RESEARCH SEMINAR IN INTERNATIONAL ECONOMICS

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Ann Arbor, Michigan 48109-1220

Discussion Paper No. 549

Exporting and Firm Performance: Chinese Exporters and the Asian Financial Crisis

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April 2006

Exporting and Firm Performance: Chinese Exporters and the Asian Financial Crisis

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First version: September 2005
This version: April 2006

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 aspects of firm performance. We find that firms whose export destinations experience greater currency depreciation have slower growth in exports and that export growth increases firm productivity as well as other measures of firm performance. Consistent with the "learning-by-exporting" hypothesis, greater exports increase the productivity of firms exporting to developed countries but not of firms exporting via Hong Kong or directly to poorer destinations.

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

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1. Introduction

Participation in export markets is often viewed as 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 development. Cross-country studies document a positive relationship between trade and growth performance (Sachs and Warner, 1995; Edwards, 1998; Frankel and Romer, 1999), but substantial controversy persists over whether there exists a causal impact of exporting on economic growth. Growth could cause exports, or both growth and exports could be caused by some other third factor.[1]

Recently, a number of papers have empirically examined the relationship between exporting and economic performance using firm-level panel data. A robust finding has been that more productive firms enter export markets. For example, 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; and Clerides, Lach, and Tybout (1998) find that exporting firms have higher productivity levels on average than non-exporters in several developing countries. However, findings on whether exporting itself increases firm productivity have been much more mixed.[2] Two papers using firm data from China by Kraay (1999) and Zhang (2005) find positive evidence for learning-by-exporting.

One weakness of all of these studies is that they cannot distinguish clearly between the effects of exporting and the unobservable differences between exporting and non-exporting firms. Typically, change in firm productivity or other performance measures is regressed on initial exporter status and other initial period controls using OLS, or the level of firm performance is regressed on current or lagged export status in addition to other controls. In the latter case, further lags are sometimes used as instruments, relying on assumptions about the underlying dynamic model (Kraay, 1999; Van Biesebroeck, 2004).

Since the decisions to export and how much to export are endogenous choices of the firm, these empirical specifications fail to convincingly isolate the causal effect of exporting on firm

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

[2]Papers that find little or no evidence of learning-by-exporting include Aw et al (2000), Bernard and Jensen (1999), Clerides, Lach, and Tybout (1998), and Delgado et al. (2002). Papers that find positive evidence of learning-by-exporting include Alvarez and Lopez (2005), Bigsten et al. (2004), Blalock and Gertler (2004), Castellani (2002), Fafchamps et al. (2005), Fernandez and Isgut (2005), Girma et al (2004), Kraay (1997), Van Besebroeck (2005), and Zhang (2005).

productivity. It is easy to imagine ways in which export status could be correlated with unobserved firm characteristics that directly influence both the level and growth rate of firm productivity. For example, dynamic firm managers may be more aggressive in entering export markets and may also be more adept learners or more aggressive in making productivity-enhancing investments. One way to control for selection bias is to jointly estimate an equation for participation in export markets using full information maximum likelihood (Clerides et al., 1998). However, this more structural approach does not solve the fundamental identification problem and may be sensitive to functional form assumptions about the joint error distribution (Bigsten et al, 2004). Another recent approach to reduce selection bias is the use of matching estimators (Girma et al., 2004; Fernandez and Isgut, 2005; Zhang, 2005). Matching can eliminate bias caused by selection on observables but cannot address bias associated with unobservable firm characteristics.

Conceptually, the fundamental 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 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 and 2000. 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.[3] 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 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.[4]

Using this identification strategy, we examine whether and how instrumented changes in exports affect measures of firm performance. We find that increases in exports are associated with improvements in total factor productivity, as well as improvements in other measures of firm performance such as total sales and return on assets. Our estimates indicate that a firm experiencing an exogenous 10 percent increase in exports enjoys productivity improvements amounting to roughly one-sixth of the sample mean productivity improvement from 1995 to 2000.

Additional results for subsamples of the data provide suggestive evidence that the association between increases in exports and productivity improvements reflects "learning by exporting," for example via inflows of advanced technology or production techniques from

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

[4] One previous study by Maurin, Thesmar, and Thoenig (2002) uses firm-specific exchange rates as an instrument to examine the effect of exporting on the skill intensity of French firms. The authors use the average real exchange rate with respect to 2 currencies (US dollar and German Deutschmark) weighted by EU and non-EU export shares prior to the period of study to instrument for the ratio of exports to domestic sales. With only two exchange rates, changes in firm-specific exchange rates could easily be correlated with initial export destination shares if relative exchange movements with the US dollar and Deutschmark are persistent. Also, unlike the Asian financial crisis, in the French case the extent and cause of exchange rate changes is not clear. The authors do not report first stage results and do not examine the effects of exporting on productivity.

overseas export customers. We find that changes in exports are positively associated with productivity improvements only in firms exporting to a developed country. By contrast, in firms exporting via Hong Kong or that export only to developing countries, there is no large or statistically significant relationship between export changes and productivity improvements. These results make sense if the potential for technology transfer from export destinations to Chinese firms is greater when exports are destined for richer nations closer to the technological frontier. Exporting to Hong Kong may fail to increase productivity because exporting firms deal with intermediaries rather than final customers, while exporting to poorer countries does not foster productivity improvements because such countries' technologies are less advanced.

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.[5] Over this period, China's export growth rate was the sixth highest in the world in the 1990s.[6] 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; Rodrik, 2006).

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 been shown to lead to increases in wage premia and wage inequality that rise with initial productivity (Verhoogen 2004, Kaplan and Verhoogen 2005; Fung, 2004). 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), are not based on potentially endogenous government actions (unlike trade liberalizations), and are not caused by major crises or regime changes that are likely to be correlated with other economic or policy changes.

The remainder of this paper is organized as follows. Section 2 provides a brief discussion of potential causal effects of exporting on firm performance. We provide an overview of our

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

[6]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).

empirical strategy in Section 3. In Section 4 we describe our data sources and the construction of key variables. We then turn to the first stage regression results in Section 5, and the IV results in Section 6. Section 7 describes robustness checks and provides additional discussion. Section 8 describes how results differ according to the development status of firms' export destinations. Section 9 concludes.

2. Pathways for the impact of exports on firm productivity

The literature has identified a number of channels through which exporting may affect firm productivity. First, overseas buyers may provide technical assistance to exporters to improve 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. Second, participation in international trade could improve firms' access to knowledge about more advanced production technologies (as in the model of Clerides, Lach, and Tybout, 1995). Third, higher quality standards in international markets compared to domestic markets could provide greater incentives for firms to upgrade production technologies (Verhoogen, 2004). Fourth, export participation may lead to faster learning about market opportunities for new products or how to tailor products to the specific needs of individual buyers (Fafchamps, 2002; Maurin et al, 2002). Fifth, exporting can increase capacity utilization by expanding sales, which also reduces firms' vulnerability to occasional downturns in the domestic market (World Bank 1993). This latter channel can affect firm productivity independent of any learning.

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 operate on the *intensive* margin, where firms continue to improve productivity as they continue to expand their export activity. The studies that have looked at the intensive margin mostly have focused on how productivity gains are related to the number of years that the firm has exported. A number of these studies have found evidence that learning is greater among younger firms, consistent with Arrow's learning-by-doing model (Alvarez and Lopez, 2005; Delgado et al., 2003; Fernandez and Isgut, 2005; Girma et al, 2994), while others have found more persistent effects (Blalock and Gertler, 2004; Kraay, 1999). Similar to our study, a few studies have examined how firm productivity

gains are related to export intensity, measured by the share of sales that are exported or by the amount of exports after controlling for sales amount. Again, some have found a significantly positive effect of export intensity on productivity growth (Castellani, 2002; Girma et al., 2004; Kraay, 1999) while others have found no large or statistically significant relationship (Aw et al, 2000; Blalock and Gertler, 2004; Clerides et al., 1998).

3. Empirical approach

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

$$Y_{it} = \beta E_{it} + \mu_i + \gamma_t + \nu_{it}\,. \tag{1}$$

In equation (1), E_{it} is log of export value. 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:

$$\Delta Y_{it} = \delta + \beta \Delta E_{it} + \varepsilon_{it}\,. \tag{2}$$

Here, δ is a constant equal to the change in year fixed effects ($\gamma_t - \gamma_{t-1}$) and ε_{it} is the error term, equal to $\nu_{it} - \nu_{it-1}$. Due to the characteristics of the data described below, 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 change in log exports, β, need not represent the causal effect of exports on the outcome variable for the reasons described earlier. It is therefore important to isolate a source of variation in firms' exports that is exogenous with respect to firm outcomes. As an instrument for firm exports, we use an exchange rate shock index defined as the weighted average real currency depreciation experienced by the firm's pre-crisis trade partners (explicit derivation below). 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.

A simple version of the first stage regression equation is:

$$\Delta E_{i98} = \alpha_0 + \alpha_1 SHOCKINDEX_{i98} + \psi_{i98}\,. \tag{3}$$

α_0 is a constant term and ψ_{i98} is a mean-zero error term. Because the impact of the

exchange rate shocks on changes in firm exports may vary across firms with differing initial characteristics, we also examine a first stage equation where the shock index is interacted with a vector of 1995 firm characteristics W_{i95}, which are also separately included as regressors:

$$\Delta E_{i98} = \alpha_0 + \alpha_1 SHOCKINDEX_{i98} + \beta'(SHOCKINDEX_{i98} * W_{i95}) + \gamma' W_{i95} + \psi_{i98} \quad (4)$$

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

$$\Delta Y_{i98} = \delta + \beta \widehat{\Delta E_{i98}} + \gamma' W_{i95} + \varepsilon_{it} . \quad (5)$$

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 only affects the dependent variable via the endogenous independent variable (the change in log exports), and not through any other channel. We address and provide evidence against potential violations of this exclusion restriction in Section 7 below.

In addition, for β to be an unbiased estimate it must also be true that the instrument for exports, the shock index, is not correlated with ongoing time trends or other shocks affecting changes in firm performance. The assumption is violated if firms exporting to countries that experienced greater depreciations were different from other firms with respect to unobserved initial (pre-shock) characteristics, *and* if changes in the outcomes would have varied according to these same characteristics even in the absence of the exchange rate shocks.

To control for this possibility, we include a vector of pre-crisis (1995) firm characteristics X_{i95} on the right-hand-side of the estimating equation:[7]

$$\Delta Y_{i98} = \delta + \beta \widehat{\Delta E_{i98}} + X_{i95} + \varepsilon_{it} . \quad (6)$$

This vector of pre-crisis firm characteristics is also included in the first-stage equation used to predict the change in exports. It includes firm variables for 1994 as well as 1995 in order to control for differences in initial levels as well as pre-shock trends. In order to verify whether the regression results are in fact contaminated by changes associated with pre-crisis firm characteristics, we examine whether the estimates are qualitatively similar when we exclude the vector of pre-crisis characteristics from the regressions.[8] It turns out that many of the control

[7] X_{i95} includes the vector of variables interacted with the shock index, W_{i95}.

