Exchange Rate Induced Export Quality Upgrading: A Firm-Level Perspective[†]

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Abstract

This paper explores the impact of exchange rate fluctuations on exported product quality. Existing studies of quality upgrading stress the link between home country depreciation and increased access to export markets. Our focus in this study is on the complimentary effect of an import currency appreciation (i.e., the domestic currency appreciates relative to the sourcing country's currency). Our main finding is that firms upgrade their export quality in response to an import currency appreciation. We first develop a partial equilibrium model to reveal the mechanism: an import currency appreciation that makes imported intermediates cheaper allows firms to switch to higher quality intermediates, which in turn, increase export quality. Using Chinese Customs data during 2000-2006, we find that an import appreciation increases both import, and export quality. Furthermore, export quality increases more for less productive firms, and for firms exporting to developed countries.

Keywords: Import Appreciation · Quality Upgrade · Import Quality· Export Quality

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1. Introduction

It is widely believed that exchange rate fluctuations are crucial to firms' export performance. A considerable number of papers document the impact of exchange rate fluctuations on export prices and volumes (Cushman, 1983; Dell, 1999; Mc Kenzie, 1999; Forbes, 2002; Marquez and Schindler, 2007; Cheung et al., 2009; Thorbecke and Simith, 2010; Berman et al., 2012; Li et al., 2015; Chen and Juvenal, 2016). However, the specific mechanism that exchange rate fluctuations affect export quality is less well understood. One avenue suggested by recent theoretic work emphasizes the role that input quality plays in final product quality (Kugler and Verhoogen, 2012; Hallak and Sivadasan, 2013). Presumably, higher quality intermediate inputs are more costly. In this paper, we argue that firms may upgrade their export quality by capitalizing on exogenous import currency appreciation (the domestic currency appreciates relative to the currency in the sourcing countries).

One of the most salient features of international trade is that a large portion of exporters are simultaneous importers (e.g. Amiti et al., 2014). This suggests that exchange rate movements affect the price of imported intermediate inputs, which in turn, affect these firms' choice of imported intermediate input quality. This paper attempts to provide empirical evidence on the link between import exchange rate fluctuations and the quality of traded products.

In order to uncover the links between exchange rate movements and traded product quality, and to guide our empirical strategy, we develop a theoretic framework to study heterogeneous firm-level quality responses to import exchange rate changes. Following Rodrigue and Tan (2016) and Amiti et al. (2014), we assume that firms use domestic and foreign imported intermediates to produce final products. Import prices are influenced by both the quality of imported intermediates and the import exchange rate. To produce high quality products (for domestic or foreign markets), firms are required to use both high quality domestic and imported intermediate inputs. In equilibrium, more productive firms tend to import higher quality intermediates and export higher quality products. In response to an import exchange rate appreciation, firms switch to (previously) more expensive and higher quality intermediates, which in turn, improves the quality of their exported products.[1] The model further predicts that if the quality transferring between intermediate inputs and final products exhibits diminishing returns, more productive firms will upgrade their product quality less when facing an import appreciation. This is because it is more costly to upgrade the product quality if it is already high, and as such, both import and export quality of more productive (higher quality) firms reacts less to import appreciations.

We test the predictions of the model with a rich dataset of Chinese trading firms during 2000-2006 period. A distinctive feature of these data is that they provide firm-level imports by source countries and exports by destination country, at HS8-digit product codes. Having import information allows us to construct a firm-level effective import exchange rate, its import sophistication, and import intermediates quality. Information on exports provides us with a measure of export product quality. Our empirical results, on the one hand, indicate that a 10% import currency appreciation increases firm-level export quality by 0.8%, and this

[1]Similar logic may not hold for import exchange rate depreciation since fixed costs of market-entry can lead to an asymmetry between entry and exit decisions in response to exchange rate changes. See, e.g., Campa (2004), or, Baldwin (1988)

quality increase is mainly driven by firms that engaged in ordinary trade.[2] On the other hand, our results demonstrate that a 10% import currency appreciation tends to increase firm-level import sophistication and quality by 0.7% and 1.5%, respectively. Furthermore, we find that the import price in developed countries fall is twice that in developing countries in response to an import currency appreciation. Without quality upgrading, this result contradicts the findings in Chen and Juvenal (2016) and Bernini and Tomasi (2015), who find that exchange rate pass-through is decreasing in traded product quality.[3]

This paper is closely related to the recent, growing literature on the connections between exchange rate fluctuations and firm-level export performance, especially studies on exchange rate pass-through (Atkson and Burstein, 2008; Amiti et al., 2014; Berman et al., 2012; Bergsten, 2010; Chatterjee et al., 2013; Campa and Goldberg, 2005; Gopinath and Rigobon, 2008; Knetter, 1993; Giri, 2012; Bernini and Tomasi, 2015), and to the literature tracing imported inputs and export performance. Broadly, the exchange rate pass-through (ERPT) literature has focused on three channels leading to incomplete pass-through. The first channel attributes incomplete pass-through to import and export price rigidities (Gopinath and Rigobon, 2008), i.e., an incompletely adjusted local price results in a low level of exchange rate pass-through. The second channel is pricing-to-market (Atkson and Burstein, 2008; Amiti et al., 2014), in which exporting firms endogenously absorb exchange rate fluctuations by adjusting their markups, which stabilizes trade price fluctuations. Third, a large literature explains incomplete pass-through by

[2]Both export and import quality are estimated following Khandelwal et al. (2013).

[3]Since, usually, intermediates imported from developed countries have higher average quality than those imported from developing countries. Without quality upgrading, we would expect price fall more for imports from developing countries.

introducing local distribution costs (Berman et al., 2012; Li et al., 2015; Chen and Juvenal, 2016; Campa and Goldberg, 2005; Chatterjee et al., 2013; Giri, 2012). Since distribution costs, which may be a large share of the price, are paid in local currency, the impact of exchange rate fluctuations on import prices will be mitigated.

Second, our work relates to the literature studying the interaction of importing materials and exporting performance. Kasahara and Rodrigue (2008), for instance, document that using imported intermediates effectively improves the productivity of Chilean manufacturing firms. Chevassus-Lozza (2013), Feng et al. (2016) and Bas and Strauss-Kahn (2015) separately find that input trade liberalization boosts both the downstream industries and firms' exports, as well as increasing the quality of export products. Our work is similar in spirit to Bernini and Tomasi (2015), who relate firm-level ERPT to the quality of imported intermediate inputs. We endogenize the intermediate input quality choice resulting from exchange rate movements, and trace the downstream effects on export quality.

Importantly, our work contributes to this exchange rate incomplete pass-through literature by introducing a firm-level endogenous quality adjustment. Faced with an import currency appreciation, a representative firm imports higher quality, and hence (formerly) more expensive intermediates, which lowers import price pass-through. As a consequence, the firm produces higher quality export products, and it charges a higher markup (price) in export destinations. This shows up as *increased* pass-though to export destinations.

Empirically, we focus on China primarily due to our extensive data set on firm-level imports and exports by country - which permits an examination of our model's implications on both the import, and export sides. In addition, China presents a promising focal point due to its emerging status and its rapid trade growth. Moreover, recent studies, e.g., Pula and Santababara (2011) emphasize the prevalence of quality upgrading by Chinese firms. Third, other studies, e.g., Li et al. (2015) focus on China's high export pass-through.[4]

The rest of this paper proceeds as follows. Section 2 outlines the economic model. Section 3 describes the dataset and the construction of the variables that will be used in our tests. The results are presented and discussed in section 4. Section 5 concludes.

2. Model

In this section, we develop a theoretical framework linking a firm's import and export quality choices to import exchange rate changes. We use this framework to formulate testable implications.

In order to focus our analysis on the relationship of import exchange rate changes and firm-level import and export quality, we make a number of assumptions. First, similar to Amiti et al. (2014), we do not model firms' entry, exit, or selection into exporting and importing, as we condition our analysis on the subset of firms, which simultaneously import and export, and focus on their import and export quality.[5] Second, this model is partial equilibrium, hence we abstract from the impact of import exchange rate changes on wages in each country, and

[4] Li et al. (2015) estimate export Chinese pass-through at 96% - well above most other countries: e.g., 79% for Belgian exporters (Amiti et al., 2014); 77% for Brazilian exporters (Chatterjee et al., 2013). Only two countries exhibit export pass-through similar to that of Chinese exporters, at nearly 100% for U.S. exporters (Knetter, 1993), and 92% for French exporters, (Berman et al., 2012)

[5] Exporters not importing also help to identify the linkage between import exchange rate changes and export quality. Therefore, these exporters are kept in the empirical analysis.

aggregate demand in the export destinations; instead, we focus on the impact of import exchange rate changes on firm-level import and export behaviors, i.e. the wage and residual demand in each country are taken as exogenously given.[6]

2.1. Demand

We assume there are three countries in the world. The home country, C (China in our case), a foreign country, F_1 importing final products from the home country, and another foreign country, F_2 producing and exporting intermediate inputs and exports. A representative export firm in the home country uses intermediate inputs produced in country C and imported from country F_2 to produce final products, which will be sold in the home country C and foreign country F_1. A representative consumer's preference in country C and F_1 takes the following CES form:

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

where $q(\omega)$ and $x(\omega)$ denote the quality and quantity of variety ω, respectively.

Representative firms can produce a variety with different quality for different markets: q_C for the home market, and q_{F_1} for the foreign market. Exporters face three types of costs for exporting: an iceberg trade cost τ_j, $\tau_j > 1$ if $j = F_1$, and $\tau_j = 1$ if $j = C$; a fixed cost f_j, and a per unit distribution cost in country j, $\eta_j = \eta w_j$. Note that the distribution cost is paid in the local currency. w_j is the wage level in country j and η is the amount of labor required for distribution. We now discuss the firms' export behavior in foreign country F_1; the results can be

[6] An alternative way to state this assumption is that individual firms do not take into account of the impact of import exchange rate movements on aggregate demand in export markets when making their importing and exporting decisions.

easily applied to the home country.

If an exporter from country C charges a price p_{F_1} in the home currency for its product exported to country F_1, the price faced by consumers in the foreign country is

$$p^c_{F_1}(\varphi) = \frac{p_{F_1}(\varphi)\tau_{F_1}}{e_{F_1}} + \eta_F \tag{2}$$

where e_{F_1} is the nominal exchange rate between the home country C and foreign country F_1. φ is the productivity of the firm. An increase in e_{F_1} implies a depreciation of the domestic currency. The quantity demanded in F_1 is

$$x_{F_1}(\varphi) = Y_{F_1} P^{\sigma-1}_{F_1} \left[\frac{p_{F_1}(\varphi)\tau_{F_1}}{q_{F_1}(\varphi)e_{F_1}} + \eta_F\right]^{-\sigma} \tag{3}$$

where Y_{F_1}, and P_{F_1} denote the aggregate income and price index in country F_1, respectively. It is easy to see from equation (3) that for a given F.O.B price p_{F_1}, a decrease in e_{F_1} (foreign currency depreciation) will lead to a higher demand in country F_1. Export profit in country F_1 is:

$$\pi_{F_1} = Y_{F_1} P^{\sigma-1}_{F_1} \left[\frac{p_{F_1}(\varphi)\tau_{F_1}}{q_{F_1}(\varphi)e_{F_1}} + \eta_F\right]^{-\sigma} [p_{F_1}(\varphi) - c(\varphi, e_{F_2})] \tag{4}$$

where $c(\varphi, e_{F_2})$ denote the unit production cost of the export product, which depends on firm-level productivity and the exchange rate between the home country C and the country F_2.

