Firm-specific Exchange Rate Shocks and Responses in Investment: Empirical Evidence from China

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Abstract

This paper investigates how exchange rate shocks induce fixed asset investment adjustments of Chinese manufacturing firms. Utilizing the comprehensive Chinese firm-level data and customs records, we construct the firm-specific effective exchange rates as a measure of the impact of exchange rates on specific companies. The magnitude of the impact may be affected by the firm's external orientation measured by the import and export intensities. The results support the theoretical view that an exchange rate appreciation of home currency against the firm's import sources has a positive effect on fixed-asset investment while an appreciation or depreciation of the home currency against the firm's export destination has no statistically significant effect. These findings provide evidence from China to contribute to the research of investment adjustment as a response to exchange fluctuations and connect with topics of unexceptional exporter performance in China.

1. Introduction

The implications of exchange rate fluctuations for the real economy have attracted researchers' attention. A large amount of empirical research in international economics has been conducted to assess the impact of currency appreciation and depreciation on some key variables such as those related to the firm's decision and those related to its value. In open economies, exchange rate changes are often considered to be an important shock that affects firms' investment decisions. The manufacturing companies participating in international trade will often respond to exchange rate changes proactively or passively based on considerations about profits and risks by adjusting investment in fixed assets.

While existing studies, such as Burstein and Gopinath (2015) and Li and Zhao (2016), have placed heavy emphasis on the pricing behavior of exporters and importers in response to currency shocks, there is still much to explore the topics about corporate decision-making in fixed-asset investment. Previous studies focusing on the impact of such changes on investment have mostly used country-level or industry-level data. However, the evidence on how exchange-rate changes induce fixed asset investment decisions at the firm-level is limited. Some latest publications (Nucci and Pozzolo, 2012) have initiated the efforts in this direction trying to investigate at a more micro level. Digging deeper into this question is of vital importance because credible research conclusions may have practical guidance for trade behaviors and public policies.

To contribute to the current discussion, this project is aimed at utilizing a comprehensive Chinese firm-level dataset to empirically examine how exchange rate shocks induce investment adjustments. The firm-level panel data of Chinese manufacturing firms during the period between 2000 to 2006 will provide a good combination of universality and representativeness. This project will refer to the methodology used by Dai and Xu (2017) studying the employment reallocation induced by exchange rate shocks. The idea of constructing firm-specific exchange rates absorbs the intuition that firms trade with different trading partners will be affected by exchange rates with different degrees and directions. The impact on different firms will be individualized and we could control for unobservable individual fixed effects, which reflect idiosyncratic features of a firm, in the regression analysis. Besides that, the panel structure of our data will also enable us to study dynamics for the individual firms

across time. It will facilitate a more precise assessment of the firm's response to shocks at certain time points. Therefore, by using the panel data with firm-specific effective exchange rates, both the individual-specific and time-specific effects could be taken into the specification to improve the precision and consistency of the estimation. We hope to obtain more valuable insights about micro-level enterprise operation mechanism in the context of international trade from the firm-level panel data.

It's worth noting that evidence from China for this trade issue may be especially valuable due to both China's important economic status and the richness and extensiveness of the data. After the reform and opening up, especially after joining the World Trade Organization, China's economy has been integrating into the global economic system and is playing an increasingly important role in the world economy, In terms of exports, China is now the largest manufacturing economy and exporter of goods in the world; In terms of imports, China is also the fastest-growing consumer market and second-largest importer of goods in the world. Moreover, since China is currently adopting a floating exchange rate regime (although not completely freely), the findings in China's exporters and importers responding to exchange rate shocks may be especially relevant for practical reference.

The past literature has identified three major channels through which the firms' investment plan may be affected by the exchange rate fluctuations (Dao, Minoiu and Ostry, 2018). The first (and the most intuitive) one is the competitiveness channel. Changes in exchange rates will affect the prices of imported and exported goods, which in turn affects revenue and production costs. Different degrees of influence of exchange rate changes on different companies will affect their respective competitiveness. The other channels are about the firms' ability to borrow and the banks' capacity to lend. This project will mainly start with the competitiveness channel rather than the financial channels while the latter could still be studied in the future. To combine the firm-specific exchange rate measures and the transmission channels through both export and import behaviors, we would modify the simple models for employment developed by Dai and Xu (2017) and Dao et al. (2018) to adapt to investment issues. Next, we will construct firm-specific exchange rates with the merged data which consists of the custom records for each firm and real exchange rate changes for each country. Then we combine the firm-specific exchange rates with the firms' external orientation measures to empirically study the relationships between the exchange rate shocks and firms'

responses in investment. Besides the main regression, we plan to classify the observations according to company type criteria and compare the estimated impacts of exchange rates in those different groups, to examine what roles will firm-specific exchange play in different types of companies.

The remainder of this essay is organized as a progress report combining the research proposal and some preliminary results. Yet we have already made the baseline research plan and expected methods, the details of the operation may still be subjected to adjustment in the process. Section 2 describes the data with descriptions of the data processing process and brief descriptive statistics. Section 3 will introduce our simple empirical strategy based on Dai and Xu (2017) and Nucci and Pozzolo (2012). Section 4 will demonstrate the preliminary results of some econometric tests. Section 5 will reflect on existing results and discuss the future plan for further completion. Section 6 will be a brief conclusion.

