INTERNATIONAL POLICY CENTER
Gerald R. Ford School of Public Policy
University of Michigan

IPC Working Paper Series Number 3

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Chinese Exporters and the Asian Financial Crisis

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September 2005

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Abstract

This paper analyzes firm panel data to examine how export demand shocks associated with the 1997 Asian financial crisis affected Chinese exporters. We construct firm-specific exchange rate shocks based on the pre-crisis destinations of firms' exports. Because the shocks were unanticipated and large in magnitude, they are an ideal instrument for identifying the impact of exporting on firm productivity and other performance measures. For the period 1995 to 1998, we estimate an elasticity of Chinese exports with respect to a foreign trading partner's real exchange rate of -0.48. Exporting is found to significantly boost a firm's total factor productivity, net value added per worker, total sales, and return on assets.

Keywords: exports, productivity, China, exchange rate shocks, Asian financial crisis
JEL codes: D24, F10, F31, L60

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1. <u>Introduction</u>

It is often claimed that participation in export markets is a prerequisite for economic growth in developing countries. For example, in a report on the East Asian miracle, the World Bank (1993) pointed to export-oriented economic policies as playing a critical role in the region's rapid economic growth. Cross-country studies document a positive relationship between trade and growth performance (Sachs and Warner, 1995; Edwards, 1998; Frankel and Romer, 1999). The perceived benefits of improving export access to developed-country markets motivate many developing countries to negotiate and sign international trade agreements.

Nevertheless, substantial controversy persists over whether there exists a causal impact of exporting on economic growth. Studies have raised serious doubts about whether the cross-country relationships between trade and growth imply that exporting causes economic growth: rather, growth could cause exports, or both growth and exports could be caused by some other third factor.[1]

One promising approach to studying this issue is to examine the impact of exporting on firm performance using firm-level data (Hallak and Levinsohn 2003). At the firm level, exporting may help improve productivity via the transfer of knowledge from overseas buyers to the exporting firms. For example, Grossman and Helpman (1991, p. 166) suggest that foreign customers might provide technical assistance to exporters in improving production efficiency. In addition, participation in international trade could improve firms' knowledge about more advanced production technologies and make them more likely to adopt them. Empirically, firms exporting to foreign markets are typically found to perform better than non-exporters on many dimensions. Clerides, Lach, and Tybout (1998) find in a panel of developing-country firms that exporters have higher productivity levels on average than non-exporters, but do not find that

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[1]See Rodriguez and Rodrik (2001) and Irwin and Terviö (2002), for example.

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firms that start exporting subsequently experience greater productivity growth. Bernard and Jensen (1999) document among US firms that, in addition to having higher productivity, exporting firms also have higher employment, shipments, wages, and capital intensity than non-exporters. Kraay (1999) finds in a panel of Chinese firms that past exports predict current firm productivity.

Unfortunately, existing studies of the impact of exporting on firm performance still leave the direction of causality open to question, mainly due to the difficulty of distinguishing between the effects of exporting and the unobservable differences between exporting and non-exporting firms. For example, even if exporter productivity does not grow faster than non-exporter productivity, this need not imply that exporting has no causal impact if exporters' initial productivities are higher and productivity improvements are more difficult at higher productivity levels. This would occur if productivity growth of a firm already at the technological frontier must await cutting-edge technological development while firms with lower productivity can boost productivity easily by adopting techniques already in use elsewhere.

Conceptually, the main problem is that non-exporters are an inappropriate counterfactual for exporters. One requires a benchmark for how exporters would have performed if they had not exported, or if their exports had been lower. A hypothetical randomized experiment assessing the impact of exporting on firms might involve randomly assigning shocks to the export demand across firms. For example, one group of firms might be assigned declines in the demand for their goods by foreign customers, while a second group would face unchanged foreign demand. In this setting, the impact of exporting would then be easily identified by comparing the change in outcomes for the firms experiencing decreased demand for their exports with the corresponding change for firms experiencing no change in demand.

This study exploits a natural experiment—Chinese exporting during the Asian financial crisis—that in key respects approximates the randomized experiment just described. In June 1997, the devaluation of the Thai baht led to speculative attacks on many other currencies worldwide. While the Chinese yuan remained pegged to the US dollar, many important destinations for Chinese exports experienced currency depreciations due to the crisis (both nominal and real). For instance, between 1995 and 1998, the period investigated in this study, the Japanese, Malaysian, and Korean currencies depreciated in real terms against the US dollar by 31%, 34%, and 43%, respectively. At the other extreme, the British pound and the US dollar experienced real appreciations against the yuan, by 14% and 7%. Because the exchange rate changes varied so widely, two observationally equivalent firms would have faced very different export demand shocks if one happened to export its goods to Korea and the other happened to export to the U.K.

The construction of firm-specific exchange rate shocks is made possible by the availability of information on firm-specific export country destinations for foreign-invested firms in China's industrial census of 1995. These data are linked to enterprise survey data for the same firms in 1998. We use the weighted average real depreciation experienced by a firm's pre-crisis trade partners as an instrument for the change in firm exports between 1995 and 1998.[2] We find the elasticity of firm exports with respect to the exchange rate is -0.48. Thus, a 10% real exchange rate devaluation (an increase in foreign currency per yuan) leads to an approximately 4.8% decline in exports. Because the timing and pattern of devaluations due to the crisis were unforeseen, this instrumental variable approach plausibly satisfies the requirement that the instrument (an exchange rate shock index) be uncorrelated with the ultimate outcomes of interest except via the channel of interest (the change in exports). An attractive aspect of this approach is

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[2] Lack of export data at the firm level for 1996 and 1997 requires us to use 1995 as our base year.

that exchange rate shocks are firm-specific, so we can control for province-sector fixed effects and thus rule out bias from unobserved regional or sectoral changes. Another advantage of our study is that China did not suffer from a currency crisis itself during the Asian financial crisis, but rather experienced relatively stable economic policies and economic performance during this period.