[8] The vector of pre-crisis control variables includes: fixed effects for province-industry combinations (of which there are between 300-400 depending on the specification); 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; foreign

variables predict both the magnitude of exchange rate shocks and changes in firm performance, but that the estimated effects of exports on outcome variables is relatively insensitive to the inclusion of the controls.[9]

In many contexts positive correlation in the error terms across similar observations biases standard errors downwards (Moulton 1986). In this context, we have correlation in the shocks experienced among firms exporting to the same or similar locations. However, in our data clustering of standard errors by export destination actually leads in practice to *more* precise estimates. We therefore report unclustered standard errors and consider these to be conservative standard error estimates.

4. Data sources and key variable definitions

The firm-level data used in this paper come from two datasets maintained by China's National Bureau of Statistics (NBS). Data for 1995 come from China's decennial industrial census, while data for 1998 and 2000 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.[10] The annual 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 require that firms verify or correct data that is suspected of being

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share of ownership; 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 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; 1995 log capital-labor ratio; 1995 fraction homogeneous products in firm's industry (as in Rauch 1999); and log 1995 weighted average per capita GDP in firm's export destinations (weighted by firm's 1995 exports).

[9] Appendix Table 1 presents coefficient estimates from regressions of the firm's exchange rate shock on a number of pre-shock (1995) firm characteristics. The first regression presents coefficient estimates without including province-industry fixed effects, and the second regression includes these fixed effects. Several individual variables are statistically significantly different from zero in both regressions, indicating that firms' export destinations experienced greater depreciations if their industry had smaller log exports to those destinations, if their industry experienced greater growth (from 1993-1995) in exports to those destinations, the firm exported a higher share of its total exports to its top two destinations, the firm exported to higher income destinations, and the firm had higher capital per worker. When province-industry fixed effects are included in the regression (second column), the firm's foreign ownership share is also positively associated with future exchange rate depreciations in the firm's export destinations.

[10] 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.

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 export 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.

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.[11] 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.

One might worry that restricting the sample to foreign-invested firms reduces somewhat the generalizability of our results. However, FDI firms account for a large and increasing share of exports both in China and throughout the world. Foreign-invested firms accounted for 31.5 percent of total Chinese exports in 1995, 44.1 percent in 1998, and 57.1 percent in 2004 (China

[11] We regress provincial PPIs 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 PPIs in 1996.

Statistical Yearbook, 2005). Most Chinese exports are processed exports tied to vertical production networks; since 1995 processed exports have accounted for the majority of China's total exports (Lemoine and Unal-Kesenci, 2004). This type of trade, especially in intermediate inputs, accounts for a large share of the recent growth in world trade (Hummels et al., 2001), and much of it is controlled by multinationals. For instance, in the United States, multinationals account for over half of total exports (Slaughter, 2000).

Also, in the Chinese context, because many Chinese domestic 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 prevalent elsewhere and so make the results *more* generalizable.

Still, it is important to consider the ways in which learning by FDI firms might differ from learning by domestic firms. It could be the case that learning opportunities from exporting are less for foreign-invested firms because foreign investors provide state-of-the-art technology. Indeed, there is considerable evidence that FDI firms have higher productivity than domestic firms throughout East Asia, including China (Hallward-Driemeier et al, 2002). In that case, we would expect FDI firms to exhibit less learning than domestic firms, and so our estimates could be interpreted as lower bounds. However, many aspects of learning are likely to be similar for FDI and domestic firms, especially when the export destination country is not the same as the source of the FDI. One might even imagine that foreign ownership is complementary to learning-by-exporting if foreign partners put pressure on export partners to transfer technology to suppliers or invest in the firm's learning capacity.

4.1 Defining firm-specific exchange rate shocks

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. Two steps are involved in creating this variable.

First, the change in the real exchange rate 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:

$$ERCHANGE_{j98} = \left[\ln\left(E_{j98}\right) - \ln\left(P_{j98}\right)\right] - \left[\ln\left(E_{j95}\right) - \ln\left(P_{j95}\right)\right], \quad (7)$$

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*.[12]

The second step is to construct a firm-level exchange rate shock variable. Let firms be indexed by *i*, and let s_{ik} be the share of a firm's total exports in 1995 that are destined for country *k* (so that the shares sum to 1).[13] The firm-level real exchange rate shock measure is:

$$SHOCKINDEX_{i98} = \sum_{k=1}^{2} (s_{ik} ERCHANGE_{k98}) \quad (8)$$

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 that export destinations might be endogenous to the shock (firms might 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 49.6% 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.[14] 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.[15] 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.

[12] 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.

[13] 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.

[14] 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.

[15] We define 24 sectors that are groupings of HS (1992) 2-digit industries into the sector categories used in the Chinese industry classification system.

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

$$ERCHANGE_{m98}^{HongKong} = \sum_{j \neq HongKong} k_{mj95} ERCHANGE_{j98}\,, \tag{9}$$

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 $SHOCKINDEX_{i98}$.

4.2 Productivity measurement

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:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it} \tag{10}$$

where y_{it} is log value added,[16] 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, which we denote 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

[16] 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. For both the OLS and LP productivity estimators, we replace zero and negative values of value added with 1 before taking logs. This adjustment is necessary for roughly 10 percent of firms.

smoothly to productivity shocks, while adjustment costs may keep investment from responding fully to such shocks. We calculate the LP log productivity estimate, θ_{it}^{LP}, using intermediate inputs as the proxy variable.[17]

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?

Figure 1 displays monthly exchange rates for selected major Chinese export destinations (expressed in Chinese yuan per unit of foreign currency, normalized to 1 in January 1995).[18] A decline in a particular country's real exchange rate should be considered a negative shock to firms exporting to that location: each unit of foreign currency would be convertible to fewer Chinese yuan, making Chinese goods more expensive in real terms.

In the base year of our firm data, 1995, currencies are for the most part quite stable. The largest changes occur after the start of the Asian financial crisis in July 1997. In particular, real exchange rates in Thailand and Korea plummet dramatically in that month. In other countries, the changes are less dramatic, and sometimes follow slightly different time patterns. Japan, for example, experiences more modest real depreciation through 1998, and then recovers. The German exchange rate actually dips prior to the crisis, in January 1997. Exchange rate changes in several other major European destinations of Chinese exports (such as France, Belgium, and the Netherlands) closely track Germany's and so are not shown on the graph.

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. Changes in log real exchange rates are between 1995 and 1998, as described above. 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 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 (exports to

[17] We use the estimator implemented as a Stata command and described by Petrin, Levinsohn, and Poi (2003).
[18] The exchange rates are as of the end of each month, and were obtained from Bloomberg L.P.

Indonesia declined by 90 percent, Korea 30 percent, Malaysia 32 percent, and Thailand 40 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.

Figure 2 provides a graphical view of export changes for the same 20 countries, in ascending order of 1995-1998 real exchange rate devaluation (from left to right and then top to bottom). Each graph displays log exports from 1990-2004, where exports are normalized so that the first year is 100 before taking logs, and all graphs have the same vertical scale. Changes in Chinese exports from 1995-1998 are indeed more negative in countries experiencing real exchange rate devaluations (in the bottom row) than in those experiencing real exchange rate appreciations (top row). These graphs are also useful to confirm that post-1997 declines in exports in the countries experiencing the largest depreciations are not just continuations of pre-existing negative export trends. In fact, the opposite appears to be true: pre-crisis exports were actually growing robustly prior to 1997 in Japan, Thailand, Malaysia, Korea, and Indonesia, and then took sharp downward dips thereafter.

Regression-based estimates of the impact of 1995-1998 real exchange rate changes on changes in exports over the same time period are presented in Table 2. In the first column, the unit of observation is exports to one of 153 Chinese export destinations. Data are from the UN COMTRADE dataset. Hong Kong re-exports are treated as exports from China to their respective destinations. We regress the change in log total export value on the shock index for the destination, and weight each observation by 1995 total exports so that the estimated relationship is not heavily influenced by exports to relatively unimportant destinations. The coefficient on the shock index (-0.632) is negative and highly statistically significant. The R-squared of the regression (0.45) is quite high as well, indicating that real exchange rate changes account for a substantial fraction of the variation in Chinese exports by destination over this time period.

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 with respect to the currencies of their export destinations.

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 therefore run regressions at the level of the product-destination (exports of HS 6-digit products to specific destinations), of which there are close to 88,000 in the COMTRADE data for Chinese exports. In the second column of the table, the dependent variable is the change in log total value of exports (analogous to the dependent variable in the first regression, except at a much higher level of disaggregation). As in the first column, the coefficient on the shock index is negative and highly statistically significant. The coefficient (-1.042) indicates that a 10 percent depreciation a foreign currency versus the Chinese yuan reduces exports to that country by 10.4 percent. While the coefficient in the second column is roughly two-thirds larger in magnitude than the coefficient in the first column, the standard error on the second column's estimate is large enough that the null hypothesis that the two coefficients are identical cannot be rejected.[19]

The third and fourth columns of the table examine the impact of the exchange rate shock on the change in log export unit value and change in log export quantity, respectively. 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. In the export unit value regression the coefficient on the shock index is negative, but is relatively small in magnitude (-0.16) and is only statistically significantly different from zero at the 10% level. In the export quantity regression, by contrast, the coefficient on the shock index is relatively large in magnitude (-0.88) and is statistically significantly different from zero at the 1% level. A 10 percent depreciation against the yuan reduces export quantity by 8.8 percent, but reduces the unit value by only 1.6 percent. These results should alleviate concern that observed productivity responses (presented later) 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

[19] The R-squared in the second column has also dropped dramatically vis-à-vis the first column, which is likely due to the fact that more factors must come into play to explain variation in exports at the detailed product-destination level than are relevant for aggregate exports to countries as a whole.

for a large number of additional control variables, and we are able to examine interactions between the shock index and various firm characteristics. Summary statistics for the firm data are provided in Table 3.

Regressions examining the impact of the shock index (and associated interaction terms) on the change in firm-level log exports are presented in Table 4. To ease the interpretation of regression coefficients, the shock index and all variables interacted with it are standardized to have mean zero and standard deviation one.

All regressions include province-industry fixed effects and the full set of pre-shock control variables described above. The first two columns present results for all 4,605 firms observed between 1995 and 1998, and the last two columns present results for the 3,930 firms observed between 1995 and 2000.

When the shock index is entered into the regression without interaction terms (columns 1 and 3), its coefficient estimate is negative, but it is only statistically significant in the first column for 1995-1998 changes (at the 10% level). In both these regressions, the F-test of the statistical significance of the shock index yields quite low F-statistics (of 2.84 and 0.98, respectively), indicating that the shock index by itself would be a somewhat weak instrument.

To gain a graphical sense of the relationship between the shock index and the changes on log exports, we examine the nonparametric relationship between the two variables after partialing out the influence of other covariates. In Figure 3, we display the relationship along with confidence interval bands, using a locally weighted regression estimator. The figure reveals a negative relationship between the two variables over both the 1995-1998 and 1995-2000 periods. The relationship appears somewhat flatter for the 1995-2000 period, particularly in the middle range of exchange rate shock values (with higher density of observations in the firm data), helping to explain the lack of statistical significance on the shock index in the 1995-2000 regression of column 3 in Table 4.