2.2. Production

We build on Amiti et al. (2014) and Rodrigue and Tan (2016) to model the cost structure of the representative firm and its import (export) quality choice.[7] Consider a representative firm with productivity φ with the following production function:

$$Y = \varphi X \tag{5}$$

where, X is the intermediate input. The production function (5) implies that intermediates are the only input in the production, and the production function features constant return to scale.

Intermediate input X consists of a bundle of intermediate goods indexed by $j \in [0, 1]$ and aggregated according to a Cobb-Douglas technology:

$$X = exp\left\{\int_0^1 \log X_j dj\right\} \tag{6}$$

where each intermediate good j can be made by combining two varieties purchased from domestic country C and sourcing country F_2:

$$X_j = \left[Z_j^{\frac{\zeta}{\zeta+1}} + a_j^{\frac{1}{\zeta+1}} M_j^{\frac{\zeta}{\zeta+1}}\right]^{\frac{1+\zeta}{\zeta}} \tag{7}$$

where Z_j and M_j denote the quantities of domestic and imported varieties of the intermediate good j used in production, respectively. $\zeta + 1$ measures the elastic-

[7] Rodrigue and Tan (2016) model the quality linkages between intermediate inputs and final products: high quality intermediate inputs result in high quality final products. Firms decide their export quality by optimally choosing intermediate inputs. Here we build on Rodrigue and Tan (2016) by taking into account the impact of exchange rate movements on firm-level optimal import decisions via the assumed positive link between the quality of intermediate inputs and the quality of final products.

ity of substitution between domestic and imported varieties, and $\zeta + 1 > 1$. a_j captures the relative importance of foreign variety, M_j, in producing intermediate goods X_j. $a_j > 1$ ($a_j < 1$) indicates that the foreign imported variety, M_j, is more (less) important in production relative to the domestic variety, Z_j. Note that the production of intermediate goods X_j is possible by using only the domestic variety Z_j. Imported variety M_j makes the production of X_j more efficient through the relative importance parameter a_j, and the 'love-of-variety' feature of the production function (7). To import foreign varieties, each firm needs to pay a fixed cost f in terms of labor.

Each intermediate variety has been made using labor. Wages in the domestic country C and sourcing country F_2 are exogenously given by W and 1, respectively.[8] Following Kugler and Verhoogen (2012), we assume the intermediate varieties market to be competitive in both the domestic country C and the sourcing country F_2. As such, Producers of intermediate varieties, Z_j and M_j, earn zero profit. Each intermediate variety differs in quality. The higher the quality, the more labor required in production. Without loss of generosity, we assume that in both the domestic and the sourcing countries, to produce any intermediate variety with quality q_j, the labor requirement is q_j. Following Rodrigue and Tan (2016), we assume that the quality of intermediate goods X_j depends on the minimum quality of the domestic and imported intermediate varieties, and the quality of intermediate input X depends on the lowest quality of $\{X_j\}_{j\in[0,1]}$. Finally, the quality of

[8] We normalize the wage level in the sourcing country F_2 to be 1.

intermediate input X affects the quality of products exported to country F_1.

$$q_{X_j} = \min\{q_{Z_j}, q_{M_j}\}$$
$$q_X = \min\{q_{X_j}\}_{j\in[0,1]}$$
$$q_{F_1} = \varphi q_X^{\alpha} \tag{8}$$

where $q_{Z_j}, q_{M_j}, q_{X_j}, q_X$, and q_{F_1} denote the quality of Z_j, M_j, X_j, X and products exported to destination F_1, respectively. α captures the concavity of the quality cost curve: a higher α implies a lower cost of increasing quality by a given amount. We refer to α as the "quality transfer rate" in subsequent discussions. Equation (8) indicates that productivity and quality are complementary,[9] higher productivity firms can produce higher quality final products using the same intermediate as a low productive firm. Moreover, if $\alpha < 1$, it would be harder to increase the quality of final products by increasing the quality of intermediates. The quality function structure implies that in equilibrium, a firm will choose intermediates such that $q_{X_j} = q_{X_k}$ for $\forall j \neq k$ and $q_{Z_j} = q_{M_j}$ for $\forall j$.

Equation (8) also implies that a firm needs to use intermediates with quality $\left(\frac{q}{\varphi}\right)^{\frac{1}{\alpha}}$ in order to produce products with quality q. If a firm uses both domestic and foreign intermediates to produce exported products with quality q, the prices of domestic and foreign intermediates are $W\left(\frac{q}{\varphi}\right)^{\frac{1}{\alpha}}$ and $\left(\frac{q}{\varphi}\right)^{\frac{1}{\alpha}} e_{F_2}\tau_{F_2}$. The total production cost is $\int_0^1 W\left(\frac{q}{\varphi}\right)^{\frac{1}{\alpha}} Z_j dj + \int_0^1 \left(\frac{q}{\varphi}\right)^{\frac{1}{\alpha}} e_{F_2}\tau_{F_2} M_j dj + Wf$, where the last term is the fixed import cost.[10] Similar to Amiti et al. (2014), firm-level marginal

[9]None of our results rely on the complementarity between the productivity and the intermediate quality. For instance, all our results continue to hold if we assume $q_{F_1} = q_X^{\alpha}$.

[10]Note that only firms that pay the fixed import cost f can import foreign made intermediates. It can be shown that only firms with sufficiently high productivity choose to pay the fixed import

production cost with quality q is

$$c(\varphi, e_{F_2}, q) = \varphi^{-\frac{1+\alpha}{\alpha}} \frac{W q^{\frac{1}{\alpha}}}{B} \tag{9}$$
$$B = \exp\left(\int_0^1 \log b_j dj\right)$$
$$b_j = \left[1 + a_j \left(\frac{e_{F_2}\tau_{F_2}}{W}\right)^{-\zeta}\right]^{\frac{1}{\zeta}}$$

where τ_{F_2} is the iceberg trade cost between the home country and foreign country F_2. Equation (9) implies that an appreciation in the home currency (a decrease in e_{F_2}) leads to a decline in the price for importing (in home currency) intermediates.

Notice that the cost function defined in equation (9) is for firms with positive imports. We do not analyze the firm-level import decision here, but we argue that only firms with sufficiently high productivity choose to pay the fixed import cost, f, given the cost structure in (9). If a firm is not engaged in importing, its marginal production cost (with quality q) is given by: $c(\varphi, q) = \varphi^{-\frac{1+\alpha}{\alpha}} W q^{\frac{1}{\alpha}}$.[11]

The profit function (4) and cost function (9) together give the optimal export price:

$$p_{F_1}(\varphi) = \frac{\sigma}{\sigma - 1} \varphi^{-\frac{1+\alpha}{\alpha}} \frac{W q^{\frac{1}{\alpha}}}{B} + \frac{\rho_{F_1} q_{F_1} e_{F_1} \eta_{F_1}}{(\sigma - 1)\tau_{F_1}} \tag{10}$$

Substitute the optimal price rule, equation (10) into the profit function, equation (4)yields, the optimal quality of the variety sold in market F_1 is:[12]

cost and enjoy a reduction in their marginal production cost.

[11]Note this marginal production cost does not rely on e_{F_2}.

[12]Details are provided in Appendix 1.

$$q_{F_1} = \left(\frac{\chi_2 - \sqrt{\chi_2^2 - 4\chi_1\chi_3}}{2\chi_1} \right)^{\frac{\alpha}{1-\alpha}} \tag{11}$$

$$\chi_1 = \frac{\tau_{F_1}\kappa^2}{\alpha e_{F_1}} \left[-\sigma(1-\alpha) + 1 \right]$$

$$\chi_2 = \kappa\eta_{F_1} \left(\sigma + 1 + \frac{1}{\alpha} \right)$$

$$\chi_3 = \frac{e_{F_1}\eta_{F_1}^2}{\tau_{F_1}}$$

$$\kappa = \varphi^{-\frac{1+\alpha}{\alpha}} \frac{W}{B}$$

Differentiating equation (11) with respect to e_{F_2}, we can show the negative relationship between the export quality, q_{F_1}, and the nominal exchange rate, e_{F_2}, between the home country and the foreign country, F_2, i.e.,

$$\frac{\partial q_{F_1}}{\partial e_{F_2}} = -\frac{\alpha}{1-\alpha} \frac{\varphi^{\frac{1+\alpha}{\alpha}}}{W} \left(q_{F_1} \right)^{\frac{2\alpha-1}{\alpha}} \Theta_1 \Theta_2 < 0 \tag{12}$$

$$\Theta_1 = \frac{\alpha e_{F_1}\eta_{F_1} \left[\sqrt{\left(\sigma + 1 + \frac{1}{\alpha}\right)^2 + \frac{4}{\alpha}\left(\sigma(1-\alpha) - 1\right)} \right] - \left(\sigma + 1 + \frac{1}{\alpha}\right)}{\tau_{F_1}\left[\sigma(1-\alpha) - 1\right]}$$

$$\Theta_2 = B\left(e_{F_2}\right)^{-\zeta-1} \left(\frac{\tau_{F_2}}{W} \right)^{-\zeta} \int_0^1 \gamma_j \left[1 + a_j \left(\frac{e_{F_2}\tau_{F_2}}{W} \right)^{-\zeta} \right]^{-1} dj$$

Inequality (12) demonstrates that export product quality to country F_1 is decreasing in e_{F_2}.[13] An import appreciation (a decrease in e_{F_2}) will lead to an improvement in the export product quality. The intuition is straightforward: when the home

[13] In principle a firm can export its products to the destinations where they import intermediate inputs from. In this case, $e_{F_1} = e_{F_2}$, while inequality (12) relies on the assumption that $e_{F_1} \neq e_{F_2}$. In the empirical part, we have controlled for the bilateral exchange rate between home and the export destination countries, and as another robustness check, we drop observations if firms export their products to the destinations which they import from.

currency appreciates relative to the currency in F_2, intermediates imported from country F_2 become cheaper. As such, all other things equal, an exporter can import intermediates of higher qualities than they could afford before the appreciation, and this will increase the quality of their exported products. Firms importing no intermediates are not affected by import exchange rate changes.

Furthermore, according to formula (12) $\frac{\partial q_{F_1}}{\partial e_{F_2}}$ can be written as $\varphi^{\frac{\alpha-3}{1-\alpha}}\Upsilon$, where Υ does not contain φ. When $\alpha << 1$, $\frac{\partial q_{F_1}}{\partial e_{F_2}}$ is decreasing in firm-level productivity. This means that when the quality transfer rate (i.e., the concavity of the quality cost curve) is sufficiently low (a small α) an import appreciation leads more productive firms to improve their export quality less, relative to less productive firms. The intuition is that more productive firms export high quality products; and it is more costly for these firms to further increase their export quality. We summarize the model's prediction formally in the following Proposition.

Proposition 1. *When the quality transferring parameter $\alpha << 1$, importing firms' export quality increases in response to an import currency appreciation. Moreover, the quality increase is decreasing in firm-level productivity.*

Proposition 1 offers several testable predictions. First, in response to an import appreciation, export firms tend to import higher quality intermediates, which improves the quality of their exported products. Second, when facing the same import appreciation, less productive firms improve their export quality more than more productive firms do. In addition, Proposition 1 implies that the product quality of firms importing no intermediates is not influenced by import exchange rate changes.

