fixed effect φ_q at quarterly basis for every quarter over time. This time fixed effect φ_q includes 28 dummy variables for the sample period 2000–2006. In addition, we also add the HS6-product fixed effect φ_p to control unobservable product characteristics.

The baseline results are displayed in Table 2. The first four columns report the results only with time fixed effect. In the last four columns, we also add product fixed effect. As shown in Table 2, both the coefficients of forward premiums β_1 and the coefficients of spot exchange rate change β_2 are significant positive in all columns. This suggests that the number of importers within a certain product rises when current or expected future exchange rate appreciation occurs. This supports our theoretical prediction that both spot and forward exchange rate appreciations raise the number of importing firms (i.e., extensive margin) significantly.

Table 2
Extensive margin of imports (from U.S.).

	Dependent variable: the change of the number of importing firms							
	$\Delta \ln Num_{pt}$				$\Delta \ln Num_{pt}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δexr_t	0.647***	0.511***	0.544***	0.481***	0.622***	0.487***	0.520***	0.458***
	(0.078)	(0.079)	(0.080)	(0.080)	(0.080)	(0.081)	(0.082)	(0.081)
$\Delta fwd^{ann}_{t,3}$	0.162***				0.159***			
	(0.034)				(0.035)			
$\Delta fwd^{ann}_{t,6}$		0.300***				0.299***		
		(0.033)				(0.034)		
$\Delta fwd^{ann}_{t,9}$			0.256***				0.254***	
			(0.033)				(0.034)	
$\Delta fwd^{ann}_{t,12}$				0.324***				0.322***
				(0.034)				(0.035)
Interest rate	−0.041***	−0.035***	−0.035***	−0.032***	−0.040***	−0.034***	−0.034***	−0.031***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Inflation rate	−0.561***	−0.697***	−0.670***	−0.743***	−0.560***	−0.696***	−0.668***	−0.741***
	(0.055)	(0.056)	(0.056)	(0.058)	(0.057)	(0.058)	(0.058)	(0.060)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product fixed effect	No	No	No	No	Yes	Yes	Yes	Yes
Observation	213,380	213,380	213,380	213,380	213,380	213,380	213,380	213,380
R-square	0.0004	0.0005	0.0004	0.0005	0.0042	0.0043	0.0043	0.0043

Notes: Robust standard errors corrected for clustering at the HS-6 product level in parentheses. The dependent variable in all specifications is the change of the (log) number of importers. All regressions include a constant term.
** $p < 0.05$.
* $p < 0.1$.
*** p < 0.01.

If we compare the magnitude of the coefficients of β_1 and β_2 within the same regression, we find that coefficient of spot exchange rate is larger than that of forward exchange rate (i.e., $\beta_1 < \beta_2$). After performing a post-estimation test (Wald test) and calculate the p-value for a one-sided test, we reject the null hypothesis $\beta_1 = \beta_2$ and conclude $\beta_1 < \beta_2$ at 1% significance level. This further supports our Proposition 1 that the response in extensive margin to the realized exchange rates is significantly stronger than to the expected future ones.

The coefficients of interest rate i_t are negative, indicating that the number of importer decreases as domestic interest rate increases. The tight liquidity condition captured by the high interest rate would constrain firms' import decisions, and thus lead to a smaller number of importers. As domestic inflation rate rises, in general firms' input costs increase, and this cost-driven inflation leads to the reduction in total output by firms. This pattern is especially obvious among small and medium size firms.[35] Thus, regarding import decision, potential importers, especially those small and medium size ones, are prone to be affected by rising input costs. Though there might exist other channels through which inflation would possibly affect a firm's decision regarding whether or not importing from abroad, we believe that, potential importers nearby the cutoff are expected to be more affected by the changes in input costs. Correspondingly, the increase in input costs leads to less firms that satisfy the cutoff condition such that the number of importing firms reduces. In short, the impact of inflation for extensive margin is significantly negative.

