A Firm-Level Reappraisal of Real Exchange Rate Undervaluation in China's Agricultural Exports and Growth

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Abstract:

Matching firm- and country-level data with a panel dataset of China's agricultural exports at the firm-product-country-level, a measure of firm-level exposure to exchange rate undervaluation has been proposed based on estimates of the bilateral undervaluation of yuan versus other currencies. Empirical models find that a firm's agricultural exports significantly and positively increase with its exposure to undervaluation. The result remains robust to alternative sample selections, measurement choices, and model specifications. The elasticity, however, differs across firms for their productivity, financial constraint, ownership, trade mode, and subsidy status. With the mediation role of increased exports, the undervaluation exposure further accelerates the firm-level growth in both productivity and scale according to the path analysis. This mediation effect takes almost a half of the acceleration effect of undervaluation on labor productivity and employment growth. It takes even the entire effect as to the growth of total factor productivity, sales, value added, and capital stock.

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Keywords: Exchange rate misalignment, firm-level undervaluation, agricultural exports, economic growth.

It has been widely alleged by both policy makers and researchers that the Chinese government has exploited currency manipulation in pursuit of an export-led growth at least for the past two decades. This statement is of particular importance to the agricultural market, since China remains the world's top producer and is now the fourth exporter in this market such that the export performance not only influences its own agricultural production with 220 million employees (Huang et al. 2007), but also affects the global market (Fuller et al. 2003) and competing industries in other countries (Williams and Luo 2017). While examinations on the role of exchange rate in agricultural exports and growth are not rare, most of them focus on exchange rate movements rather than misalignment, or in China's case, undervaluation. However, these two concepts are different both in application and theory. For instance, urging China to revalue its currency, yuan, might not benefit farmers in importing countries or necessarily trigger a domestic "fear of floating", if the appreciation is compensated by an increase in China's relative productivity a la the Balassa-Samuelson effect (Balassa 1964; Samuelson 1964). Exchange rates can be driven by economic fundamentals (Ghura and Grennes 1993; Rodrik 2008). It is thus currency undervaluation that gives rise to extra export competitiveness (Freund and Pierola 2012). Besides, despite rapid development of the new new trade theory (Melitz 2003) and increased availability of firm-level data, they have not been sufficiently utilized to analyze agricultural exports and growth, especially regarding the role of exchange rate (Pick and Vollrath 1994). Hence, existing findings might suffer from the aggregation bias (Berman, Martin, and Mayer 2012; Melitz 2003; Rose and Yellen 1989) and the endogeneity issue (Nouira and Sekkat 2012; Rodrik 2005), which may further cause disputes about using exchange rate policies for an export-led growth.

Our article fills these gaps by providing a first-hand investigation to the effect of exchange rate undervaluation on China's agricultural exports and growth at the disaggregated level. Based on firm-product-country-level export flows that are matched with firm and country characteristics, we create a measure of each exporter's exposure to currency undervaluation using estimates of yuan's bilateral undervaluation against each currency and the ex-ante distribution of export destinations for the firm. We then detect the relationship between this measure and the firm's agricultural exports. Comparing with country- and industry-level tests, the concern of reverse causality is arguably alleviated by the adoption of firm-level data, since it is difficult if not impossible for a single firm to influence yuan's misalignment. With the control of industry-year fixed effects and a full array of firm characteristics, confounding factors, i.e. another source of the endogeneity issue, shall also be less influential to our results since most common shocks on exchange rate and exports are macro. For robustness concerns, the benchmark regression is supplemented by reexaminations using alternative samples and models, particularly income measures utilized to estimate currency undervaluation. These exercises consistently reveal a positive role of undervaluation in agricultural exports.

We then examine how this role differs across firms to account for the possible aggregation bias, again by taking advantage of our firm-level data. To be specific, we consider the productivity level, financial constraints, ownership, trade mode, and the status as subsidy recipient to be the source of inter-firm heterogeneities respectively. We split the data on each dimension, and estimate the export elasticity to undervaluation in each subsample for comparison. For robustness concerns, alternative measures are used for each firm characteristic. Significance tests uncover that low-productivity, less financially constrained, non-private, processing, and subsidized firms respond more substantially to undervaluation than their counterparts. By taking a new angle on heterogeneous firm behaviors in a context of currency misalignment, the evidence supplements the recent development of the new new trade theory. Our findings also suggest that different export effects of exchange rate movements can be revealed from empirical studies based on different compositions of firms, which may help explain the mixed evidence recorded in the literature, in particular that of the J-curve phenomenon.

Finally, we utilize path analysis to investigate if the increased exports with undervaluation lead to a faster firm growth. Controlling firm and industry-year fixed effects, we construct growth equations respectively for productivity, total sales, valued added, as well as the scale of employment and capital stock at the firm level, which is in line with empirical studies of the β-convergence theory at the macro level (e.g. Rodrik 2013). The effect of undervaluation is introduced either independently, or together with that of exports. Using the Sobel statistics (Sobel 1982), we scrutinize the mediation role of exports in the relationship between undervaluation and growth by testing the significance of the difference in estimated coefficients across these specifications. The growth equations coherently reveal a positive contribution of undervaluation, and the test results indicate a critical mediation role of exports in all cases. These findings not only shed new light on the widely accepted view of export-led growth at the macro level (Frankel and Romer 1999) with disaggregated evidence, but also help to clarify the role of currency undervaluation which tends to receive debates in the macro literature. Moreover, by comparing the estimated response of employment and capital stock to undervaluation, we can indicate whether the firm's short-term output is restricted and which factor is more restrictive if so, as the J-curve literature intends to explore. These estimates can be used to calculate the change in the capital-labor ratio as well, which measures the firm's performance in climbing up the technological ladder.

A Literature Review

This article is closely related to studies on the influence of exchange rate movements on the trade balance and export performance. According to the standard theory, exchange rate depreciations tend to improve an economy's trade balance if the Marshall-Lerner condition holds, although in the short run, changes in the trade balance may exhibit a J-curve (Berman and Berthou 2009). With aggregate or bilateral trade data, however, studies on the J-curve phenomenon are inconclusive at best. On the one hand, their results delicately rely on: (1) whether the nominal or real exchange rate is concerned (Miles 1979); (2) what unit of measurement is used for the trade balance (Himarios 1985); (3) how the simultaneity issue between exchange rate and trade balance and the autocorrelation issue in each series are treated (Brissimis and Leventankis 1989); (4) the model specification especially for lags (Bahmani-Oskooee 1985); (5) the country and period under examination (Bahmani-Oskooee 1985); and (6) shocks leading to exchange rate changes and if investment booms exist (Backus, Kehoe, and Kydland 1994). On the other hand, the role of exchange rate varies widely across sectors and firms, so studies at the aggregate level are susceptible to the aggregation bias (Rose and Yellen 1989).

Recently, inspections of the exchange rate effect on firm exports and its heterogeneities across firms have been rapidly growing. Campa (2004) find more exports with devaluations, which mainly take place on the intensive margin. With a first-hand evidence of the firm-level exchange rate pass-through effect, quantity response, and adjustment on the extensive margin, Berman, Martin, and Mayer (2012) find that high-productivity firms react to depreciations more in the markup but less in the volume. They claim that the negligible pass-through effect revealed by previous works comes from the aggregation bias. Berman and Berthou (2009) highlight heterogeneities due to the degree of financial constraints and "balance-sheet effect". They argue that the export response to devaluations is mitigated by poor financial health. With a focus on heterogeneities across products, Chatterjee, Dix-Carneiro, and Vichyanond (2013) reveal that devaluations lead to greater price increases for products that are closer to the firm's core competency and consequently a less skewed product scope. As to the case of China, Zhang and Liu (2012) show significant exchange rate effects on both export margins, with heterogeneities identified by firm size, location, and industry. With transaction-level export data, Li, Ma and Xu (2015) find a high exchange rate pass-through effect and a modest quantity response. Heterogeneities in their study arise from both firm- and destination-level factors.

In the literature of agricultural production and trade, the exchange rate impact has also attracted increasing attention. Using quarterly aggregated data in a devaluation period of the US dollar, Clark (1974) uncovers an expected effect of exchange rate movements on agricultural trade. He also points out that the agricultural trade balance improves more substantially than that for manufactured goods. Schuh (1974) identifies the overvalued US dollar as the key overlooked variable to explain the "farm problem" featured by the sector's weak competitiveness. Relaxing overly restrictive assumptions in previous works, Chambers and Just (1979) unveil more pronounced price and volume responses to exchange rate changes. Meanwhile, another strand of literature reveals a negative effect of exchange rate volatility on agricultural trade (Cho, Sheldon, and McCorriston 2002). Compared with studies on manufacturing trade, however, firm-level data are seldom used for the agricultural sector, despite its greater openness that may make inter-firm heterogeneities different (Cho, Sheldon, and McCorriston 2002).