2. Data and Measurement

2.1. Data

2.1.1. Firm data

The measures of the characteristics of Chinese firms are obtained from the Chinese Industrial Enterprises (CIE hereafter) data conducted by the National Bureau of Statistics of China (NBSC) during 1999-2006. The companies registered on the CIE database consist of more than 100,000 manufacturing firms in China. The data provide details about firms' identification, ownership, industry type, and about 80 balance sheet variables. The variables used in this project include the number of employees, total wage payments, the value of fixed assets and corresponding annual depreciation, sales income and total operation inputs.

Since we want to study the panel data over time, we deflate the sales income value using output deflators from Brandt, Van Biesebroeck, and Zhang (2012), while deflating capital depreciation, wage payments and total operation inputs using Brandt input deflators. The fixed capital stock value uses investment deflators instead. The deflators in Brandt et al. (2012) are identified by the 4-digit CIC industry type code in China. The CIC code system experienced a change from 2002 to 2003. We constructed

a concordance between the CIC codes used by CIE datasets of both before and after 2002 and the adjusted CIC codes used in Brandt deflators. The deflators could then be merged with full CIE datasets and we obtain the real value for those variables over time.

2.1.2. Trade data

The transaction-level import and export data are from the Chinese Customs Database from China's General Administration of Customs. This database covers the most comprehensive information of all Chinese trade transactions including import and export values, quantities, product names and codes, source and destination countries, custom's regimes, company types (e.g. SOEs or private enterprises) and company contact information (e.g. the firm name, registered telephone number, zip code, and contact person name).

Since this project uses the trade data only to construct firm-specific effective exchange rates, the product-level information is irrelevant to our interests and research priorities at this stage. The only information that matters is the matched records between the total trade (import or export) value aggregated at the firm-country level and the firm information. This essay will only briefly mention the subsequent supplementary processing but omit the specific details of the data matching. [1]

The matched trade datasets include the annul records of both imports and exports ranging from 2000 to 2006 from CGAC. The FRDM codes registered in the CIE datasets are matched with the Harmonized System identification codes in the custom data which link the trade records to the company information. Besides the matched codes, the key information in the customs records are obtained after matching such as destination (or source) countries, and the corresponding value and quantities aggregated at the company-country-year level. Other information such as shipment categories and transportation ways are kept for possible further research purposes.

We match the CIE data with the customs trade data using FRDM codes and company names. In the merging process, 89.78% of the trade records in the customs data and 71.52% of the companies in CIE data are matched successfully. (The merged dataset

[1] Thanks to the previous efforts of Professor Yao Li and her team, this data matching work has been completed (Fan, Li, & Yeaple, 2015). The details of data construction and description could be found in the appendix A in the online appendix of Fan, Li, & Yeaple (2015)

accounts for about 39% of China's total exports (USD $\$1.41\times 10^{12}$) and about 33% of total imports (USD $\$1.06\times 10^{12}$) over this period from 2000 to 2006).

2.1.3. Exchange rate and price index

The annual nominal exchange rate data are obtained from the Global Economic Monitor (GEM) in the Databank of The World Bank for 195 countries and regions during 2000-2006. We manually modify the original data by translating the country names into Chinese to matched with CIE data and transforming the nominal exchange rates to ones relative to RMB rather than USD.

We also download the consumer price index data from Penn World Tables 7.1 to construct real exchange rates. Both exchange rate data and price index data above are publicly accessible. After merging, we obtained real exchange rates of 175 of China's trading partners during 2000-2006.

2.1.4. Sample

To construct a meaningful sample for empirical research, we drop unsatisfactory firms in the CIE database according to the following screening criteria following Cai and Liu (2009): (1) key financial variables (such as total assets, net value of fixed assets, sales, gross value of industrial output) are negative or missing; (2) material is negative or material input is greater than the current price gross output; (3) the total assets are not higher than the liquid assets or total fixed assets; (4) the identification number is missing or not unique; (5) the established time is invalid; (6) the wage and benefit are negative; (7) the depreciation value is negative; (8) the number of employees hired by a firm is missing or less than 10. Moreover, we also double-check to ensure there are no duplicated firms each year.

Besides the unqualified firms, we drop all trade transactions with the destination of the "People's Republic of China", which may represent domestic sales of commodities originally produced for exports. We also drop firms whose total export value or import value in the customs data is larger than total sales in CIE data (to avoid confusion when constructing import and export intensity variables). Since the objects of our research focus on manufacturing companies, we also exclude those firms to operate in non-manufacturing sectors by limiting the industry code within the range of [1310, 4229].

The filtered sample includes 211,805 observations for 80,525 firms. There are two points to be noticed. First, our panel dataset is unbalanced, which means there may not be full records from 2000 to 2007 for all firms. The reason may be that some companies did not enter the export (import) market or they had quitted exporting (importing) for some years during this time. Although the pattern will decrease the number of available observations in the regression, it may not necessarily weaken the effectiveness and credibility of empirical research because the amount of data is still large and representative. Second, while most of the companies here are both exporters and importers, there are still net importers and net exporters (either export value or import value equals to zero). In the preliminary stage of research, we allow the coexistence of different types of trading participants. However, we may further classify or further filter the observations in the future, and we will discuss details at the end of the article in Section 5.