Using this identification strategy, we examine whether and how instrumented changes in exports are associated with several measures of firm performance. We find that increases in exports are associated with improvements in total factor productivity, value added per worker, total sales, and return on assets. The magnitude of these effects is relatively large.

The Chinese case is particularly interesting for studying the effect of exporting on firm outcomes because in recent years, China's export growth has been phenomenal and China has emerged as one of the world's largest exporters. From 1990 to 1999, Chinese exports nearly tripled from US$88.3 billion to US$253 billion.[3] Over this period, China's export growth rate was the sixth highest in the world in the 1990s.[4] By 1999, China had become the world's 10th largest exporter. There also is evidence that during the 1990s the technological sophistication of Chinese exports increased substantially (Schott, 2004).

This paper is related to other work that has used sudden trade liberalizations or currency crises in specific countries as exogenous shocks to firms, comparing firm-level outcomes before and after the regime change. Increases in exporting driven by the 1994 Mexican peso crisis have

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[3]US dollar figures are real, base 1995. Export data are from the World Bank's World Development Indicators 2004 dataset.

[4]Only South Korea, Ireland, Guinea-Bissau, Mexico, and Mozambique had faster export growth. Chinese export performance is even more striking given that these other countries started the period from significantly lower base levels (with the exception of South Korea, whose export volumes are comparable with China's).

[6] All firms in China are supervised by a specific administrative level of government. China's administrative structure includes the following geographic levels, from largest to smallest: provinces, prefectures, counties, townships, and villages. Cities are divided into districts and neighborhoods. The 1995 industrial census also collected some basic information on village-level firms, but the level of detail was insufficient for analysis.

been shown to lead to increases in wage premia and wage inequality that rise with initial productivity (Verhoogen 2004, Kaplan and Verhoogen 2005). Pavcnik (2002) finds that trade liberalization in Chile led to greater productivity improvements in plants that were import competing. Our paper differs in that we examine shocks that are heterogeneous across firms (unlike the Mexican currency crisis) and that are not based on potentially endogenous government actions (unlike trade liberalizations).

The remainder of this paper is organized as follows. Section 2 provides a brief discussion of potential causal effects of exporting on firm performance. In Section 3 we describe our data sources and describe the construction of key variables. We provide an overview of our empirical strategy in Section 4. We then turn to the first stage regression results in Section 5, the IV results in Section 6, and a test for a potential violation of the exclusion restriction in Section 7. Section 8 concludes.

2. Pathways for the impact of exports on firm productivity

Why might exporting affect growth in firm productivity? A variety of pathways have been suggested.

Overseas buyers might provide technical assistance to exporters in improving production efficiency, as suggested by Grossman and Helpman (1991, p. 166) and Evenson and Westphal (1995). Westphal, Rhee, and Pursell (1985) document such practices among foreign buyers from Korean exporting firms. In addition, participation in international trade could improve firms' knowledge about more advanced production technologies and make them more likely to adopt

them. Clerides, Lach, and Tybout (1995) provide a theoretical model with such "learning-by-exporting."

Exporting can also help firms maintain their capacity utilization at higher levels even as sales to the domestic market suffer the occasional downturn (World Bank 1993). In the short run when firms are unable to make large adjustments to their capital stocks and labor forces, firms experiencing favorable improvements in export demand should therefore show gains in measured productivity. Conversely, declines in export demand should make firms more likely to have excess capacity and exhibit lower measured productivity.

Most studies of the link between exporting and firm productivity focus on the extensive margin of exporting, asking whether mere participation in the export market affects firm outcomes. However, the above pathways could just as easily be imagined to operate on the *intensive* margin, where firms continue to improve productivity as they continue to expand their export activity. This paper's empirical results relate to this intensive margin of exporting.

3. <u>Data sources and key variable definitions</u>

The firm-level data used in this paper come from two datasets maintained by China's National Statistics Bureau (NBS). Data for 1995 come from China's decennial industrial census, while data for 1998 come from NBS's annual industrial enterprise survey. The 1995 industrial census includes detailed data on all firms belonging to the township administrative level or above[6] The 1998 industrial enterprise survey, on the other hand, includes firms with annual sales income above five million yuan, regardless of administrative level. Provision of survey

information by firms is compulsory under Chinese law, and local statistical bureau offices demand that firms verify or correct data that is suspected of being inaccurate. Unfortunately, in 1996 and 1997, data was only kept for a subsample of very large enterprises, making it unsuitable for analysis.

The 1995 industrial census required firms to report a full set of firm accounting data on revenue, expenditures, exports, investment (including R&D investment), labor, capital, and intermediate inputs. In addition, foreign and joint venture firms (but not other firms) were asked to identify their top two exporting destination countries, and the value of exports to each. In the annual industrial enterprise survey, firms report similar accounting information, but provide no information on trading partners. Each firm in the two data sources has a unique identifier code, so it is possible to link observations across years to create a firm panel dataset.

Because the key innovation of this paper involves constructing exchange rate shocks from information on firms' export destinations prior to the 1997 Asian financial crisis, we focus our analysis on foreign and joint venture firms (those with a positive foreign ownership share) that had positive exports in 1995.