The article also relates to works on exchange rate effects on firm performance. Baggs, Beaulieu, and Fung (2009) find reduced firm sales and survival rates with appreciations. Responses are weaker for productive firms. Noting opposite forces exhibited by the revenue and cost channels, Nucci and Pozzolo (2001, 2010) and Dai and Xu (2017) show that the net effect of exchange rate depreciations on firm investment and employment depends on the firm's external orientation. With a focus on the capital-labor ratio, Leung and Yuen (2010) find a negative impact of depreciations, albeit in a limited magnitude. Taking the 1997 Asian financial crisis as a natural experiment, Park et al. (2010) propose a measure of firm-level exchange rate shocks. Using it as the instrumental variable, they unveil that devaluations lead to a faster export growth and consequently improved firm productivity, total sales, and return to assets. Eichengreen and Tong (2015) scrutinize the exogenous shocks of yuan's sudden appreciation in 2005 and 2010 on the valuation of firms in 44 countries, and find the result to depend on their products. All these papers, nonetheless, are concerned with exchange rate movements rather than currency misalignment. The Balassa-Samuelson effect, which may naturally result in exchange rate movements, could thus be confounded with the exchange rate effect that they estimate.

In the literature of economic growth, in contrast, discussions on currency misalignment can be dated back at least to the mercantilist view. Nevertheless, since most works still use aggregated data, substantial disagreements could be observed in their conclusions. Krueger (1978) and Balassa (1982) analyze the effect of undervaluation on trade and growth by taking it as a substitute to import quotas and tariffs or an alternative subsidy to exports. Using cross-country data of the past several decades, Hausmann, Pritchett, and Rodrik (2005), Rodrik (2008), and Freund and Pierola (2012) find that an undervalued currency facilitates economic growth. With Granger causality tests, Nouira, Plane, and Sekkat (2011) reveal that undervaluation raises the price competitiveness of manufacturing exports, which has a potential to benefit growth. Instead of export expansion, Levy-Yeyati and Sturzenegger (2007) and Gluzmann, Levy-Yeyati, and Sturzenegger (2012) highlight increased employment, savings, and investment as channels underling the pro-growth effect of undervaluation. Besides, several studies such as Prasad, Rajan, and Subramanian (2007) also demonstrate a counter-growth effect of overvaluation.

A competing strand of literature, however, has revealed a negligible, if not deleterious, role of undervaluation in growth. While finding a statistically significant effect for undervaluation, Easterly (2001) reports that its magnitude is secondary to that of infrastructure, education, and inflation. With panel cointegration and GMM estimations, Nouira and Sekkat (2012) fail to find pro-growth effects of undervaluation. Eichengreen (2011) argues that chronical undervaluation can result in the middle income trap and growth slowdown despite a temporary pro-growth effect. According to Chen (2017), undervaluation might also cause an inefficient amount of low-yield foreign reserves, an overly loose monetary policy, a low consumption rate, and fewer R&D activities. Furthermore, Cottani, Cavallo, and Khan (1990) and Ghura and Grennes (1993) demonstrate the need to avoid any kind of currency misalignment.

A common challenge to these studies is the threat of endogeneity in the undervaluation measure. To cope with this issue, scholars either expand specifications to include as many confounding factors as possible, or use the GMM strategy or instrumental variables. However, the inclusion of additional variables only corrects a part of endogeneity that falls in the error term while the GMM strategy can suffer from the weak exogeneity concern (Nouira and Sekkat 2012). As for instrumental variables, Rodrik (2005) points out that they hardly “satisfy both the exogeneity and exclusion requirements”. The firm-level study as our article conducts provides an alternative strategy, since undervaluation is arguably exogenous to a single firm.

We also note that misalignment measures even with regard to yuan alone are diverse. Typically, approaches of two classes are adopted. The first centers on the purchasing power parity (PPP), often corrected for the Balassa-Samuelson effect (Easterly 2001; Rodrik 2008; Subramanian 2010). The second defines misalignment as deviations off equilibrium estimated by macro or behavioral models with imposed internal and external balances (Cottani, Cavallo, and Khan 1990; Ghura and Grennes 1993). These approaches have their own merits, but model-based measures may attenuate estimates of misalignment if yuan approaches its equilibrium (Cheung, Chinn, and Fujii 2010). These models may also be ad hoc or restrictive, and to back out misalignment requires proper elasticity estimates (Cheung, Chinn, and Fujii 2010). In fact, whether the equilibrium exchange rate can be determined more accurately by taking more factors in the model is case dependent (Cheung, Chinn, and Pascual 2005). The onerous data requirements (Cheung, Chinn, and Fujii 2010) and difficulty to define the baseline state (Subramanian 2010) may further undermine the applicability of this approach to China. In contrast, with the wide data coverage, we find that yuan’s bilateral undervaluation against almost all currencies can be estimated with the PPP approach. More importantly, this approach estimates misalignment against all currencies at once, thus offering a consistent estimation with “the virtue of being general equilibrium in nature” (Subramanian 2010). We adopt this approach in this article.

Data

The data used in this article is combined with three datasets: a firm-product-destination level export dataset, a firm-level survey dataset, and a country-level dataset. The detailed description for each of them and the method of merging is as follows.

The agricultural export data of China at the firm-product-destination level

To investigate the influence of undervaluation on agricultural exports at the firm level, we adopt a highly disaggregated dataset of export transactions at the firm-product-destination level from 2000 to 2006, which is released by the General Administration of Customs of China (GACC). This dataset covers all export flows from China, with each entry corresponding to exports of a particular product from a particular firm to a particular destination on a monthly basis. Products are defined at the HS 8-digit level, firms are identified by unique 10-digit IDs under the custom's system, and destinations are identified by unique 3-digit codes for 243 countries or regions. Aside from the basic information of each transaction that includes the export value in US dollars, export quantities, product unit, value per unit, customs port, customs regime (e.g. processing or ordinary trade), and transit mode (e.g. by sea or air), GACC also reports some information about the firm, including its Chinese name, phone number, postal code, city-level location, and ownership type.

For the purpose of this article, we only utilize export flows of agricultural products, which are included in the first 24 chapters under the HS coding system and can be identified using HS 2-digit codes. As implied by the GACC data, agricultural exports accounted for 3.4% in China's total export over the seven-year period in terms of the number of export flows and 4.1% in terms of export value. Both shares, however, have been declining over time: the share measured with the number of export flows decreased from 5.1% in 2000 to 2.5% in 2006, and that measured with export value decreased from 6.0% to 3.1% in the same period. These numbers indicate that the value per flow of agricultural exports has slightly increased relative to that of non-agricultural exports, seeing that the share in the number of flows was more than halved while that in value was not.

Since to each exporter, the degree of currency undervaluation in a destination market does not change across products, we can aggregate export flows at the firm-destination level. All the product-level information such as the type, quantity, and unit value of an export flow will be naturally eliminated after this aggregation. Nonetheless, such a firm-destination-level data well serves our purpose to construct a firm-level measure of currency undervaluation and investigate how it affects the firm performance. Finally, we aggregate the monthly data by year, because as will be soon discussed, the data for firm characteristics are reported on a yearly basis.

It shall be noticed that Hong Kong remains a large destination for China's agricultural exporters. The share in the number of export flows was 11.9% while that in export value was 10.8% in 2000-

2006. Among China's exports to Hong Kong, a notable portion was re-exported to other destinations (Feenstra and Hanson 2004). It is necessary to correct the composition of destinations for each firm by taking into account re-exports through Hong Kong. Such a precise correction, however, requires transaction-level data of Hong Kong's re-exports, which is unfortunately unavailable to us. We thus follow Park et al. (2010) by assuming that any export flow from Mainland China to Hong Kong was re-exported to final destinations following the same distribution with all Hong Kong's re-exports of this product.

The firm-level survey data of China

Although the GACC data documents China's export flows in detail, it does not provide sufficient information about firm characteristics for us to estimate the effect of undervaluation on exports and firm performance. Firm-level survey data, therefore, should be utilized to work with the GACC data. The firm-level data that we use in this article is the Annual Survey of Industrial Firms (ASIF) during 2000-2006. This is a panel dataset collected and maintained by China's National Bureau of Statistics. It well represents China's industrial sector, since all state-owned enterprises (SOEs) and above-scale non-SOEs (i.e. non-SOEs with main operating revenues exceeding five million yuan, approximately equivalent to 0.75 million US dollars under the current exchange rate) of which the total production value accounted for about 95% of the country's industrial sector according to the National Economic Census were covered by the survey.

