Journal of Business Economics and Management
ISSN 1611-1699 print/ISSN 2029-4433 online
2012 Volume 13(3): 489–498
doi:10.3846/16111699.2011.620144

TECHNOLOGY TRANSFER AND ENTERPRISE PERFORMANCE: A FIRM-LEVEL ANALYSIS IN CHINA

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Received 28 January 2011; accepted 06 March 2011

Abstract. This paper attempts to explore the relationship between openness and a Chinese firm's productivity using 1999–2002 panel data on 26 industries covering 2400 enterprises. The current literature has focused mainly on the relationship between productivity and exports, using country-level data, leaving a gap in the relationship between imports and productivity unfilled, in particular at the firm specific level. However, our study complements the existing literature by using the latest set of data, and more importantly, by examining the effects of exports and importing machinery on the firm's performance. Using the dynamic panel data econometrics technique, we find evidence that firms can improve productivity by importing more capital good and utilizing foreign technologies from technologically advanced economies. Finally the effects of importing capital goods on productivities and that of exporting activities are compared.

Keywords: China, enterprise, productivity, technology transfer.

Reference to this paper should be made as follows: Bilgin, M. H.; Lau, C. K. M.; Karabulut, G. 2012. Technology transfer and enterprise performance: a firm-level analysis in China, *Journal of Business Economics and Management* 13(3): 489–498.

JEL Classification: C15, F14.

1. Introduction

Solow (1956) model concludes that the growth rate of output in the long-run depends upon the rate at which technological change occurs. Exports and foreign direct investment (FDI) is one channel though which technology and hence economic performance could be enhanced. A number of studies document a direct relationship between trade and economic growth using cross-country data[1]. For the study in China, using provincial data set from 1952 to 2005, Lau (2010) examines the determinants of conditional convergence in China. The results indicate that low inflation, transport and telecom-

[1] The relevant empirical literature includes Sachs and Warner (1995), Edwards (1998), and Frankel and Romer (1999).

munication infrastructure, and trade openness could stimulate economic growth in China. Recently, a number of papers have empirically examined the relationship between exporting and economic performance using firm-level panel data. Even studies find stylized fact that exporting firms achieve higher productivity than non-exporters[2], and exporting activities granger cause productivity[3].

However, there is a lack of literature on examining the relationship between a firm's productivity and imports though which technological progress occurred for Chinese firms, except Fan and Hu (2008), they use the World Bank data covering the time period, 1998–2000 and reach the conclusion that importing machinery could improve firm performance. Nevertheless, our study complements the existing literature by using the latest data set, and more importantly, by examining the effects of exports and importing machinery on a firm's performance in a dynamic panel econometrics setup. In the following sections, we examine and compare the effects of exports, imports of capital and machinery, and in-house R & D on a firm's productivity.

The remainder of this paper is organized as follows. Section 2 reviews the results of previous studies and discusses potential causal effects of exports and imports on firm performance. Section 3 describes the data we have used in this study. Section 4 provides research methodology and constructs key variables. Empirical results and its implications will be discussed in section 5. Section 6 concludes the paper and suggests some directions for further research.

2. Impact of globalization on firm productivity

2.1. Exporting activities

There exist several studies which focus on the causal relationship between exports and productivity. Kunst and Marin (1989) explore this relationship based on Austrian data using time series analysis and find no evidence of causal link from exports to productivity. Marin (1992) analyzes causality between export and labor productivity for the United States, United Kingdom, Germany, and Japan. This study also suggests that there is no causality between these two variables. Some further studies claim that these studies have some methodological problems and find evidence of causal link from exports to productivity.

Exporting activity may affect firm productivity for the following reasons: First, Grossman and Helpman (1991) and Evenson and Westphal (1995) suggest that overseas buyers may provide technical assistance to domestic exporting firms, hence improving firm productivity. Second, Clerides *et al.* (1998) argue in their model that active involvement of exporting firms in the international market could improve firm productivity because of easier access to world frontier technology at a lower cost. Third, a higher international standard on product quality could motivate exporting firms upgrading their pro-

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[2] For example, Bernard and Jensen (1997) and Clerides *et al.* (1998).

[3] See for example, Aw *et al.* (2008, 2009), Alvarez and Lopez (2005, 2008), Blalock and Gertler (2004), Castellani (2002), Fernandez and Isgut (2005), Girma *et al.* (2004), Kraay (1999), Van Biesebroeck (2005), and Zhang (2005).

duction technology (Verhoogen 2008). Fourth, participation in the export market could reduce information cost on new product innovation and market demand (Fafchamps *et al.* 2002; Maurin *et al.* 2002).

2.2. Importing activities

The casual relationship between imports of capital and productivity has not been examined extensively in current literature, in particular at the firm specific level[4]. Previous studies have shown a positive relationship between import of capital and economic growth at the national level as a channel for technological diffusion. Levine and Renelt (1992), Coe and Helpman (1995), Coe *et al.* (1997), while Blomstrom *et al.* (1994), Eaton and Kortum (1996, 1997), and Keller (2002, 2004), whereas Keller (2000) use disaggregated data in his study.