Foreign-invested 1995 exporters that also appear in the 1998 annual survey therefore make up the sample for analysis. There are 9,022 foreign-invested firms in 1995 with positive exports and that had sales above the threshold for inclusion in the 1998 enterprise survey. Our final sample for analysis includes 4,135 (45.8%) that could be followed through 1998 and that had complete data on all variables used in the analyses.[7]

One might worry that restricting the sample to foreign-invested firms reduces somewhat the generalizability of our results. However, foreign-invested firms account for a substantial

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[7] We have confirmed that among these 9,022 firms observed in 1995, selection into the 1998 sample has no large or statisitically significant relationship with the exchange rate shock used as an instrumental variable in the empirical analysis.

fraction of exports from China, at 31.5 % of total Chinese exports in 1995 and 44.1 % in 1998.[8]

Because many Chinese domestically-owned firms were publicly owned during the period of study, restricting attention to the more market-oriented foreign-invested firms may actually make our results better reflect the effects of exporting in open market environments and in that sense make the results *more* generalizable..

All economic variables are expressed in real 1995 terms using province-level producer price indices obtained from the NBS. In 1997 and 1998, provincial-level producer price indices (PPIs) are used as deflators. In 1996, only a national producer price index is available, which we adjust to each province based on province-specific trends.[9] Real exchange rate data for destination countries of Chinese exports were constructed using nominal exchange rates and consumer price indices obtained from the World Bank's World Development Indicators 2004 for all countries except Taiwan. Nominal exchange rate data for Taiwan come from Bloomberg, L.P., while the Taiwanese CPI was obtained from the Statistical Bureau of the Republic of China (http://eng.stat.gov.tw).

The analysis also makes use of disaggregated export data for China and re-export data for Hong Kong from the UN Comtrade dataset.

3.1 Firm-level exchange rate shock measure

In the analysis, we use the weighted average real depreciation experienced by a firm's pre-crisis trade partners as an instrument for the change in firm exports between 1995 and 1998.

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[8] Data are from the China Statistical Yearbook (2001).
[9] We regress provincial PPI's for the years 1997 to 2003 on the national PPI, provincial consumer price indices (CPIs), and provincial retail price indices (RPIs), and include provincial fixed effects. The provincial CPIs and RPIs do not increase the fit of these regressions, so coefficients from a parsimonious specification with the national PPI and provincial fixed effects are used to estimate provincial PPI's in 1996.

Two steps are involved.

First, the change in the real exchange rate shock is constructed for each trading partner country. Let the set of all Chinese export destination countries be indexed by $j \in \{1, 2, \ldots, J\}$. For each destination j, the change in the real exchange rate vis-à-vis the Chinese yuan is:

$$ERCHANGE_{j98} = \left[\ln\left(E_{j98}\right) - \ln\left(P_{j98}\right) \right] - \left[\ln\left(E_{j95}\right) - \ln\left(P_{j95}\right) \right],$$

where E_{jt} is the nominal exchange rate (currency units per yuan) and P_{jt} is the price level (consumer price index) for destination j in year t.[10]

The second step is to construct a firm-level exchange rate shock variable. Let firms be indexed by i, and let s_{ij} be the share of a firm's total exports in 1995 that are destined for country j (so that the shares sum to 1).[11] The firm-level real exchange rate shock measure is:

$$SHOCKINDEX_{i98} = \sum_{j=1}^{2} \left(s_{ij} ERCHANGE_{j98} \right)$$

In other words, for a firm exporting to just one country j in 1995, the shock index is simply $ERCHANGE_{j98}$. For firms exporting to more than one foreign country in 1995, that firm's shock index is the *weighted average* real exchange rate change across those destination countries, with each destination's exchange rate change weighted by the share of 1995 exports going to that country. It is important that the shock index is defined solely on the basis of export destinations *prior to* the 1997 crisis, to eliminate concerns about reverse causation: firms might

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[10] The calculation does not take into account the change in the Chinese domestic price level because this will not vary across firms and so will be accounted for by the constant term in the empirical analysis.
[11] Because the survey only asks about firms' top two export destinations, we construct these shares ignoring any exports going to countries beyond the top two. In practice, this is not a very important assumption because firms' exports turn out to be highly concentrated by destination. In 1995, 77.6% of firms export to only a single country, 84.0% export to no more than two, and in 91.9% of firms exports to the top two destinations make up three-quarters or more of total exports.

shift the composition of their exports to destinations experiencing better exchange rate shocks.

We modify the shock index when firms report Hong Kong as one of their export destinations, which is the case for 49.1% of firms. Nearly all Chinese exports to Hong Kong are re-exported (Feenstra and Hanson, 2002), so that the relevant exchange rate change is not with respect to the Hong Kong dollar, but rather with respect to the ultimate export destination. However, firms do not report the ultimate destination of their shipments to Hong Kong.[13] We therefore assume that any shipments to Hong Kong are distributed to third countries in proportions equivalent to the distribution of Hong Kong re-exports of products in the firm's industrial sector.[14] We then use Hong Kong re-export destination shares by sector to construct weighted average real exchange rate shocks by sector, and assign the sector-specific shock index to the portion of each firm's exports that go to Hong Kong.

Formally, the real exchange rate change for Hong Kong re-exports in sector m is taken to be:

$$ERCHANGE_{m98}^{HongKong} = \sum_{j \neq HongKong} k_{mj95} ERCHANGE_{j98} \,,$$

where k_{mj95} is the share of re-exports destined for country j in Hong Kong's total re-exports of sector m in 1995. $ERCHANGE_{j98}$ is as defined before. This sector-specific real exchange rate change for Hong Kong is then used for firms in sector m in calculating $SHOCKINDEX_{i98}$.

3.2 Productivity measures

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[13] Indeed, they may not even know exactly the ultimate destination of their shipments to Hong Kong if their products are sold to trading companies who later decide where shipments are re-exported.
[14] We define 24 sectors that are groupings of HS (1992) 2-digit industries that can be mapped into the sector categories used in the Chinese industry classification system.