It shall be noticed, however, ASIF is a survey of industrial firms. Thus, we are only able to find firm characteristics for agricultural exporters that were involved in the industrial sector. In addition, even if a firm appears in both datasets, its characteristics recorded in ASIF may not be merged to its export flows documented in GACC for reasons that we discuss below. Nevertheless, for agricultural exporters whose firm characteristics are successfully merged from ASIF, 86% of them belonged to the food industry, which includes the agro-food processing, food manufacturing, and beverage manufacturing industries in particular, as the two-digit Chinese Standard Industrial Classification (CSIC) codes reported in ASIF indicate.[1] As long as the industry distribution of agricultural exporters does not depend on the success of merging, which shall be a reasonable assumption, we can deduce from the merged sample that most agricultural exporters in the industrial sector were in the food industry. The rest of agricultural exporters in the industrial sector belong to other industries such as the animal oil, grease, and glue manufacturing industries or the Chinese medicine industry.

As noted by empirical works dealing with the ASIF sample, the raw data could be noisy, mostly because some firms may mis-report. We follow Brandt, Van Biesebroeck, and Zhang (2012) and Yu (2015) to clean the sample. In particular, firms with key information (e.g. total sales and fixed assets' value) missing or an employment scale smaller than eight people are excluded. We further exclude observations violating basic accounting rules, such as total sales being negative or total assets being less than the value of fixed assets or liquid assets, as Guariglia, Liu, and Song (2011). Similar to Yu (2015), the sample size for each year is reduced to about 70% after data cleaning.

The merged firm-level data

While both the GACC and ASIF data provide the Chinese name of and a unique code for each firm, the matching between them is technically challenging. To be specific, the Chinese name of a firm may change over time for mergers and acquisitions, or may differ when some words get abbreviated or changed (e.g. "Ltd Co." becomes "Co.") during recording the same firm name. The coding system for firms is even completely different, as GACC uses 10-digit codes while ASIF uses 9-digit codes. To cope with these challenges, we adopt the two-step method proposed by Yu (2015) to merge these datasets.

In particular, we first merge the datasets purely based on Chinese names, so exporters and firms sharing exactly identical names are matched. For those that are not matched, we then take the second step with the use of postal codes and the last seven digits of phone numbers. To be specific, exporters and firms sharing the same postal codes and the last seven digits of phone numbers are regarded as

[1] To account for CSIC code changes in 2003, the GB/T 4754-2002 classification system has been converted to the GB/T 4754-1994 system.

the same firm, because within a specific postcode area, phone numbers shall be unique to firms (Yu 2015). This two-step matching procedure retains as many successfully merged data as possible.

As Table 1 manifests, the number of firms in our merged sample increased from 1,405 in 2000 to 3,593 in 2006, with a total of 5,716 non-repeating firms for the entire period. These firms account for 19.9% of all agricultural exporters documented in GACC in terms of number and 30.8% in terms of export value. It does not, however, imply that the rate of successful merging is low, because some agricultural exporters are out of the industrial sector and cannot be merged with the ASIF data. Since we have no information about whether an agricultural exporter belongs to the industrial sector, there is no way in theory to derive the actual success rate. Nonetheless, examining the food industry alone can provide an approximation. As we mentioned above, 86% of the merged sample are firms in this industry. According to Table 1, we can thus infer that 14.3% of firms in the industry are included in our merged sample. Meanwhile, we also note that 17.2% of firms in the food industry were exporters during the sample period, since the ASIF data report positive annual export values for them—though not further distinguished by products or destinations. Thus, at least for the food industry, our rate of successful merging reaches 14.3% / 17.2% = 83.1%, which is comparable to Yu (2015).

[Table 1 about here]

The country-level data

One of the contributions of this article is that we proposed a measure of the firm-level exposure to currency undervaluation. As we will discuss below, country-level data are required to compute this measure. We rely on two sources for the country-level data. One is the Penn World Table (PWT) 9.0 from which we obtain data for real exchange rates and the output- or expenditure-side real GDP per capita. The other is the World Development Indicators (WDI) 2012, from which we obtain the data for real GDP per capita and per worker as alternative measures of income level in addition to output- and expenditure-side GDP per capita. During the sample period, firms in our merged data exported to 161 destination markets, with the number of markets increased from 119 in 2000 to 155 in 2006. In the empirical analysis below, we first merge the PWT and WDI data of these 161 countries to the

GACC data that is aggregated at the firm-destination level. We are thus able to calculate each firm's undervaluation exposure. This GACC data with the undervaluation measure is then merged with the ASIF data to derive our final dataset. Table 2 provides descriptive statistics for this sample.

[Table 2 about here]

Measuring the Firm-Level Exposure to Currency Undervaluation

The relative value between two currencies in terms of purchasing power is typically measured by real exchange rates. Using indirect quotes, the real exchange rate for currency 1 to currency 2 is defined as $RER_{12} = e_{12} \times P_1 / P_2$, where e_{12} is the nominal exchange rate in indirect quotes, and P_1 and P_2 are aggregate price levels in the two countries. Real appreciations of currency 1, i.e. increases in RER_{12}, weaken the competitiveness of country 1's products in country 2, since either the nominal exchange rate increases such that products with unchanged domestic prices become more expensive to importers, or domestic prices increase in a relative sense. As Rodrik (2008), we will directly use the measure of real exchange rates reported in PWT 9.0 (i.e. "the price level of output-side real GDP at current PPPs in 2011 US dollars") in empirical analyses, considering the more complete coverage of this variable than that of nominal exchange rates and PPP conversion factors (i.e. price ratios).

According to the conventional view of purchasing power parity, a value of RER_{12} that is smaller than unity implies undervaluation of currency 1 against currency 2. This predication, however, shall be adjusted for the Balassa-Samuelson effect since nontraded products are relatively more expensive in richer countries, which will yield a positive correlation between the aggregate price level and the income level even if the law of one price holds for all traded products. To account for this correlation, we follow Rodrik (2008) to estimate

(1) $$\ln RER_{ct} = \beta_0 + \beta_1 \times \ln INCOME_{ct} + f_t + \varepsilon_{ct},$$

where RER_{ct} is the real exchange rate of country c's currency to the US dollar in year t, $INCOME_{ct}$ is the income level, f_t denotes year fixed effects, and ε_{ct} is the error term as usual. The income level will be mainly measured by output-side real GDP per capita using PWT 9.0. To check the robustness, it will be alternatively measured by expenditure-side real GDP per capita, again using PWT 9.0, and by real GDP per capita and real GDP per worker using WDI 2012.

Let the fitted value of RER from equation (1) be $\widehat{RER}$. Then a greater $\widehat{RER}$ than RER reflects that country c's currency is undervalued against the US dollar. The rate of undervaluation equals

$$\ln UNDER_{ct} = \ln\widehat{RER}_{ct} - \ln RER_{ct}. \quad (2)$$

In order to measure whether yuan (CNY) is undervalued against country c's currency, we calculate the difference between $\ln UNDER_{CNYt}$ and $\ln UNDER_{ct}$ which reflects whether yuan is relatively more undervalued when the US dollar is used as the benchmark for both currencies. To abuse our notation, this difference will be denoted by $\ln UNDER'_{ct}$, i.e. $\ln UNDER'_{ct} = \ln UNDER_{CHYt} - \ln UNDER_{ct}$.

Based on these bilateral undervaluation measures for yuan against each currency, we construct a firm-level exposure to undervaluation in the spirit of effective exchange rates as follows:

$$\ln UNDER_{ijt} = \Sigma_c\ (\omega_{ijct\text{-}1} \times \ln UNDER'_{ct}). \quad (3)$$

In equation (3), subscripts i, j, c, and t respectively denote firm, industry, country, and year. $\omega_{ijct\text{-}1}$ is the ratio of firm i's exports to country c in terms of value. The export share is lagged for one period to alleviate the concern of endogeneity, e.g. reallocation of exports to countries where yuan becomes more undervalued. With equation (2), the firm-level undervaluation measure in equation (3) can be rewritten as

$$\ln UNDER_{ijt} = \Sigma_c\ [\omega_{ijct\text{-}1} \times (\ln\widehat{RER}_{CHYt} - \ln\widehat{RER}_{ct})] - \Sigma_c\ [\omega_{ijct\text{-}1} \times (\ln RER_{CHYt} - \ln RER_{ct})]. \quad (4)$$

Apparently, the firm-level undervaluation measure is composed of two parts. $\ln RER_{CHYt} - \ln RER_{ct}$ is exactly the real exchange rate for yuan against country c's currency, so the second term of equation (4) represents the firm-level real effective exchange rate (REER), as in Dai and Xu (2017). The first term, in contrast, is the REER of fitted values. Hence, the firm-level undervaluation measure equals the gap between the firm-level REER that would prevail in PPP adjusted for the Balassa-Samuelson effect and the REER that is observed.