2.2. Measurement

Using the datasets described above, we construct several key measurement variables. Those key variables will quantify the cross-firm variations in both external orientation and effective exchange rates from the wide heterogeneousness across Chinese firms. We will use those measurement variables in the empirical strategy part.

2.2.1. Fixed Asset Investment Value

The first variable of interest is the firm's real investment in fixed assets. To scale the variable values to a reasonable and comparable size, we adapt the logarithmic representation of the real investment value denominated in RMB. The investment expenditure is not directly provided in the CIE dataset; instead, we use the changes in fixed assets value plus the depreciation in last year to construct the investment expenditure variable. It is of vital importance to use proper deflators for those real values to compare across time. We use Brandt-Rawski investment deflators, suggested by Brandt et al. (2012), to deflate the fixed assets. The depreciation, however, is deflated by the input deflators provided by Brandt et al. (2012). It is worth noting that by adopting this method of variable construction, some investment values may be negative, and it causes trouble for logarithmic conversion. To deal with this problem and to prevent the results from driven by extreme outliers, we will first winsorize

observations of the investment variable at 3 to 97 percentile and add by the absolute value of the minimum to make all investment values to be positive.[2]

2.2.2. Variables of external orientation

The two key variables measuring external orientation are export intensity $\chi_{i,t-1}$ and import intensity $\varphi_{i,t-1}$. $EX_{ik,t-1}$ $(IM_{ik,t-1})$ is the firm's aggregate export (import) value from country k. We specify export intensity as total exports ($EX_{ik,t-1}$) over total sales $S_{i,t-1}$ and import intensity as total imports ($IM_{ik,t-1}$) over total costs ($TC_{i,t-1}$). According to Dai and Xu (2017), we set the total costs ($TC_{i,t-1}$) as the total variable costs including a firm's total wage payment and total operation inputs. [3] We lag these variables for one period to avoid endogeneity.

$$\chi_{i,t-1} = \frac{\sum_k EX_{ik,t-1}}{S_{i,t-1}} \quad (1)$$

$$\varphi_{i,t-1} = \frac{\sum_k IM_{ik,t-1}}{TC_{i,t-1}} \quad (2)$$

2.2.3. Firm-specific effective exchange rates

We construct the firm-specific export-weighted and import-weighted exchange rate with export value and import value aggregated at the firm-country level and real exchange rates. The firm-specific effective exchange rate could be viewed as the exchange rate shock each company receives based on its trading partners. The import (export) firm-specific exchange rate is calculated by weighting the exchange rate changes by the relative import (export) percentage share from its import sources (export destinations).

Two remarks are in order. First, the original trade value is denominated in US dollars according to customs data while we transform it into RMB with the nominal exchange rate of RMB against the US dollar. All variables of trade value are lagged for one year to alleviate potential endogeneity. Second, since we want to use real exchange rate

[2] "Winsorization" is a useful statistical transformation method by limiting extreme values in the statistical data to reduce the effect of possibly spurious outliers. It is named after Charles P. Winsor from Hastings, Jr., Cecil; Mosteller, Frederick; Tukey, John W.; Winsor, Charles P. (1947)

[3] An alternative version of total costs includes not only labor and material costs but also capital costs. The details about theoretical feasibility and future empirical verification will be discussed in Section 5

instead of nominal exchange rate for empirical tests, we combine the bilateral nominal exchange rates from The World Bank with the consumer price index CPI from Penn World Tables 7.1 to construct bilateral real exchange rate changes ($\triangle lne_{kt}$). The representation of the logarithmic change shows the relative fluctuation of the exchange rate relative to RMB.

$$\triangle EXFEER_{it} = \sum_k \left(\frac{EX_{ik,t-1}}{\sum_k EX_{ik,t-1}} \right) \triangle lne_{kt} \quad (3)$$

$$\triangle \mathrm{IM}FEER_{it} = \sum_k \left(\frac{IM_{ik,t-1}}{\sum_k IM_{ik,t-1}} \right) \triangle lne_{kt} \quad (4)$$

2.3. Summary Statistics

2.3.1. Trading patterns of Chinese firms

Table1

Share of firms by its top 5 import sources and export destinations (percentage)

	Import			Export		
	2000	2006	overall	2000	2006	overall
United States	9.85%	11.01%	10.29%	18.48%	20.25%	19.40%
Japan	21.71%	21.39%	21.51%	17.96%	12.24%	14.66%
Korea	12.25%	12.67%	12.56%	5.59%	7.07%	6.69%
Taiwan	24.29%	21.05%	22.55%	4.33%	4.18%	4.33%
Hong Kong	7.91%	6.00%	5.94%	22.05%	12.40%	15.89%

Table 1:Share of firms by its top import sources and export destinations

Note: The columns demonstrate the percentage of companies that import or export the most from particular countries in 2000, 2006 and in the overall period from 2000 to 2006. The five countries or regions listed in the table have been the five largest trading partners of China during this period (excluding regional alliances such as the EU), although their internal rankings may have changed.

In our data of Chinese data, the export destinations and import source countries are widely diverse across firms. Table 1 demonstrates the basic description of the trading patterns of the firms in the sample. We list the share of firms by their top 5 import sources and export destinations in percentage form during different time periods.