The above discussion is framed in terms of the product quality in the home market. However, the quality response to import exchange rate changes in the home country is similar to those in the foreign country. Since the focus in this paper is on export quality, we omit the discussions of the home market.

In the next section, we introduce the data used to test the predictions of the model, as well as the construction of the main variables used in our regressions.

3. Data and Main Variables

3.1. Data

Our empirical analysis uses indicators constructed mainly from three datasets: (1) a micro trade dataset containing comprehensive Chinese firms' import and export information during 2000-2006; (2) Annual Surveys of Industrial Production, which offer firm-level production side information; and, (3) a macro-level exchange rate dataset. We describe each separately in detail below.

3.1.1. Customs transaction level trade data

One of our main data sources is the Chinese Customs trade dataset covering all Chinese firms' trade information during 2000-2006. These data are collected by Chinese General Administration of Customs (GAC). This dataset reports comprehensive firm-product-destination-level trade information monthly, such as free on board (f.o.b) trade values (in U.S. dollars) and trade volumes at HS 8-digit product category for firms in each transaction. Since the GAC data is recorded at monthly frequency, we follow other researchers (e.g. Manova and Zhang, 2012; Tang and Zhang, 2012) and aggregate the customs data (trade value and trade volume) by firm, product, and destination country (sometimes also by shipment) to an annual-level. The dataset also records the origin country of imports as well as the destination of exports and contains firm specific information such as name, address, ownership, and trade regime, etc.

Although the product information recorded in the customs dataset is at HS 8-digit level, we aggregate products to HS 6-digit level to avoid potential coding errors at HS 8-digit level (see Li et al., 2015). This aggregation reduces the sample size only trivially since, at a HS 6-digit category, firms usually export (import) only one HS 8 product to (from) a destination country. Table 1 shows the average number of traded products at HS 8-digit and HS 6-digit levels, respectively. The figures demonstrate that the average number of traded products recorded under HS 8-digit and HS 6-digit systems do not differ significantly. Following Li et al. (2015) and others, we use unit value defined as the trade value divided by the trade quantity to be the proxy for product price.

[Table 1 is to be here]

Transactions in the dataset have been classified into 18 different custom regimes. Among all custom regimes, "ordinary trade" and "processing trade" ("processing and assembly trade" and "processing with imported materials trade") account for more than 90% of total trade values in each year. Under the "processing and assembly trade regime", a domestic Chinese firm is offered payment-free raw materials and parts by its foreign trading partners, and the firm has to sell its products to the same foreign trading partner after local assembly. Similarly, although firms under "processing with imported materials" can choose their import/export trading partners, they still differ from firms exporting under the "ordinary trade" regime, since their products must comply with certain known standards.[14] These features

[14]These standards include product quality, color, used raw materials , etc.

of the "processing trade" regime make the influence of exchange rate changes negligible on import and export quality for firms operating under this regime. As such, our main regressions only focus on firms exporting under "ordinary trade" regime.[15]

3.1.2. Firm-Level Production Data

Although the Chinese Customs trade dataset provides detailed information on firm-product-destination level trade transactions, it does not contain production-side information. The Annual Surveys of Industrial Production (ASIP) dataset provides firm-level production information. This dataset reports detailed information on the three major accounting statements for comprehensive state-owned enterprises (SOEs) and non-SOEs with annual sales exceeding 5 million RMB (which is roughly US $770,000). During the sample period 2000-2006, the number of firms contained in the dataset varies between 162,885 and 301,961. These recorded enterprises account for more than 90% of total industrial output and over 70% of total industrial employment in 2004 (Brandt et al., 2012). The dataset also reports comprehensive key financial variables, such as firm-level gross output, capital stock, wage rate, material input costs, employment etc. The information helps to control for firm-level factors which might affect the quality of products.

In order to use both the firm-level trade and production information, a key step is to match the ASIP dataset with the Chinese Customs dataset. Although both datasets provide firm identifers, these identifiers are not common across the data sets. As such we cannot match the two datasets by firm identifer. Following

[15] We also run regressions for firms operating under the "processing trade" regime as a robustness check.

Upward et al (2013), we match the two datasets by using the firms' name and establishment year. Table 2 reports the matching results.

[Table 2 is to be here]

Table 2 indicates that in the matched sample, the total number of exporters and importers accounts for 30.87% and 28.82% of the total exporters and importers in the Customs dataset, respectively. The total export and import values in the matched sample account for 24.63% and 21.55% of the total export and import values recorded in the Customs dataset, respectively.[16]

3.1.3. Country Level Macro Data

The exchange rate is a key variable in this paper, which is obtained from Penn World Table (PWT7.1). The Penn World Table (PWT thereafter) provides bilateral nominal exchange rates, which are pegged to US dollar; we transform these into Chinese RMB against foreign currency. We combine this macro-level dataset with our previous matched sample using the country code available in both datasets. Note that the PWT does not contain all countries that Chinese firms traded with. Hence, combining the marco and micro data further decreases the sample size. Detailed matched results are reported in Panel C of Table 2.

Results indicate that after combining the exchange rate information with our matched sample, the number of exporting destinations and importing countries falls to 125 import countries and 155 export countries. The number of trading firms (importing and exporting), traded varieties and values do not change much. This

[16]Our matching rate is slightly lower than that reported in other papers using the data sets (e.g. Upward et al, 2013), because we only match firms exporting under the "ordinary trade" regime with the ASIP dataset.

implies that those countries not contained in the PWT are not important trade partners with China. In addition, in a subsequent regression we use consumer price indices (CPIs) to adjust the firm-level nominal exchange rate to a real exchange rate to check the robustness of our results. The CPIs in different countries are taken from the International Financial Statistics (IFS).

3.2. Main Variables

3.2.1. Quality Measure

Following Khandelwal (2010) and Hallak and Sivadasan (2013), this study defines 'quality' as any attribute which raises consumer's demand other than price. That is, according to the utility function (1), given price, increases in the quality measure q_c help to increase demand in country country c. Given the utility function, quality can be inferred from the observed price and demand. Following Khandelwal et al. (2013), traded "quality" of product k shipped to (imported from) destination country (sourcing country) c by firm f in year t is denoted as q_{fkct}, and it satisfies the following demand function:[17]

$$x_{fkct} = q_{fkct}^{\sigma-1} p_{fkct}^{-\sigma} P_{ct}^{\sigma-1} Y_{ct} \tag{13}$$

where x_{fkct} denotes the demand for product k in destination c at year t, exported by firm f. P_{ct} and Y_{ct} are the price index and aggregate income of country c in year t, respectively. Taking logs of both sides of equation (13), and rearrange terms we get:

$$ln(x_{fkct}) + \sigma ln(p_{fkct}) = \varphi_k + \varphi_{ct} + \varepsilon_{fhct} \tag{14}$$

[17]The demand function (13) is identical to the demand function defined in (3). The distribution cost, tariff, and exchange rate are contained in the price, p_{fhct}.

where φ_k denotes a product fixed effect, which captures the difference in prices and demand across different product categories arising from inherent product specific characteristics other than quality. φ_{ct} is the country-year fixed effect, which controls for the influence of the aggregate price level, P_{ct}, and aggregate income, Y_{ct}, on product's price and demand. We regress $ln(x_{fkct}) + \sigma ln(p_{fkct})$ on the product fixed effect, country-year fixed effect, and a quality measure represented by: $\hat{q}_{fkct} = \frac{\hat{\varepsilon}_{fkct}}{\sigma - 1}$. The intuition behind this approach is that conditional on a price, products with high quality tend to have higher demand.

A crucial step in obtaining the quality measure is to find the value of the elasticity of substitution, σ. In the literature, researchers adopt different methods and data to estimate the value of σ. This enables us to construct quality measures without estimating the demand equation. After surveying a large number of gravity-based estimates of Armington elasticity of substitution, Anderson and Van Wincoop (2004) conclude that a reasonable range of σ is between $[5, 10]$. In our basic estimation, we adopt the lower bound value for the elasticity of substitution, i.e., $\sigma = 5$. As a robustness check, we also take the upper bound value of elasticity of substitution, $\sigma = 10$. In addition, we also try an alternative measure of elasticity of substitution, which is estimated by Broda et al. (2006) at the HS 3-digit level for all Chinese exports, to construct quality measures.[18]

3.2.2. *Firm-Level Effective Exchange Rates*

A large macro-economics literature investigates the impact of exchange rate movements on aggregate outcomes. For instance, Kenen and Rodrik (1986), Lastrapes and Koray (1990), Hooper and Kohlhagen (1978), Baxter and Stockman

[18] The elasticities of substitution have been estimated by Broda et al. (2006).

(1989), Branson and Love (1988), Campa and Goldberg (1995, 2001), and Goldberg et al (1999) investigate the influence of exchange rate changes on country-level economic variables. Nucci and Pozzolo (2010), Chatterjee et al. (2013), Ekholm et al. (2012), Berman et al. (2012) analyze effects at the industry-level. Typically, in these studies the aggregate effective exchange rate is constructed by summing up the weighted bilateral exchange rate between different trade partners, where the weights are the bilateral trade shares. This methodology, while appropriate for constructing aggregate effective exchange rates is not suitable for our firm-level analysis. Clearly, movements of the aggregate effective exchange rate cannot reveal the heterogeneity in firm-level effective exchange rate changes. We therefore construct the firm-level effective import exchange rate based on firms' import shares in the base year from each sourcing country as follows:

$$EER_{ft} = \sum_{c=1}^{n} \delta_{fc0} ln(ER_{ct}/ER_{c0}) \tag{15}$$

where EER_{ft} denotes the effective import exchange rate faced by firm f in year t. ER_{ct} and ER_{c0} are the nominal exchange rate between Chinese Yuan and the currency of country c in year t, and in the base year, respectively.[19] δ_{fc0} denotes firm f's import share from the sourcing country c in the base year.[20] Since we focus on firm-level quality upgrading through an import mechanism, we use bilateral import shares as the weight instead of bilateral export shares. Based on the definition in equation (15), an increase in EER_{ft} implies a depreciation in

[19] In this research, we take the initial year of the sample (2000) as the base year.

[20] A firm's import base year is this firm's initial import year. Fixing the import share is made to mitigate endogeneity issues. Firms will import more from countries whose currency depreciates more against Chinese Yuan.

the firm-level effective import exchange rate.

We calculate the fluctuations of effective import exchange rate at firm-level between 2000-2006 according to equation (15). The empirical distribution is reported in Table 3.

[Table 3 is to be here]

Table 3 shows that firm-level effective import exchange rate changes exhibit a wide dispersion. This is attributed to the wide variations in sourcing partners across firms. In our sample, 64.50% of firms experience effective import exchange rate appreciations, and the rest experience effective import exchange rate depreciations.

3.2.3. Other Control Variables

In the regressions, we also control for a series of firm-level characteristics to exclude their impact on firms' product quality choice. First, we control for firm-level productivity, since firm-level productivity has been shown to be positively related to firm-level product quality (Berman et al., 2012; Verhoogen, 2008).[21] Second, following Bernini and Tomasi (2015), we proxy firm size using the log number of employees working in each firm. We also control for the capital intensity measured as the log values of tangible assets per employee. In general, firms with higher capital intensity and larger size are more likely to adopt more advanced technologies and produce higher quality products. Lastly, we follow Bas and Strauss-Kahn (2015) and incorporate the number of imported varieties as an explanatory variable. Table 4 reports descriptive statistics for our main variables.