Alternatively, by comparing the import decision for entrants and non-importers, we check that how exchange rate changes affects entry probability for all the potential importer among manufacturing firms. In order to track each individual firm's import status, we merge the NBSC data with Customs data. In this way, we could observe whether the manufacturing firm imports or not at each time t. Since the firm-level survey data from NBSC is annual data, the entry portability test is conducted at yearly basis. The main result presented here is based on the merged dataset from 2000 to 2009 that is the longest time length available to us at yearly basis. If we conduct robustness based on the sample from 2000 to 2006 (i.e., the sample period for the monthly tests), our theoretical predictions still hold.[36] We use two types of econometric models: logit model and linear probability model. The specification for entry probability is as follows:

$$\Pr(Entry = 1)_{ft} = \psi[\beta_1 \Delta fwd^{ann}_{t,k} + \beta_2 \Delta exr_t + \beta_3 \pi_t + \beta_4 i_t + \varphi_f] \tag{25}$$

Now, the dependent variable *Entry* is a dummy to indicate import status: we define $Entry = 1$ if the firm imports at time t but did not import at time $t-1$; on the other hand, we define $Entry = 0$ if the firm did not import at $t-1$ and still does not import at time t. Same as Eq. (24), we include exchange rates changes $\Delta fwd^{ann}_{t,k}, \Delta exr_t$, interest rate i_t and inflation rate π_t as independent variables. Here, we add the firm fixed effect φ_f to control time-invariant firm-level characteristics. Time fixed effect is excluded because the specification is at yearly basis. The results are reported in Table A.2 in Appendix.[37]

As shown in Table A.2, the coefficients of the forward premiums $\triangle fwd^{ann}_{t,k}$, including three-, six-, nine- and twelve-month forward premiums, are significant positive (i.e., β_1 is significant positive). Entry probability also positively depends on the realized spot exchange rate changes Δexr_t, which is suggested by the significantly positive coefficient of β_2 in the table. Both of the logit model (in Column 1–4) and linear probability model (in Column 5–8) display similar patterns with each other. This shows that, by comparing importing firms with their peer non-importers, firm's import decision depends on both realized exchange rate fluctuations and the expectations of future changes. Moreover, the coefficients of Δexr_t are larger than the coefficients of $\Delta fwd^{ann}_{t,k}$ (i.e., $\beta_1 < \beta_2$), which shows that the effect of spot exchange rate on importing entry probability is larger than the impact of future exchange rate.

4.2. Intensive margin

Our model predicts that the intensive margin, unlike the extensive margin, does not respond significantly to anticipated future exchange rate fluctuations. Intensive margin only responds to the realized exchange rate fluctuations. In this section, we test the effects of exchange rate movements on import value for individual existing importer (i.e., intensive margin). We conduct our empirical test based on the custom data from Jan 2000 to Dec 2006. The empirical specification is as follows:

$$\Delta \ln v_{ft} = \beta_1 \Delta fwd^{ann}_{t,k} + \beta_2 \Delta exr_t + \beta_3 \pi_t + \beta_4 i_t + \varphi_f + \varphi_q + \varepsilon_{it} \tag{26}$$

Now the subscript t represents month. Correspondingly, the dependent variable Δv_{ft} is the changes of firm f's (log) import value from the United States in month t. The list of independent variables is similar to that of extensive margin test, which includes annualized forward exchange rate premiums $\Delta fwd^{ann}_{t,k}$ calculated on various maturities, spot exchange rate move-

[35] The literature suggests that large firms enjoy greater flexibility in timing their investments (Kadapakkam et al., 1998), while small and medium size firms are more liquidity constrained in their investment behavior (Audretsch and Elston, 2002).

[36] Because the results of the sample from 2000–2006 are not qualitatively different, they are not reported here in order to conserve space, but are available upon request.

[37] In Table A.2, we cluster standard errors at industry level which is the 4-digit CIC (Chinese Industrial Classification) based on the NBSC firm survey data to take into account any correlation between firms within an industry in columns 5–8. To control for the potential serial correlation within each firm over time and any possible correlation between firms within a region, we also conduct the robustness checks with clustering at the firm and region (4-digit regional code, namely, city) levels and find similar results (see Table A.3 in Appendix for results of Logit model with different clustering). Since the results of linear probability model with different clustering are similar to logit model, we do not report results with various clusters of standard errors for linear probability model in order to save space but those results are available upon request.