China's top 5 trading partners are robust in 2000, 2006 and the overall period from 2000-2006: The United States, Japan, Korea, Taiwan, and Hong Kong. As observed from Table 1, there is a considerable percentage of companies importing from or exporting to each of China's top trading partners. This pattern indicates that the choice

of trading partners of Chinese companies is very diverse. Except for the United States, the remaining four are developed economies adjacent to China, which also which is somewhat consistent with the gravity model of international trade.

2.3.2. Fluctuation in the RMB exchange rate

After analyzing the trading pattern of Chinse pattern, we demonstrate the overall fluctuation in the annual real bilateral exchange rate against the currencies of the major trading partners: the US dollar, Japanese Yen, and the Korean Won and New Taiwan dollar from 2000 to 2006. [4] We could observe that the real exchange rate against USD did not change a lot in 2000-2004 due to the nominal pegging scheme of RMB to US dollars. In July 2005, the peg was lifted to a slight appreciation of RMB against USD as a result of the evolution of exchange policy. The Japanese Yen appreciated by around 20% while the New Taiwan dollar appreciated by around 10%. The Korean Won, however, depreciated against RMB by about 10%.

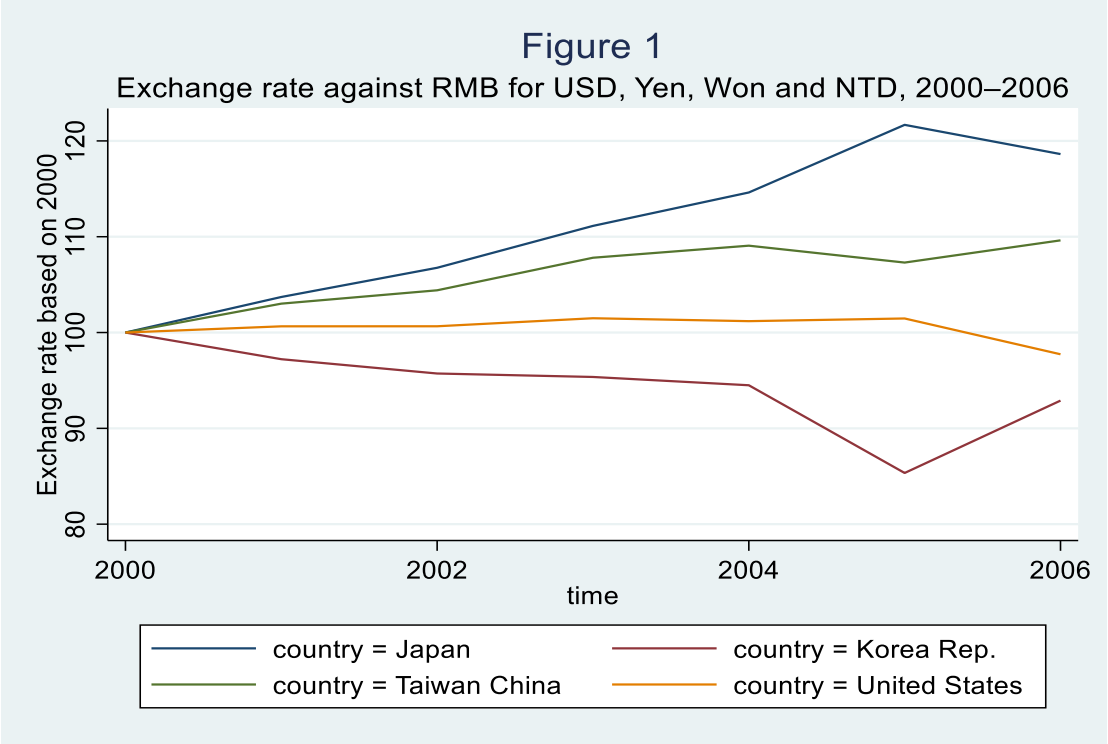

Figure 1:Exchange rate against RMB for USD, Yen, Won and NTD, 2000–2006

Note: All the exchange rates in Figure 1 are standardized based on the level of 2000 as 100.

[4] Hong Kong Dollar is omitted because the relative fluctuation of exchange rate of HKD against RMB is similar to which of USD due to the linked exchange rate system between the Hong Kong dollar and the United States dollar.

The heterogeneous movements of RMB exchange rate change against the major trading partners together with the diverse trading patterns of Chinse manufacturing firms are two motivations for us to use the firm-specific exchange rate methods.

2.3.3. Summary of Measurement Variables

As described in the measurement part, we construct some key variables to study the responses in investment decisions to the firm-specific exchange rate shocks. Table 2 shows the summary statistics of those key variables.

Table 2: Summary statistics

Summary statistics

Variable	Observations	Mean	SD	Min	P5	P95	Max
ln (Investment)	152089	9.363	0.703	0.000	8.820	10.705	17.359
Import intensity	152089	0.125	0.213	0.000	0.000	0.639	1.000
Export intensity	152089	0.304	0.323	0.000	0.000	0.938	1.000
△ IMFEER	152089	0.002	0.021	-1.307	-0.026	0.035	0.122
△ $EXFEER$	152089	-0.007	0.033	-1.253	-0.059	0.035	0.236
ln (Sales)	152089	10.754	1.327	2.936	8.881	13.148	18.934

Table 2: Summary statistics of the key variables

Notes: The summary statistics table uses all observations in the sample although some observations may include null value for some of the variables listed here. The observations have already been winsorized from the original sample so that all investment figures could be transformed into the logarithm. See Section 2.2.1 for details.