Empirical Strategies

We first take the firm-level undervaluation measure constructed in equation (3) to the following two-way fixed-effects model to identify the role of currency undervaluation in exports:

(5) $$\ln EXP_{ijt} = \alpha_0 + \alpha_1 \times \ln UNDER_{ijt} + \boldsymbol{\beta} \cdot \boldsymbol{x} + f_i + f_{jt} + \varepsilon_{ijt}.$$

The dependent variable is the log value of firm *i*'s total export value in year *t*, EXP_{ijt}. The vector $\boldsymbol{x}$ represents a series of firm-level controls that may affect the export value. According to the literature, these controls include: (1) ln*SALES*, the log value of total sales; (2) ln*WAGE*, the log value of wage rates, which is measured by total wage expenses divided by the total number of workers; (3) ln*TFP*, the log value of total factor productivity, which is estimated with the method proposed by Olley and Pakes (1996); (4) *FINCON*, the ratio between interest expenses and the value of fixed assets, which is widely used to reflect financial constraints at the firm level among studies using the same dataset as our article, considering that loans remain the most important external source of finance to Chinese firms and the variable features more availability than alternative measures (more discussions on this variable will be provided below); (5) *SUBSIDY*, the ratio between subsidized income and total sales; (6) *PROFIT*, the difference between total profits and subsidized income divided by total sales, as a measure of profitability; (7) *FOREIGN*, a dummy variable indicating whether the firm has a foreign ownership as registered; (8) *PROCESSING*, a dummy variable indicating whether in terms of value, the majority of the firm's exports of all products and to all destinations is made via processing trade. With concerns of simultaneity, these control variables are all lagged by one period. In equation (5), f_i and f_{jt} are firm and industry-year fixed effects, respectively capturing uncontrolled firm characteristics and industry-year factors (e.g. industry-specific trends, shocks, or opportunities). Again, ε_{ijt} is the error term. Coefficient α_1 is expected to be positive if exports increase with undervaluation.

We then investigate whether increased exports associated with currency undervaluation benefit the firm-level growth. In particular, we would like to ask whether currency undervaluation increases the growth rate, and if so, whether it comes from the mediation effect of increased exports. Therefore, we consider the following empirical model:

(6) $$\Delta \ln Y_{ijt} = \beta_0 + \beta_1 \times \ln UNDER_{ijt} + \gamma_1 \times \ln EXP_{ijt} - \beta_2 \times \ln Y_{ijt\text{-}1} + f_i + f_{jt} + \varepsilon_{ijt}.$$

In equation (6), Y_{ijt} is any measure of firm performance, which in our anlaysis alternatively includes: (1) *LP*, the labor productivity measured by value added per worker; (2) *TFP*, the total factor productivity estimated by the Olley-Pakes method; (3) *SALES*, the total sales; (4) *VA*, the value added; (5)

L, the number of workers; (6) K, the real capital stock estimated as in Brandt, Van Biesebroeck, and Zhang (2012). We have $\Delta \ln Y_{ijt}$ on the left-hand side of equation (6) to measure the growth rate of Y_{ijt}. On the right-hand side, coefficients β_1 and γ_1 respectively capture impacts of the firm's exposure to undervaluation and its involvement in exports on the growth rate $\Delta \ln Y_{ijt}$. Since β_1 reflects the relationship between growth and undervaluation that is unexplained by the level of exports, it serves as a measure of the "direct" or "unmediated" contribution of undervaluation to growth. The one-period lag of Y_{ijt} in log values is also controlled, so a positive β_2 suggests that the growth is converging. As before, both firm and industry-year fixed effects are included to capture unobserved factors at these levels.

In order to identify the mediation effect, i.e. whether currency undervaluation leads to increased exports while the latter contribute to growth, we have to take both equations (5) and (6) into account. Since coefficient α_1 in equation (5) represents the effect of undervaluation on exports and coefficient γ_1 in equation (6) represents the effect of exports on growth, the product of these coefficients, i.e. $\alpha_1 \times \gamma_1$, measures the "indirect" contribution of undervaluation to growth stemming from the mediation effect of exports. The significance of $\alpha_1 \times \gamma_1$ can be tested using either Sobel (1982) statistics or the bootstrapping method. For the ease of presentation, test results using Sobel statistics will be reported in this article, since they are similar to those of bootstrapping estimates. The caveat of the Sobel test is that the same set of observations must be used when estimating direct and indirect effects.

Results on Currency Undervaluation and Firm Exports

As the core variable in this study, the firm-level exposure to undervaluation will be constructed from bilateral undervaluation measures first according to equations (2) and (3). Although both PWT 9.0 and WDI 2012 are available since the mid of the last century, we restrict ourselves to the period of 2000-2006 when estimating $\widehat{RER}_{ct}$ from equation (1), such that the window of country-level data matches with that of firm-level data. The estimated value of β_1 varies with the income measure used in equation (1). Using the first three measures, the value ranges from 0.27 to 0.29, which stays close to 0.24 as Rodrik (2008) discover for a longer period. It rises to 0.35 with the use of the last measure, i.e. real GDP per worker reported in WDI 2012, which reduces the number of country-year pairs to

819 from about 1200. In spite of different values, however, these estimates are all significant at the 1% level, lending strong support to the existence of the Balassa-Samuelson effect. In most empirical analyses below, the output-side real GDP per capita will be used to estimate bilateral undervaluation and thus the firm-level exposure. As we will see in Table 4, alternative estimates yield similar results about the role of undervaluation.

Using the fixed-effects model specified in equation (5), we find highly significant estimates of α_1 in Table 3, no matter whether additional control variables are included. Particularly, a 1% increase in the firm-level exposure to undervaluation leads to a 1.07-1.12% more export value. Such a stable estimate for this elasticity implies that changes in the degree of currency undervaluation tends to be orthogonal to those of other firm characteristics. Moreover, an adjusted R^2 of 0.83 in the first column of the table and its limited increase in the second column demonstrate the strong explanatory power of currency undervaluation. In fact, none of the wage rate, subsidy rate, foreign ownership, or mode of processing trade exhibits a significant impact on the export value, at least when firm and industry-year fixed effects are both controlled. As one could expect, firms with more sales, higher profit rates, and looser financial constraints (i.e. a greater *FINCON*) make more exports. These effects, however, are small comparing with that of currency undervaluation, as shown by the magnitude of coefficients. In addition, low-productivity firms are found to have more exports, standing in contrast to what the new new trade theory predicts. Similar findings, which is known as the productivity puzzle of China, have been documented in a number of empirical studies, and may be a result of firms that are purely involved in processing trade (Dai, Maitra, and Yu 2016).

It shall be noted that our finding of a positive effect of undervaluation on export is not restricted to the merged sample. In the last column of Table 3, a re-estimation is conducted using all the GACC data of agricultural exports. That is, agricultural exporters outside the industrial sector and those not matched with ASIF firms are both included with the merged sample. Firm characteristics except the undervaluation measure cannot be controlled, because such information is not available from GACC. Since the firm's industry is not reported either, year fixed effects have to be used in place of industry-year fixed effects in equation (5). The estimated elasticity of export value to undervaluation in this enlarged sample is 1.26 and still significant at the 1% level. This is similar to our finding in the first two columns.

[Table 3 about here]

To examine the robustness of our finding about the positive role of currency undervaluation on exports, we consider several alternative indicators of the firm-level undervaluation exposure. In the first three columns of Table 4, we respectively measure the income level that captures the Balassa-Samuelson effect in equation (1) using expenditure-side real GDP per capita (*EGDPPC*), real GDP per capita (*GDPPC*), and real GDP per worker (*GDPPW*). Firms' exposure to undervaluation is then re-calculated by equation (3) using these re-estimated bilateral undervaluation measures. As one can tell from Table 4, the estimated elasticity of exports remains close to that found in Table 3, indicating robustness of the result to the choice of income measures. In the rest four columns, we replace export shares in lags by those of the same year with undervaluation measures in equation (3). We introduce a letter *t* to the end of each column name to indicate such a change. As before, income is respectively measured by output-side real GDP per capita (*OGDPPC*) and the alternative indicators (*EGDPPC*, *GDPPC*, and *GDPPW*). The estimated elasticity of exports declines to 0.31-0.39 from a level above unity. It implies that the firm-level undervaluation exposure tends to be over-estimated when current export shares are employed, probably because firms could instantaneously increase export shares to countries where a greater degree of currency undervaluation is enjoyed.

[Table 4 about here]

One might also concern that equation (5) only reflects the immediate impact of undervaluation on exports. We thus re-estimate the model by gradually including lags of the firm-level exposure to undervaluation. Consider a firm that has been consistently observed throughout the seven-year window of our firm-level data. Only its exposure to undervaluation in the last six years can be estimated, since export shares are lagged by one period in equation (3). In addition, we have to sacrifice another year's observation to control the firm-specific fixed effect. Hence, equation (5) may include lags of the undervaluation exposure up to four periods, on top of the current exposure. As one can find from

Table 5, the instantaneous elasticity of exports largely remains intact with the inclusion of these lags. Previous exposure to undervaluation, in contrast, does not significantly influence the current export value. It lends support to our focus on equation (5), which only specifies a contemporaneous linkage between undervaluation and exports.