[Table 4 is to be here]

[21] We estimate firm-level productivity following Levinsohn and Petrin (2003).

4. Exchange Rate Fluctuations and Export Quality

In this section, we test Proposition 1 by empirically estimating the impact of effective import exchange rate changes on firm-level export quality. In what follows, we first conduct the benchmark regression. Second, we investigate the heterogeneous effect of exchange rate changes on export quality across firms with different productivities. Lastly, we conduct a series of robustness checks.

4.1. Benchmark Regressions

According to our model, an appreciation in the firm-level import exchange rate leads firms to import higher quality intermediate inputs. Higher quality intermediates improve the quality of exported products. As such, Proposition 1 predicts a negative correlation between the firm-level effective import exchange rate, EER, and the firm-level export quality (EER increase means an import currency appreciaiton). We test this prediction by running the benchmark regression:[22]

$$q^{ex}_{fkct} = \beta_0 + \beta_1 EER_{f,t-1} + \lambda X_{f,t-1} + \eta_{fkc} + \eta_t + \zeta_{fkct} \tag{16}$$

where q^{ex}_{fkct} represents the quality of product k exported to country c by firm f in year t. $EER_{f,t-1}$ is firm i's effective import exchange rate in year $t-1$, which is calculated according to equation (15). $X_{f,t-1}$ is a vector of time-varying attributes of firm f in year $t-1$, containing firm-level productivity, capital intensity,

[22]Similar specifications are used by Berman et al. (2012), Chen and Juvenal (2016), Greenaway et al. (2008), and Chatterjee et al. (2013), who note that the estimated coefficients will capture the long term response of the dependent variable (quality) to changes in the exchange rate. For robustness, we also estimate the benchmark regression after taking firm-difference, and we find that our results remain qualitatively unaffected. These results are omitted here for space considerations.

and firm size. η_{fkc} and η_t are the firm-product-destination fixed effects and year fixed effects, respectively. The former captures the impact of time-invariant firm-product-destination attributes on firm-level exported quality (e.g. distribution costs, trade costs, etc.), while the latter captures the influence of macro shocks on firm-level exported quality. ζ_{fkct} is the error term including all unobservable factors affecting export quality.

[Table 5 is to be here]

In column 1 of Table 5, we run regression (16) by excluding all control variables but the fixed effects. The result shows that a 10% import currency appreciation (a decrease in EER) will increase firm-level export quality by about 0.84%. In column 2, we add more control variables in the regression, but the estimated effect of an import currency appreciation remains unchanged.

We next divide our sample into two subsamples, one containing observations exporting to developed countries, and the other containing observations exporting to developing countries. Developed countries are defined by the World Bank as countries with per-capita GNIs above $9,760 in 2007 using the Atlas conversation factor, while countries whose per-capita GNIs below $9,760 are classified as developing countries. Columns 3 and 4 report export quality responses to import exchange rate changes for observations exporting to developed and developing countries, respectively. The results demonstrate a heterogeneous response of export quality in developed and developing countries.

In column 5, we run the regression for firms engaged in processing trade. The result indicates that import exchange rate changes have a negative but statistically insignificant influence on firm-level export quality. This result is in line with

Greenaway et al. (2008), who find that firms engaged in processing trade in China are usually multinational firms (MNEs). Greenaway et al. (2008) conjecture that MNEs can internalize exchange rate fluctuations and hence minimize the effects of exchange rate movements in a number of ways, e.g., varying the speed of payments, hedging foreign exchange transactions across countries, etc.

4.2. Heterogeneous Effects

Existing evidence suggests that firms exhibit heterogeneous reactions in response to exchange rate changes. For example, Bernini and Tomasi (2015) and Chen and Juvenal (2016) argue that firms exporting high quality products have a lower exchange rate pass-through. Berman et al. (2012) and Li et al. (2015) both document that more productive firms respond more to exchange rate movements in their F.O.B export price, and Amiti et al. (2014) demonstrate that exchange rate pass-through is decreasing in firm-level import intensity and export market share.

In this section, we extend the results in Table 5 examine how firm-level productivity affects firm-level quality upgrading in response to an import appreciation. In order to investigate the role that productivity plays, we add an interaction term of firm-level productivity (TFP) with the effective import exchange rate to our benchmark specification:

$$q^{ex}_{fkct} = \beta_0 + \beta_1 EER_{f,t-1} + \beta_2 EER_{f,t-1} \times TFP_{f,t-1} + \lambda X_{f,t-1} + \eta_{fkc} + \eta_t + \zeta_{fkct} \quad (17)$$

where $TFP_{f,t-1}$ is the productivity of firm f in year $t-1$. Our primary productivity measure is estimated following Levinsohn and Petrin (2003). Designated "LP" method in thereafter. As robustness checks, we also estimate alternative productivity measures, such as using Olley and Pakes (1996) (OP method) and OLS methods,[23] and re-estimate regression (17). β_2 captures the heterogeneous export quality reaction to import exchange rate changes. The estimator results from specification given by equation (17) are reported in Table 6.

[Table 6 is to be here]

Column 1-3 in Table 6 reports the estimate results from specification (17) by using productivities estimated from LP, OP and OLS methods, respectively. All productivity measures are in levels. The results in column 1-3 indicate that although exported quality is increasing in response to an import exchange rate appreciation, quality upgrading declines as firm-level productivity increases. These results suggest that more productive firms upgrade their exported quality at slower rates relative to less productive firms.

As an additional check on this conclusion, in Column 4 - 6, we estimate specification (17) using productivity percentiles instead of the levels. Specifically, we interact the import exchange rate with different bins constructed from the estimates of firm-level productivity. We construct dummy variables for exporters belonging to each percentile category based on their own productivity and the distribution of productivity by industry and year. We next interact percentile dummies with import effective exchange rates. The bottom bin is chosen as the reference group. As before, our results show that firms with higher productivity upgrade their exported quality less than firms with lower productivity in response to an appreciation. Specifically, firms with the highest 10% productivity increase their export quality

[23] The OLS method neglects the simultaneity between inputs and productivity when estimating productivity.

1.2% less than firms with the lowest productivity in our sample. In contrast, the difference is only 0.95% between firms with productivity belonging to the top 50% percentile and the firms with the lowest productivity.

The results reported in Table 6 are consistent with Proposition 1. The intuition is that more productive firms export higher quality products. In response to an import appreciation, these more productive firms cannot upgrade their exported quality as much as less productive firms, as the quality transferring between intermediates and final outputs becomes harder when initial quality is higher.[24] Another possible explanation for this result is that high productive firms use high quality intermediates. If they have used the best intermediates, there is no room for them to further upgrade their export quality.[25]

4.3. Robustness

In the previous section, the empirical results show that an import currency appreciation will lead firms to upgrade the quality of their exports to developed markets, and this quality upgrading slows as firms become more productive. In this section, we conduct a series of robustness checks to confirm our empirical findings. First, we check if our results are driven by missing variables or sample selection bias. Second, we investigate whether our results are robust to alternative measures of quality and the effective exchange rate. Third, we examine whether our results hold for different subsamples based on firm-level characteristics, to

[24] According to our model, when $\alpha < 1$, the quality transferring exhibits diminishing returns.

[25] According to our model, more productive firms will export products of a higher quality. To verify this intuition, we also checked how firms that export at different quality level respond to exchange rate movements. We find that firms that export higher quality products upgrade their product quality less in response to the same import currency appreciation. These results are available upon request.

different standard error clustering methods, and after controlling for different fixed effects. Lastly, we check our basic results by using a difference-in-difference (DID) approach.

4.3.1. Missing Variables and Sample Selection

It is plausible that if a firm imports from the same country as it exports to, the influence of exchange rate movements on this firm will be somewhat offset. Similarly, import tariff could also affect firm-level export price and quality, i.e. Bas and Strauss-Kahn (2015). Without controlling for the exchange rate in the destination country and import tariffs cause a missing variable issue. Furthermore, our sample contains only firms with positive imports,[26] which might cause a sample selection issue. We estimate the benchmark regression by adding more controls and an *inverse Mill's Ratio* to alleviate the missing variable issue and sample selection bias. These results are reported in Table 7.

[Table 7 is to be here]

Column 1 of Table 7 reports the results after controlling for the bilateral exchange rate between China and export destinations. In column 2, we drop observations if the final product is exported to the same country that intermediate inputs are imported from. Specifically, if a firm exports to countries A, B and imports from country A, we will only keep exports to country B in our regression. Both column 1 and column 2 aim to avoid exchange rate movements in the destination and sourcing countries might offset each other. Results of controlling for

[26]We drop firms without any imports during 2000-2006, as the effective import exchange rate are always zero for these firms.

import tariffs are reported in column 3. Column 4 reports the results of controlling for firm-level self-selection into import.[27] Results demonstrate that firms upgrade their export quality in response to an increase in the effective import exchange rate.

4.3.2. Different Measurements

To alleviate the concern that our quality and effective exchange rate measures are biased, we construct an alternative quality measure by letting the elasticity of substitution elasticity equal to 10,[28] and use regression (14) to estimate export quality. We also follow Bas and Strauss-Kahn (2015), and rely on the elasticity of substitution at the HS 3-digit product level estimated by Broda et al. (2006) to construct another quality measure. With these two alternative quality measures, we run the benchmark regression (16) again. The results are reported in the column 1- 2 in Table 8, and suggest that our results are not sensitive to which quality measure we use, i.e., changes in the import effective exchange rate tend to have a statistically significant effect on firm-level export quality, with import currency appreciations leading to quality upgrades.

Countries also differ in their inflation rate. Without deflating exchange rates by inflation, our measured effective import exchange rate is nominal. Following Li

[27] A firm's import decision usually relies on its productivity, export values and number of varieties. High productivity firms are more likely to import, while firms export more in terms of either extensive or intensive margins are more likely to use foreign materials. Therefore, the selection equation is set as: $D_{imp_{ft}} = \gamma_1 TFP_{f,t-1} + \gamma_2 EXP_{f,t-1} + \gamma_3 Variety_{f,t-1}$, where D_{ft} is a dummy variable which takes value 1 if firm f chooses to import in year t, and 0 otherwise. $EXP_{f,t-1}$ and $Variety_{f,t-1}$ denote firm-level aggregate values and number of varieties in year $t-1$.

[28] Recall that in the benchmark regression, we let the elasticity of substitution equals to 5, which is the lower bound. 10 is the upper bound of elasticity of substitution in Anderson and Van Wincoop (2004).

et al. (2015), we use the CPI in each country as the deflator to construct the real effective exchange rate as:

$$EER^r_{ft} = \sum_{c=1}^{n} \delta_{fc0} ln(\frac{ER_{ct}}{CPI_{CHN,t}} / \frac{ER_{c0}}{CPI_{ct}}) \tag{18}$$

where EER^r_{ft} denotes the real import effective exchange rate. $CPI_{CHN,t}$ and CPI_{ct} is the consumer price index in China and country c, respectively. We re-estimate regression (16) using the real effective import exchange rate, and we continue to find that import currency appreciations are associated with subsequent improvements in exported quality. The result is shown in column 3 of Table 8. Lastly, when we calculate the effective import exchange rate, the import share, δ_{fc0}, is fixed. However, this share would vary by year: firms import more from countries whose currency depreciates more relative to the Chinese Yuan. In column 4 of Table 8, we substitute δ_{fc0} by δ_{fct} to construct firm-level effective import exchange rate and re-estimate regression (16).[29] We continue to find that firms upgrade their quality when facing an effective import appreciation.