Firm-level productivity is a primary outcome of interest in our analysis. We consider two types of productivity measures: an OLS estimator and the estimator proposed by Levinsohn and Petrin (2003) that corrects for bias due to the endogeneity of inputs with respect to productivity.

The OLS estimator assumes that the production technology is Cobb-Douglas, and is based on estimation of the following OLS regression equation:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it}$$

where y_{it} is log value added,[15] l_{it} is log number of employees, k_{it} is log fixed assets, and ε_{it} is a mean-zero error term. The residual from this regression is the log of productivity, from which one can readily calculate the productivity term θ_{it}^{OLS} for firm i in year t.

A problem with the OLS productivity estimator is that it is based on coefficient estimates on capital and labor and that are likely to be biased. Of particular concern is the possibility that firms with higher productivity will have different input usage than firms with lower productivity (Olley and Pakes 1996, Levinsohn and Petrin 2003). This will lead to biased estimates of the coefficients on capital and labor that cannot be definitively signed in advance. Thus the OLS productivity estimator will be biased as well. Levinsohn and Petrin (2003) (henceforth LP) propose an estimator that uses intermediate inputs as proxies for productivity, in contrast to the Olley and Pakes (1996) estimator which uses investment as a proxy. The LP estimator has the advantage that intermediate inputs are typically reported for most firms, while investment is often zero in datasets of developing country firms. Intermediate inputs also may respond more smoothly to productivity shocks, while adjustment costs may keep investment from responding fully to such shocks. We calculate the LP productivity estimate, θ_{it}^{LP}, using intermediate inputs

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[15] Value added is explicitly reported in the annual industrial enterprise survey data. In the 1995 Industrial Census, value added is calculated as current revenue minus intermediate inputs plus value-added tax.
[17] We use the estimator implemented as a Stata command and described by Petrin, Levinsohn, and Poi (2003).

as the proxy variable.[17]

An issue for both the OLS and LP productivity estimates is that nearly 10 percent of sample firms have a zero or negative value added in one of the two years. We report results for estimators that allow the productivity estimate to be missing for observations with zero or negative value added, and those where the productivity estimate is calculated for such observations by allowing the log value added to be replaced by zero.

4. <u>Empirical approach</u>

We estimate the impact of exporting on various firm-level outcomes. Consider the following regression equation for outcome Y_{it} (e.g., productivity) for firm i observed in year t:

$$Y_{it} = \beta E_{it} + \mu_i + \gamma_t + \nu_{it}$$

E_{it} is log exports. μ_i is a fixed effect for firm i, γ_t is a year fixed effect, and ν_{it} is a mean-zero error term. We work with the first-differenced specification of this equation to eliminate time-invariant characteristics of firms that may be associated with both exports and the outcome variable:

$$\Delta Y_{it} = \delta + \beta \Delta E_{it} + \varepsilon_{it}$$

Here, δ replaces the change in year fixed effects ($\gamma_t - \gamma_{t-1}$) and becomes the constant in the equation, and ε_{it} is a new error term replacing $\nu_{it} - \nu_{it-1}$. Due to the characteristics of the data described earlier, changes are taken between the years 1995 and 1998 ($t = 1998$, $t-1 = 1995$).

A problem with estimating this regression equation via ordinary least-squares is that the coefficient on exports, β, need not represent the causal effect of exports on the outcome variable.

It is therefore important to isolate a source of variation in a firm's exports that is exogenous with respect to the firm's outcomes. As an instrument for firm exports, we use the weighted average real currency depreciation experienced by the firm's pre-crisis trade partners (the shock index described in the previous section). We posit that firms whose trade-partner countries experienced larger depreciations should see larger declines in exports. Our strategy, then, is to examine whether and how these instrumented changes in exports are associated with changes in firm performance.

Specifically, the first stage regression equation in the IV approach will be:

$$\Delta E_{i98} = \alpha_0 + \alpha_1 SHOCKINDEX_{i98} + \psi_{i98}$$

where α_0 is a constant term and ψ_{i98} is a mean-zero error term.

The predicted value of exports from this first stage, $\widehat{\Delta E_{i98}}$, is used instead of ΔE_{i98} in the second-stage regression:

$$\Delta Y_{i98} = \delta + \beta \widehat{\Delta E_{i98}} + \varepsilon_{it}$$

For β to be an unbiased estimate of the impact of the change in log exports on the change in the outcome variable, it must be true that the instrument for exports, the shock index, is not correlated with ongoing time trends or other shocks affecting the outcome. For example, one concern could be that exporters who were exporting to countries experiencing real currency depreciations post-1997 also tended to be firms that were already in decline prior to the crisis. If this were the case, then we might observe declines in exports coinciding with declines in firm performance over the study period, but these would not reflect the causal impact of the export declines.

To address such concerns, we include a vector of pre-crisis (1995) firm characteristics X_{i95} on the right-hand-side of the estimating equation:

$$\Delta Y_{i98} = \delta + \beta \Delta \widehat{E_{i98}} + X_{i95} + \varepsilon_{it}$$

This vector of pre-crisis firm characteristics also is included in the first-stage equation used to predict the change in exports.[18]

Correlation among firms with similar shocks is likely to be a problem in this setting, biasing OLS standard error estimates downward (Moulton (1986)). Standard errors therefore allow for an arbitrary variance-covariance structure among firms that experienced similar exchange rate shocks: we cluster standard errors by the largest 1995 export partner country.[19]

5. **The impact of exchange rate shocks on exports**

How much of an effect did the large exchange rate shocks during the Asian financial crisis have on Chinese exports to different countries? In Table 1, we describe the magnitude of real exchange rate changes and export growth for China's top 20 export partner countries using Chinese export data as reported in the UN Comtrade dataset. Real exchange rate changes are measured by a shock index equal to the ratio of the real exchange rate in 1998 and that in 1995. Exports to each country include the value of both direct exports to the country and re-exports from Hong Kong.