In columns 2 and 4 of the table, the shock index is interacted with several 1995 firm characteristics: weighted per capita income in the firm's export destinations (with export shares as weights), the fraction of products in the firm's industry classified as homogeneous products (from Rauch 1999), the foreign ownership share, log capital per worker, log sales, and the export share of sales.

Across both regressions, coefficients on the fraction homogeneous products, foreign

ownership share, and log capital per worker are all positive in sign, and coefficients on log sales are negative. In both regressions, the coefficients on foreign ownership share are statistically significantly different from zero at conventional levels. In other words, exports in firms with greater foreign ownership shares decline less when their export partners experience exchange rate devaluations. This may reflect the fact that exports in such firms are more likely to be destined for overseas owners or firms otherwise linked in some way to the Chinese exporters so that exports are less price-elastic. For example, exports of firms with higher foreign ownership may frequently be part of global within-firm production processes, so that their export demand may be insensitive to relatively large exchange rate fluctuations.[20] Multinationals also may use financial instruments to hedge against exchange rate risk.

The coefficient on the shock index main effect in columns 2 and 4 should be interpreted as the impact of a one-standard-deviation shock on the log change in exports for a firm with the mean value of each of the interacted firm characteristics. Neither coefficient on the main effect is statistically significantly different from zero (although both are negatively signed). However, the estimates imply large negative effects of the exchange rate shocks for firms with low foreign ownership. For example, the 1995-1998 estimates indicate that for a firm with foreign ownership two standard deviations below the mean (8%, compared to the mean of 68%), and the mean values of all the other interacted firm characteristics, a one-standard-deviation increase in the shock index led to a 11.4 percent decline in exports (standard error of this estimate is 4.6 percent). The corresponding number for the 1995-2000 estimates is even larger, at 17.8 percent (standard error 7.7 percent) for a firm two standard deviations below mean foreign ownership.

F-statistics for the test of the joint significance of the shock index and associated interaction terms in columns 2 and 4 (4.99 and 12.72, respectively) are substantially larger than the corresponding F-statistics in columns 1 and 3, suggesting that including the interaction terms in the set of instruments is desirable to ameliorate weak-instrument problems (Bound, Jaeger, and Baker 1995).

However, these instruments are still relatively weak given the F-statistic thresholds recommended by Stock and Yogo (2005) for avoiding size distortions in IV estimation. For this reason, the subsequent instrumental variables estimates report standard errors and 5%

[20] We regard exploring these hypotheses (and others) explaining heterogeneity in the impact of exchange rate shocks on firm exports as important avenues for future research.

significance tests based on Andrews, Moreira, and Stock (forthcoming), who provide a method for adjusting critical values of test statistics in the presence of weak instruments so that significance tests have the correct size.[21]

6. The impact of exporting on firm performance

To analyze the effect of exporting on firm performance, we regress the change in various firm performance measures on the change in log exports. Table 5 presents OLS and IV regression estimates of the coefficient on the change in log exports, separately for the 1995-1998 sample (top panel of table) and 1995-2000 sample (bottom panel). The dependent variables are all in first-differences, and are listed across the top of the table. As in the first stage regressions, we control for province-sector fixed effects and a vector of pre-crisis control variables in all regressions.

In the IV regressions, the first-stage equations are those in Table 4, columns 2 and 4 (for the 1995-1998 and 1995-2000 samples, respectively.) Below each IV coefficient estimate, we display the Andrews, Moreira, and Stock 5% Wald critical value and the Wald statistic for the test of the null hypothesis that the IV estimate is equal to zero. Whenever the Wald statistic takes on values greater than the (regression-specific) 5% Wald critical value, the null hypothesis is rejected at the 5% level.

Overall, we find strong evidence that increases in exporting lead to increases in firm productivity, particularly when enough time has elapsed since the export shock (in the 1995-2000 sample). For both the OLS and LP productivity measures, the IV estimate of the impact of the change in exports is positive in the 1995-1998 sample (but not statistically significantly different from zero), and is positive and statistically significantly different from zero in the 1995-2000 sample. The coefficient estimates in regressions using the 1995-2000 sample are more than twice the magnitude of those for the 1995-1998 sample. These patterns suggest that the productivity benefits that firms gain from exporting are greater after some time, and do not accrue immediately.

These productivity effects are not extremely large, but neither are they negligible. A 10 percent increase in exports (0.1 increase in log exports) leads to a 0.157 increase in log OLS productivity and a 0.171 increase in log LP productivity. These numbers should be compared to

[21] The test has been implemented as the "condivreg" command in Stata by Moreira and Poi (2001).

mean productivity improvements over 1995-2000, which were 0.89 for OLS productivity and 1.01 for LP productivity (Table 3). So the 10 percent increase in exports leads to OLS and LP productivity improvements amounting to roughly one-sixth of the mean productivity improvement over the time period.

Consistent with the positive productivity effects of exporting, we also find statistically significant positive effects of exporting on sales and on return on assets over both time periods. There is also a positive and significant effect on sales per worker in the 1995-1998 sample, but this effect declines in magnitude and is not statistically significantly different from zero in the 1995-2000 sample. According to the IV coefficient estimates, a 10 percent increase in exports increases sales by nearly 6 percent (over both time periods), and return on assets by 0.68 percentage points from 1995-1998 and by 0.87 percentage points from 1995-2000.

In regressions for workers and capital, coefficient estimates are not statistically significantly different from zero in the 1995-1998 sample (and are actually negative in sign). In the 1995-2000 sample these coefficients are positive, and are not quite statistically significant (Wald statistics are somewhat below the Andrews, Moreira, and Stock 5% Wald critical values). This may be taken as suggestive evidence that firms hire more capital and labor in response to increases in exports over the 1995-2000 period. To the extent that capital and labor do respond to the instrumented change in exports, they respond quite similarly (coefficient estimates in the capital and worker regressions are very similar), so the capital-worker ratio exhibits little relationship with the change in exports in the IV regressions.

The instrumented change in exports has a positive and statistically significant effect on total wages per worker in the 1995-1998 period, while in the 1995-2000 period this effect is not statistically significant (but still positive). It is possible that firms must pay workers more to obtain higher output, when the number of workers and the amount of capital is unchanged from 1995-1998 (perhaps due to efficiency wage considerations). From 1995-2000, when there is suggestive evidence that workers and capital respond somewhat to export increases, firms no longer need to pay workers higher wages to achieve higher output.

Finally, increases in exports are associated with statistically significant increases in the share of firm ownership that is held by foreigners in the 1995-2000 sample, but not in the 1995-1998 sample. Firms may become more attractive to potential foreign investors when they experience exogenous improvements in exports (and thus improvements in other firm

performance measures). As with the productivity outcomes, it is reasonable that this effect appears with some lag.

For nearly all dependent variables in Table 5, IV estimates of the coefficient on log exports are larger in magnitude than the OLS estimates. The difference is proportionately greatest in the productivity regressions for the 1995-2000 sample. For example, in the regression for LP productivity in 1995-2000, the OLS coefficient on the change in log exports is 0.425, but in the IV regression the coefficient is 1.711. The large difference between IV and OLS is also evident in the regressions for wages/worker, which is sometimes used as an alternative measure of firm productivity.

What might explain larger coefficient magnitudes in the IV results? One possibility is that the OLS estimates in the productivity regressions are biased by omitted variables that lead to increases in firm scale (including increases in exports) but that have minimal or negative productivity effects. For example, firms undergoing mergers with other firms, or rapidly expanding their production facilities, would exhibit simultaneous increases in various indicators of firm scale, such as sales, workers, and capital, as well as exports. Mergers or expansion activity may have a temporary negative effect on productivity (due to, say, inefficiencies during reorganization of production lines), biasing downwards the OLS coefficient on the change in exports in the productivity regressions.

7. Robustness checks

In this section we attempt to shed further light on the nature of the impact of exporting on firm outcomes. In doing so, we refer to previous tables and also provide additional regression-based evidence.

7.1. Are productivity improvements simply due to increases in capacity utilitization?

An important question when interpreting the estimated effect of exporting on firm productivity is whether the relationship simply reflects changes in capacity utilization. This concern arises if firms are unable to change their capital stocks and labor forces in response to a reduction in export demand. Then reductions in exports (and thus total firm sales and value added), keeping labor and capital constant, would lead to reductions in *measured* productivity, but such productivity declines would be simply due to changes in capacity utilization. This effect stands in contrast to the technological changes or efficiency improvements that are the focus of

typical productivity studies.

While the absence of measures of firm capacity utilization in our data makes it impossible to address this issue directly, we find this interpretation of the results unlikely because of the time pattern of the results. In Table 5, the impact of instrumented export changes on total firm sales is similar in both time periods: a 10 percent increase in exports leads to a 5.7 percent increase in sales in 1995-1998, and a 5.8 percent increase in sales in 1995-2000. If changes in capacity utilization were the primary explanation for the export-driven changes in measured productivity, we would expect that the impact of export changes on measured productivity would be *lower* in the 1995-2000 sample than in the 1995-1998 sample, as firms were able to adjust their capital and labor over time.

As it turns out, however, the productivity impact of exports follows exactly the opposite pattern across the two samples. The impact of export changes on firm productivity is larger in the latter sample than in the former. This is consistent with efficiency improvements or other technological progress that take some time to materialize after the increase in exports, and not with changes in capacity utilization.

7.2. Potential violations of the IV 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. Here we address two potential alternative channels for the exchange rate shocks' effects on firm productivity: via increases in foreign investment, and via intermediate input prices.

One concern is that the exchange rate shocks may directly affect foreign investment in the sample firms. We documented in Table 5 that instrumented changes in exports lead to increases in foreign investment over the 1995-2000 period, and argued that this may be due to firms' increased attractiveness in the wake of export-driven performance improvements. But another possibility is that because existing foreign ownership tends to differentially come from the same countries to which firms export, the exchange rate shocks directly affect the cost of acquiring additional ownership shares by existing foreign owners. An exchange rate appreciation

in a firm's export partners would raise exports, but would also reduce the cost for investors in the same overseas locations to acquire additional ownership shares in the firm.[22]

If such an effect is important in practice, some fraction of the productivity improvements that accompany increased exports may be due to the increased foreign investment, rather than solely due to the increased exports. (For example, increased foreign ownership may lead to increased technology transfer from the overseas investors.) In this case, the IV estimates of the impact of exports on productivity would be *overstated*.

To gauge the extent to which increased foreign ownership shares (in and of themselves) might be biasing the results, we include a control for the change in foreign ownership share in the regressions. If increases in foreign ownership are an important channel for increases in firm productivity, inclusion of this control should reduce the coefficient on the instrumented change in log exports.