[Table 8 is to be here]

4.3.3. Different Subsamples, Clustering and Fixed Effects

Another concern is that multiproduct firms may behave differently from single product firms.[30] A multiproduct firms can adjust its product mix in response to shocks (Bernard et al., 2011). Also market size and degree of market competition

[29]We notice that the variable import share cause an endogeneity issue. Here we only want to test whether our results are robust to different measures of import exchange rate.

[30]See Chatterjee et al. (2013) for a model combining multiproduct firms and heterogeneous pricing-to-market response to exchange rate changes. They find that following a depreciation, firms increase markups relatively more for their top products.

determine multiproduct firms' export mix (Mayer et al., 2011). When a multiproduct firm ceases production of a product far from its core competence, demand for its core competence products may increase. This *cannibalization effect* can cause a pseudo quality increase in the firm's core competence product.[31] To address the concern that the exported quality changes are driven by this pseudo quality change in multiproduct firms, we estimate our benchmark regression (16) by keeping only single product firms. This result is reported in column 1 of Table 9. The negative (and significant) sign on the import exchange rate change implies that an import currency appreciation increases the exported quality of single product exporters as before.

One more concern might be our exclusion of firms engaged in processing trade. That is as discussed in the data description section (section 3.1.1), we only keep firms engaged in ordinary trade in our sample. However, notice that in response to exchange rate fluctuations, a firm may find it profitable to switch from the ordinary trade regime to the processing trade regime, or vice versa. In addition, firms' entry and exit from exporting markets in response to the movements of exchange rate also might bias our estimation.[32] Although Bas and Strauss-Kahn (2015) claim that the trade status of Chinese exporters is stable over time,[33] the entry and exit rate from exporting market is non-trivial in our data. We therefore estimate the benchmark specification with a subsample in which firms continuously export

[31]The market cannibalization effect changes the demand of a particular product in a market. The demand changes will be attribute to quality changes if the cannibalization effect is not taken into account of.

[32]However, Greenaway et al. (2008) find that exchange rate movements have a trivial effect on UK manufacturing firms' entry probability.

[33]Bas and Strauss-Kahn (2015) find that during 2000-2006, only 5% firms switch from the ordinary to the processing trade status, and 7% did the reverse.

under the ordinary trade regime throughout the 2000-2006 period. The result is reported in column 2 of Table 9. Again we find a negative and significant coefficient for EER, which is consistent with our benchmark regression results.

Another issue arises with respect to standard error clustering (Cameron et al., 2011), since our dependent variable is at firm-product-destination level, and the main explanatory variable is at firm level. Moulton (1990) shows that regressing an individual level variable on more aggregate variables could induce a downward bias in the estimation of the standard error. In order to address this possible bias, we re-estimate the benchmark specification, and cluster the standard errors at the HS 6-digit level (column 3); country level (column 4); product-country level (column 5); and product-firm level (column 6), respectively. The results shown in Table 9 are virtually unaffected by the method of clustering the standard errors.

Industry shocks may also force firms to switch their production from one industry to another, or change their product quality. Indeed, in our sample 7.4% firms changed their production at least once. To control for industry annual shocks, we replace year fixed effects by industry-year fixed effects. At the meanwhile, unobserved annual macro shocks in different destinations might affect firm-level export quality decisions, e.g., a financial crisis in a particular destination could dampen local consumers' preference to high quality products. Therefore, we control for country-year fixed effects.

The results in column 7 and 8 demonstrate that even after controlling for industry-year and country-year fixed effects, we still obtain a negative and statistically significant coefficient on EER, further confirmation of our benchmark results.

[Table 9 is to be here]

4.3.4. DID Estimation

Lastly, it might be argued that there are omitted macro variables in our benchmark regression, which makes the casual relationship between import exchange rate movements and export quality questionable. For instance, some unobserved macro variables might cause a quality upgrading trend among all Chinese exporters. Given the fact that more than 60% Chinese exporters experience effective import appreciations during 2000-2006, the casual relationship we examined above could be a pseudo relationship without controlling for export quality trends. In order to alleviate this concern, we notice that the export quality of firms without imports should not be affected by import exchange rate changes. This feature makes firms not importing intermediates an ideal control group; firms with positive intermediate imports belong to the treated group. With the two groups of exporters, we attempt to conduct one more robustness check by employing a strategy similar to a difference-in-difference approach, where exporters with- and without-imported intermediates belong to the treated and control groups, respectively.[34] In this way, we can exclude the impact of unobservable quality trends on our results.

For simplicity, we call firms that simultaneously engage in export and import as "two-way exporters", and firms only export as "one-way exporters". As shown in Table 10, 34.3% − 42.7% of firms exporting under ordinary trade regime are two-way exporters during 2000-2006. These two-way exporters account for 84.8% − 88% of total export values each year.

[34] Similar to the argument in Bas and Strauss-Kahn (2015), this is not a traditional difference-in-difference estimation as the treatment (i.e., the fluctuations in the effective import exchange rate) affects the treated group over time.

[Table 10 is to be here]

With the two-way and one-way exporters in our sample, we estimate the following DID specification:

$$q^{ex}_{fkct} = \gamma_0 + \gamma_1 EER_{f,t-1} + \gamma_2 EER_{f,t-1} Twoway_f + \gamma_3 Twoway_f + \zeta_{fkc} + \zeta_t + \varepsilon_{fkct} \quad (19)$$

where, $Twoway_f$ is dummy variable, which takes value 1 if firm f is a two-way exporter, 0 otherwise. All other variables have the same definitions as in equation (16). Since two-way exporters can switch to higher quality intermediates in response to an import appreciation, which in turn, increases their export quality, we expect the coefficient of the interaction term, γ_2, to be negative. Note that during the sample period, firms may switch from two-way exporters to one-way exporters, or vice verse. It is problematic to define the switchers as either two-way or one-way exporters. Hence, avoid the possibility that switchers contaminating our results, we keep only firms maintaining their status, two-way or one-way exporters, throughout their life span. It should be pointed out that the dummy variable $twoway_f$ will be dropped from the estimation when we include a control for firm-product-country fixed effect, as in our sample no firm switches its status. These results are reported in Table 11.

[Table 11 is to be here]

In columns 1-3 of Table 11, we use the firm-level effective import exchange rate defined by equation (15). In column 1 and column 2, export quality is estimated following Khandelwal et al. (2013) by setting the elasticity of substitution to be 5 and 10, respectively. In column 3, export quality is estimated according to Broda et al. (2006). The coefficient γ_2 are negative and significant throughout column 1-3. This confirms our earlier results that in response to an import appreciation, export quality increases for two-way exporters.

In columns 4-5, export quality is estimated as in column 1 (the elasticity of substitution has been set to 5). In column 4, we use the firm-level real exchange rate as given in equation (18). In contrast, in column 5, the firm-level nominal exchange rate is constructed by using equation (15), but we use the initial year's import share (substitute δ_{fct} by δ_{fct_0}). The estimated coefficient γ_2 in columns 4-5 remain negative and statistically significant. All these results suggest that in response to an import appreciation, firms with imported intermediates tend to upgrade their export quality. This is again consistent with our benchmark results.

In the next section, we further examine the impact of effective import exchange rate changes on firm-level imported quality.

5. Exchange Rate Fluctuations and Import Quality

In the last section, we documented a casual effect of import exchange rate movements on firm-level export quality. In this section, we examine the impact of import exchange rate changes on firm-level import quality. If an exporter switches to higher quality intermediate inputs in response to an import appreciation, it would confirm the mechanism proposed in our model.

We first investigate the impact of import exchange rate changes on firm-level import price and sophistication. The specification we estimate for imported price is as follows:

$$lnUV_{fkct} = \alpha_0 + \alpha_1 lnRER_{k,t-1} + D_{fkc} + D_t + \varepsilon_{fkct} \quad (20)$$

where UV_{fkct} represents the unit value of intermediate k (at HS 6-digit level) imported from sourcing country c by firm f in year t. $RER_{k,t-1}$ measures the nominal exchange rate between China and the sourcing country c in year $t-1$. Notice the difference between $RER_{k,t-1}$ and $EER_{f,t-1}$. The former is country specific, while the latter is firm specific. An increase in $RER_{k,t-1}$ indicates a depreciation in the domestic currency (Chinese yuan in our case). D_{fkc} and D_t separately capture the firm-product-country fixed effect and year fixed effect. ε_{fkct} is the error term. Note that all variables are in levels (rather than first difference), and hence, the estimated coefficients can be treated as capturing the long term response of import unit values to changes in the bilateral exchange rate. Following Chen and Juvenal (2016), we assume that the exchange rates are exogenous to the pricing decisions of individual firms given the disaggregation of the data.

To test the impact of import exchange rate movements on firms' import sophistication, we estimate the following specifications proposed by Bas and Strauss-Kahn (2015):

$$Sophistication_{ft} = \lambda_0 + \lambda_1 lnEER_{f,t-1} + D_f + D_t + \epsilon_{ft} \tag{21}$$

where $Sophistication_{ft}$ denotes the import sophistication of firm f in year t. As in Schott (2008), firm-level import sophistication is measured by the firm's import share from developed countries. $EER_{f,t-1}$ is the firm-level import exchange rate as before.[35] Since firm specific characteristics and macro shocks might affect firms' sourcing country decision, we also include firm fixed effect, D_f and year fixed effect, D_t, in the regression.[36]

The coefficients of interest in regression (20) and (21) are α_1 and λ_1, respectively. The coefficient α_1 is expected to be positive, while the coefficient λ_1 is expected to be negative. A positive α_1 implies that an decrease in EER (i.e., an appreciation in the domestic currency) will lead to a lower import price. In contrast, a negative λ_1 implies that a decrease in EER (an appreciation in the import exchange rate) increases firm-level import sophistication. Our results are reported in Table 12.

[Table 12 is to be here]

Panel A in Table 12 reports the results for import price (equation 20). We begin with a sample containing firms exporting under the ordinary trade regime. The result in column 1 of Panel A shows a positive α_1, which implies that an appreciation leads to a decline in import unit price. It is arguable that during 2000-2006, a surge in raw materials and energy prices might drive this result in column 1. Hence, we estimate (20) again by excluding observations of importing raw materials and energy.[37] The results are shown in column 2 of Panel A. The result in column 2 is quite similar to that reported in column 1. This suggests

[35]Note that in the unit value regression, we adopt bilateral exchange rate as the explanatory variable, while in the sophistication regression, we use firm-level import exchange rate as explanatory variable. The reason is that the former, import unit value, is at the firm-product-country level, and hence bilateral exchange rate is more straightforward, while the latter, sophistication, is at firm-level, we have to use the firm-level import exchange rate as the independent variable.

[36]We use only the Customs data to estimate regression (20) and (21).

[37]We exclude all agricultural and mineral products from the estimation (i.e., products belong to the HS2 classification 01 to 27).

that the estimated positive α_1 is not caused by a surge in prices of raw materials and energy. Also notice that $\alpha_1 < 1$, which implies an incomplete pass-through of exchange rates on import price, a result found by many earlier researchers (e.g. Campa and Goldberg, 2005; Goldberg and Knetter, 1997; Gopinath and Rigobon, 2008, etc.).