From the 5th percentile of import intensity and export intensity, we could find that some companies are not connected to either import or export market. It is to say, while most of the firms are two-way trading participants, some firms are only net exporters or net importers. However, some other companies are highly reliant on the international trade markets for sales and for inputs. As for the firm-specific exchange rate, the substantial variability is also suggested by the considerable coefficients of variation for import-weighted effective exchange rate changes ($0.021/0.002 = 10.5$) and export-weighted effective exchange rate changes ($0.033/0.007 \approx 4.21$). Those indicate the wide variation of firms' exposure to the exchange rate fluctuation. That is, given the same period with the same exogenous international finance factors, different firms may response quite differently, due to the above-mentioned variation.

3. Empirical strategy

We adopt an regression specification at the firm level which is a simpler version of the ones used by Dai and Xu (2017) and Nucci and Pozzolo (2012) as a baseline regression equation to study the effects of two channels that shape the response of a firm's investment decision to exchange rate changes as follows:

$$lnI_{it} = \beta_0 + \beta_1 \varphi_{i,t-1} \triangle IMFEER_{it} + \beta_2 \chi_{i,t-1} \triangle EXFEER_{it} + \mu_i + \nu_j + \eta_t + \varepsilon_{it} \quad (5)$$

The $\varphi_{i,t-1}$ and $\chi_{i,t-1}$ are respectively firm-level import intensity and export intensity, lagged for one period to avoid potential endogeneity induced by their possible correlation with the exchange rate.[5] The import intensity and export intensity serve as a measure of the extent to which a company is dependent on imports/exports. We believe the effect of exchange rate fluctuations is stronger for firms that rely more on imported inputs or export sales. $\triangle IMFEER_{it}$ and $\triangle EXFEER_{it}$ are firm-specific changes in the imported weighted effective exchange rate and export-weighted exchange rate respectively. [6] In the dataset, we obtain a 4-digit industry code for each firm. Hence, we will utilize the 4-digit industry fixed effects ν_j to control the industry-specific trends of fixed asset investment. Besides, we also introduce year fixed effects η_t to control the equilibrium relationship between domestic factor prices and exchange rates changing over the years.[7] Moreover, we use firm-specific fixed effects μ_i to actively absorb all corporate traits that may influence investment decisions as an innovative contribution to the existing works. The specific measures will be described in detail in the next section about data.

The coefficients of interest are β_1 and β_2 which capture the influence of exchange rates on investment decisions through input cost channel (β_1) and export cost channel (β_2) respectively. The signals of those coefficients will indicate the direction of responses in investment to the changes in exchange rates. As mentioned above, these coefficients

[5] Other specifications such as current period import/export intensity or time-invariant ones could be tested for robustness checks in the next step study.

[6] The import competition channel is mentioned by past literature (Dai and Xu, 2017), however, we temporarily ignore the impact of this channel at this stage of research. We will discuss the future plan in the Section 5.

[7] Similar to that in Dai and Xu (2017), we could adapt an alternative specification to combine the industry fixed effects and year fixed effects into the industry-year fixed effects allowing for the above time variant relationship to be industry-specific for robustness checks. However, this may not be necessary in this paper because the cross-industry flow of capital is freer than the labor force.

are identified from both the cross-firm variation in external orientation (import and export intensity) and the cross-firm variation in effective exchange rates resulted from variations in exchange rate fluctuations between different countries and in trading partners' weights among different companies. Therefore, our empirical results can only be interpreted only as of the exchange rates' effects on the relative response in investment decisions across firms. The absolute investment effects of exchange rates may be affected by various exogenous economic factors which are absorbed by the fixed effects mentioned above.

Other control variables are added to the baseline empirical equations (5) to enhance the robustness and credibility of the model. The total sales income (in RMB) and the total number of employees are is instrumented to control the investment opportunities. What's more, we also include a lagged value of the dependent variable in the empirical model to account for autocorrelations referring to Nucci and Pozzolo (2010). [8]

An example of robustness-check specification with more control variables are shown as Equation (6):[9]

$$lnI_{it} = \beta_0 + \beta_1 \varphi_{i,t-1} \triangle IMFEER_{it} + \beta_2 \chi_{i,t-1} \triangle EXFEER_{it} + \beta_3 \triangle \ln S_{it} + \beta_4 lnL_{it} + \beta_5 lnI_{it-1} + \mu_i + \nu_j + \eta_t + \varepsilon_{it} \quad (6)$$

4. Results

4.1. Baseline OLS estimation results

We conduct multivariable OLS regression to estimate the effects of firm-specific exchange rate shocks on investment responses. The preliminary OLS estimation results of Equation (5) from a panel data sample are summarized in Table 3.

The two crucial variables in our model, $\varphi_{i,t-1} \triangle IMFEER_{it}$ and $\chi_{i,t-1} \triangle EXFEER_{it}$ refer to the interaction of firm-specific real exchange rate changes with the firm's exposure to international trade in both the international product markets (sales income side) and the international inputs markets (input cost side) with lag effects. While our

[8] According to Nucci and Pozzolo (2010), it is argued that a possible source of autocorrelation is the adjustment lags typical of investment projects (Caballero, 1997).
[9] More details of the results of various empirical tests will be included at the Section 4

data and research methods refer to the articles of Dai and Xu (2017) and Nucci and Pozzolo (2012), the preliminary results are not essentially identical for Chinese firms' investment issues.