[Table 5 about here]

Evidence of Heterogeneous Effects across Firms

Recent development of the new new trade theory unveils more pronounced differences in trade performance across firms than those across sectors (Melitz 2003). The impact of undervaluation on exports may also differ for firm characteristics. According to Li, Ma and Xu (2015), more productive firms experience greater price increases and smaller quantity increases in real depreciations than their less productive counterparts. The difference in quantity responses, however, is more substantial than that in price responses, indicating that the net growth in export value shall be negatively related with the firm's productivity level. This inference is confirmed by our finding in Table 6. Respectively using labor productivity (*LP*) defined as value added per worker and total factor productivity (*TFP*) estimated by the Olley-Pakes method, we split firms into two groups based on time-varying cutoffs that equal the median productivity of each year. This classification corrects common trends that may be observed in productivity measures. The estimated effect of undervaluation on export value is larger in subsamples of low-productivity firms. In particular, the elasticity is larger by about 21% no matter which productivity measure is used. Such differences are significant, as indicated by Wald-tests that respectively yield p-values of 0.025 and 0.038.

[Table 6 about here]

The elasticity of exports to undervaluation is then compared across firms facing different levels of financial constraints. Measuring financial constraints is a difficult task, since such constraints are unobserved, and different measures do not always agree with each other or sometimes can even fail to capture the true status (Farre-Mensa and Ljungqvist 2016). A conservative approach is, therefore, to use various measures to check if robust patterns can be revealed. Three measures are respectively considered. *FINCON*, which equals the ratio between interest expenses and the value of fixed assets as defined above, represents the firm's capability to borrow loans (Li and Yu 2013). With the market capitalization ratio in GDP being only 0.32, loans are the most important external source of finance to Chinese firms (Allen, Qian and Qian 2005). Interest expenses, which in principle include all debt payments and serve as the proxy for the amount of pending loans, can hence approximately measure the overall degree of financial constraints (Cull, Xu and Zhu 2009). We rescale interest expenses by the value of fixed assets to eliminate the firm size effect (Petersen and Rajan 1994). Since the financial information to compute canonical firm-level financial constraint measures, e.g. the KZ, SA, and WW indices, is incomplete, *FINCON* has been widely used in studies that work with the ASIF data. Cai, Liu and Xiao (2005) and Cull, Xu and Zhu (2009) provided more discussions on the relevance of this variable, and Li and Yu (2013) and Sun and Li (2011) demonstrated its robustness to endogeneity. A larger *FINCON* implies that the firm is less financially constrained.

Another measure of financial constraints is the interest coverage ratio *COVER*, defined as earnings before interest and taxes divided by interest expenses. Calculated as the number of times that a firm can make interest payments on current debts using its income, *COVER* technically reflects the likelihood of financial distress (Whited 1992). It measures the firm's internal financial constraints, since if sufficient internal funds can be generated, the need of borrowing and the possibility to meet debt limits will both decline (Guariglia 2008; Whited 1992). As Guariglia (2008) summarized, this ratio has been widely used in the literature on how financial constraints influence firm performance. A greater value implies a lower degree of constraints.

The last measure of financial constraints that we consider is constructed based on Hovakimian (2009), an influential paper that proposed a method to estimate the investment-cash flow sensitivity at the firm level. In particular, two types of "average" investment made by a firm are considered for any period. The first is simply the arithmetic mean or unweighted mean of its investment within the period. The second is a weighted mean, with the weight for each year being the share of that year's cash flows in the total amount of cash flows over all years. For firms that are financially constrained, investment correlates with cash flows (Fazzari et al., 1988), so the weighted average investment will be larger than that is unweighted. In other words, the difference between weighted and unweighted average investment can represent the degree of financial constraints. To generate time variations in this measurement which we denote by *INV-CASH*, we calculate it in a three-year rolling window for each year. A larger *INV-CASH* indicates a higher degree of constraints.

As Table 7 demonstrates, the effect of undervaluation on export value is larger in the subsample of firms that are less financially constrained, despite which financial constraint measure is used. The difference increases from 16% for the case of *FINCON* to 86% for that of *INV-CASH*. With *p*-values respectively equal to 0.031, 0.049, and 0.027, such differences are statistically significant. A number of empirical studies find financial constraints to hinder firms' export participation and performance (e.g. Greenaway, Guariglia, and Kneller 2007; Sun and Li 2011). Berman and Berthou (2009) noted that the exchange rate impact is smaller among financially constrained firms. Our results are in line with this literature. Currency undervaluation strengthens the firm's competitive advantage in foreign markets. To benefit from this advantage, however, the firm shall expand more export quantities than its price sacrifice. This might explain why we find greater export elasticity for less constrained firms, as their production scale can be expanded more easily.

[Table 7 about here]

Related to the differences revealed for financial constraints, we also discover that the elasticity of export is heterogeneous across ownership types. Firms' ownership is defined either according to their registration, using the codes given by the National Bureau of Statistics, or the structure of paid-in capital. We follow Guariglia, Liu, and Song (2011) to define SOEs as firms with state-owned or collective capital exceeding 50% of the total paid-in capital. Similarly, private and foreign firms are identified respectively for firms with private or foreign capital as the majority of paid-in capital. With presence of the political pecking order that prevails China's credit market, private firms are more financially constrained than their state-owned and foreign counterparts (Poncet, Steingress, and Vandenbussche 2010). In line with Table 7, we thus find the effect of undervaluation on export to be the smallest for private firms in Table 8. The finding of larger export elasticity for SOEs and foreign firms also echoes the literature reporting these firms' exceptional benefits from yuan's undervaluation and the role of exchange rate in foreign capital attraction (Eichengreen 2011; Xing 2006).

[Table 8 about here]

Finally, we examine whether the effect of undervaluation differs for the mode of trade and the presence of subsidies. As described above, the trade mode is defined by taking all export flows for each firm-year duplet into account. In particular, if the majority of these flows in terms of value are processing trade, then the firm is regarded as a processing exporter in that year. As Table 9 manifests, processing exporters exhibit greater elasticity of exports by 79.3%. Such a difference is significant, as indicated by a *p*-value of 0.000 associated with the Wald-test. According to Dai, Maitra, and Yu (2016), the productivity level is generally lower for processing exporters. The finding in Table 9 thus confirms the larger elasticity for low-productivity firms revealed in Table 6. It also complies with Table 8, for the relatively high share of processing trade among foreign firms (Ma, Wang and Zhu 2015). It shall be noted that imports of intermediary inputs are traditionally expected to attenuate the effect of exchange rate on export. However, China seems to be a special case as empirical evidence suggests that processing trade only has a negligible impact on this effect with differences in other aspects such as productivity and ownerships being controlled (Eichengreen and Tong 2015; Zhang and Liu 2012).

The last two columns of Table 9 presents a comparison based on whether firms obtain subsidies. Apparently, greater elasticity of exports is found in the subsample with subsidies. The difference is 69.2% and significant with a *p*-value of 0.000. Since state-owned firms are more likely to be subsidy recipients and subsidized firms feature lower financial constraints (Girma et al. 2009), this result is in line with Table 7 and Table 8. As Girma et al. (2009) notice, the data on subsidies are not limited to export subsidies, but also include all production-related subsidies such as those granted to secure employment and promote product sophistication. Hence, the difference revealed for subsidized and unsubsidized firms shall not be taken straightforwardly as a demonstration that subsidized firms are simply designed to export.

[Table 9 about here]

Undervaluation, Growth, and the Mediation Role of Exports

Recently, the seminal paper of Rodrik (2008) has renewed interest in exploring how misaligned currencies influence economic performance, which has a long history that can be dated back to the mercantilist view (Gluzmann, Levy-Yeyati, and Sturzenegger 2012). Most of these empirical studies, however, still use nationwide data and their conclusions may remain subject to doubts (Rodrik 2005; Gluzmann, Levy-Yeyati, and Sturzenegger 2012; Nouira and Sekkat 2012). With the firm-level exposure to undervaluation that we constructed in this article, a re-investigation can be provided using disaggregated data. As mentioned above, we consider six measures of firm performance: *LP* and *TFP* reflect productivity, and *SALES*, *VA*, *L*, and *K* reflect scale. We introduce ln*UNDER* into a standard growth equation to capture the growth effect of currency undervaluation as in Rodrik (2008). To identify the mediation role of exports, the export value is also controlled. Thus, in equation (6) that serves as our final empirical specification, β_1 and β_2 respectively represent direct effects of undervaluation and export on growth. Since coefficient α_1 in equation (5) evaluates the undervaluation-to-export elasticity, the product $\alpha_1 \times \gamma_1$ provides a measure for the growth effect of undervaluation that is mediated by exports. Its statistical significance is derived from the Sobel test.