In columns 3 and 4 of Panel A, we divide imported intermediates from developed countries and developing countries, and run the regression (20) for each subsample, respectively. The definition of developed and developing countries are the same as before(see subsection 3.1). The results in column 3 indicate that a 10% appreciation corresponds to a 4.79% decrease in the price of imports from developed countries. This influence is twice the import price decrease in developing countries (2.56%), and seems to contradict evidence in Chen and Juvenal (2016) and Bernini and Tomasi (2015), who both find that firms exporting higher quality products, tend to exhibit smaller pass-through. However, since developed countries usually produce higher quality intermediates than developing countries do, (ignoring importers switching to higher quality intermediates), we should expect a smaller decline in import prices falling of intermediates imported from developed countries. Our model predicts that quality upgrading is harder for firms exporting (importing) higher quality products (intermediates) if the quality transferring between intermediates and final products exhibits diminishing returns. Therefore, all other things equal, in response to an import currency appreciation, firms importing from developing countries upgrade their imported intermediate quality more than those importing from developed countries. This leads to the import price in developing countries decreasing less than that in developed countries.[38]

Results in Panel B of Table 12 investigate the effect of firm-level import exchange rate changes on firms' import sophistication. In columns 1-2, we do not control for year fixed effects, while in columns 3 and 4 we control for firm fixed effects and year fixed effects. In addition, in columns 1 and 3, we construct the import sophistication measure using firms' import share from developed countries, in terms of values:

$$Sophistification_{ft} = \frac{Importing\ Values\ from\ Developed\ Countries}{Total\ Import\ Values}$$

In columns 2 and 4, we construct the firm-level import sophistication using firms' import share from developed countries, in terms of quantities:

$$Sophistification_{ft} = \frac{Importing\ Quantities\ from\ Developed\ Countries}{Total\ Import\ Quantities}$$

All results demonstrate the pattern that when the domestic currency appreciates, firms' import share from developed countries increases. This is consistent with increases in firm-level import sophistication in response to import appreciation.

In sum, Table 12 indicates that when the domestic currency appreciates, firm-level import prices decrease, and more so for intermediates from developed countries, and that firm-level import sophistication increases.

[38] An alternative interpretation is that in response to an appreciation, a portion of firms switch their imports from developing countries to developed countries (see column 3 of Panel B in Table 12). These sourcing country switching firms import inferior intermediates than firms continuously importing from developed countries, and hence, the average importing price from developed countries decrease. This leads to the import price falling more in developed countries.

5.1. Exchange Rate Fluctuations and Imported Products Quality

Although firms' import price and sophistication exhibit patterns supporting our quality upgrading story, we realize that import price changes in different sourcing countries might not be driven by import quality changes, but rather by markup changes. Also firms' import sophistication increases might simply reveal that firms begin importing more varieties from developed countries. In order to address these concerns, we follow the steps used previously in the estimation of exported product quality (see Section 4.3.2), in the construction of our imported intermediate quality measures. These results are reported in Table 13.

[Table 13 is to be here]

In columns 1-4 of Table 13, import quality is estimated by using specification (14) but here we replace export quantities and prices by import quantities and prices. As before, the elasticity of substitution has been set to be 5. Column 1 regresses import quality on the import exchange rate. Columns 2-4 repeat the regression in column 2, but with different fixed effects. Specifically, column 2 controls for firm-product-country and year fixed effects; column 3 controls for firm-product-country and product-year fixed effects; and column 4 controls for firm-product-country and country-year fixed effects, respectively. Results in columns 1-4 suggests that in response to an import appreciation, firm-level import quality increases.

In column 5, we continue to estimate firm-level import quality using specification (14) but we set the elasticity of substitution equal to 10. In column 6, we follow the method used by Broda et al. (2006) to construct another import quality measure. As before, results in columns 5-6 indicate a negative and significant coefficient on $EER_{f,t-1}$.

In column 7, we use CPIs in each country to deflate the nominal exchange rate and construct the effective real import exchange rate according to equation (18). In column 8 we construct firm-level import exchange rate as in columns 1 - 6 by using specification (15), but replace the constant import share, δ_{fct_0}, by the time-varying import share, δ_{fct}. Again, the results suggest that firm-level import quality increases with import currency appreciation, whether we consider nominal or real exchange rates.

6. Conclusions

This paper examines the impact of exchange rate fluctuations, in particular, firm-level import exchange rate fluctuations, on firm-level import and export quality. Our argument is that a decrease in firm-level import exchange rate (i.e. an appreciation in the domestic currency) enables firms to upgrade their exported product quality by buying higher quality intermediates, which they could not afford before.

We first develop a theoretical model highlighting the role of exchange rates in firm-level imported intermediates, and their export product quality decisions. Following others (e.g. Rodrigue and Tan, 2016; Bas and Strauss-Kahn, 2015), we assume a positive linkage between the quality of intermediate input and the quality of final products. The model predicts that firm-level export product quality increases in response to an import appreciation, which is achieved by switching to a higher quality of imported intermediates. Furthermore, if the quality transferring between the intermediate inputs and final outputs exhibits diminishing returns, firms exporting higher quality products (importing higher quality intermediates) tend to increase their exported products quality (imported intermediates quality) less than those exporting lower quality products in response to an appreciation.

Using a rich and unique database of Chinese firms' trade data, we test the model's predictions, and examine the casual effect of firm-level import exchange rates on firm-level export and import quality. We uncover a series of important findings: first, an import currency appreciation leads to an increase in firm-level exported product quality. This result is robust across a number of specifications. Second, an import currency appreciation is associated with a decrease in firms' import prices and an increase firm-level import sophistication, consistent with our quality upgrading story. Third, an import currency appreciation boosts the quality of the firms imported intermediates. All of our empirical finding are in line with our model's predictions. Our findings also provide an alternative interpretation for the puzzle of nearly complete pass-through among Chinese exporters documented by Li et al. (2015): quality upgrading offsets exporters' incentive to cut export price in response to an appreciation.

Finally, we note that there is very little in our model specific to China, or indeed to a developing country context. This suggests that our findings may apply more broadly. Of course, one limitation of the partial equilibrium model we employ is that the firm-level exchange rates, which are the key driver of quality upgrading, exclude the general equilibrium implications for wages, and for aggregate demand in the export markets. We leave these extensions for future work.

Appendix

Tables

Table 1: The average traded product numbers per firm

	Export		Import	
Year	HS8 product Level	HS6 Product Level	HS8 product Level	HS8 product Level
2000	42	39	86	76
2001	42	39	78	69
2002	48	45	75	67
2003	49	46	69	69
2004	51	47	65	58
2005	53	48	61	54
2006	51	46	56	50

Notes: Data Source: authors own calculation based on the dataset collected by China's General Administration of Customs.

Table 2: The descriptive statistics of the sample

Panel A: Customs Data								
	Export				Import			
	#Export Firms	#Export Countries	#Export Products	#Export Value	#Import Firms	#Import Countries	#Import Products	#Import Value
Total	213,619	219	5,386	1,509,631	150,503	211	5,382	1,388,666
Average	87,808	212	4,954	215,661	55,729	184	4,932	198,380
Panel B: Merged with ASPI								
	Export				Import			
	#Export Firms	#Export Countries	#Export Products	#Export Value	#Import Firms	#Import Countries	#Import Products	#Import Value
Total	65,936	216	5,070	371,882	43,381	191	5,045	299,269
Average	25,283	206	4,282	53,126	15,180	148	4,207	42,753
Panel C: Merged with IFS								
	Export				Import			
	#Export Firms	#Export Countries	#Export Products	#Export Value	#Import Firms	#Import Countries	#Import Products	#Import Value
Total	65,033	157	5,055	351,664	40,422	151	5,023	271,955
Average	24,874	155	4,252	50,238	13,985	125	4,151	38,851

Notes: Data Source: Authors' calculations based on three datasets described in the text. Note: (1)When calculating the total number of firms, countries and export products, we combined the data over years, and only count each variable once when it first time appears. When calculating the average variables, we average them over years. (2) the unit of the traded value is billion.

Table 3: Distribution of Effective Exchange Rate Changes, 2000-2006

	Range	Number of Firms	Share
Appreciation	< -0.1	10,554	11.04%
	$(-0.1, -0.05)$	11,612	12.15%
	$(-0.05, 0)$	39,472	41.31%
Depreciation	$(0, 0.05)$	15,167	15.87%
	$(0.05, 0.1)$	6,510	6.81%
	> 0.1	12,245	12.81%

Table 4: The statistics of the main variables

	Observations	Mean	S.D.	Min	Max
Exporters					
Estimated Quality	1,188,111	0.374	1.431	-12.380	14.242
Effective Exchange Rate	1,188,111	0.004	0.052	-0.967	0.372
Productivity	1,188,111	4.682	1.038	-5.666	10.989
Capital Intensity	1,188,111	5.313	1.085	-6.397	14.795
Log Number of Labors	1,188,111	5.949	1.254	0	11.965
Imported Varieties	1,188,111	2.018	1.474	0	6.652
Importers					
Estimated Quality	1,079,353	0.323	1.990	-13.457	18.528
Effective Exchange Rate	1,079,353	0.015	0.078	-0.967	0.372
Productivity	1,079,353	4.838	1.234	-4.905	10.989
Capital Intensity	1,079,353	6.334	1.185	-6.397	14.795
Log Number of Labors	1,079,353	6.088	1.499	0	11.965
Imported Varieties	1,079,353	3.889	1.309	0	6.652

Note: The quality is estimated with elasticity of substitution equal to 5, which is used in the basic regression.

Table 5: Exchange rate fluctuations and firms' exported product quality

Samples	(1) Full Sample (Ordinary)	(2) Full Sample (Ordinary)	(3) Exporting to DC	(4) Exporting to LDC	(5) Processing Exporters
EER	-0.092^{**}	-0.084^{**}	-0.070^{**}	-0.095	-0.194
	(-2.66)	(-2.42)	(-1.96)	(-1.14)	(-1.36)
$Imported$ $Varieties$		-0.027	-0.021	-0.046	0.115
		(-1.29)	(-0.91)	(-0.90)	(0.94)
$Labor$		0.079^{***}	0.084^{***}	0.055^{***}	0.124^{***}
		(14.29)	(14.54)	(4.03)	(5.88)
$CaptialIntensity$		0.046^{***}	0.045^{***}	0.048^{***}	0.049^{***}
		(9.50)	(8.63)	(3.73)	(3.27)
TFP		0.021^{***}	0.021^{***}	0.018^{***}	0.037^{***}
		(9.32)	(8.74)	(3.22)	(4.55)
$Constant$		-0.461^{***}	-0.516^{***}	-0.225	-0.767^{***}
		(-9.44)	(-9.86)	(-1.64)	(-5.67)
firm-prod-dest FE	Yes	Yes	Yes	Yes	Yes
year FE	Yes	Yes	Yes	Yes	Yes
Observations	1,188,111	1,188,111	947,632	232,604	635,814
R^2	0.782	0.782	0.778	0.797	0.864

Note: The table reports estimates of Eq.(4). Estimations in columns (3) and (4) are for firms exporting to developed countries and developing countries respectively. firm-prod-dest FE represents firm-product-destination fixed effects. ∗∗∗,∗∗,∗ indicate significance at the levels of 1%, 5% and 10% respectively. t-statistics in Parentheses

Table 6: Heterogeneous effects of effective exchange rate on exported products quality