The results of this exercise are presented in Table 6 for the 1995-2000 sample (along with a number of other robustness checks, to be described in short order.) In the top row, the original IV estimates from Table 5 are presented for comparison. In the next row, the regressions include a control for the change in foreign ownership share. It turns out that the IV estimate in the productivity regressions (as well as results for all the other outcome variables) are essentially unchanged with the inclusion of this control. The coefficient on the change in foreign ownership variable itself (not shown) is consistently small and statistically insignificant in all regressions. There is therefore no indication that improvements in firm performance driven by correlated changes in foreign ownership are imparting substantial bias to the results.

A second potential violation of the exclusion restriction occurs if firms tend to import intermediate inputs from the same countries to which they export. For example, Chinese firms may be importing intermediate inputs from parent companies overseas, assembling these inputs into finished products, and then sending them back to their parent companies in the same locations. For such firms, exchange rate depreciation in a firm's overseas export locations would also be depreciation for its sources of intermediate inputs. The firm's exports should fall, while the prices of its intermediate inputs (in Chinese yuan) should also fall. Any reduction in firm productivity due to the decline in export prices would be *offset* by declines in intermediate input

[22] When capital markets are imperfect, wealth shocks can enable greater investment, so currency appreciations in investor countries may lead to greater FDI outflows (Froot and Stein 1991).

prices (the yuan value of intermediate inputs should decline, which in itself *increases* measured productivity). This logic suggests that effects of the exchange rate shocks on the yuan value of intermediate inputs should lead to IV estimates of exports on productivity that are biased towards zero.

To gauge the extent to which changes in intermediate inputs prices might be biasing the results, we include a control for the change in log intermediate inputs in the regressions. The third row in Table 6 presents the results of this exercise for the 1995-2000 sample. The coefficients on the change in log exports in the productivity regressions have declined slightly (as have coefficients in regressions for other outcome variables), but the coefficients in the productivity regressions remain statistically significant at the 5% level. The results provide no reason to believe that the impact of exporting on productivity mainly reflects changes in intermediate inputs prices.

7.3. Importance of control variables

Inclusion in the regressions of province-industry fixed effects as well as a wide variety of control variables for pre-shock firm characteristics was motivated by the desire to account as much as possible for any ongoing time trends in firm outcomes that may be correlated with firms' initial characteristics. It is important at this point to test the sensitivity of the empirical results to inclusion of these covariates in the regressions.

In the third row of Table 6, we present IV regression results where no right-hand-side controls are included in the regression (with the exception of the main effects of the variables that are interacted with the shock index.) As it turns out, for all dependent variables, dropping the control variables has very little effect on the estimated coefficients, and in many cases actually makes them larger in magnitude and raises their levels of statistical significance. For example, in the LP productivity regression, the coefficient on the change in log exports rises from 1.711 to 1.927.

7.4. Transfer pricing issues

Because our sample consists of FDI firms, one possible concern is that transfer pricing in response to exchange rate changes could complicate the interpretation of our results. However, if transfer pricing by multinationals seeks to move profits to countries where taxation is lower, then optimal transfer pricing should not be affected by exchange rate changes, which do not affect relative taxation rates. However, an exchange rate devaluation in an export destination

country will reduce the profits of Chinese exporters (assuming that the effect on profits of a lower export sales price dominates declines in the price of any imported inputs from the same country). If multinationals respond by moving profits to Chinese affiliates via transfer pricing in order to cushion the effect of the shock and take advantage of low Chinese tax rates, this would create a negative association between exports and profits which would lead us to underestimate the effect of exports on firm performance.

7.5. Sample selection issues

Foreign-invested 1995 exporters that also appear in the 1998 or 2000 annual surveys make up the sample for analysis. There are 13,606 foreign-invested firms in 1995 with positive exports and with complete data for all variables of interest. Our final sample for analysis includes 4,605 that could be followed through 1998 and that had complete data on all variables used in the analyses (a 66% rate of non-matching); the analogous figure for matching through 2000 is 3,339 (a 71% non-matching rate).

With such a high rate of non-inclusion in the sample, it is important to consider whether our results are likely to be contaminated by sample selection. First of all, it should be kept in mind that the 13,606 firms in 1995 include firms of all sizes, while (due to survey design) the firms in the 1998 and 2000 surveys are only firms above 5 million yuan in sales revenues. In 1995, 4,992 of the 13,606 firms (36.7%) had sales below 5 million yuan. Even in the complete absence of sample selection, there would a high rate of non-inclusion because many firms would remain below the 5 million threshold.

It would be problematic, however, if the likelihood of remaining below the 5 million sales threshold (or of falling below it from above) were related to the shocks of interest. In addition, the shocks of interest could in principle also affect the likelihood that firms exit the sample via shutdown or merger with another firm. If the composition of the samples were affected by the shocks of interest, then one might raise the concern that results are biased by compositional changes in the sample of firms. For example, if the firms experiencing the most negative shocks were also less likely to be observed in 1998 or 2000, then effects of export shocks on firm outcomes would be understated (because the set of firms experiencing the worst shocks would be relatively depopulated of the firms whose outcomes deteriorated the most).

The first two columns of Appendix Table 2 present regression results testing whether the exogenous shocks of interest are correlated with non-inclusion in the sample between 1995 and

the latter survey years. For each of the 13,606 firms observed in 1995 and that have complete data on all variables, we construct the predicted change in log exports from the first stage regressions of Table 5. In column 1, the dependent variable is an indicator for a firm being included in the 1998 sample, and the predicted change in exports is from Table 5, column 2. In column 2, the dependent variable is an indicator for a firm being included in the 2000 sample, and the predicted change in exports is from Table 5, column 4. The regressions include all province-industry fixed effects and pre-shock control variables included in other regressions. Because the regressions include a generated regressor (the predicted change in log exports), bootstrapped standard errors are reported.

As it turns out, the coefficients on the predicted change in log exports in both columns 1 and 2 are very small in magnitude and are not statistically significantly different from zero. There is no evidence that the shocks of interest affect inclusion in either the 1998 or the 2000 sample, and therefore no indication that bias due to sample selection is a cause for concern.

Another potential source of sample selection is due to the fact that the change in log exports is our endogenous independent variable. Because the log of zero is not defined, regressions exclude firms that did not export in the latter year. (All sample firms had nonzero exports in 1995.) This could lead to bias if exit from exporting were correlated with the exchange rate shock. To check this, in the latter two columns of Appendix Table 2 we regress an indicator variable for exit from exporting on the predicted change in log exports for all firms that are observed in 1998 and 2000, without dropping those with zero exports in those years. We find that there is no statistically significant relationship between the predicted change in log exports and exit from exporting. There is therefore no indication that bias due the exclusion of firms with zero exports in the post-shock period is an important cause for concern.

7.6 Balanced sample

The regression results of Table 5 are for different samples of firms in the 1995-1998 and 1995-2000 periods. One might be concerned that comparisons of results across the two samples might be sensitive to attrition between 1998 and 2000. To gauge the extent to which such concerns are valid, we present results over the 1995-1998 and 1995-2000 periods for a sample of firms that are included in *both* samples. Appendix Table 3 presents the first stage results (and is analogous to Table 4), and Appendix Table 4 presents the OLS and IV results (analogous to Table 5).

The first-stage, OLS, and IV results are in most respects very similar in the balanced sample in comparison to the unbalanced results. The main difference of note is that the IV estimates of the impact of the change in log exports on productivity are now statistically significant in 1995-1998 (but are still smaller in magnitude than the corresponding estimates in 1995-2000).

8. Do the results reflect "learning-by-exporting"?

If exporting raises firm productivity by raising firms' exposure to technological advances in their export destinations (perhaps mediated by the firms that purchase their exports), then we should expect the impact of exporting to be larger when firms export to developed countries than when they export to developing countries. In this context, exporters to Hong Kong should probably be considered separately, as any technological inflows may be attenuated when a Hong Kong-based trading company mediates trade flows between a Chinese firm and its ultimate destination in a developed country.

To test whether the impact of exogenous shocks to exports on firms differ according to the development status of export destinations, we repeat the IV estimates for three mutually exclusive subsamples of firms: firms that report that at least one of their export destinations is a developed country, firms exporting to Hong Kong but to no developed country, and firms for which no reported export destinations are developed countries.[23]

Results for the 1995-2000 sample are reported in Table 7. In the top row, the sample is restricted to firms exporting to some developed country, and the estimated impact of exporting on productivity and the other firm performance measures is very similar to the original estimates.

By contrast, results are very different in the second and third rows, where the samples are, respectively, firms exporting to Hong Kong but to no developed country, and firms exporting only to developing countries. In the second and third rows of the table, nearly all of the coefficients on the change in log exports are substantially smaller in magnitude than in the original results and are not statistically significantly different from zero (the exceptions are results for sales, sales/worker, and intermediate inputs in the third row).

[23] We consider the following export destinations to be "developed": Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States, Canada, Japan, Australia, New Zealand, Singapore, and Puerto Rico.

These results are consistent with exporting leading to productivity improvements via inflows of advanced technology or production techniques from developed countries. It is likely that exporting to Hong Kong fails to lead to productivity gains because exporting firms are relatively removed from the ultimate export destinations, while exporting to poorer countries does not foster productivity improvements because of the relative lack of productive technologies in the export destinations.

9. 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, total sales, and return on assets. The export-driven productivity changes we observe are likely to be the result of "learning by exporting", because the export-productivity relationship appears mainly in firms exporting to developed countries.

These 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.

References

Andrews, Donald W.K., Marcelo J. Moreira, and James H. Stock (forthcoming). Optimal Two-Sided Invariant Similar Tests for Instrumental Variables Regression, *Econometrica*.

Atkeson, Andrew, and Ariel Burstein (2005). *Trade Costs, Pricing to Market, and International Relative Prices*, mimeo, UCLA.

Alvarez, Roberto, and Ricardo Lopez (2005). Exporting and performance: evidence from Chilean plants, *Canadian Journal of Economics* 38(4): 1384-1400.

Aw, Bee Yan, Sukkyun Chung, and Mark Roberts (2000). Productivity and turnover in the export market: micro-level evidence from the Republic of Korea and Taiwan (China), *The World Bank Economic Review* 14(1): 65-90.

Bernard, Andrew B., and J. Bradford Jensen (1999). Exceptional Exporter Performance: Cause, Effect, or Both?, *Journal of International Economics* 47: 1-25.

Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Bauthier, J. Gunning, A. Oduro, R. Oostendorp, C. Pattillo, M. Soderbom, F. Teal, and A. Zeufack (2004). Do African manufacturing firms learn from exporting?, *Journal of Development Studies* 40(3): 115-141.

Blalock, G., and P. Gertler (2004). Learning from exporting revisited in a less develoed country setting, *Journal of Development Economics* 75(2): 397-416.

Blonigen, Bruce (1997). Firm-specific assets and the link between exchange rates and foreign direct investment, *The American Economic Review* 87(3): 447-465.

Bound, John, David Jaeger, and Regina Baker (1995). Problems with Instrumental Variables Estimation when the Correlation Between the Instruments and the Endogenous Explanatory Variables is Weak, *Journal of the American Statistical Association*, Vol. 90, No. 430, pp. 443-450.