Among the top twenty trading partners, the four countries whose real exchange rates with

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[18] The vector of pre-crisis control variables includes: 1995 log sales income; 1994 log sales income; 1995 share of exports to top two destinations; indicator for firm existing in 1994; indicator for firm exporting in 1994; indicators for foreign share of ownership (>=0 and <25%, >=25 and <50%, >=50 and <75%, >=75 and <100%; =100% omitted); log of sector weighted average exports to 1995 destinations (weighted by firm's 1995 export destinations), separately for 1993, 1994, 1995, and 1996; indicator variables for 1995 firm size categories; 1995 exports as share of firm sales; 1994 exports as share of firm sales; indicator for firm exporting entire output in 1995; log exports in 1995; log exports in 1994.

[19] Within the set of firms whose primary 1995 export partner is Hong Kong, we create additional cluster groups for the firm's industrial sector.

respect to the Chinese yuan experienced the largest depreciations were Indonesia (90 percent), Korea (43 percent), Malaysia (34 percent), and Thailand (32 percent). These were also the four country destinations with the largest reductions in Chinese exports from 1995 to 1998 (Indonesia-90 percent, Thailand-40 percent, Malaysia-34 percent, and Thailand-32 percent). In contrast, exports increased to all countries whose currencies with respect to the yuan appreciated. The fastest export growth rates were to Brazil (42 percent), the USA (36 percent), Spain (32 percent), and Italy (29 percent). Of these countries, only Spain's currency depreciated, slightly by 11 percent.

Next, we estimate the response of Chinese country-specific exports to exchange rate shocks during the 1995 to 1998 period, using HS 6-digit level export data available from the UN Comtrade dataset. The unit of observation is each country destination-product combination, which leads toa sample size of over 87,000 observations. We regress the change in log value of exports on the log of the shock index defined above. As before, Hong Kong re-exports are treated as exports from China. We find that a 10 percent appreciation of the Chinese yuan reduces exports to the trading partner country by 9.1 percent (Table 2, first column).

The Comtrade data also provide information on quantities, enabling us to look separately at the effect of exchange rate shocks on changes in quantities and changes in unit values. Unit values could adjust if firms price to market by cutting prices and reducing markups when the Chinese yuan appreciates. Such behavior has been found in other studies (Katayama, Lu, and Tybout 2005; Atkeson and Burstein, 2005), and could lead us to overstate the impact of exports on productivity, if more favorable exchange rate shocks raise exporters' markups, and thus measured productivity, without increasing the ability of the firm to produce a greater quantity of goods with the same amount of inputs. Earlier studies (e.g., Pavcnik, 2002) do not deal with the

markup issue. Changes in unit values also could reflect changes in product quality (Hallak, 2004).

We find that nearly all of the change in export value in response to exchange rate shocks results from changes in quantities rather than changes in unit values (Table 2, columns 2 and 3). A 10 percent depreciation against the yuan reduces export quantity by 7.55 percent and reduces the unit value by only 1.56 percent. These results should alleviate concern that measured productivity responses result primarily from changes in markups.

We conduct a similar analysis using the firm data. In this case, we are unable to distinguish between quantities and unit values. However, with firm data, we are able to control for a large number of additional control variables. Summary statistics for the firm data are provided in Table 3.

As before, we regress change in log exports on the log of the shock index. Results are reported in Table 4, Panel A. A simple bivariate regression finds that a 10 percent yuan appreciation reduces exports by 2.79 percent (first column). However, as additional controls are added, the strength of the relationship increases both in terms of magnitude and statistical significance. When province-industry fixed effects are added, the reduction in exports associated with a 10 percent yuan appreciation reaches 3.09 percent, and when we also add pre-crisis control variables, it reaches 4.79 percent. The high F-statistic of 13.14 for the log shock index in the preferred first stage specification (Table 4, Panel A, column 3) suggests that coefficients and their standards errors for the IV regression are unlikely to biased due to the problem of weak instruments.

To verify that we have appropriately specified the impact of exchange rate shocks on exporting behavior, we examine the nonparametric relationship between the change in log

exports and the log of the shock index after partialing out the influence of other covariates. In Figure 1, we display the relationship along with confidence interval bands, using a locally weighted regression estimator. The figure reveals a striking, nearly linear negative relationship between the two variables. In fact, we experimented with other nonlinear specifications (squared terms, splines, etc.) and found none that improved the fit of the first-stage regression.

Because the log of zero is not defined, estimations exclude firms that did not export in 1998. All sample firms exported in 1995 by definition. This could lead to bias if exit from exporting were correlated with the exchange rate shock. To check this we regress an indicator variable for exit from exporting on the same set of variables used to examine the determinants of change in log exports. We find that there is no statistically significant relationship between exchange rate shocks and exit from exporting.

6. **The impact of exporting on firm performance**

To analyze the effect of exporting on firm performance, we regress the change in firm performance measures on the change in log exports from 1995 to 1998, instrumenting the change in log exports with the log of the firm-specific exchange rate shock index. We first report the reduced form estimates of the effect of the exchange rate shock on firm performance measures (Table 5, first column), and the OLS results for the effect of changes in exports on changes in firm performance (second column). The IV results are reported in the third column. As in the first stage estimation, we control for province-sector fixed effects and a vector of pre-crisis control variables in all regressions.