	(1)	(2)	(3)	(4)	(5)	(6)
EER	-0.290^{**}	-0.436^{***}	-0.338^{***}	-0.131^{***}	-0.129^{***}	-0.120^{***}
	(-2.23)	(-2.65)	(-2.75)	(-2.77)	(-3.06)	(-3.28)
$EER \times TFP$	0.044^{**}	0.070^{**}	0.056^{**}			
	(2.33)	(2.09)	(2.24)			
$EER\times$ *Top* $50\%TFP$				0.095^{*}		
				(1.80)		
$EER\times$ *Top* $25\%TFP$					0.098^{*}	
					(1.79)	
$EER\times$ *Top* $15\%TFP$						0.120^{**}
						(2.04)
Imported Varieties	-0.026	-0.014	-0.026	-0.026	0.015	0.015
	(-1.23)	(-0.47)	(-1.24)	(-1.24)	(0.68)	(0.68)
Labor	0.078^{***}	0.087^{***}	0.077^{***}	0.078^{***}	0.078^{***}	0.078^{***}
	(14.62)	(10.93)	(14.61)	(14.63)	(13.20)	(13.24)
Capital Intensity	0.045^{***}	0.043^{***}	0.045^{***}	0.045^{***}	0.044^{***}	0.044^{**}
	(9.25)	(6.17)	(9.23)	(9.25)	(8.39)	(8.41)
TFP	0.020^{***}	0.012^{***}	0.020^{***}	0.020^{***}	0.016^{***}	0.016^{***}
	(9.11)	(3.80)	(9.09)	(9.12)	(6.82)	(6.77)
Constant	-0.457^{***}	-0.403^{***}	-0.455^{***}	-0.456^{***}	-0.364^{***}	-0.364^{***}
	(-9.03)	(-5.18)	(-9.01)	(-9.04)	(-6.09)	(-6.08)
firm-prod-dest FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,188,111	1,188,111	1,188,111	1,188,111	1,188,111	1,188,111
R^2	0.781	0.794	0.781	0.781	0.792	0.792

Note: TFP in the column (1) is estimated with LP method; TFP in the column (2) is estimated with OP method; TFP in the column (3) is estimated with OLS method. Percentiles in the last three columns are computed in each year. The benchmark group is the bottom productivity bin in each column. firm-prod-dest FE represents firm-product-destination fixed effects. $***$,$**$,$*$ indicate significance at the levels of 1%, 5% and 10% respectively.

Table 7: Robustness-Missing Variables and Sample Selection

	(1)	(2)	(3)	(4)
EER	-0.085^{**}	-0.138^{***}	-0.084^{**}	-0.104^{***}
	(-2.41)	(-3.28)	(-2.42)	(-3.01)
Imported Varieties	-0.030	-0.075^{***}	-0.027	-0.008^{***}
	(-1.39)	(-1.29)	(-1.28)	(-3.79)
Labor	0.081^{***}	0.060^{***}	0.079^{***}	0.035^{***}
	(15.21)	(9.49)	(14.89)	(6.56)
Capital Intensity	0.047^{***}	0.043^{***}	0.046^{***}	0.020^{***}
	(9.65)	(7.43)	(9.50)	(4.11)
TFP	0.021^{***}	$0.020***$	0.021^{***}	0.005^{**}
	(9.26)	(7.54)	(9.32)	(9.25)
ER	0.003			
	(0.76)			
Tariff			0.005^{*}	
			(1.68)	
Lambda				-5.095
				(-39.59)
Constant	-0.497	-0.346^{***}	-0.461^{***}	-0.465^{***}
	(-9.51)	(-5.82)	(-9.19)	(-9.27)
firm-prod-dest FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1,188,111	862,575	1,188,111	1,188,111
R^2	0.782	0.800	0.782	0.783

Note: Column 1 reports the results of controlling for destination exchange rate; column 2 reports the results for firms that export and import from different destinations; column 3 controls for import tariff, and the results in column 4 are estimated from Heckman two-stage regression. firm-prod-dest FE represents firm-product-destination fixed effects. $***,**,*$ indicate significance at the levels of 1%, 5% and 10% respectively. t-statistics in parentheses.

Table 8: Robustness-Different Measures of Exchange Rate and Quality

	(1)	(2)	(3)	(4)
EER	-0.076^{**}	-0.204^{***}	-0.084^{**}	-0.032^{**}
	(-2.48)	(-4.39)	(-2.42)	(-2.04)
Imported Varieties	-0.031^{*}	0.080^{**}	-0.027	-0.025
	(-1.67)	(2.30)	(-1.30)	(-1.21)
Labor	0.034^{***}	0.174^{***}	0.079^{***}	0.079^{***}
	(7.27)	(23.72)	(14.93)	(15.00)
Capital Intensity	0.018^{***}	0.087^{***}	0.046^{***}	0.046^{***}
	(4.22)	(13.23)	(9.51)	(9.59)
TFP	0.014^{***}	$0.047***$	0.021^{***}	0.021^{***}
	(6.94)	(13.23)	(9.30)	(9.25)
Constant	-0.016	-1.250^{***}	-0.462^{***}	-0.465^{***}
	(-0.37)	(-18.09)	(-9.20)	(-9.27)
firm-prod-dest FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1,188,111	1,188,111	1,188,111	1,188,111
R^2	0.805	0.768	0.782	0.782

Note: The dependent variable in column (1) is the estimated quality by setting the elasticity of substitution equal to 10. The dependent variable in column (2) is the estimated quality by setting the elasticity of substitution equal to Broda et al. (2006). The effective exchange rate in column (3) is calculated using the real exchange rate between China and the destination country, while the effective exchange rate in column (4) is calculated using the variable importing share in the base year. firm-prod-dest FE represents firm-product-destination fixed effects. $***$,$**$,$*$ indicate significance at the levels of 1%, 5% and 10% respectively. t-statistics in parentheses.

Table 9: Robustness-Different Sample Sample, Standard Error Clustering and Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EER	-0.478^{**}	-0.116^{**}	-0.084^{*}	-0.084^{*}	-0.084^{**}	-0.084^{*}	-0.095^{***}	-0.068^{**}
	(-2.44)	(-2.05)	(-1.70)	(-1.86)	(-1.96)	(-1.75)	(-2.69)	(-1.96)
Imported Varieties	0.087	-0.090^{**}	-0.027	-0.027	-0.027	-0.027	-0.032	-0.016
	(0.66)	(-2.38)	(-1.06)	(-1.15)	(-1.21)	(-1.03)	(-1.53)	(-0.79)
Labor	0.150^{***}	0.053^{***}	0.079^{***}	0.079^{***}	0.079^{***}	0.079^{***}	0.075^{***}	0.072^{***}
	(4.34)	(5.39)	(10.25)	(11.07)	(12.36)	(10.37)	(13.94)	(15.06)
Capital Intensity	0.114^{***}	0.016^{**}	0.046^{***}	0.046^{***}	0.046^{***}	0.046^{***}	0.041^{***}	0.045^{***}
	(3.80)	(1.97)	(6.86)	(7.00)	(8.06)	(7.24)	(8.45)	(10.20)
TFP	0.029^{**}	0.017^{***}	0.021^{***}	0.021^{***}	0.021^{***}	0.021^{***}	0.020^{***}	0.020^{***}
	(2.12)	(4.22)	(6.53)	(6.78)	(7.24)	(6.58)	(8.32)	(8.96)
Constant	-1.124^{***}	-0.047	-0.461^{***}	-0.461^{***}	-0.461^{***}	-0.461^{***}	-0.609	-0.381^{***}
	(-3.59)	(-0.52)	(-6.14)	(-6.78)	(-7.61)	(-6.49)	(0.37)	(309.13)
firm-prod-dest FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No
prod-year FE	No	No	No	No	No	No	Yes	NO
dest-year FE	No	No	No	No	No	No	No	Yes
Observations	44,130	304,498	1,194,578	1,194,578	1,194,578	1,194,578	1,194,578	1,188,111
R^2	0.883	0.825	0.781	0.781	0.781	0.781	0.781	0.782

Note: Column (1) is estimated by using the subsample of single-product firms. Ccolumn (2) is estimated by using the subsample of firms engaged in ordinary trade and appears in the whole sample period. Results through column (3) to column (6) are estimated with standard errors clustered at product level, country level, country-product level and firm product level, respectively. Instead of controlling for year fixed effect, we control industry-year fixed effect to get the result in the column (7). firm-prod-dest FE represents firm-product-destination fixed effects; prod-year FE represents 2-digit industry and year fixed effects, dest-year FE represents destination-year fixed effects. $***$,$**$,$*$ indicate significance at the levels of 1%, 5% and 10% respectively. t-statistics in parentheses

Table 10: Statistics on Different Types of Exporters

	Exporters		Two-way Exporters		One-way Exporters	
Year	Number	Export Values	Number	Export Values	Number	Export Values
2000	21,003	141,990	9,149	134,596	11,854	7,394
2001	21,779	162,027	9,865	155,090	11,914	6,937
2002	25,469	197,432	11,599	187,776	13,870	9,656
2003	33,539	270,680	13,941	255,155	19,598	15,524
2004	48,574	365,843	17,105	399,317	31,469	26,525
2005	63,943	426,308	19,057	384,104	44,886	42,204
2006	90,939	585,987	23,838	508,402	67,101	77,585

Data Source: authors own calculation based on the dataset collected by Chinas General Administration of Customs. Notes: Export Values are measured by$1,000,000

Table 11: Difference-in-Difference Estimation Results

	Export Quality				
	(1)	(2)	(3)	(4)	(5)
$EER \times Twoway$	-0.208^{***}	-0.145^{***}	-0.078^{***}	-0.046^{***}	-0.045^{***}
	(-14.25)	(-11.34)	(-3.18)	(-2.77)	(-6.56)
$Constant$	-0.148^{***}	-0.090^{***}	-0.183^{***}	-0.109^{***}	0.147^{***}
	(-91.76)	(-63.63)	(-76.72)	(-67.80)	(91.22)
firm-prod-dest FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	10,390,662	10,390,662	10,390,662	10,390,662	10,390,662
R^2	0.750	0.769	0.712	0.740	0.750

Notes: Column (1)-(3) uses the effective firm-level exchange rate calculated by equation (15), while column (4)-(5) uses the real effective firm-level exchange rate calculated by equation (18) but with a constant base year import share, δ_{fct_0}. In column (1), (4) and (5), export quality is constructed by setting the elasticity of substitution equal to 5. In column (2), export quality is constructed by setting the elasticity of substitution equal to 10. In column (2), export quality is constructed by setting the elasticity of substitution equal to Broda et al. (2006). firm-prod-dest FE represents firm-product-destination fixed effects. $***$,$**$,$*$ indicate significance at the levels of 1%, 5% and 10% respectively. t-statistics in parenthesis.