Table 3
Intensive margin of import (from U.S.).

	Dependent variable: the change of import value for each firm							
	$\Delta \ln v_{ft}$				$\Delta \ln v_{ft}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δexr_t	1.129**	1.064**	1.188**	1.118**	1.006***	0.954**	1.085***	1.015***
	(0.511)	(0.517)	(0.524)	(0.526)	(0.372)	(0.376)	(0.380)	(0.382)
$\Delta fwd^{ann}_{t,3}$	−0.058				−0.126			
	(0.197)				(0.156)			
$\Delta fwd^{ann}_{t,6}$		0.046				−0.024		
		(0.213)				(0.163)		
$\Delta fwd^{ann}_{t,9}$			−0.131				−0.222	
			(0.230)				(0.168)	
$\Delta fwd^{ann}_{t,12}$				−0.032				−0.114
				(0.237)				(0.177)
Interest rate	−0.072***	−0.071***	−0.075***	−0.073***	−0.068***	−0.067***	−0.072***	−0.070***
	(0.026)	(0.026)	(0.027)	(0.027)	(0.021)	(0.021)	(0.021)	(0.021)
Inflation rate	0.074	−0.022	0.148	0.054	0.054	−0.032	0.152	0.056
	(0.416)	(0.427)	(0.438)	(0.446)	(0.304)	(0.313)	(0.315)	(0.323)
Firm fixed effect	No	No	No	No	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observation	128,492	128,492	128,492	128,492	128,492	128,492	128,492	128,492
R-square	0.0001	0.0001	0.0001	0.0001	0.0089	0.0089	0.0089	0.0089

Notes: Robust standard errors corrected for clustering at the industry (HS6) level in parentheses. The dependent variable in all specifications is the change of the (log) import value for each firm. All regressions include a constant term.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

ments Δexr_t, interest rate i_t and inflation rate π_t. Similar as in the extensive margin test, we also include the time fixed effect φ_q for every quarter over time to control the time trend if any. In addition, we add the firm fixed effect φ_f to control time-invariant firm-level characteristics.

The baseline results of the intensive margin are reported in Table 3. The first four columns are the results only with time fixed effect. The last four columns include both firm fixed effect and time fixed effect. We find that the effect of annualized forward premiums $\Delta fwd^{ann}_{t,k}$ becomes insignificant and its coefficient could be positive or negative in all columns. Its coefficients could be positive or negative. On the other hand, the realized exchange rate changes Δexr_t still has significant positive coefficients on individual firm's import value.

This result suggests that the future appreciation of domestic currency does not significantly influence the import value of existing importers. Importers seldom adjust import value in accordance to their expectation of future exchange rate movements. They only adjust import value when the current exchange rate fluctuation really happens. In other words, comparing with the extensive margin, there is no significant "pre-reaction" to the future exchange rate fluctuations at the intensive margin.

For other variables, interest rate has negative effect on the changes of import value. Hence, tighten of liquidity condition has constrained firms' marginal increase of import value. The effect of inflation on import value per firm is insignificant. The potential reason is as follows. In contrast to the extensive margin where a firm's decision is discrete, i.e., whether or not to import, the firm's decision at intensive margin is continuous, i.e., how much to import by an **existing** importing firm based on current production plan. Besides the negative effect of inflation on import value, large firms may take advantage of the increase in domestic inflation: when domestic inflation rate rises, large firms may successfully switch from domestic intermediate inputs to foreign imported intermediate inputs since the relative price of domestic intermediate inputs rises. As a result, for surviving firms who keep operating in importing market, the average import value per firm may be affected by an opposite, positive force. It is not clear which force would dominate and possibly they cancel out each other. Therefore, the effect of inflation on intensive margin may be ambiguous. This is consistent with our empirical finding that the coefficients on inflation for intensive margin are insignificant.

In the baseline specification of the intensive margin test, we cluster at industry level to control for any correlation between firms within an industry if any. We use the core imported product that has the largest import value within firm to determine which industry a firm belongs to.[38] To show the robustness of our results and to control for the serial correlation within each firm over time or any correlation among firms within a region, we also experiment with clustering at different levels, including the firm level and the regional level. The results are reported in Table A.4 in Appendix. All the previous results, such as significant positive coefficients on the realized exchange rate changes Δexr_t and insignificant coefficients on forward exchange rate premiums, still hold with standard errors clustered at various levels.