Castellani, D. (2002). Export behavior and productivity growth: evidence from Italian manufacturing firms, *Weltwirtschaftliches Archiv* 138(4): 605-628.

Clerides, Sofronis K., Saul Lach, and James Tybout (1998). Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco, *Quarterly Journal of Economics* 113(3): 903-947.

Delgado, M., J. Farinas, and S. Ruano (2002). Firm productivity and export markets: a non-parametric approach, *Journal of International Economics* 57(2): 397-422.

Edwards, S. (1998). Openness, productivity, and growth: What do we really know?, *Economic Journal* 108: 383-398.

Evenson, Robert and Larry Westphal (1995). Technological change and technology strategy, in T. N. Srinivasan and Jere Behrman, eds., *Handbook of Development Economics*, Vol. 3. Amsterdam: North-Holland.

Fafchamps, Marcel, S. El Hamine, and A. Zeufack (2002). Learning to export: evidence from Moroccan Manufacturing, mimeo, Oxford University.

Feenstra, Robert, and Gordon Hanson (2004). Intermediaries in entrepot trade: Hong Kong re-exports of Chinese goods, *Journal of Economics and Management Strategy* 13: 3-36.

Fernandez, Ana, and Alberto Isgut (2005). Learning-by-doing, learning-by-exporting, and productivity: evidence from Columbia, mimeo.

Frankel, J. and D. Romer (1999). Does trade cause growth?, *American Economic Review*, 89(3): 379-399.

Froot, Kenneth, and Jeremy Stein (1991). Exchange rates and foreign direct investment: an imperfect capital markets approach, *Quarterly Journal of Economics* 106(4): 1191-1217.

Fung, Loretta (2004). Large real exchange rate movements, firm dynamics, and productivity growth, mimeo, University of Alberta.

Girma, S., D. Greenaway, and R. Kneller (2004). Does exporting increase productivity?: a microeconometric analysis of matched firms, *Review of International Economics* 12(5): 855-866.

Grossman, Gene and Elhanan Helpman (1991). *Innovation and Growth in the World Economy*. Cambridge, MA: MIT Press.

Hallak, Juan Carlos (forthcoming). Product quality, Linder, and the direction of trade, *Journal of International Economics.*

Hallak, Juan Carlos and James Levinsohn (2004). Fooling ourselves: evaluating the globalization and growth debate, mimeo, University of Michigan, 2004.

Hallward-Driemeier, Giuseppe Iarossi, and Kenneth Sokoloff (2002). Exports and manufacturing productivity in East Asia: A comparative analysis with firm-level data, NBER Working Paper 8894.

Hummels, David, Jun Ishii, and Kei-Mu Yi (2001). The nature and growth of vertical specialization in world trade, *Journal of International Economics* 54: 75-96.

Irwin, D. and M. Terviö (2002). Does trade raise income? Evidence from the twentieth century, *Journal of International Economics*, 58: 1-18.

Kaplan, David and Eric Verhoogen (2005). Quality upgrading and establishment wage

policies: evidence from Mexican employer-employee data, mimeo, Columbia University and ITAM.

Katayama, Hajime, Shihua Lu, and James R. Tybout (2005). Firm-level productivity studies: illusions and a solution, mimeo, Pennsylvania State University.

Kraay, Aart (1999). Exportations et performances economiques: etude d'un panel d'entreprises Chinoises, *Revue d'Economie du Developpement* 1-2 : pp. 183-207. (English title: exports and economic performance: evidence from a panel of Chinese enterprises)

Lemoine, Francoise, and Deniz Unal-Kesenci (2004). Assembly trade and technology transfer: the case of China, *World Development* 32(5): 829-850.

Levinsohn, James and Amil Petrin (2003). Estimating production functions using inputs to control for unobservables, *Review of Economic Studies* 70: 317-341.

Maurin, Eric, David Thesmar, and Mathias Thoenig (2002). Globalization and the demand for skill: an export based channel, mimeo, CERAS-ENPC.

Moreira, Marcelo J. and Brian P. Poi (2001). Implementing Conditional Tests with Correct Size in the Simultaneous Equations Model, *Stata Journal*, Vol. 1, No. 1, pp. 1-15.

Moulton, Brent (1986). Random group effects and the precision of regression estimates, *Journal of Econometrics* 32(3): 385-397.

Pavcnik, Nina (2002). Trade liberalization, exit, and productivity improvements: evidence from Chilean plants, *Review of Economic Studies* 69: 245-276.

Petrin, Amil, James Levinsohn, and Brian P. Poi (2003). Production function estimation in STATA using inputs to control for unobservables, mimeo, University of Chicago.

Rauch, James (1999). Networks versus markets in international trade, *Journal of International Economics* 48: 7-35.

Rodriguez, F. and D. Rodrik (2001). Trade policy and economic growth: A skeptic's guide to cross-national evidence," in Bernanke, B. and K. Rogoff (eds.), *NBER Macroeconomics Annual 2000*, MIT Press, Cambridge, MA.

Rodrik, Dani (2006). What's so special about China's exports?, NBER Working Paper 11947.

Sachs, J. and A. Warne (1995). Economic reform and the process of global integration, *Brooking Papers on Economic Activity* 1995(1): 1-118.

Schott, Peter (2006). The relative sophistication of Chinese exports, NBER Working Paper.

Slaughter, Matthew (2000). Production transfer within multinational enterprises and American wages, *Journal of International Economics* 50: 449-472.

Stock, James H. and Motohiro Yogo (2005). Testing for Weak Instruments in Linear IV Regression, mimeo, Harvard University.

Van Biesebroeck, J. (2005). Exporting raises productivity in sub-Saharan African manufacturing plants, *Journal of International Economics* 67: 373-391.

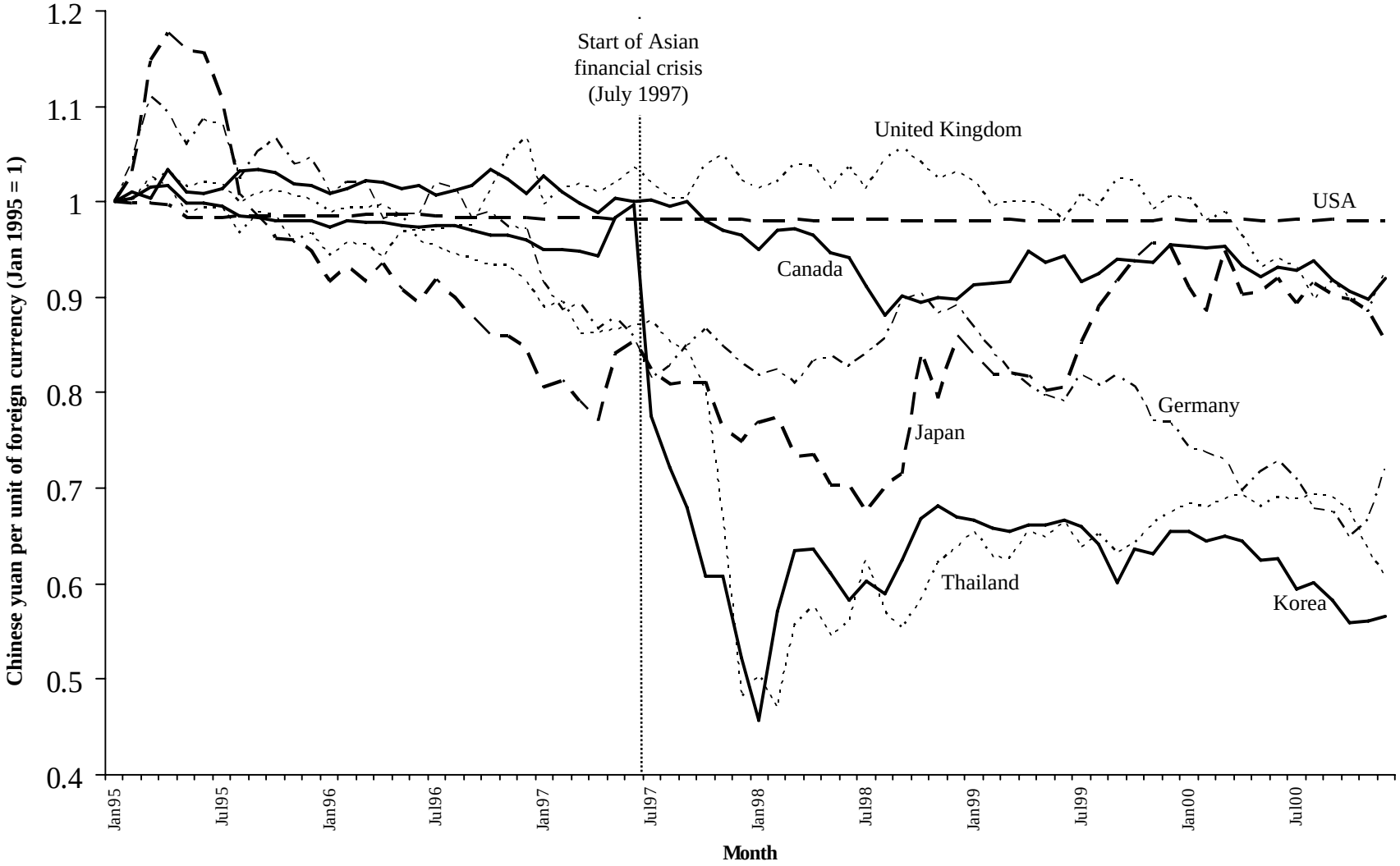
Verhoogen, Eric (2004). Trade, quality upgrading and wage inequality in the Mexican manufacturing sector: theory and evidence from an exchange rate shock, mimeo, Columbia University.

Westphal, Larry, Yung Whee Rhee, and Garry Pursell (1988). Korean industrial competence: where it came from, World Bank Staff Working Paper 469, Washington D.C.

World Bank (1993). *The East Asian Miracle: Economic Growth and Public Policy*. Washington DC: Oxford University Press.

Zhang, Yifan (2005). Exporting and performance: firm-level evidence from China, mimeo, University of Pittsburgh.

Figure 1: Real Exchange Rates in Selected Destinations of Chinese Exports, Jan 1995 to Dec 2000
(Chinese yuan per unit of foreign currency, normalized to 1 in Jan 1995)



NOTES-- Exchange rates are as of last day of each month. Data source is Bloomberg L.P.

Figure 2: Chinese Exports to Top 20 Destinations, 1990-2004 (Source: UN COMTRADE)
(Destinations in increasing order of post-1997 real exchange rate depreciation, from left to right, top to bottom.)