Table 3: Baseline estimation results

	(1) Only import channel	(2) Only export channel	(3) Baseline
$\varphi_{i,t-1} \triangle IMFEER_{it}$	0.757**		0.744**
	(0.322)		(0.325)
$\chi_{i,t-1} \triangle EXFEER_{it}$		0.111	0.071
		(0.134)	(0.137)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	110117	110117	110117
R^2	0.026	0.026	0.026

Standard errors in parentheses

* p<0.1 ** p<0.05 *** p<0.01

Table 3:Baseline estimation results

Note: *p<0.10; **p<0.05; ***p<0.01. Standard errors in parentheses. All standard errors clustered by company identification (FRDM). A constant term is included in all regressions. Three columns demonstrate regression results with only import channel, only the export channel and both channel (which is the baseline result of interest) respectively. All columns use industry fixed effects and year fixed effects. Investments, effective exchange rates are in logarithms. The R^2 reported is the overall R^2 value.

We first list the regression results including either only import or export channel in Column (1) and Column (2) of Table 3. Then in column (3), we list the baseline results based on the empirical strategy as shown in Equation (5). In our baseline regression, we include industry fixed effects and year fixed effects. We obtain a coefficient of 0.744 for import channel which is significant at the 5% level while obtaining a coefficient of 0.071 for the export channel which is not significant. The results in Table 3 examine the two key channels through which the exchange rate fluctuations influence the responses of investment for Chinese manufacturing firms both separately (as in Column (1) and (2)) and jointly (as in Column (3)).

The results of the estimation are partially consistent with the predictions as Nucci and Pozzolo (2012). The coefficient associated with $\varphi_{i,t-1} \triangle IMFEER_{it}$ is positive, which indicates that the firm tends to increase its fixed asset investment after an exchange rate appreciation at a rate that increases with the share of imported inputs in its total

operating inputs. In other words, importers benefit from the exchange rate appreciation and they respond to the shocks by investing more in the fixed assets and the extent of this response is positively correlated with the degree of external orientation. However, the coefficient associated with $\chi_{i,t-1} \triangle EXFEER_{it}$, which indicates the effects of exchange rate shocks through the export sales channel, is not statistically significant. In other words, in the preliminary version of the empirical specification, we did not find significant evidence to support the theoretical predictions that the investors tend to grow via the channel of revenue growth after depreciation at a rate which is positively correlated with the share of export sales to its total sales revenues.

The results with industry and time fixed effects demonstrate that the effect of exchange rate changes in investment varies at each time point and industry sector and depends on the external orientation of different firms. The unbalanced results for import cost channel and export revenue channel in the data of Chinese manufacturing firms against the theoretical predictions by Nucci and Pozzolo (2012) may contribute to the main innovative finding of this paper. Through this preliminary result, we suspect that the import and export of Chinese industrial enterprises have very different operational mechanisms or that there are certain exogenous factors that have different effects on the investment decisions of import and export enterprises. The reasons behind this phenomenon need to be further explored and some possible explanations will be discussed in Sector 5.

4.2. Robustness checks

After the baseline regression, we add some additional controls for robustness checks as in Table 4 to ensure that our baseline results are robust to support our prediction.

Column (1) shows the baselin4e results as the OLS estimation results in Section 4.1 using the baseline specification with two key explanatory variables and industry and year fixed effects. In column (2) – (4), we modify the regression model of column (1) by adding additional control variables. In column (2), we include the firm's log total sales, the log of the total number of employees and company types fixed effects as additional controls. The total sales and total employments give a glimpse of the firm's operation scale which be correlated with the needs and capabilities of the investment. Moreover, the company types (i.e. state-owned company, private company or foreign-invested company, etc.) provides more information about the company's nature. We

understand that there may be concerns that the investment decisions in SOEs may be highly restricted by central planning and the SOEs may demonstrate a distinguished

Table 4: Robustness check

Dependent variable: lnI_{it}	(1) Baseline	(2) Control sales, employment & company type	(3) (2)+lagged investment	(4) (3)+control change of sales
$\varphi_{i,t-1} \triangle IMFEER_{it}$	0.744**	0.771**	0.989**	1.065**
	(0.325)	(0.325)	(0.416)	(0.414)
$\chi_{i,t-1} \triangle EXFEER_{it}$	0.071	0.079	0.018	0.021
	(0.137)	(0.134)	(0.182)	(0.182)
lnS_{it}		0.116***	0.142***	
		(0.007)	(0.009)	
$\triangle lnS_{it}$				0.064***
				(0.007)
lnL_{it}		0.078***	0.098***	0.152***
		(0.008)	(0.010)	(0.010)
lnI_{it-1}			-0.233***	-0.227***
			(0.009)	(0.009)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Company type FE	No	Yes	Yes	Yes
N	110117	109165	78311	78311
R^2	0.026	0.037	0.092	0.087
Standard errors in parentheses		* p<0.1	** p<0.05	*** p<0.01

pattern from the private and foreign companies (and we may dig deeper into this issue in the future as discussed in section 5). As shown in Table 4, the results are not overthrown after including those control variables

Table 4:Robustness check

Note: *p<0.10; **p<0.05; ***p<0.01. Standard errors in parentheses. All standard errors clustered by company identification (FRDM). A constant term is included in all regressions. Column (1) is the baseline result as in Table 3. Column (2) adds additional control of company sales, employments and company type fixed effects. Column (3) further adds control of the lagged variable of investment. Column (4) controls the change of sales instead of sales value itself. Investments, effective exchange rates, sales, and employments are in logarithms. The R^2 reported is the overall R^2 value.