[38] Here industry refers to HS6 product category.

As Bernard et al. (2014) pointed out, there is a timing issue when firm could enter the same market in different date within the month. The import value at the first month may be biased between the time of entry and the following time. We focus on the continuing importers, i.e., the firm import for both month t and previous months $t-1$ and $t-2$ in the sample for the intensive test.[39] Keeping only the continuing importers would not affect our empirical patterns. As shown in Table A.5 in Appendix, the results based on the sample of only continuing importers do not alter our previous findings. In addition, one might concern that exchange rate movements and inflation rate are correlated through exchange rate pass-through. In order to alleviate this concern, we conduct another sensitivity test by dropping inflation rate from the control variables, and find that excluding inflation does not affect our main results for both extensive and intensive margins.[40]

Lastly, we acknowledge the possibility that there might exist some global or domestic factors that could potentially affect import responses at both extensive and intensive margins as well as USD/CNY exchange rates. It is a challenge to solve such endogeneity issue, especially when both spot and forward rates are simultaneously considered. The potential endogeneity is more likely caused by omitted variables that might primarily come from financial or other macroeconomic shocks. Fortunately, the potential endogeneity concerns would be attenuated to a great extent under the China-US trade context (see more detailed discussion in Li and Zhao (2016)), due to capital control by China that breaks the linkage between domestic financial conditions and exchange rate movements. Furthermore, it is unlikely there are such factors which could lead to differential responses between intensive margin and extensive margin (i.e., those factors only affect extensive margin but not intensive margin), whereas also play a role in shaping changes of exchange rates. In the paper we take into account such macroeconomic shocks by controlling for interest rate and inflation. A more desirable way would be using instrumental variable estimation to address this issue. However, it is hard to find valid instruments for both spot and forward exchange rates, and in particular, for forward exchange rate movements, which is left for future study.

5. Robustness

5.1. Sub-sample tests with ordinary trade

An important feature of Chinese imports is that processing trade accounts for a large portion of imports (Manova and Yu, 2016). One trade mode of processing trade is referred to as "processing with supplied inputs". Under such trade regime, a Chinese firm can receive inputs from its trading partners, assemble them and export directly to its trading partners. Another mode of processing trade is referred to as "processing with imported inputs". Firms under such strategy pay for imported inputs from foreign suppliers and export all processed goods. The characteristics of processing firms are different from ordinary firms. As a result, including processing firms would pollute our estimated results. To rule out this concern, we conduct a robustness check using the sub-sample of ordinary trade firms.[41]

The robustness check follows the same approach as in previous baseline regression. For extensive margin adjustment, we employ the change of the (log) number of importers within HS 6-digit product as dependent variable and test its response to both current and future exchange rate fluctuation among ordinary trade sample.[42] For intensive margin test, we employ the change of the (log) import values of ordinary trade firms as dependent variable. The first four columns in Table 4 report the import response along the extensive margin based on ordinary trade firms, and the last four columns in Table 4 present the import response along the intensive margin based on ordinary trade firms.

As shown in the first four columns in Table 4, the coefficients of both the spot exchange rate changes Δexr_t and expected future exchange rate changes $\Delta fwd_{t,k}^{ann}$ are significant and positive. Moreover, the coefficient of spot exchange rate movements β_2 is larger than future exchange rate movements β_1. These findings show that both spot exchange rate and future exchange rate would affect the extensive margin and the effect of spot exchange rate is larger. As to the intensive margin, as shown in the last four columns in Table 4, import value only responds to current spot exchange rate changes, but does not respond significantly to future exchange rate movements. Hence, using the ordinary trade firms would not affect our previous results.

We also present results of the sub-sample of non-ordinary trade in Table A.6 in Appendix. Compared with ordinary trade firms, we find that non-ordinary trade firms do not show significant responses to exchange rate movements at the intensive margin, but present similar responses as ordinary trade firms along the extensive margin. There are several potential reasons behind this phenomenon.