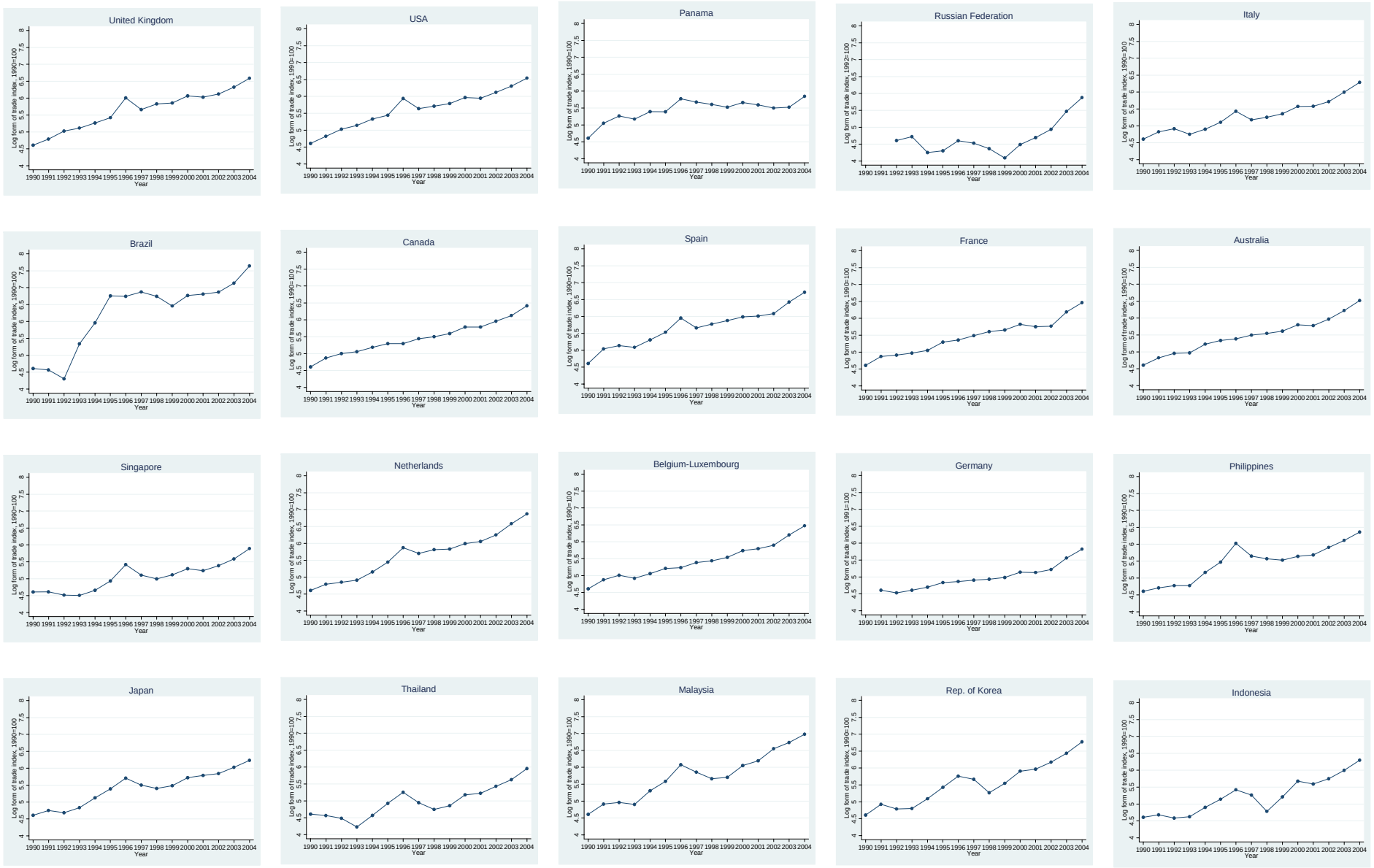
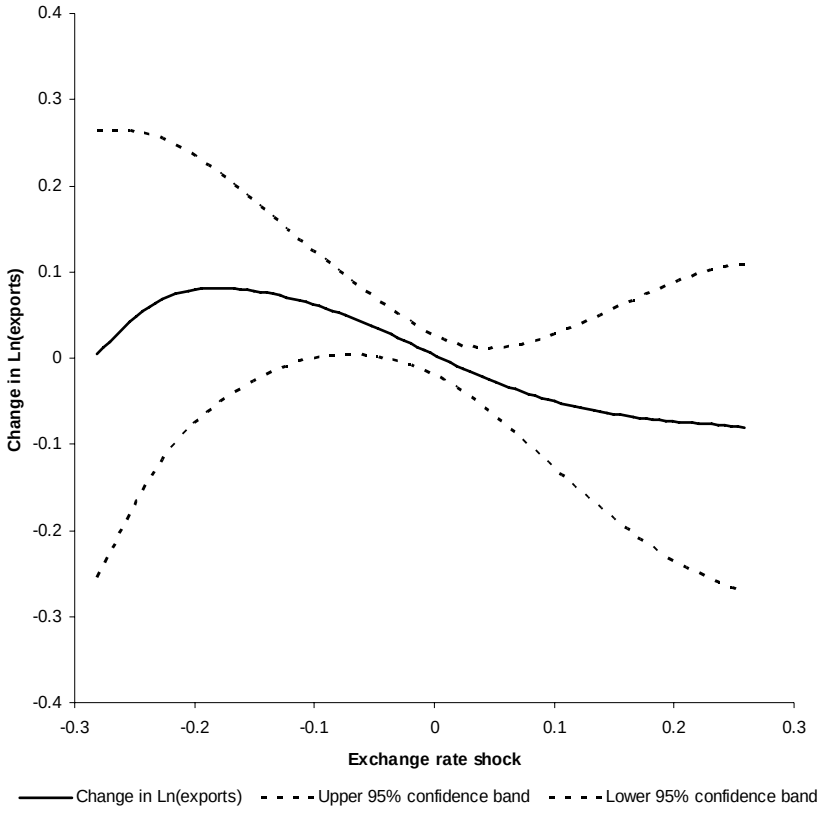
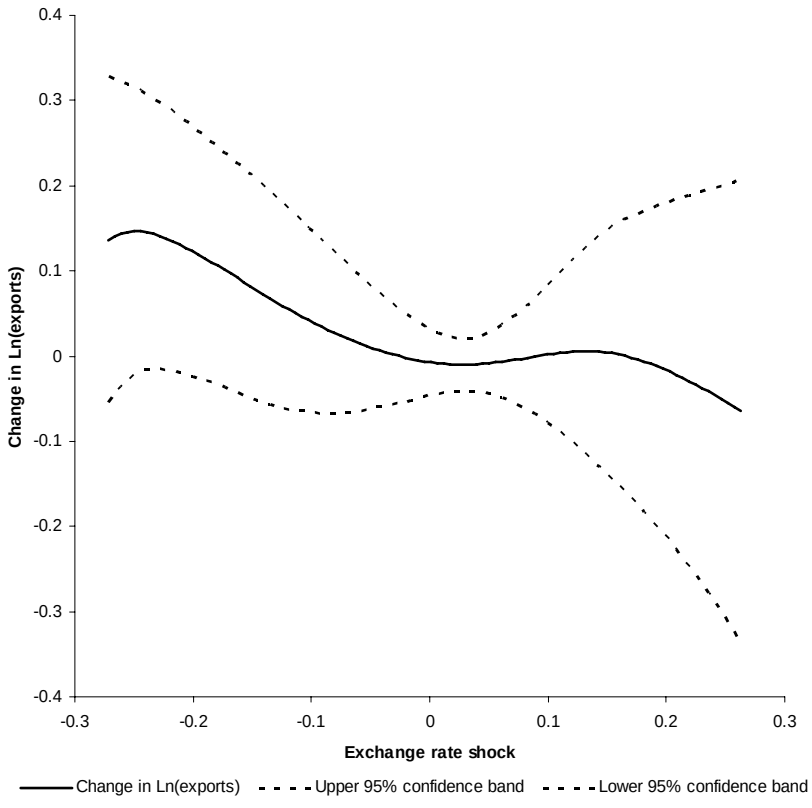


Figure 3: Exchange rate shock and change in exports

(Non-parametric Fan regressions, conditional on province-industry fixed effects and pre-crisis control variables)



1995-1998



1995-2000

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; foreign share of ownership; 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 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; 1995 log capital-labor ratio; 1995 fraction homogeneous products in firm's industry; and log 1995 weighted average per capita GDP in firm's export destinations (weighted by firm's 1995 exports).

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), 1995-1998	1995 exports (US$ billions)	% of total exports in 1995
United Kingdom	-0.14	0.23	6.9	3.6%
USA	-0.07	0.36	54.4	28.0%
Panama	-0.03	0.19	1.7	0.9%
Russian Federation	-0.02	0.04	1.8	0.9%
Italy	-0.01	0.29	3.6	1.8%
Brazil	-0.01	0.42	1.8	0.9%
Canada	0.04	0.24	3.6	1.8%
Spain	0.11	0.32	2.2	1.1%
France	0.13	0.30	4.1	2.1%
Australia	0.13	0.18	3.6	1.9%
Singapore	0.14	-0.30	6.6	3.4%
Netherlands	0.15	0.25	5.3	2.7%
Belgium-Luxembourg	0.16	0.26	2.0	1.0%
Germany	0.16	0.13	11.5	5.9%
Philippines	0.23	-0.18	2.5	1.3%
Japan	0.31	0.06	37.1	19.1%
Thailand	0.32	-0.40	2.7	1.4%
Malaysia	0.34	-0.32	2.3	1.2%
Rep. of Korea	0.43	-0.30	8.5	4.4%
Indonesia	0.90	-0.90	2.0	1.0%

NOTES -- Data source is UN Comtrade dataset. "Shock index" is change in log real exchange rate from 1995-1998 expressed as fraction of 1995 value (i.e. 10% depreciation is 0.1, 10% appreciation is -0.1). 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 Real Exchange Rate Shocks on Chinese Exports (1995-1998)
(Ordinary least-squares regressions)

Dependent variable:	ΔLn(total value of exports)	ΔLn(total value of exports)	ΔLn(export unit value)	ΔLn(export quantity)
Unit of observation:	Destination	Product-destination	Product-destination	Product-destination
Shock index	-0.632	-1.042	-0.161	-0.881
	(0.057)***	(0.293)***	(0.088)*	(0.262)***
R-squared	0.45	0.04	0.00	0.02
Num. obs.	153	87,934	87,934	87,934

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES -- Standard errors (in parentheses). Data source is UN Comtrade dataset. Unit of observation in first regression is an export destination country. Unit of observation in other regressions is a destination-product combination, where product is HS (1992) 6-digit category. Observations weighted by first-period (1995) total exports. 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