In column (3), we add lagged investment value to the estimation specification referring to Nucci and Pozzolo (2012) to control for autocorrelation.[10] All coefficients of log sales, the log of the number of employments and lagged investment show 99% level

[10]Our baseline specification directly uses the investment values rather than the first differences. We also test the first differences empirical specification to account for nonstationary of the exchange rate and attached the regression results in the Appendix.

significance while the significance of the coefficients of key variables stays robust as our baseline one. In column (4), we adopt an alternative way of controlling the first difference in total sales instead of total sales following Nucci and Pozzolo (2012).[11] Again, the results in Column (4) suggest that this alternative version of control variables does not qualitatively change the baseline results.

5. Discussion

5.1. A possible explanation for the insignificance of the export channel

In our previous results, we found that firms' responses to exchange rate shocks differently due to their heterogeneous external orientation and trading partner distribution. The import cost channel seems to be consistent with the theory while the export revenue shows no significance in China. The unexpected patterns of Chinese exporters in different segments of trade have aroused the interest of researchers. While early empirical work has documented the exceptionally superior performance of exporting firms relative to domestic market sellers (as in Bernard and Jensen, 1999), China, as the world's largest exporter, seems to behave as the exception paradoxically. Dai, Maitra, and Yu (2016) argued that puzzling abnormality should be attributed to processing exporters who only assemble tariff exempted imported inputs and re-export to foreign markets. Li, Smeets, and Warzynski (2016) extended this discussion of exceptional exporter performance using a detailed production survey of the Chinese manufacturing industry. They proposed an intuitive explanation that exporters charge an abnormally low price for foreign markets compared to the domestic market. The price difference is particularly notable in processing trade (which is somehow consistent with Dai, Maitra, and Yu (2016)).

Referring to the past literature, we propose the following conjecture: the processing exporters accounting for a significant portion of total Chinese exporters have less flexibility or less incentive to adjust their fixed-asset investment to exchange rate fluctuations because of the relatively fixed contractual processing arrangement. In other words, the investment decisions of those firms rely basically on the external order status

[11] As explained by Nucci and Pozzolo (2012), using the change of sales as instrument variable is to avoid the bias of estimates from a correlation between changes of sales and investment responses.

rather than on their own revenue-cost analysis when they enjoy low fixed costs of processing exporting and favorable trade and industrial policies or subsidies. This market distortion may explain why the exporters failed to respond to the export-side firm-specific exchange rate shocks compared to which of the import side. In a further study, we may classify the dataset into subsamples of processing and non-processing exporters to examine our explanations by empirical evidence.

5.2. The import competition channel

The third channel other than import cost channel, export price channel is imported competition channel which is used in the model of Dai and Xu (2017) and Nucci and Pozzolo (2012). This channel captures the influence of exchange rates on investment adjustment by changing the extent to which firms compete with foreign producers in the domestic market. If the home currency appreciates against the foreign currencies of the firm's import sources, the home-currency price of exporters will decrease and so will the home market price index. Under this circumstance, the level of import competition will raise and then firms will have a weaker incentive to invest more in fixed assets.

One specific variable used in this channel is the import-penetration exchange rate ($\triangle IMPEER_{it}$). Similar to the imported-weighted effective exchange rates $\triangle IMFEER_{it}$ and exported-weighted effective exchange rates $\triangle EXFEER_{it}$, this variable weights the exchange rate changes by the import penetration rate of its import sources on the home country. The import penetration rate of each import source is calculated by dividing the import value from this source country by the total domestic sales and total import value, with both the numerator and the denominator to be industry-specific. The mathematical representation is shown as (7). Since the importance of this channel will be larger for those firms who have a lower external orientation (i.e. depend more on the domestic market), the coefficient before the import-penetration exchange rate will be one minus the export intensity to capture this effect. The new baseline equation is shown as (8).

$$\triangle \mathrm{IM}FEER_{it} = \sum_{k}\left(\frac{IM_{jk,t-1}}{DOMSALE_{jt-1} + \sum_k IM_{jk,t-1}}\right) \triangle lne_{kt} \qquad (7)$$

$$lnI_{it} = \beta_0 + \beta_1\varphi_{i,t-1} \triangle IMFEER_{it} + \beta_2\chi_{i,t-1} \triangle EXFEER_{it} + \beta_3\left(1-\chi_{i,t-1}\right) \triangle IMPEER_{jt} + \mu_i + \nu_j + \eta_t + \varepsilon_{it} \qquad (8)$$

There are three reasons that we did not include this term into our empirical strategy yet. First, we could not precisely confirm the total domestic sales of each industry from our data. As in Section 3.1, neither CIE data nor customs data is complete for all firms or all transactions in China, the effectiveness of aggregated level variables such as total domestic sales may not be rigorous and reliable. Second, $\triangle IMPEER_{jt}$ is at the industry level rather than at the firm level. It has a lower priority than the first two channels. Third, the empirical results in Dai and Xu (2017) for import competition channel are not statistically significant which weaken the importance of this channel.