First, a non-ordinary importing firm participates in global value chain usually by importing components and exporting final goods to its foreign trade partner. The foreign partner entails additional costs for marketing and distribution purposes to serve foreign consumers. The non-ordinary trade firm would only reap a proportion of the total profit that usually depends

[39] The dependent variable in our basic regressions is the change of the (log) import value, which implies that the firm should import for both month t and previous month $t-1$. Here, we make a further restriction.

[40] Since excluding inflation does not change the main results, to conserve space we do not report those results in the paper but they are available upon request.

[41] We categorize all transaction records in Chinese customs data into two types, namely, ordinary trade and non-ordinary trade (mostly processing trade), and then aggregate to two sub-samples: ordinary trade sample and non-ordinary trade sample.

[42] We explore the effect of exchange rate fluctuation on firms' entry probability for ordinary trade firms using Logit and linear probability models. Our previous empirical findings still hold. The results are available upon request.

Table 4
Sub-sample of ordinary trade.

	Extensive margin				Intensive margin			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δexr_t	0.638***	0.512***	0.559***	0.500***	1.484***	1.447**	1.589***	1.470**
	(0.090)	(0.091)	(0.092)	(0.092)	(0.571)	(0.575)	(0.581)	(0.582)
$\Delta fwd_{t,3}^{ann}$	0.163***				−0.043			
	(0.038)				(0.225)			
$\Delta fwd_{t,6}^{ann}$		0.297***				0.033		
		(0.038)				(0.235)		
$\Delta fwd_{t,9}^{ann}$			0.235***				−0.209	
			(0.038)				(0.252)	
$\Delta fwd_{t,12}^{ann}$				0.302***				−0.008
				(0.039)				(0.258)
Macro-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product fixed effect	Yes	Yes	Yes	Yes	No	No	No	No
Firm fixed effect	No	No	No	No	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observation	167,610	167,610	167,610	167,610	60,289	60,289	60,289	60,289
R-square	0.009	0.009	0.009	0.009	0.020	0.020	0.020	0.020

Notes: Robust standard errors in columns (1)–(4) corrected for clustering at the HS6 product level in parentheses; robust standard errors in columns (5)–(8) corrected for clustering at the industry level in parentheses. The dependent variable in specifications (1)–(4) is the change of the (log) number of importers. The dependent variable in specifications (5)–(8) is the change of (log) import value for each firm. All regressions include a constant term and macro-level controls. Macro-level Controls refer to interest rate and inflation rate.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

on its share in total costs of the collaborated production. When domestic currency appreciates, exported goods produced by the non-ordinary trade firm becomes more expensive and foreign demand decreases consequently. This in turn reduces the profit gain of the non-ordinary firm from the cost reductions after exchange rate appreciation. Therefore, for an existing importing firm, the response of its import value to exchange rate fluctuations for a non-ordinary trade firm is expected to be weaker than that of an ordinary trade firm. In particular, if the aforementioned adverse effects are strong enough, the import value responses of the non-ordinary trade firm to exchange rate movements may be fully offset and become not significant at all. This conjecture is supported by our empirical results of the intensive margin where the response of import value per firm for non-ordinary trade firms indeed becomes insignificant in Table A.6.

Second, our model only predicts that after domestic currency appreciation, more firms become importers, and potential importers' response to spot exchange rate changes is stronger than to future exchange rate changes. Once a firm decides to start importing, which trade mode it will choose is not endogenously determined in our model. In other words, the trade mode is pre-determined. In the reality, a firm's choice of trade regime is constrained by many factors, such as lack of access to credit, lack of market accessibility, production infrastructure, technique, intellectual product protection action and so on. Moreover, once a firm has selected its trade mode, it hardly changes its original trade regime. As the choice of trade regime depends on many other factors, the current paper is silent to which trade regime the firm will choose once it decides to start importing. The empirical results in Table A.6 show that non-ordinary firms also respond positively to both spot and forward exchange rate movements along the extensive margin, and their responses to spot exchange rate movements are stronger than to future exchange rate fluctuations.