Overall, we find strong evidence that exporting increases firm productivity and suggestive evidence that exporting firms shift to more capital- and skill-intensive technologies. For all four of the productivity measures tested, the reduced form results reveal a statistically significant negative effect of exchange rate shocks on productivity. All four OLS estimates and three of the four IV estimates find that exporting increases firm productivity. Comparing the magnitudes of the IV coefficient estimates to the standard deviations of the productivity measures (Table 3), we calculate that a 10 percent increase in exports increases productivity by three to five percent of one standard deviation, depending on the productivity measure. Consistent with the finding of higher productivity, we also find statistically significant positive effects of exporting in both OLS and IV specifications on sales, sales per worker, return on assets, and value added per worker. The reduced form effects of exchange rate shocks on these outcomes are also statistically significant. According to the IV coefficient estimates, a ten percent increase in exports increases sales by 2.6 percent, sales per worker by 5.4 percent, return on assets by 0.85 percent, and value added per worker by 5.9 percent.

With the exception of sales, and including all of the productivity measures, the IV estimates reported thus far are larger in magnitude than the OLS estimates. This is somewhat surprising since one might expect export changes and firm productivity measures both to be positively correlated with unobserved productivity changes. Part of the explanation could be attenuation bias due to measurement error in exports. But a measurement error explanation is not consistent with the finding that for indicators of firm size (i.e., capital, labor, and total sales), the IV coefficient estimates are smaller than the OLS estimates. In the case of labor, the IV coefficient estimate actually becomes negative, compared to the positive OLS estimate. This result is particularly interesting, because it suggests that increasing exports by 10 percent actually

reduces the number of employees in the firm by 2.9 percent, rather than increasing labor by 1.5 percent as suggested by the OLS result. This reversal itself may help explain why IV estimates produce greater effects on per worker firm performance measures.

The opposite directions of bias in the OLS coefficients for outcomes related to productivity versus firm size can be rationalized if there are omitted variables that lead to greater firm scale but that have minimal or negative productivity effects. For example, firms undergoing mergers with other firms would exhibit simultaneous increases in various indicators of firm scale, such as sales, workers, and capital, as well as exports. The omitted variable (merger activity) leads the OLS coefficient on the change in exports to be biased upwards compared to the IV coefficient. But mergers may also have a temporary negative effect on productivity (say, inefficiencies during reorganization of production lines), biasing downwards the OLS coefficient on the change in exports in the productivity regressions.

The IV results for the effect of exports on wages per worker, fixed assets, and fixed assets per worker are all statistically insignificant, as are the reduced form effects of the exchange rate shocks on these outcomes. The signs are consistent with exporting leading to more capital- and skill-intensive production methods. The reduction in workers when exports increase is also consistent with this interpretation.

Part of the observed impact of changes in exports on productivity may also be driven by the inability of firms to adjust their capital stocks downward in response to exogenous export declines. In other words, declines in exports may lead to lower capacity utilization in the short run, and so measured productivity is lower.

7. Test of a potential violation of the exclusion restriction

The analysis so far assumes that the exchange rate shocks only affect the various firm-level outcomes via their effect on the firm's exports (this is the IV exclusion restriction). However, it is possible that the exchange rate shocks directly affect various firm outcomes independently of their effect on firm exports. If this is the case, it would be inappropriate to instrument for exports with the exchange rate shocks and then examine the impact of instrumented exports on firm outcomes, as such estimates would be biased.

In particular, it is possible that the exchange rate shocks may directly affect foreign investment in the sample firms. We can examine this possibility directly by checking whether the exchange rate shocks affect the share of firms' paid-up capital owned by foreigners.

Results are presented in the last row of Table 5. As it turns out, the change in foreign ownership of firm capital is not statistically significantly related to the log shock index or to the change in log exports. There is therefore no indication that we need be concerned that the exchange rate shocks may affect firm outcomes through changes in foreign investment.

8. Conclusion

This paper has examined the impact of exogenous shocks to export demand on the performance of Chinese firms. In 1997, the Asian financial crisis led to large real exchange rate shocks in several important destinations of Chinese exports. Because most firms were not well diversified in their countries of export, changes in export demand showed great heterogeneity

across firms. We find that greater real currency depreciation in a firm's export partners led to larger declines in firm exports from before to after the Asian crisis, and that exporting increases firms' total factor productivity, net value added per worker, total sales, and return on assets. The export-driven productivity changes we observe are unlikely to be the result of changes in markups but could reflect short run changes in capacity utilization.

These initial results suggest that a number of additional analyses would be worthwhile undertaking. For example, it should be of interest to examine productivity spillovers to firms that were not exporting prior to the Asian crisis: when firms' exports fluctuate in response to exchange rate changes in their export destinations, does the performance of other nearby firms change? The search for evidence of such spillovers could take place within geographic areas (provinces) and within industrial sectors.

This paper estimates the impact of increases in exporting among firms who were already exporting in an initial period. But it is also interesting to ask about the impact of *entry* into exporting, which may be different. An approach for examining this question that builds on the present analysis would be to use the average exchange rate shock in one's province and industry as an instrument for export entry. This strategy could work if informational spillovers from other exporters or economies of scale on the part of firms that service exporters (transport providers, pure trading firms) lead the costs of export entry to decline when total exports from a locality rise. We are pursuing these and other extensions in ongoing work.

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Figure 1: Exchange rate shock and change in exports (1995-1998)
Non-parametric Fan regression, conditional on province-industry fixed effects and pre-crisis control variables.