	Full sample			Balanced 1998/2000 sample		
Changes between 1995 and 1998						
	Mean	Std. Dev.	Num. Obs.	Mean	Std. Dev.	Num. Obs.
Shock index	0.13	0.15	4,605	0.13	0.15	3,930
Δ Ln(exports)	0.34	1.36	4,605	0.48	1.48	3,930
Δ Ln(productivity, OLS)	0.48	2.98	4,605	0.89	2.80	3,930
Δ Ln(productivity, LP)	0.56	3.01	4,605	1.01	2.84	3,930
Δ Ln(workers)	0.12	0.60	4,605	0.20	0.70	3,930
Δ Ln(capital)	0.13	0.72	4,605	0.12	0.86	3,930
Δ Ln(capital/worker)	0.00	0.81	4,605	-0.09	0.89	3,930
Δ Ln(wages/worker)	0.24	0.73	4,565	0.37	0.70	3,897
Δ return on assets	-0.01	0.16	4,605	0.01	0.20	3,930
Δ Ln(sales)	0.29	0.96	4,604	0.48	1.09	3,929
Δ Ln(sales/worker)	0.17	0.85	4,604	0.28	0.90	3,929
Δ Ln(intermediate inputs)	0.23	0.98	4,605	0.40	1.10	3,930
Δ foreign ownership share	0.01	0.19	4,596	0.01	0.20	3,918
Pre-crisis (1995) characteristics						
	Mean	Std. Dev.	Num. Obs.	Mean	Std. Dev.	Num. Obs.
Sales (US$)	8,358,553	33,028,042	4,605	8,587,380	34,343,436	3,930
Exports (US$)	4,830,488	16,967,606	4,605	5,161,165	17,900,849	3,930
Export share of sales	0.73	0.35	4,605	0.75	0.34	3,930
Export share of top 2 destinations	0.95	0.16	4,605	0.95	0.16	3,930
Per cap. GDP in export dest. (US$)	25,308	11,039	4,605	25,657	11,127	3,930
% homogeneous in firm's industry	0.06	0.09	4,605	0.06	0.09	3,930
Foreign ownership share	0.68	0.30	4,605	0.70	0.30	3,930
Capital/worker (US$)	9,618	19,413	4,605	9,809	19,580	3,930

NOTES -- Data are from Chinese Industrial Census 1995 and Annual Firm Survey 1998. "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 0.1, 10% appreciation is -0.1). Productivity measures are OLS (regression of log value added on log fixed assets and log employment) and Levinsohn-Petrin (LP). % homogeneous in firm's industry from Rauch (1999).

Table 4: Impact of exchange rate shocks on exports of Chinese firms
(OLS estimates)

Dependent variable:	Δ Ln(exports)			
Time period for Δ Ln(exports):	1995-1998	1995-1998	1995-2000	1995-2000
	(1)	(2)	(3)	(4)
Shock index	-0.046	-0.059	-0.038	-0.015
	(0.022)**	(0.034)*	(0.027)	(0.040)
Shock index *		-0.026		0
Per capita income in destinations, 1995		(0.012)**		(0.015)
Shock index *		0.031		0.036
% homogeneous in industry, 1995		(0.024)		(0.029)
Shock index *		0.027		0.081
Foreign ownership share, 1995		(0.020)		(0.022)***
Shock index *		0.05		0.012
Ln(capital/worker), 1995		(0.019)***		(0.022)
Shock index *		-0.02		-0.029
Ln(sales), 1995		(0.023)		(0.026)
Shock index *		0.004		-0.049
Export share of sales, 1995		(0.026)		(0.031)
Province-industry fixed effects	Y	Y	Y	Y
Pre-crisis control variables	Y	Y	Y	Y
Observations	4605	4605	3930	3930
R-squared	0.38	0.38	0.4	0.41
F-test: Joint signif. of instrument(s)	4.25	3.06	2.06	2.7
P-value	0.04	0.00	0.15	0.01

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

NOTES -- Standard errors in parentheses. Unit of observation is a firm. There are between 300-400 province-industry fixed effects, depending on regression (firms are in 26 provinces and 24 industries). Changes are from 1995-1998 or 1995-2000. Firms included in sample all had nonzero exports in 1995. See Table 3 for variable definitions and other notes. Shock index and variables interacted with shock index all are normalized to have mean 0 and standard deviation 1.

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; foreign share of ownership; 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 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; 1995 log capital-labor ratio; 1995 fraction homogeneous products in firm's industry; and log 1995 weighted average per capita GDP in firm's export destinations (weighted by firm's 1995 exports).

Table 5: Impact of change in exports on change in firm outcomes
(Coefficients on Δ Ln(exports) in OLS and IV regressions)

	Dependent variable: Change in…										
	Ln (productivity, OLS)	Ln (productivity. LP)	Ln (workers)	Ln (capital)	Ln (capital / worker)	Ln (wages / worker)	Return on assets	Ln (sales)	Ln (sales / worker)	Ln (intermed. inputs)	Foreign ownership share
1995-1998											
Ordinary least-squares	0.381	0.475	0.158	0.124	-0.033	0.042	0.024	0.427	0.27	0.411	0.005
	(0.039)	(0.039)	(0.007)	(0.009)	(0.010)	(0.010)	(0.002)	(0.008)	(0.009)	(0.010)	(0.002)
	[4605]	[4605]	[4605]	[4605]	[4605]	[4565]	[4605]	[4604]	[4604]	[4605]	[4596]
Instrumental variables	0.692	0.687	-0.001	-0.126	-0.125	0.286	0.068	0.574	0.574	0.48	0.014
	(0.556)	(0.552)	(0.109)	(0.143)	(0.148)	(0.155)	(0.032)	(0.121)	(0.147)	(0.142)	(0.035)
	[4605]	[4605]	[4605]	[4605]	[4605]	[4565]	[4605]	[4604]	[4604]	[4605]	[4596]
5% Wald critical value	4.28	3.54	5.48	3.07	3.72	2.92	3.4	13.96	6.01	7.67	3.26
Wald statistic	1.69	1.7	0	0.84	0.78	3.71	4.87	24.78	16.71	12.49	0.19
1995-2000											
Ordinary least-squares	0.311	0.425	0.189	0.187	-0.001	0.069	0.029	0.485	0.297	0.476	0.002
	(0.037)	(0.036)	(0.008)	(0.011)	(0.011)	(0.009)	(0.003)	(0.009)	(0.010)	(0.010)	(0.003)
	[3930]	[3930]	[3930]	[3930]	[3930]	[3897]	[3930]	[3929]	[3929]	[3930]	[3918]
Instrumental variables	1.572	1.711	0.228	0.236	0.009	0.154	0.087	0.577	0.348	0.392	0.099
	(0.582)	(0.580)	(0.115)	(0.151)	(0.152)	(0.135)	(0.037)	(0.120)	(0.132)	(0.142)	(0.042)
	[3930]	[3930]	[3930]	[3930]	[3930]	[3897]	[3930]	[3929]	[3929]	[3930]	[3918]
5% Wald critical value	3.55	3.58	5.98	4.63	3.71	3.2	3.79	18.97	9.38	11.19	3.24
Wald statistic	8.04	9.61	4.33	2.69	0	1.43	6.11	25.52	7.64	8.34	6.05

NOTES-- Each coefficient (standard error) is from a separate regression of the change in firm outcome on Δ Ln(exports). Sample size in brackets. In IV regressions, first stage regressions are in even-numbered columns Table 5. IV estimates, 5% Wald critical values, and Wald statistics based on Andrews, Moreira, and Stock (2005). All regressions include fixed effects for province-industry and all pre-crisis control variables listed in Table 5. See Tables 3 and 5 for variable definitions and other notes.

Table 6: Other robustness checks for impact of change in exports on change in firm outcomes, 1995-2000
(Coefficients on Δ Ln(exports) in IV regressions)

	Dependent variable: Change in…										
	Ln (productivity, OLS)	Ln (productivity. LP)	Ln (workers)	Ln (capital)	Ln (capital / worker)	Ln (wages / worker)	Return on assets	Ln (sales)	Ln (sales / worker)	Ln (intermed. inputs)	Foreign ownership share
Baseline IV estimates	1.572	1.711	0.228	0.236	0.009	0.154	0.087	0.577	0.348	0.392	0.099
	(0.582)	(0.580)	(0.115)	(0.151)	(0.152)	(0.135)	(0.037)	(0.120)	(0.132)	(0.142)	(0.042)
	[3930]	[3930]	[3930]	[3930]	[3930]	[3897]	[3930]	[3929]	[3929]	[3930]	[3918]
5% Wald critical value	3.55	3.58	5.98	4.63	3.71	3.2	3.79	18.97	9.38	11.19	3.24
Wald statistic	8.04	9.61	4.33	2.69	0	1.43	6.11	25.52	7.64	8.34	6.05
Controlling for change in foreign share	1.635	1.765	0.214	0.213	0	0.139	0.089	0.568	0.354	0.381	n.a.
	(0.587)	(0.584)	(0.114)	(0.150)	(0.152)	(0.135)	(0.037)	(0.120)	(0.132)	(0.142)	
	[3918]	[3918]	[3918]	[3918]	[3918]	[3885]	[3918]	[3917]	[3917]	[3918]	
5% Wald critical value	2.83	3.81	5.98	4.11	4.15	3.27	3.72	17.64	9.84	8.89	
Wald statistic	8.55	10.08	3.85	2.22	0	1.17	6.31	24.98	7.93	7.9	
Controlling for change in log intermediate inputs	1.388	1.468	0.136	0.088	-0.048	-0.035	0.071	0.355	0.219	n.a.	0.092
	(0.669)	(0.665)	(0.138)	(0.183)	(0.191)	(0.172)	(0.045)	(0.105)	(0.152)		(0.050)
	[3930]	[3930]	[3930]	[3930]	[3930]	[3897]	[3930]	[3929]	[3929]		[3918]
5% Wald critical value	3.84	3.46	3.45	3.3	3.6	2.78	3.07	6.36	4.88		3.17
Wald statistic	4.76	5.38	1.07	0.25	0.07	0.05	2.81	12.6	2.26		3.78
No control variables	1.796	1.927	0.214	0.233	0.027	0.174	0.103	0.666	0.45	0.396	0.079
	(0.510)	(0.509)	(0.094)	(0.125)	(0.125)	(0.109)	(0.034)	(0.114)	(0.117)	(0.121)	(0.033)
	[3934]	[3934]	[3934]	[3934]	[3934]	[3900]	[3934]	[3933]	[3933]	[3934]	[3922]
5% Wald critical value	3.45	3.84	5.54	4.82	3.24	2.79	3.91	15.02	7.36	12.06	3.16
Wald statistic	12.43	14.34	5.25	3.48	0.05	2.55	9.43	34.11	14.95	10.75	5.76

NOTES-- Each coefficient (standard error) is from a separate regression of the change in firm outcome on Δ Ln(exports). Sample size in brackets. IV estimates, 5% Wald critical values, and Wald statistics based on Andrews, Moreira, and Stock (2005). All regressions include fixed effects for province-industry and all pre-crisis control variables listed in Table 5. See Tables 3 and 5 for variable definitions and other notes.