5.2. Sub-sample tests after 2003

Since China adopted exchange rate reform in July 2005, we observe significant variation of spot exchange rate after the reform. There is variation of spot rate between CNY and USD before July 2005, which is usually within a given fluctuation safe band. Similarly, for forward exchange rate, significant variation starts from the year 2003. Since the year 2003, the expectation of RMB movements comes to a new stage. The forward rates move towards a clearer pattern with substantial variation. As a robustness check, we focus on the period after 2003 to explore the changes of import along two margins to both spot and forward exchange rate movements.

With a sub-sample of the monthly import data after the year 2003, we repeat our baseline estimations of extensive margin as in Eq. (24) and of intensive margin as in Eq. (26). The results are reported in Table 5 where columns 1–4 and 5–8 in present the import response along the extensive margin and the intensive margin, respectively.

The tests along the two margins with sub-sample after 2003 display a very similar pattern as in our baseline regressions. At the extensive margin, we find that both the realized exchange rate changes Δexr_t and expected future exchange rate changes $\Delta fwd_{t,k}^{ann}$ have significantly effects on the change of the (log) number of importing firms. Also, by comparing the magnitude of coefficients, the realized exchange rate movements have larger effects than the future movements (i.e., ($\beta_2 > \beta_1$ is

Table 5
Sub-sample of 2003 afterwards.

	Extensive margin				Intensive margin			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δexr_t	2.644***	2.765***	2.490***	2.746***	2.076***	2.152***	1.901***	2.043***
	(0.175)	(0.173)	(0.174)	(0.171)	(0.591)	(0.581)	(0.578)	(0.576)
$\Delta fwd_{t,3}^{ann}$	0.580***				0.132			
	(0.084)				(0.210)			
$\Delta fwd_{t,6}^{ann}$		0.925***				0.262		
		(0.096)				(0.219)		
$\Delta fwd_{t,9}^{ann}$			0.584***				−0.075	
			(0.110)				(0.236)	
$\Delta fwd_{t,12}^{ann}$				1.152***				0.148
				(0.112)				(0.242)
Macro-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product fixed effect	Yes	Yes	Yes	Yes	No	No	No	No
Firm fixed effect	No	No	No	No	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observation	125,284	125,284	125,284	125,284	107,716	107,716	107,716	107,716
R-square	0.008	0.008	0.007	0.008	0.010	0.010	0.010	0.010

Notes: Robust standard errors in columns (1)–(4) corrected for clustering at the HS6 product level in parentheses; robust standard errors in columns (5)–(8) corrected for clustering at the industry level in parentheses. The dependent variable in specifications (1)–(4) is the change of the (log) number of importers. The dependent variable in specifications (5)–(8) is the change of (log) import value for each firm. All regressions include a constant term and macro-level controls. Macro-level Controls refer to interest rate and inflation rate.
**$p < 0.05$.
* $p < 0.1$.
*** $p < 0.01$.

empirically supported by Wald test). Hence, expected future currency appreciation encourages potential importers to start importing, but its effect is smaller than the already realized currency appreciation.

At the intensive margin, columns 5–8 in Table 5 show that the realized exchange rate appreciations Δexr_t have significant impacts on import value of each individual firms, but future expected exchange rate appreciations $\Delta fwd_{t,k}^{ann}$ do not have significant effects on import value. The result further justifies our predictions in Proposition 2: import value of existing importers only significantly responds to the realized exchange rate fluctuations but does not responds to the expected future exchange rate fluctuations.

Table 6
Level regressions along two margins.

	Extensive margin				Intensive margin			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δexr_t	6.689***	5.992***	5.344***	5.245***	2.857***	3.010***	3.027***	3.193***
	(0.088)	(0.089)	(0.090)	(0.091)	(0.354)	(0.348)	(0.345)	(0.346)
$\Delta fwd_{t,3}^{ann}$	3.800***				−0.152			
	(0.033)				(0.158)			
$\Delta fwd_{t,6}^{ann}$		4.278***				0.051		
		(0.035)				(0.198)		
$\Delta fwd_{t,9}^{ann}$			4.856***				0.112	
			(0.037)				(0.249)	
$\Delta fwd_{t,3}^{ann}$				4.958***				0.594**
				(0.038)				(0.295)
Macro-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product fixed effect	Yes	Yes	Yes	Yes	No	No	No	No
Firm fixed effect	No	No	No	No	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observation	465,503	465,503	465,503	465,503	482,426	482,426	482,426	482,426
R-square	0.905	0.905	0.906	0.906	0.697	0.697	0.697	0.697