As Table 10 displays, the direct growth effect of undervaluation, i.e. β_1, is insignificant for the total factor productivity, total sales, value added, and capital stock. In contrast, the indirect effect $\alpha_1 \times \gamma_1$ remains significant at the 1% level in these cases. Hence, the mediation role of exports almost completely accounts for the growth effect of undervaluation. For the labor productivity and employment, both the direct growth effect and the mediation effect are statistically significant. Nevertheless, the direct growth effect is only significant at the 10% and 5% level respectively, while the mediation effect still remains significant at the 1% level. In terms of the relative magnitude, the export channel respectively takes 0.084 / (0.084 + 0.110) = 43.3% and 0.086 / (0.086 + 0.091) = 48.6% of the effect of undervaluation on labor productivity and employment growth. To sum up, Table 10 lends support to the existence of the growth effect of undervaluation and the important mediation role played in this effect by exports.

The overall magnitude of the firm-level growth effect of undervaluation that Table 10 finds is larger than that estimated by country-level studies (Gluzmann, Levy-Yeyati, and Sturzenegger 2012; Rodrik 2008). Taking both direct and indirect effects into account, a 10% firm-level undervaluation leads to a 2 percentage point increase in the growth rate of labor productivity, a 0.4 percentage point increase in that of TFP, a 1.5 percentage point increase in that of total sales, a 1.6 percentage point increase in that of value added, a 1.8 percentage point increase in that of employment, and a 0.3 percentage point increase in that of capital stock. All of these increases exceed 0.2, i.e. the increase in the growth rate of GDP per capita that is typically found in cross-country studies (Gluzmann, Levy-Yeyati, and Sturzenegger 2012; Rodrik 2008). In addition, except for TFP and capital stock, these increases even exceed 0.8, i.e. the increase in per capita GDP growth found for China (Rodrik 2010). Such a difference might come from two sources. On the one hand, the firms that we study in our article are all manufacturing exporters, so their larger response to undervaluation indicates that the benefit of undervaluation is biased toward the tradable sector, which is in line with Prasad, Rajan, and Subramanian (2007). On the other hand, Table 6 finds that low-productivity firms benefit more from undervaluation than their high-productivity counterparts. The firm-level estimation of the response to undervaluation is expected to be larger than that at the aggregate level, since in the latter exercise, low-productivity firms have small weights.

A remarkable result from Table 10 is that comparing to the case of capital stock, undervaluation not only exhibits a significantly positive direct impact on employment growth, but also accelerates this growth via a greater mediation role of exports. Therefore, the overall response to undervaluation is greater for employment growth than for the growth in capital stock. In other words, the capital to labor ratio tends to decline with undervaluation, in line with the evidence that Gluzmann, Levy-Yeyati, and Sturzenegger (2012) found at the aggregate level. With a 10%firm-level undervaluation, the growth rates of employment and capital stock respectively accelerate by 1.8 and 0.3 percentage points, so the growth rate of the capital to labor ratio declines by 1.5 percentage points. This implies that the capital to labor ratio is expected to decline by 1.5% if the economy initially stays in the steady state with a constant capital to labor ratio. Such a magnitude is close to the finding of a 1.7%

decrease by Leung and Yuen (2010) at the industry-level for Canada.

Finally, in Table 10, coefficient β_2 is consistently positive in all cases. It indicates that for each type of firm performance, the pattern of β-convergence can be identified.

[Table 10 about here]

Conclusions

Based on a merged dataset of disaggregated agricultural export flows of China, this article proposed a method to estimate the firm-level exposure to currency undervaluation, and investigated the role of undervaluation in agricultural exports and growth at the firm level. Empirical models reveal a robust positive effect of undervaluation on exports. This effect varies for firm characteristics. The path analysis indicates that undervaluation further accelerates growth in firm productivity and scale, with a remarkable mediation role of increased exports. This article thus lends support to the view of export-led growth with undervalued exchange rates.

While undervaluation is found to benefit both exports and growth in this article, disputes about the role of currency manipulation in the literature shall not be brushed off. Firstly, as our estimation demonstrates, undervaluation results in a decreased capital-labor ratio, which could render firms to stay in labor-intensive industries, retard their move along the technological ladder, and hamper their long-term growth (Eichengreen 2011). Second, the growth effect of undervaluation that we identify at the firm level should not be directly taken to the aggregate level either, seeing that undervaluation can simultaneously produce insufficient consumption and excessive investment, which are not the interest of this article but tend to threaten the overall growth performance (Nouira and Sekkat 2012). Taking into account these concerns, the results of this article must not be interpreted to urge policy-makers to pursue undervalued exchange rates forever. In fact, the undervaluation strategy shall only be adopted discretionally by weighing the positive trade-cum-growth effect against chronicle damages that it could yield. In the case of China, its recent move toward a more flexible exchange rate regime and reduced degree of yuan's undervaluation is thus probably a timely policy shift.

References

Allen, F., Qian, J., & Qian, M. (2005). Law, finance, and economic growth in China. *Journal of Financial Economics*, *77*(1), 57-116.

Backus, D. K., Kehoe, P. J., & Kydland, F. E. (1994). Dynamics of the trade balance and the term of trade: The J-curve? *American Economic Review*, *84*(1), 84-103.

Baggs, J., Beaulieu, E., & Fung, L. (2009). Firm survival, performance, and the exchange rate. *Canadian Journal of Economics*, *42*(2), 393-421.

Bahmani-Oskooee, M. (1985). Devaluation and the J-curve: Some evidence from LDCs. *Review of Economics and Statistics*, *67*(3), 500-504.

Balassa, B. (1964). The purchasing-power parity doctrine: A reappraisal. *Journal of Political Economy*, *72*(6), 584-596.

Balassa, B. (1982). *Development Strategies in Semi-Industrial Economies*. Baltimore, MD: Johns Hopkins University Press.

Berman, N., & Berthou, A. (2009). Financial market imperfections and the impact of exchange rate movements on exports. *Review of International Economics*, *17*(1), 103-120.

Berman, N., Martin, P., & Mayer, T. (2012). How do different exporters react to exchange rate changes? *Quarterly Journal of Economics*, *127*(1), 437-492.

Brandt, L., Van Biesebroeck, J., & Zhang, Y. (2012). Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. *Journal of Development Economics*, *97*(2), 339-351.

Brissimis, S. N., & Leventakis, J. A. (1989). The effectiveness of devaluation: A general equilibrium assessment with reference to Greece. *Journal of Policy Modeling*, *11*(2), 247-271.

Cai, H., Liu, Q., & Xiao, G. (2005). *Does Competition Encourage Unethical Behavior? The Case of Corporate Profit Hiding in China*. Mimeo, University of California at Los Angeles.

Campa, J. M. (2004). Exchange rates and trade: How important is hysteresis in trade? *European Economic Review*, *48*(3), 527-548.

Chambers, R. G., & Just, R. E. (1979). A critique of exchange rate treatment in agricultural trade models. *American Journal of Agricultural Economics*, *61*(2), 249-257.

Chatterjee, A., Dix-Carneiro, R., & Vichyanond, J. (2013). Multi-product firms and exchange rate fluctuations. *American Economic Journal: Economic Policy*, *5*(2), 77-110.

Chen, S. S. (2017). Exchange rate undervaluation and R&D activity. *Journal of International Money and Finance*, *72*, 148-160.

Cheung, Y. W., Chinn, M. D., & Fujii, E. (2010). Measuring misalignment: Latest estimates for the Chinese yuan. In S. Evenett (Ed.), *The US-Sino Currency Dispute: New Insights from Economics, Politics and Law* (pp. 79-

90). London: Center for Economic Policy Research.

Cheung, Y. W., Chinn, M. D., & Pascual, A. G. (2005). Empirical exchange rate models of the nineties: Are any fit to survive? *Journal of International Money and Finance, 24*(7), 1150-1175.

Cho, G., Sheldon, I. M., & McCorriston, S. (2002). Exchange rate uncertainty and agricultural trade. *American Journal of Agricultural Economics*, *84*(4), 931-942.

Clark, P. B. (1974). *The Effects of Recent Exchange Rate Changes on the US Trade Balance*. Discussion Paper No. 52, Board of Governors of the Federal Reserve System.

Cottani, J. A., Cavallo, D. F., & Khan, M. S. (1990). Real exchange rate behavior and economic performance in LDCs. *Economic Development and Cultural Change*, *39*(1), 61-76.

Cull, R., Xu, L. C., & Zhu, T. (2009). Formal finance and trade credit during China's transition. *Journal of Financial Intermediation*, *18*(2), 173-192.

Dai, M., Maitra, M., & Yu, M. (2016). Unexceptional exporter performance in China? The role of processing trade. *Journal of Development Economics*, *121*, 177-189.

Dai, M., & Xu, J. (2017). Firm-specific Exchange Rate Shocks and Employment Adjustment: Evidence from China. *Journal of International Economics, 108*, 54-66.

Easterly, W. (2001). The lost decades: Developing countries' stagnation in spite of policy reform 1980-1998. *Journal of Economic Growth, 6*(2), 135-157.

Eichengreen, B. (2011). Escaping the middle-income trap. *Economic Policy Symposium Proceedings*, 409-419.

Eichengreen, B., & Tong, H. (2015). Effects of renminbi appreciation on foreign firms: The role of processing exports. *Journal of Development Economics, 116*, 146-157.