Change in Ln(exports) ▬▬▬ Upper 95% confidence band ▪ ▪ ▪ Lower 95% confidence band

NOTES -- Pre-crisis control variables are: 1995 log sales income; 1994 log sales income; 1995 share of exports to top two destinations; indicator for firm existing in 1994; indicator for firm exporting in 1994; indicators for foreign share of ownership (>=0 and <25%, >=25 and <50%, >=50 and <75%, >=75 and <100%; =100% omitted); log of industry weighted average exports to 1995 destinations (weighted by firm's 1995 export destinations), separately for 1993, 1994, 1995, and 1996; indicator variables for firm size categories; 1995 exports as share of firm sales; 1994 exports as share of firm sales; indicator for firm exporting entire output in 1995; log exports in 1995; log exports in 1994.

Table 1: Exports, exchange rate shocks, and change in exports (China, 1995-1998)
(Top 20 Chinese export destinations in 1995)

Destination	Shock index	Change in Ln(exports)	1995 export rank	1995 exports (US$ billions)	% of total exports in 1995
United Kingdom	0.86	0.23	5	6.9	3.6%
USA	0.93	0.36	1	54.4	28.0%
Panama	0.97	0.19	20	1.7	0.9%
Russian Federation	0.98	0.04	18	1.8	0.9%
Italy	0.99	0.29	11	3.6	1.8%
Brazil	0.99	0.42	19	1.8	0.9%
Canada	1.04	0.24	10	3.6	1.8%
Spain	1.11	0.32	15	2.2	1.1%
France	1.13	0.30	8	4.1	2.1%
Australia	1.13	0.18	9	3.6	1.9%
Singapore	1.14	-0.30	6	6.6	3.4%
Netherlands	1.15	0.25	7	5.3	2.7%
Belgium-Luxembourg	1.16	0.26	17	2.0	1.0%
Germany	1.16	0.13	3	11.5	5.9%
Philippines	1.23	-0.18	13	2.5	1.3%
Japan	1.31	0.06	2	37.1	19.1%
Thailand	1.32	-0.40	12	2.7	1.4%
Malaysia	1.34	-0.32	14	2.3	1.2%
Rep. of Korea	1.43	-0.30	4	8.5	4.4%
Indonesia	1.90	-0.90	16	2.0	1.0%

NOTES -- Data source is UN Comtrade dataset. "Shock index" is change in real exchange rate from 1995-1998 expressed as fraction of 1995 value (i.e. 10% depreciation is 1.1, 10% appreciation is 0.9). Change in ln(exports) is from 1995-1998. Exports to Hong Kong are dropped from dataset, and Hong Kong's reported re-exports are considered exports of China to respective destinations. Destinations in table account for 84% of total Chinese exports in 1995.

Table 2: Impact of Exchange Rate Shocks on Chinese Exports (1995-1998)
(Unit of observation: destination-product)

Dependent variable:	Change in …		
	Ln(total value)	Ln(unit value)	Ln(quantity)
Ln(shock index)	-0.911	-0.156	-0.755
	(0.393)**	(0.094)	(0.354)**
R-squared	0.02	0.00	0.01
Num. obs.	87,934	87,934	87,934

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES -- Standard errors (in parentheses) clustered by destination. Data source is
UN Comtrade dataset. Unit of observation is a destination-product combination,
where product defined as HS (1992) 6-digit category. Observations weighted by 1995
total exports. All changes are from 1995-1998. "Shock index" is export destination's
change in real exchange rate from 1995-1998 expressed as fraction of 1995 value
(i.e. 10% depreciation is 1.1, 10% appreciation is 0.9). "Total value" is total value of
exports. "Unit value" is total value divided by quantity. Exports to Hong Kong are
dropped from dataset, and Hong Kong's reported re-exports are considered exports
of China to respective destinations.

Table 3: Summary statistics for Chinese firms

	Mean	Std. Dev.	Min.	10th pctile.	Median	90th pctile.	Max.	Num. Obs.
Changes between 1995 and 1998								
Shock index	1.13	0.14	0.29	0.94	1.08	1.31	1.90	4,135
Ln(shock index)	0.11	0.13	-1.25	-0.06	0.07	0.27	0.64	4,135
Δ Ln(exports)	0.25	1.11	-3.25	-0.99	0.20	1.60	4.43	4,135
Δ foreign ownership share	0.01	0.18	-1.00	-0.04	0.00	0.11	1.00	4,128
Δ Ln(sales)	0.19	0.79	-2.15	-0.73	0.16	1.18	3.40	4,102
Δ Ln(sales/worker)	0.09	0.77	-4.66	-0.73	0.06	0.97	4.05	4,131
Δ productivity (OLS)	0.36	3.28	-33.26	-1.38	0.18	2.27	95.37	3,688
Δ productivity (OLS, mod.)	0.63	7.18	-133.93	-2.69	0.28	4.40	158.30	4,132
Δ productivity (LP)	97.04	1024.92	-14390.51	-294.07	47.80	529.42	34027.12	3,688
Δ productivity (LP, mod.)	27.29	272.81	-3865.53	-100.97	15.09	161.68	9916.97	4,132
Δ return on assets	-0.02	0.16	-2.62	-0.15	-0.01	0.11	1.26	4,135
Δ Ln(value added/worker)	0.31	1.59	-8.86	-1.31	0.22	2.27	9.57	4,132
Δ Ln(workers)	0.10	0.56	-3.55	-0.48	0.06	0.73	4.09	4,132
Δ Ln(wages/worker)	0.20	0.69	-8.39	-0.39	0.21	0.79	5.16	4,104
Δ Ln(capital)	0.10	0.69	-6.76	-0.49	-0.03	0.90	5.43	4,135
Δ Ln(capital/worker)	0.00	0.77	-6.49	-0.77	-0.05	0.86	5.75	4,132
Pre-crisis values of variables								
Firm existed in 1994 (indicator)	0.98	0.15	0.00	1.00	1.00	1.00	1.00	4,135
Exports > 0 (indicator)	0.93	0.26	0.00	1.00	1.00	1.00	1.00	4,135
Foreign ownership share	0.67	0.30	0.00	0.25	0.68	1.00	1.00	4,135
Export share of top 2 destinations	0.95	0.16	0.001	0.83	1.00	1.00	1.00	4,135