Notes: Robust standard errors in columns (1)–(4) corrected for clustering at the HS6 product level in parentheses; robust standard errors in columns (5)–(8) corrected for clustering at the industry level in parentheses. The dependent variable in specifications (1)–(4) is the (log) number of importers. The dependent variable in specifications (5)–(8) is the (log) import value for each firm. All regressions include a constant term and macro-level controls. Macro-level Controls refer to interest rate and inflation rate.
*$p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

5.3. Level tests along two margins

As a robustness, we explore the responses of the import level along two margins to both spot exchange rate movements and forward exchange rate fluctuations. The only difference between the test with baseline test lies in that the dependent variable is the import level along two margins, rather than the import changes. For the extensive margin test, the dependent variable is the (log) number of importers within the p product category at month t; for the intensive margin test, the dependent variable is the log of import value for each individual importing firm f at month t. The independent variables include exchange rates changes $\Delta fwd_{t,k}^{ann}$, Δexr_t, interest rate i_t and inflation rate π_t. We also add the product fixed effect in extensive margin test and add firm fixed effect φ_f in intensive margin test, respectively. We add the fixed effect φ_q for every quarter over time in both tests. This time fixed effect φ_q would control the time trend if any.

The results are displayed in Table 6. The first four columns focus on the extensive margin responses. We find that both the realized exchange rate changes Δexr_t and expected future exchange rate changes $\Delta fwd_{t,k}^{ann}$ have significantly effects on the (log) number of importers. Also, by comparing the magnitude of coefficients, the realized exchange rate movements have larger effect than the future exchange rate movements (i.e., $\beta_2 > \beta_1$ is empirically supported by Wald test). The pattern further supports our Proposition 1.

The column 5–8 report the adjustment along the intensive margin to the exchange rate changes. It shows that the realized exchange rate changes Δexr_t have significantly coefficients on the log of import value of each individual firms, but future expected exchange rate changes $\Delta fwd_{t,k}^{ann}$ do not have significant effects on the import value. The result furtherly justifies our predictions in Proposition 2: import value of existing importers only significantly responds to the realized exchange rate changes but does not respond to the expected future exchange rate changes. Consequently, our previous results are robust no matter either using the growth test or uisng the level test.

6. Conclusion

This paper explores how firms adjust their import decision along both the extensive margin and the intensive margin according to current and future exchange rate movements. In our dynamic heterogeneous trade model, firms are sensitive not only to current exchange rate fluctuations but also to future exchange rate changes. However, the reaction of firms in response to these two stimuli differs. When current exchange rate appreciates, importers tend to expand their import value due to decreased price of imported goods. More new firms rush into the importing market to gain profit. When future exchange rate appreciates, existing importing firms, by contrast, become sluggish to adjust their import value. As for firms' willing to dip a toe in import market, due to the probability to fail, they are inclined to enter in advance to capture the potentially higher future profits stemming from expected appreciation of currency. To sum up, firms adjust their import value, i.e. intensive margin, if and only if current exchange rate shifts. Number of importing firms, i.e. extensive margin, changes in response to fluctuation of not only current exchange rate but also expected future exchange rate. The differences in impact of current and future exchange rate movements on firms' import decisions along two margins are further supported by our empirical test by using US-China bilateral trade data.

Our analytical framework can be used for further study along two lines. First, as for firms with different level of productivity, financial liquidity and even locations, they may respond differently to anticipated future exchange rate fluctuations. By linking firm-level characteristics to firms' responses to future exchange rate changes, we are able to more comprehensively portray firm's different ability to react to upcoming exchange rate fluctuations. Second, the firm-level behavior adjustment and the underlying mechanism indicated in our study provide a micro-foundation for the trade pattern at aggregate level. Further study, in richer and more specific exploration, may endeavor to examine how responses to future exchange rate changes at the firm level contribute to shape import value or trade balance at the aggregate level.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jimonfin.2017.11.002.

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