Farre-Mensa, J., & Ljungqvist, A. (2016). Do measures of financial constraints measure financial constraints? *Review of Financial Studies*, *29*(2), 271-308.

Fazzari, S. M., Hubbard, R. G., Petersen, B. C., Blinder, A. S., & Poterba, J. M. (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity*, (1), 141-206.

Feenstra, R. C., & Hanson, G. H. (2004). Intermediaries in entrepot trade: Hong Kong re-exports of Chinese goods. *Journal of Economics & Management Strategy*, *13*(1), 3-35.

Frankel, J. A., & Romer, D. (1999). Does trade cause growth? *American economic review*, 379-399.

Freund, C., & Pierola, M. D. (2012). Export surges. *Journal of Development Economics, 97*(2), 387-395.

Fuller, F., Beghin, J., De Cara, S., Fabiosa, J., Fang, C., & Matthey, H. (2003). China's accession to the World Trade Organization: What is at stake for agricultural markets? *Review of Agricultural Economics, 25*(2), 399-414.

Ghura, D., & Grennes, T. J. (1993). The real exchange rate and macroeconomic performance in Sub-Saharan Africa. *Journal of Development Economics*, *42*(1), 155-174.

Girma, S., Gong, Y., Gorg, H., & Yu, Z. (2009). Can production subsidies explain China's export performance? Evidence from firm-level data. *Scandinavian Journal of Economics*, *111*(4), 863-891.

Gluzmann, P. A., Levy-Yeyati, E., & Sturzenegger, F. (2012). Exchange rate undervaluation and economic growth: Díaz Alejandro (1965) revisited. *Economics Letters*, *117*(3), 666-672.

Greenaway, D., Guariglia, A., & Kneller, R. (2007). Financial factors and exporting decisions. *Journal of International Economics*, *73*(2), 377-395.

Guariglia, A. (2008). Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms. *Journal of Banking & Finance*, *32*(9), 1795-1809.

Guariglia, A., Liu, X., & Song, L. (2011). Internal finance and growth: Microeconometric evidence on Chinese firms. *Journal of Development Economics*, *96*(1), 79-94.

Hausmann, R., Pritchett, L., & Rodrik, D. (2005). Growth accelerations. *Journal of Economic Growth*, *10*(4), 303-329.

Himarios, D. (1985). The effects of devaluation on the trade balance: a critical view and re-examination of Mile's 'new results'. *Journal of International Money and Finance*, *4*(4), 553-563.

Hovakimian, G. (2009). Determinants of investment cash flow sensitivity. *Financial Management*, *38*(1), 161-183.

Huang, J., Yang, J., Xu, Z., Rozelle, S., & Li, N. (2007). Agricultural trade liberalization and poverty in China. *China Economic Review*, *18*(3), 244-265.

Krueger, A. O. (1978). *Foreign Trade Regimes and Economic Development: Liberalization Attempts and Consequences*. Cambridge, MA: Ballinger Publishing Company.

Leung, D., & Yuen, T. (2010). Do exchange rates affect the capital-labour ratio? Panel evidence from Canadian manufacturing industries. *Applied Economics*, *42*(20), 2519-2535.

Levy-Yeyati, E., & Sturzenegger, F. (2007). *Fear of Floating in Reverse: Exchange Rate Policy in the 2000s*. Working Paper RWP07-047, Harvard University.

Li, H., Ma, H., & Xu, Y. (2015). How do exchange rate movements affect Chinese exports? A firm-level investigation. *Journal of International Economics*, *97*(1), 148-161.

Li, Z., & Yu, M. (2013). Exports, productivity and credit constraints: A firm-level empirical investigation of China. *Economic Research Journal*, (6), 85-99.

Ma, H., Wang, Z., & Zhu, K. (2015). Domestic content in China's exports and its distribution by firm ownership. *Journal of Comparative Economics*, *43*(1), 3-18.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695-1725.

Miles, M. A. (1979). The effects of devaluation on the trade balance and the balance of payments: some new results.

Journal of Political Economy, *87*(3), 600-620.

Nouira, R., Plane, P., & Sekkat, K. (2011). Exchange rate undervaluation and manufactured exports: A deliberate strategy? *Journal of Comparative Economics*, *39*(4), 584-601.

Nouira, R., & Sekkat, K. (2012). Desperately seeking the positive impact of undervaluation on growth. *Journal of Macroeconomics*, *34*(2), 537-552.

Nucci, F., & Pozzolo, A. F. (2001). Investment and the exchange rate: An analysis with firm-level panel data. *European Economic Review*, *45*(2), 259-283.

Nucci, F., & Pozzolo, A. F. (2010). The exchange rate, employment and hours: What firm-level data say. *Journal of International Economics*, *82*(2), 112-123.

Olley, S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications industry. *Econometrica*, *64*(6), 1263-1297.

Park, A., Yang, D., Shi, X., & Jiang, Y. (2010). Exporting and firm performance: Chinese exporters and the Asian financial crisis. *Review of Economics and Statistics*, *92*(4), 822-842.

Petersen, M. A., & Rajan, R. G. (1994). The benefits of lending relationships: Evidence from small business data. *Journal of Finance*, *49*(1), 3-37.

Poncet, S., Steingress, W., & Vandenbussche, H. (2010). Financial constraints in China: firm-level evidence. *China Economic Review*, *21*(3), 411-422.

Pick, D. H., & Vollrath, T. L. (1994). Real exchange rate misalignment and agricultural export performance in developing countries. *Economic Development and Cultural Change*, *42*(3), 555-571.

Prasad, E. S., Rajan, R. G., & Subramanian, A. (2007). Foreign capital and economic growth. *Brookings Papers on Economic Activity*, (1), 153-230.

Rodrik, D. (2005). *Why We Learn Nothing from Regressing Economic Growth on Policies*. Mimeo, Harvard University.

Rodrik, D. (2008). The real exchange rate and economic growth. *Brookings Papers on Economic Activity*, (2), 365-412.

Rodrik, D. (2010). Making room for China in the world economy. *American Economic Review*, *100*(2), 89-93.

Rodrik, D. (2013). Unconditional convergence in manufacturing. *Quarterly Journal of Economics*, *128*(1), 165-204.

Rose, A. K., & Yellen, J. L. (1989). Is there a J-curve? *Journal of Monetary Economics*, *24*(1), 53-68.

Samuelson, P. A. (1964). Theoretical notes on trade problems. *Review of Economics and Statistics*, *46*(2), 145-154.

Schuh, G. E. (1974). The exchange rate and US agriculture. *American Journal of Agricultural Economics*, *56*(1), 1-13.

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. *Sociological*

Methodology, *13*, 290-312.

Subramanian, A. (2010). *New PPP-Based Estimates of Renminbi Undervaluation and Policy Implications*. Peterson Institute for International Economics Policy Brief No. PB10-8.

Sun, L. & Li, R. (2011). Do financing constraints restrain Chinese firms' export participation? *China Economic Quarterly*, *11*(1), 231-252.

Whited, T. M. (1992). Debt, liquidity constraints, and corporate investment: Evidence from panel data. *Journal of Finance*, *47*(4), 1425-1460.

Williams, G. W., & Luo, J. (2015). Exchange rate policy and global supply chains: The case of the Chinese Renminbi and global soybean and soybean product markets. *Applied Economic Perspectives and Policy, 39*(1), 177-198.

Xing, Y. (2006). Why is China so attractive for FDI? The role of exchange rates. *China Economic Review, 17*(2), 198-209.

Yu, M. (2015). Processing trade, tariff reductions and firm productivity: Evidence from Chinese firms. *Economic Journal*, *125*(585), 943-988.

Zhang, X., & Liu, X. (2012). How responsive are Chinese exports to exchange rate changes? Evidence from firm-level data. *Journal of Development Studies*, *48*(10), 1489-1504.

Table 1. Comparison of the GACC, ASIF, and Merged Data.

	Agricultural exporters in GACC		Number of firms in ASIF after cleaning		Merged sample	
	Number	Export value	All	Food industry	Number	Export value
2000	10,322	14.8	103,059	11,594	1,405	2.7
2001	10,976	15.5	111,688	11,664	1,685	3.6
2002	11,707	17.4	123,174	12,418	2,001	4.3
2003	13,272	20.7	137,337	13,643	2,419	5.5
2004	15,239	22.5	198,032	16,797	3,169	8.3
2005	17,152	26.5	201,266	18,460	3,289	9.5
2006	19,985	30.2	226,400	20,897	3,593	11.6

Notes: The export value is measured in billions of US dollars.

Table 2. Descriptive Statistics of the Merged Sample.