Table 7: Impact of change in exports on change in firm outcomes, by development status of export destinations, 1995-2000
(Coefficients on Δ Ln(exports) in IV regressions)

	Dependent variable: Change in…										
	Ln (productivity, OLS)	Ln (productivity. LP)	Ln (workers)	Ln (capital)	Ln (capital / worker)	Ln (wages / worker)	Return on assets	Ln (sales)	Ln (sales / worker)	Ln (intermed. inputs)	Foreign ownership share
Exporting to developed countries	1.463	1.623	0.26	0.313	0.052	0.032	0.072	0.548	0.28	0.458	0.01
	(0.531)	(0.531)	(0.103)	(0.135)	(0.132)	(0.123)	(0.036)	(0.105)	(0.116)	(0.132)	(0.031)
	[1940]	[1940]	[1940]	[1940]	[1940]	[1923]	[1940]	[1939]	[1939]	[1940]	[1938]
5% Wald critical value	3.09	3.62	5.16	3.96	3.54	3.58	3.89	14.98	8.11	11.54	3.38
Wald statistic	8.96	11.07	7.55	6.36	0.19	0.08	4.81	32.63	6.9	14.3	0.12
Exporting to Hong Kong (but to no developed country)	0.215	0.32	0.168	0.253	0.085	-0.127	0.009	0.24	0.072	0.245	0.015
	(0.565)	(0.557)	(0.141)	(0.191)	(0.196)	(0.169)	(0.038)	(0.157)	(0.175)	(0.174)	(0.047)
	[1688]	[1688]	[1688]	[1688]	[1688]	[1676]	[1688]	[1688]	[1688]	[1688]	[1680]
5% Wald critical value	3.05	3.95	6.46	4.45	3.38	4.01	4.06	17.77	6.48	13.27	2.85
Wald statistic	0.17	0.38	1.62	2	0.21	0.64	0.06	2.64	0.2	2.26	0.12
Exporting only to developing countries	0.333	0.418	0.144	0.099	-0.045	0.095	0.029	0.552	0.408	0.487	0.001
	(0.532)	(0.532)	(0.106)	(0.147)	(0.146)	(0.137)	(0.034)	(0.131)	(0.132)	(0.156)	(0.036)
	[302]	[302]	[302]	[302]	[302]	[298]	[302]	[302]	[302]	[302]	[300]
5% Wald critical value	3.96	3.55	5.15	4.69	3.74	3.28	3.22	20.2	10.28	10.17	3.52
Wald statistic	0.84	1.33	3.95	1	0.21	1.15	1.6	38.03	20.34	21.34	0

NOTES-- Each coefficient (standard error) is from a separate regression of the change in firm outcome on Δ Ln(exports). Sample size in brackets. IV estimates, 5% Wald critical values, and Wald statistics based on Andrews, Moreira, and Stock (2005). All regressions include fixed effects for province-industry and all pre-crisis control variables listed in Table 5. See Tables 3 and 5 for variable definitions and other notes.

Appendix Table 1: Predicting firm's exchange rate shock with pre-crisis variables
(Chinese exporting firms, 1995)
(OLS estimates)

Dependent variable: Shock index, 1995-1998

	(1)	(2)
Ln(sales), 1995	-0.002	-0.003
	(0.0040)	(0.0040)
Δ Ln(sales), 1994-1995	-0.002	-0.001
	(0.0030)	(0.0030)
Firm has 1994 sales (indicator), 1995	-0.022	-0.014
	(0.0220)	(0.0200)
Ln(exports), 1995	0	0.004
	(0.0040)	(0.0040)
Δ Ln(exports), 1994-1995	0.003	0.001
	(0.0020)	(0.0020)
Firm has 1994 exports (indicator), 1995	-0.015	-0.004
	(0.0130)	(0.0120)
Ln(total exports in firm's industry to same destinations), 1995	-0.007	-0.019
	(0.001)***	(0.002)***
Δ Ln(total exports in firm's industry to same destinations), 1993-1995	0.141	0.202
	(0.007)***	(0.008)***
Export share of sales, 1995	0.03	-0.008
	(0.015)**	(0.0140)
Δ Export share of sales, 1994-1995	-0.01	-0.002
	(0.0130)	(0.0120)
Firm exports 100% of sales (indicator), 1995	-0.021	-0.003
	(0.005)***	(0.0050)
Exports to top 2 destinations as share of total exports, 1995	0.035	0.048
	(0.013)***	(0.012)***
Ln(per cap. GDP in export destinations), 1995	0.032	0.046
	(0.003)***	(0.003)***
% homogeneous in firm's industry, 1995	0.277	
	(0.023)***	
Foreign ownership share, 1995	-0.01	0.016
	(0.0070)	(0.007)**
Δ Ln(capital/worker), 1995	0.004	0.006
	(0.002)**	(0.002)***
Province-industry fixed effects	-	Y
Observations	4,605	4,605
R-squared	0.15	0.43

* significant at 10%; ** significant at 5%; *** significant at 1%
NOTES-- Unit of observation is a firm. There are 363 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.

Appendix Table 2: Impact of predicted change in exports on sample selection
(Ordinary least-squares regressions)

Dependent variable:	Included in 1998 sample (indicator)	Included in 2000 sample (indicator)	Exit from exporting between 1995 and 1998 (indicator)	Exit from exporting between 1995 and 2000 (indicator)
Time period:	1995-1998	1995-2000	1995-1998	1995-2000
Predicted change in exports	0.001	0.001	0.012	0.045
	(0.170)	(0.150)	(0.276)	(0.305)
Province-industry fixed effects	Y	Y	Y	Y
Pre-crisis control variables	Y	Y	Y	Y
Observations	13,606	13,606	5,370	4,702
R-squared	0.24	0.21	0.21	0.25

* significant at 10%; ** significant at 5%; *** significant at 1%

Addendum:

Number of firms included in final sample	4,605	3,930	4,605	3,930
Rate of inclusion in sample	34%	29%	86%	84%
Predicted change in exports is from:	Table 5, column 2	Table 5, column 4	Table 5, column 2	Table 5, column 4

NOTES -- Bootstrapped standard errors in parentheses. Unit of observation is a firm. Sample is all firms with complete data on right hand-side variables in 1995 Chinese industrial census (first two columns) or all firms matched between 1995 and latter year (last two columns).

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; foreign share of ownership; 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 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; 1995 log capital-labor ratio; 1995 fraction homogeneous products in firm's industry; and log 1995 weighted average per capita GDP in firm's export destinations (weighted by firm's 1995 exports).

Appendix Table 3: Impact of exchange rate shocks on exports of Chinese firms (balanced 1998/2000 sample)
(OLS estimates)

Dependent variable:	Δ Ln(exports)			
Time period for Δ Ln(exports):	1995-1998	1995-1998	1995-2000	1995-2000
	(5)	(6)	(7)	(8)
Shock index	-0.051	-0.034	-0.03	-0.007
	(0.021)**	(0.042)	(0.037)	(0.066)
Shock index *		-0.016		-0.005
Per capita income in destinations, 1995		(0.012)		(0.018)
Shock index *		0.022		0.052
% homogeneous in industry, 1995		(0.025)		(0.028)*
Shock index *		0.04		0.073
Foreign ownership share, 1995		(0.014)***		(0.016)***
Shock index *		0.024		0.01
Ln(capital/worker), 1995		(0.020)		(0.020)
Shock index *		-0.03		-0.044
Ln(sales), 1995		(0.034)		(0.030)
Shock index *		-0.031		-0.033
Export share of sales, 1995		(0.032)		(0.036)
Province-industry fixed effects	Y	Y	Y	Y
Pre-crisis control variables	Y	Y	Y	Y
Observations	3339	3339	3339	3339
R-squared	0.44	0.44	0.42	0.42
F-test: Joint signif. of instrument(s)	5.62	4.59	0.69	8.94
P-value	0.02	0.00	0.41	0.00

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

NOTES -- Standard errors in parentheses. Unit of observation is a firm. There are between 300-400 province-industry fixed effects, depending on regression (firms are in 26 provinces and 24 industries). Changes are from 1995-1998 or 1995-2000. Firms included in sample all had nonzero exports in 1995. See Table 3 for variable definitions and other notes. Shock index and variables interacted with shock index all are normalized to have mean 0 and standard deviation 1.

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; foreign share of ownership; 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 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; 1995 log capital-labor ratio; 1995 fraction homogeneous products in firm's industry; and log 1995 weighted average per capita GDP in firm's export destinations (weighted by firm's 1995 exports).

Appendix Table 4: Impact of change in exports on change in firm outcomes (sample balanced across 1998, 2000)
(Ordinary least-squares and instrumental variables estimates)

	Dependent variable: Change in…										
	Ln (productivity, OLS)	Ln (productivity. LP)	Ln (workers)	Ln (capital)	Ln (capital / worker)	Ln (wages / worker)	Return on assets	Ln (sales)	Ln (sales / worker)	Ln (intermed. inputs)	Foreign ownership share
1995-1998											
Ordinary least-squares	0.37	0.465	0.159	0.138	-0.021	0.061	0.023	0.458	0.299	0.445	0.008
	(0.051)	(0.051)	(0.009)	(0.012)	(0.013)	(0.013)	(0.003)	(0.010)	(0.012)	(0.013)	(0.003)
	[3339]	[3339]	[3339]	[3339]	[3339]	[3312]	[3339]	[3338]	[3338]	[3339]	[3323]
Instrumental variables	1.474	1.446	-0.045	-0.069	-0.024	0.45	0.077	0.675	0.718	0.519	0.037
	(0.774)	(0.759)	(0.142)	(0.174)	(0.184)	(0.209)	(0.041)	(0.151)	(0.199)	(0.177)	(0.045)
	[3339]	[3339]	[3339]	[3339]	[3339]	[3312]	[3339]	[3338]	[3338]	[3339]	[3323]
5% Wald critical value	3.91	4.03	5.98	3.74	3.55	2.83	3.23	14.26	6.33	10.77	2.76
Wald statistic	4.04	4.05	0.11	0.18	0.02	5.15	3.93	22.28	14.58	9.56	0.77
1995-2000											
Ordinary least-squares	0.33	0.454	0.205	0.191	-0.014	0.061	0.029	0.499	0.295	0.487	0.005
	(0.041)	(0.041)	(0.009)	(0.012)	(0.012)	(0.010)	(0.002)	(0.009)	(0.010)	(0.011)	(0.003)
	[3339]	[3339]	[3339]	[3339]	[3339]	[3312]	[3339]	[3338]	[3338]	[3339]	[3323]
Instrumental variables	1.509	1.637	0.21	0.207	-0.003	0.279	0.069	0.6	0.388	0.424	0.105
	(0.624)	(0.619)	(0.123)	(0.164)	(0.166)	(0.145)	(0.034)	(0.130)	(0.143)	(0.153)	(0.046)
	[3339]	[3339]	[3339]	[3339]	[3339]	[3312]	[3339]	[3338]	[3338]	[3339]	[3323]
5% Wald critical value	3.23	4.02	5.1	5.52	3.2	3.78	4.24	16.29	7.97	13.9	3.25
Wald statistic	6.51	7.78	3.25	1.79	0	4.12	4.61	23.9	8.22	8.57	5.84

NOTES-- Each coefficient (standard error) is from a separate regression of the change in firm outcome on Δ Ln(exports). Sample size in brackets. IV estimates, 5% Wald critical values, and Wald statistics based on Andrews, Moreira, and Stock (2005). All regressions include fixed effects for province-industry and all pre-crisis control variables listed in Table 5. See Tables 3 and 5 for variable definitions and other notes.