5.3. Company types and investment

The firms in our sample are classified into five different categories: state-owned enterprise, private enterprise, collective enterprises, foreign-owned enterprise, and joint ventures. The state-owned enterprise (SOE) in China is a type of business enterprise where the state has significant control through ownership. In the past and present, state-owned enterprises have played an important role in the national economic sector. From the mid-1980s to 1990s, the state-owned enterprises underwent a series of reforms including an increase of autonomy, reduction of government-planned activities, incentive schemes for managers and workers. The private ownership of economic resources was eliminated by the end of the 1950s, however, private economic activities along with foreign capital appeared again with foreign capital, were allowed and expanded in the 1980s with the official "Reform and Opening-up" policy. The economic reform has changed China's economic structure and laid the basic model for the behavior of Chinese companies now. The SOEs together with non-SOEs, foreign-invested enterprises operating in China, and China's own private enterprises have contributed to economic growth in China (Bai, Lu, and Tao, 2006).

The unique differences between the performance of Chinese state-owned enterprises and private enterprises have also attracted the attention of economists in recent years. Cheng, Li, and Li (2018) conducted a complete analysis of differences in productivity and financial returns between SOEs and private enterprises in China. Therefore, we are also curious about the heterogeneous responses of those firms of different ownership types in fixed-asset investment towards exchange rate fluctuations. We have already used company type fixed effects to absorb the differences from ownership in the effect of exchange rate variations on investment. We plan to conduct subgroup analysis

according to ownership of international trade participants referring to the method of Li, Xu, and Zhao (2014) to examine whether firms' responses affected by their ownership.

5.4. An alternative construction of cost variable

This part is a supplementary discussion of the alternative construction of the cost variable for import intensity as mentioned in Footnote 8. Another version of total costs includes total wage payment and total operation inputs plus 15% of fixed assets. This specification will include not only labor and material costs but also capital costs.

The previous assumption of Dai and Xu (2017) in which only labor costs and intermediate material inputs are included may not be accurate. The downward bias of this assumption which loses the depreciation of capital will cause the sales to cost ratio to be much larger than the true markup. Therefore, in our alternative specification, total costs equal the sum of wage bill payments in the data, materials costs in the data, and returns to capital calculated as real fixed assets in the data times the capital return rate. Our data indicate that for a typical representative Chinese company, the interest payment to debt ratio is 10%, which we use as an interest rate and the deprecation rate is 5%, which implies a rental rate of capital so that the cost of capital R equals to 15%. In this way, our sales to cost ration is more in line with the markup, otherwise, the total cost may be too small.

We try both definitions of total costs and demonstrate the alternative empirical results here as Table (5). As observed in Table (5), all existing results of import and export channels are not qualitatively changed by adapting this alternative cost variable specification and they stay fairly robust thorough robustness checks.

Table 5: Regression results with the alternative version of cost variable

Dependent variable: lnI_{it}	(1) Baseline	(2) Control sales, employment & company type	(3) (2)+lagged investment	(4) (3)+control change of sales
$\varphi_{i,t-1} \triangle IMFEER_{it}$	0.745**	0.759**	0.926**	0.998**
	(0.320)	(0.320)	(0.415)	(0.414)
$\chi_{i,t-1} \triangle EXFEER_{it}$	0.045	0.057	0.016	0.017
	(0.137)	(0.135)	(0.182)	(0.182)
lnS_{it}		0.116***	0.141***	
		(0.007)	(0.009)	
$\triangle lnS_{it}$				0.065***
				(0.007)
lnL_{it}		0.080***	0.100***	0.154***
		(0.008)	(0.010)	(0.010)
lnI_{it-1}			-0.232***	-0.226***
			(0.009)	(0.009)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Company type FE	No	Yes	Yes	Yes
N	111238	110283	79036	79036
R^2	0.026	0.037	0.091	0.086
Standard errors in parentheses		* p<0.1	** p<0.05	*** p<0.01

Table 5: Regression results with the alternative version of the cost variable

Note: *p<0.10; **p<0.05; ***p<0.01. Standard errors in parentheses. All standard errors clustered by company identification (FRDM). A constant term is included in all regressions. Column (1) is the baseline result as in Table 3. Column (2) adds additional control of company sales, employments and company type fixed effects. Column (3) further adds control of the lagged variable of investment. Column (4) controls the change of the sales instead of sales value itself. Investments, effective exchange rates, sales and employments are in logarithms. The R^2 reported is the overall R^2 value. The only difference between Table 4 and Table 5 is the construction of the cost variable for import intensity.

6. Conclusion

This paper studies how Chinese manufacturing firms' response to exchange rate fluctuations by adjusting fixed asset investment decisions. Using Chinese firm-level data and customs data, we constructed firm-specific effective exchange rates to capture the unique exchange rate shocks pertinent to each firm. Adapting this innovative measure, we investigate the different investment patterns of firms with heterogeneous external orientations and trading partner distributions. The empirical evidence

demonstrates an unbalance pattern in which the effects through the import cost channel on investment responses are statistically significant while the effects through the export revenue channel are not statistically significant. The explanation of this result may be related to the unexceptional exporter performance in China.

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