Variable name	Definition						
Country level		Obs.	Mean	Std.	Median	P10	P90
ln*RER*	log(real exchange rate) w.r.t. USD, PWT	935	-0.853	0.526	-0.902	-1.492	-0.112
ln*OGDPPC*	log(output-side real GDP per capita), PWT	935	9.017	1.228	9.077	7.251	10.536
ln*EGDPPC*	log(expenditure-side real GDP per capita), PWT	935	9.030	1.255	9.099	7.236	10.584
ln*GDPPC*	log(real GDP per capita), WDI	911	8.850	1.288	8.978	6.939	10.415
ln*GDPPW*	log(real GDP per worker), WDI	720	9.597	0.998	9.788	8.042	10.761
Firm level estimated variables	Firm-level undervaluation	Obs.	Mean	Std.	Median	P10	P90
ln*UNDER*1	with income measured by *OGDPPC*	11,281	0.580	0.276	0.629	0.154	0.879
ln*UNDER*2	with income measured by *EGDPPC*	11,281	0.540	0.269	0.576	0.121	0.832
ln*UNDER*3	with income measured by *GDPPC*	11,281	0.484	0.257	0.519	0.079	0.767
ln*UNDER*4	with income measured by *GDPPW*	11,124	0.446	0.250	0.478	0.074	0.723
Firm level continuous raw variables		Obs.	Mean	Std.	Median	P10	P90
ln*EXP*	log(export value), GACC	17,561	13.252	2.291	13.702	10.160	15.691
ln*SALES*	log(sales), ASIF	17,561	10.493	1.320	10.361	8.919	12.292

ln*VA*	ln(value added), ASIF	16,911	9.064	1.425	8.991	7.396	10.984
ln*L*	ln(number of workers), ASIF	17,561	4.949	1.146	4.883	3.497	6.461
ln*K*	ln(real capital stock), ASIF	17,395	9.061	1.767	9.023	6.936	11.348
ln*WAGE*	log(wage rate), ASIF	17,523	2.378	0.741	2.336	1.600	3.281
ln*TFP*	log(TFP, OP method), ASIF	16,491	0.861	0.530	0.950	0.280	1.383
ln*LP*	log(labor productivity), ASIF	16,911	4.116	1.136	4.129	2.726	5.544
FINCON, %	Interest expenses / value of fixed assets, ASIF	17,144	5.367	9.637	1.959	0.000	14.302
COVER	Interest coverage ratio, ASIF	9,561	7.687	10.457	3.391	1.026	20.833
INV-CASH	Investment-cash flow sensitivity, ASIF	3,070	0.001	0.037	0.000	-0.023	0.025
SUBSIDY, %	Subsidy / sales, ASIF	16,618	0.049	0.151	0.000	0.000	0.157
PROFIT, %	Net profit / sales, ASIF	17,180	2.244	9.135	2.037	-5.169	30.990
Firm level binary raw variables		Obs.		= 1		= 0	
PROCESSING	Processing exporter dummy, ASIF	17,561		2,707		14,854	
Firm level ternary raw variables		Obs.	Private		SOEs		Foreign
*OWNERSHIP*1	Ownership as registered, ASIF	17,561	5,501		1,189		10,871
*OWNERSHIP*2	Ownership by paid-in capital, ASIF	17,250	8,415		1,956		6,879

Notes: Detailed variable definitions can be found in the text.

Table 3. Benchmark Results on Currency Undervaluation and Firm Exports.

	Merged sample		All ag-exporters
	Without Controls	With Controls	
	(1)	(2)	(3)
ln*UNDER*	1.120***	1.066***	1.260***
	(0.072)	(0.085)	(0.011)
ln*SALES*		0.198***	
		(0.024)	
ln*WAGE*		-0.015	
		(0.021)	
ln*TFP*		-0.081***	
		(0.030)	
FINCON (%)		0.005***	
		(0.001)	
SUBSIDY (%)		0.023	
		(0.075)	
PROFIT (%)		0.005***	
		(0.002)	
FOREIGN = 1		0.021	
		(0.084)	
PROCESSING = 1		0.311	
		(0.341)	
Firm FEs	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	No
Year FEs	No	No	Yes
Number of obs.	9,766	9,401	419,150

Adjusted R2	0.829	0.832	0.791

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 4. Alternative Measures of Currency Undervaluation.

	EGDPPC	*GDPPC*	*GDPPW*	*OGDPPCt*	*EGDPPCt*	*GDPPCt*	*GDPPWt*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln*UNDER*	1.145***	1.191***	1.170***	0.312***	0.360***	0.391***	0.328***
	(0.075)	(0.080)	(0.083)	(0.077)	(0.079)	(0.080)	(0.081)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs.	9,773	9,780	9,630	15,047	15,038	15,050	14,808
Adjusted R2	0.830	0.829	0.826	0.787	0.787	0.787	0.786

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5. Dynamic Effects of Currency Undervaluation.

	$T-1$	$T-2$	$T-3$	$T-4$
	(1)	(2)	(3)	(4)
ln*UNDER*	1.264***	1.103***	1.136***	1.395***
	(0.094)	(0.125)	(0.165)	(0.313)
ln$UNDER_{-1}$	-0.045	0.117	-0.251	-0.428
	(0.097)	(0.134)	(0.189)	(0.328)
ln$UNDER_{-2}$		0.098	0.149	0.030
		(0.140)	(0.206)	(0.378)
ln$UNDER_{-3}$			-0.181	-0.412
			(0.191)	(0.363)
ln$UNDER_{-4}$				0.611
				(0.380)
Firm FEs	Yes	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes	Yes
Number of obs.	5,712	3,353	1,867	878
Adjusted R2	0.852	0.866	0.888	0.892

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6. Heterogeneities with Productivity Levels.

	LP		*TFP*	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
ln*UNDER*	1.244***	1.028***	1.132***	0.930***
	(0.107)	(0.118)	(0.112)	(0.115)
Firm FEs	Yes	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes	Yes
Number of obs.	4,042	4,189	4,120	3,907
Adjusted R2	0.862	0.822	0.852	0.847

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7. Heterogeneities with Financial Constraints.

	FINCON		*COVER*		*INV-CASH*	
	Small	Large	Small	Large	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
ln*UNDER*	1.060***	1.230***	0.879***	1.094***	0.408*	0.760***
	(0.132)	(0.122)	(0.178)	(0.166)	(0.240)	(0.274)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs.	3,668	3,744	1,867	1,938	795	843
Adjusted R2	0.842	0.812	0.862	0.823	0.899	0.891

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. Heterogeneities with Ownership Types.

	By paid-in capital			As registered		
	Private	SOEs	Foreign	Private	SOEs	Foreign
	(1)	(2)	(3)	(4)	(5)	(6)
ln*UNDER*	0.865***	1.439***	1.225***	0.921***	1.103***	1.271***
	(0.105)	(0.311)	(0.124)	(0.133)	(0.396)	(0.092)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs.	4,055	699	3,939	2,453	385	6,544
Adjusted R2	0.836	0.797	0.836	0.840	0.831	0.828

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9. Heterogeneities with Trade Modes and Subsidies.

	Processing trade		Subsidies	
	No	Yes	Without	With
	(1)	(2)	(3)	(4)
ln*UNDER*	1.025***	1.838***	0.943***	1.596***
	(0.079)	(0.188)	(0.089)	(0.204)
Firm FEs	Yes	Yes	Yes	Yes
Industry-year FEs	Yes	Yes	Yes	Yes
Number of obs.	8,033	1,625	7,033	1,282
Adjusted R2	0.821	0.847	0.832	0.853

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10. Mediation Effects of Exports in the Relationship between Undervaluation and Growth.

Growth of ($\Delta \ln Y$)	*LP*	*TFP*	*SALES*	*VA*	*L*	*K*
	(1)	(2)	(3)	(4)	(5)	(6)
Direct path						
$p(\ln UNDER, \Delta \ln Y) = \beta_1$	0.110*	0.028	-0.035	-0.029	0.091**	-0.004
	(0.056)	(0.025)	(0.030)	(0.053)	(0.033)	(0.040)
Indirect path						
$p(\ln UNDER, \ln EXP) = \alpha_1$	1.052***	1.043***	1.051***	1.081***	1.150***	1.130***
	(0.062)	(0.063)	(0.059)	(0.061)	(0.060)	(0.061)
$p(\ln EXP, \Delta \ln Y) = \gamma_1$	0.080***	0.039***	0.140***	0.143***	0.075***	0.029***
	(0.010)	(0.004)	(0.005)	(0.009)	(0.006)	(0.007)
Mediation effect ($\alpha_1 \times \gamma_1$)	0.084***	0.040***	0.147***	0.155***	0.086***	0.033***
	(0.011)	(0.005)	(0.010)	(0.013)	(0.008)	(0.008)
Convergence effect (β_2)	0.918***	0.942***	0.592***	0.820***	0.854***	0.796***
	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)

Number of obs.	8713	8314	9288	8724	9292	9170
Adjusted R2	0.479	0.509	0.348	0.431	0.452	0.422

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Significance of the mediation effect is indicated by the Sobel statistics (Sobel, 1982).