NOTES -- Data are from Chinese Industrial Census 1995 and Annual Firm Survey 1998. Unless otherwise specified, pre-crisis values of variables are from 1995. "Shock index" is real exchange rate index based on firm's pre-crisis export composition, normalized to 1 in 1995 (i.e. 10% depreciation is 1.1, 10% appreciation is 0.9). Exchange rate index for exports to Hong Kong is trade-weighted average HS 2-digit sector exchange rate index of Hong Kong re-exports (assumes all Chinese exports to Hong Kong are re-exported). Value-added variable replaced with 1 if zero or negative. Productivity measures are OLS (regression of log value added on log fixed assets and log employment) and Levinsohn-Petrin (LP). For each productivity measure, an additional modified estimate ("mod.") is also calculated when replacing negative or zero value added with 1 (so log value added = 0). All outcome variables trimmed of top and bottom 1% of observations to remove outliers.

Table 4: Impact of exchange rate shocks on Chinese exporters (1995-1998)
(OLS estimates)

Panel A: Dependent variable is Δ Ln(exports)

Ln(shock index)	-0.279	-0.309	-0.479
	(0.145)*	(0.203)	(0.132)***
Province-industry fixed effects	-	Y	Y
Pre-crisis control variables	-	-	Y
R-squared	0.00	0.11	0.30
Num. obs.	4,135	4,135	4,135
F-statistic: signif. of instrument	3.70	2.32	13.14
P-value	0.0575	0.1307	0.0005

Panel B: Dependent variable is indicator for exit from exporting by 1998

Ln(shock index)	-0.051	-0.087	-0.036
	(0.085)	(0.072)	(0.041)
Province-industry fixed effects	-	Y	Y
Pre-crisis control variables	-	-	Y
R-squared	0.00	0.15	0.23
Num. obs.	4,909	4,909	4,909

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES -- Standard errors (in parentheses) clustered by primary 1995 export partner (except when primary 1995 export partner is Hong Kong, in which case clustering unit is firm industry). Unit of observation is a firm. There are 358 province-industry fixed effects (firms are in 26 provinces and 24 industries). All changes are from 1995-1998. Firms included in sample all had nonzero exports in 1995. "Indicator for exit from exporting" equal to 1 if firm had zero exports in 1998. See Table 3 for variable definitions and other notes.

Pre-crisis control variables are: 1995 log sales income; 1994 log sales income; 1995 share of exports to top two destinations; indicator for firm existing in 1994; indicator for firm exporting in 1994; indicators for foreign share of ownership (>=0 and <25%, >=25 and <50%, >=50 and <75%, >=75 and <100%; =100% omitted); log of industry weighted average exports to 1995 destinations (weighted by firm's 1995 export destinations), separately for 1993, 1994, 1995, and 1996; indicator variables for firm size categories; 1995 exports as share of firm sales; 1994 exports as share of firm sales; indicator for firm exporting entire output in 1995; log exports in 1995; log exports in 1994.

Table 5: **Effect of exchange rate shock and exports on change in firm outcomes**
(Chinese exporting firms, 1995-1998)
(OLS and IV estimates)

Coefficients (std. errors) in regression of given outcome on Ln(shock index) or Δ Ln(exports)

| | Coefficient on: | | | Num. of obs. |
| | Ln(shock index) | Δ Ln(exports) | | |
	(instrument)	OLS	IV	
Δ Ln(sales)	-0.137	0.4130	0.2690	4,052
	(0.074)*	(0.019)***	(0.125)**	
Δ Ln(sales/worker)	-0.266	0.2710	0.5450	4,088
	(0.118)**	(0.018)***	(0.247)**	
Δ productivity	-0.474	0.3460	1.0970	3,627
	(0.186)**	(0.035)***	(0.582)*	
Δ productivity (OLS, mod.)	-0.823	0.5630	1.5200	4,070
	(0.436)*	(0.066)***	(0.873)*	
Δ productivity (LP)	-146.67	120.073	334.516	3,622
	(73.484)**	(9.932)***	(234.056)	
Δ productivity (LP, mod.)	-46.194	30.794	85.907	4,061
	(16.580)***	(2.887)***	(40.219)**	
Δ return on assets	-0.045	0.0210	0.0850	4,059
	(0.020)**	(0.002)***	(0.034)**	
Δ Ln(value added/worker)	-0.33	0.3000	0.5870	4,062
	(0.134)**	(0.028)***	(0.233)**	
Δ Ln(workers)	0.149	0.1450	-0.2940	4,071
	(0.070)**	(0.010)***	(0.161)*	
Δ Ln(wages/worker)	-0.069	0.0390	0.1420	4,048
	(0.0840)	(0.011)***	(0.1770)	
Δ Ln(capital)	-0.026	0.1070	0.0480	4,085
	(0.0790)	(0.012)***	(0.1410)	
Δ Ln(capital/worker)	-0.029	-0.0290	0.0530	4,079
	(0.1130)	(0.016)*	(0.2050)	
Δ foreign ownership share	0.0190	0.0040	-0.0370	4,128
	(0.0200)	(0.0040)	(0.0400)	

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Each coefficient (standard error) is from a separate regression of the change in firm outcome on Ln(shock index) or Δ Ln(exports). In IV regressions, first stage is as in regression in column 3 of Table 4, Panel A. All regressions include fixed effects for province-industry and all pre-crisis control variables listed in Table 4. See Tables 3 and 4 for variable definitions and other notes.