Table 12: The impact of exchange rate fluctuations on import price and import sophistication

Panel A: Import Price	(1) Full Sample	(2) Without Raw Materials	(3) Importing from Developed Countries	(4) Importing from Developing Countries
RER	0.477***	0.498***	0.479***	0.256***
	(39.73)	(39.29)	(38.16)	(7.28)
Constant	3.348***	3.467***	3.384***	2.043***
	(1353.86)	(1352.53)	(1205.57)	(21.83)
firm-prod-dest FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	6,193,865	5,960,234	5,910,180	283,685
R^2	0.899	0.893	0.894	0.956

Panel B: Import Sophistication	(1) Share of imported value DC	(2) Share of imported quantity DC	(3) Share of imported value DC	(4) Share of imported quantity DC
RER	−0.068***	−0.119***	−0.042*	−0.094**
	(-3.37)	(-2.85)	(-1.87)	(-2.07)
Imported Varieties	−0.004	0.029	−0.001	0.015
	(-0.24)	(0.97)	(-0.05)	(0.54)
Constant	−0.106***	−0.191***	−0.098***	−0.179***
	(-31.21)	(-27.55)	(-24.21)	(-21.94)
Firm FE	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Observations	166,676	166,676	166,676	166,676
R^2	0.543	0.447	0.538	0.439

Note: firm-prod-dest FE represents firm-product-destination fixed effects. ∗ ∗ ∗,∗∗,∗ indicate significance at the levels of 1%, 5% and 10%, respectively.

Table 13: Exchange rate fluctuations and firms' imported product quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EER	−0.078***	−0.155**	−0.356***	−0.179***	−0.144***	−0.651***	−0.155***	−0.101**
	(-3.11)	(-3.29)	(-3.69)	(-7.09)	(-3.34)	(-8.03)	(-3.29)	(-2.49)
Imported Varieties		0.467***	0.442***	0.235***	0.314***	0.991***	0.467***	0.0483***
		(9.56)	(8.92)	(4.93)	(7.02)	(11.81)	(9.56)	(9.84)
Labor		0.140***	0.148***	0.075***	0.084***	0.288***	0.140***	0.141***
		(16.76)	(17.25)	(9.78)	(11.06)	(20.12)	(16.76)	(16.87)
Capital Intensity		0.106***	0.105***	0.060***	0.064***	0.206***	0.106***	0.107***
		(13.00)	(12.55)	(7.75)	(8.55)	(14.70)	(12.98)	(13.06)
TFP		0.026* * *	0.025***	0.026***	0.018***	0.060***	0.026***	0.027***
		(8.13)	(7.49)	(8.13)	(6.18)	(10.71)	(8.17)	(8.19)
Constant	0.374***	−1.373***	−1.252***	−0.293***	−0.669***	−3.000***	−1.372***	−1.385***
	(61.52)	(-15.38)	(-4.43)	(-85.28)	(-8.20)	(-19.62)	(-15.37)	(-15.53)
firm-prod-dest FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes			Yes	Yes	Yes	Yes
prod-year FE				Yes				
dest-year FE			Yes					
Observations	1,079,353	1,079,353	1,079,353	1,079,353	1,079,353	1,079,353	1,079,353	1,079,353
R^2	0.697	0.697	0.698	0.697	0.708	0.745	0.697	0.697

Note: firm-prod-dest FE represents firm-product-destination fixed effects; prod-year FE represents 2-digit industry and year fixed effects. dest-year FE denotes destination-year fixed effects. ∗∗∗,∗∗,∗ indicate significance at the levels of 1%, 5% and 10% respectively. The dependent variable in the column (5) is the quality estimated with the substitution elasticity equaling to 10. The dependent variable in the column (6) is the quality estimated with the substitution elasticity from Broad et al.(2006). The effective exchange rate in the column (7) is calculated with the real exchange rate between China and the importing country, while the effective exchange rate in the column (8) is calculated with the time-varying importing share.

Appendix 1

Proof

The optimal product quality in market F_1.

ProfWe first substitute the optimal price rule, equation (7) into the profit function, equation (4):

$$\pi_{F_1} = Y_{F_1} P_{F_1}^{\sigma-1} \left[\frac{\frac{\sigma}{\sigma-1} c(\varphi, e_{F_2}) \tau_{F_1} + \frac{q_{F_1} e_{F_1} \eta_{F_1}}{\sigma-1}}{q_{F_1} e_{F_1}} + \eta_{F_1} \right]^{-\sigma} \left[\frac{1}{\sigma-1} c(\varphi, e_{F_2}) + \frac{q_{F_1} e_{F_1} \eta_{F_1}}{(\sigma-1)\,\tau_{F_1}} \right]$$

$$= Y_{F_1} P_{F_1}^{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \frac{1}{\sigma-1} \left[\frac{\tau_{F_1} \kappa q_{F_1}^{\frac{1-\alpha}{\alpha}}}{e_{F_1}} + \eta_{F_1} \right]^{-\sigma} \left(\kappa q_{F_1}^{\frac{1}{\alpha}} + \frac{e_{F_1} \eta_{F_1} q_{F_1}}{\tau_{F_1}} \right) \quad \text{(A1)}$$

$$\kappa = \varphi^{-\frac{1+\alpha}{\alpha}} \frac{W}{B}$$

$$B = \exp\left(\int_0^1 \gamma_j \log b_j dj \right)$$

$$b_j = \left[1 + a_j \left(\frac{e_{F_2} \tau_{F_2}}{W} \right)^{-\zeta} \right]^{\frac{1}{\zeta}}$$

$\frac{\partial \pi_{F_1}}{\partial q_{F_1}} = 0$ implies that

$$(-\sigma) \left[\frac{\tau_{F_1} \kappa q_{F_1}^{\frac{1-\alpha}{\alpha}}}{e_{F_1}} + \eta_{F_1} \right]^{-\sigma-1} \frac{\tau_{F_1} \kappa}{e_{F_1}} \frac{1-\alpha}{\alpha} q_{F_1}^{\frac{1-2\alpha}{\alpha}} \left(\kappa q_{F_1}^{\frac{1-\alpha}{\alpha}} + \frac{e_{F_1} \eta_{F_1} q_{F_1}}{\tau_{F_1}} \right)$$
$$+ \left[\frac{\tau_{F_1} \kappa q_{F_1}^{\frac{1-\alpha}{\alpha}}}{e_{F_1}} + \eta_{F_1} \right]^{-\sigma} \left(\frac{1}{\alpha} \kappa q_{F_1}^{\frac{1-\alpha}{\alpha}} + \frac{e_{F_1} \eta_{F_1}}{\tau_{F_1}} \right) = 0 \quad \text{(A2)}$$

rerange each term in (A2), we have the following F.O.C for quality:

$$\frac{-\sigma\tau_{F_1}\kappa}{e_{F_1}}\frac{1-\alpha}{\alpha}\left(\kappa q_{F_1}^{\frac{2(1-\alpha)}{\alpha}}+\frac{e_{F_1}\eta_{F_1}}{\tau_{F_1}}q_{F_1}^{\frac{1-\alpha}{\alpha}}\right)+\left[\frac{\tau_{F_1}\kappa^2}{e_{F_1}}\frac{1}{\alpha}q_{F_1}^{\frac{2(1-\alpha)}{\alpha}}+\left(\kappa\eta_{F_1}+\frac{1}{\alpha}\kappa\eta_{F_1}\right)q_{F_1}^{\frac{1-\alpha}{\alpha}}+\frac{e_{F_1}\eta_{F_1}^2}{\tau_{F_1}}\right]=0$$

$$\Rightarrow \underbrace{\frac{\tau_{F_1}\kappa^2}{\alpha e_{F_1}}[-\sigma(1-\alpha)+1]}_{\chi_1}q_{F_1}^{\frac{2(1-\alpha)}{\alpha}}-\underbrace{\kappa\eta_{F_1}\left(\sigma+1+\frac{1}{\alpha}\right)}_{\chi_2}q_{F_1}^{\frac{1-\alpha}{\alpha}}+\underbrace{\frac{e_{F_1}\eta_{F_1}^2}{\tau_{F_1}}}_{\chi_3}=0 \quad \text{(A3)}$$

Note that $\chi_1 < 0$ when $\alpha << 1$, $\chi_2 > 0$ and $\chi_3 > 0$. From (A3), we can compute the optimal product quality in market F_1 as:

$$\begin{aligned} q_{F_1}^{\frac{1-\alpha}{\alpha}} &= \frac{\chi_2-\sqrt{\chi_2^2-4\chi_1\chi_3}}{2\chi_1} \\ &= \frac{1}{\kappa}\Theta_1 \end{aligned} \quad \text{(A5)}$$

where Θ is a function without κ and e_{F_2},

$$\Theta_1 = \frac{\alpha e_{F_1}\eta_{F_1}\left[\sqrt{\left(\sigma+1+\frac{1}{\alpha}\right)^2+\frac{4}{\alpha}\left(\sigma(1-\alpha)-1\right)}\right]-\left(\sigma+1+\frac{1}{\alpha}\right)}{\tau_{F_1}\left[\sigma(1-\alpha)-1\right]}$$

.Notice that another quality solution $q_{F_1}^{\frac{1-\alpha}{\alpha}} = \frac{\chi_2+\sqrt{\chi_2^2-4\chi_1\chi_3}}{2\chi_1} < 0$, and hence, we ignore the negative quality solution. Equation (5) demonstrates that the adjusted quality $q_{F_1}^{\frac{1-\alpha}{\alpha}}$ is decreasing in κ.

$$\begin{aligned} \frac{\partial\left(q_{F_1}^{\frac{1-\alpha}{\alpha}}\right)}{\partial e_{F_2}} &= -\frac{1}{\kappa^2}\Theta_1\frac{\partial\kappa}{\partial B}\frac{\partial B}{\partial e_{F_2}} < 0 \\ &\Rightarrow \frac{\partial\left(q_{F_1}\right)}{\partial e_{F_2}} < 0 \text{ if } \alpha << 1 \end{aligned}$$

recall that $\kappa = \varphi^{-\frac{1+\alpha}{\alpha}} \frac{W}{B}$. It is easy to show that

$$\frac{\partial q_{F_1}^{\frac{1-\alpha}{\alpha}}}{\partial e_{F_2}} = \frac{1-\alpha}{\alpha} \left(q_{F_1}\right)^{\frac{1-2\alpha}{\alpha}} \frac{\partial q_{F_1}}{\partial e_{F_2}} \tag{A6}$$

$$\Rightarrow \frac{\partial q_{F_1}}{\partial e_{F_2}} = \frac{\alpha}{1-\alpha} \left(q_{F_1}\right)^{\frac{2\alpha-1}{\alpha}} \left(-\frac{1}{\kappa^2}\Theta_1\right) \frac{\partial \kappa}{\partial e_{F_2}}$$

$$= -\frac{\alpha}{1-\alpha} \frac{\varphi^{\frac{1+\alpha}{\alpha}}}{W} \left(q_{F_1}\right)^{\frac{2\alpha-1}{\alpha}} \Theta_1 \Theta_2$$

$$\Theta_1 = \frac{\alpha e_{F_1} \eta_{F_1} \left[\sqrt{\left(\sigma+1+\frac{1}{\alpha}\right)^2 + \frac{4}{\alpha}\left(\sigma(1-\alpha)-1\right)}\right] - \left(\sigma+1+\frac{1}{\alpha}\right)}{\tau_{F_1}\left[\sigma(1-\alpha)-1\right]}$$

$$\Theta_2 = B\left(e_{F_2}\right)^{-\zeta-1} \left(\frac{\tau_{F_2}}{W}\right)^{-\zeta} \int_0^1 \gamma_j \left[1 + a_j \left(\frac{e_{F_2}\tau_{F_2}}{W}\right)^{-\zeta}\right]^{-1} dj$$

(A6) has two implications: first, the export quality q_{F_1} is decreasing in the import exchange rate e_{F_2}; second, for firms with lower export quality, low q_{F_1}, the quality response to e_{F_2} is larger.

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