Among those studies, Coe *et al.* (1997) concentrate on developing countries. They find that developing countries benefit more from foreign R&D spillovers, the more open they are and the more skilled their labor force is. Amiti and Konings (2007) estimate the productivity gains from reducing tariffs on intermediate goods. Their results show that reducing tariffs on intermediate goods increases productivity for firms that import their inputs.

Having viewed these several different aspects on the channels of enhancing a firm's productivity, the literature also examines the role of the government in facilitating a firm's productivity. In a review paper, Hoekman and Javorcik (2004) argue that any government policies facilitating firm adjustment to globalization should address the issues of market failure. For example, policies that encourage FDI inflows can address the problem of market failure that arises from knowledge externalities. The globalization process may increase productivity of indigenous firms in several ways. Firstly, FDI inflows provide incentives for domestic firms to improve technology, quality, product variety, and productivity in the long run. In a recent survey, over 40 percent of domestic enterprises in the Czech Republic and Latvia report that FDI inflows increased the level of competition in their sectors, hence forcing them to improve productivity (Hoekman, Javorcik 2004). Secondly, FDI may act as a mechanism of technology transfer, Hoekman and Javorcik (2004) report that almost a quarter of domestic firms and 15 percent of the population in Latvia learns about new technologies from multinationals operating in their countries. Lastly, access to new markets may also increase the productivity of local firms because multinationals may be interested in sourcing locally and there are pressures for multinationals to adhere to technical audits and a quality certifications requirement (Hoekman, Javorcik 2004).

3. Data sources and description

The data used in this paper is constructed from a World Bank Survey for Chinese manufacturing firms during the period 2000–2002. The survey covers 1609 manufacturing firms, including 353 textile and clothing firms. The surveyed firms are located in five

[4] Relevant studies using cross-country data includes Eaton and Kortum (2001), Liu *et al.* (2002), Caselli and Wilson (2004), Lupez and Shnchez (2005), and Narayanan (2006).

major cities (Beijing, Guangzhou, Shanghai, and Tianjin). The surveyed enterprises are randomly drawn from 6 manufacturing sectors (apparel and garments, food and beverage, metals and machinery, electronic components, vehicles and vehicle parts, and chemicals and pharmaceutics).

Table 1 summarizes the average output, profit and labor productivity, which amount to 144.7 million, 25.1 million and 69.2 thousand RMB respectively in our sample. Furthermore, we use three variables to proxy production three important production inputs in the production function: capital is proxied by the value of fixed assets; labor is proxied by the number of employees, and lastly the value of intermediate goods. Capital, labor, and intermediate goods respectively averaged 87.0 million RMB, 459 workers and 87.0 million RMB with large variations among sampled firms.

In order to capture demographic effect on firm productivity, we further create three variables; the age of the firm (AGE), the state owned enterprises (SOE) dummy, and the foreign company owned enterprise dummy (OWN). The sampled firms were aged 16.6 years on average in our sample. The SOE dummy takes the value of 1 or 0; it equals 1 if a firm is a state-owned enterprise and 0 if not. In our sample, about 28.7 percent of the firms are SOEs. Also, the OWN dummy takes the value of 1 or 0; it equals 1 if a firm is a foreign-owned enterprise and 0 if not. In our sample, about 16.4 percent of the firms are foreign company owned enterprises. In addition, one third of the sampled firms import machinery and equipment from developed countries, and 12.8 percent of firms are exporting firms and the average export sales amounted to 31.9 million RMB.

Table 1. Summary statistics

Variable	Unit	Mean	Std. Dev.
Output	Million RMB	144718.10	834790.20
Profit	Million RMB	25055.51	315233.00
Profit per Employee	Thousand RMB	69.23	1724.94
Capital	Million RMB	87010.16	471461.50
Labor	Worker	459.39	1095.99
Intermediate Goods	Million RMB	79076.92	363388.40
Age	Year	16.58	14.02
SOE Dummy	Dummy (0–1)	0.29	0.45
OWN Dummy	Dummy (0–1)	0.16	0.37
Exporter	Dummy (0–1)	0.13	0.33
Importer	Dummy (0–1)	0.31	0.46

4. Empirical methodologies

We use two standard approaches that are adopted in the existing literature in estimating firm performance. The first approach examines total factor productivity (TFP) by estimating a standard Cobb-Douglas production function. The second investigates the effects of the proposed repressors on a firm's performance indicators.

$$\ln(\text{Output})_{it} = a_0 + a_1\ln(\text{Labor}_{it}) + a_2\ln(\text{IntermediateGoods}_{it}) + a_3\ln(\text{Capital}_{it}) + a_4\text{Export}_{it} + a_5\text{Import}_{it} + a_6X_{it} + e_{it}, \quad (1)$$

where i and t denote firm i and time t respectively, and ε is the error term, and was sued to proxy for TFP. Import is a dummy variable, which takes the value of one if a firm imports machinery/equipment. Export is also a dummy variable, which takes the value of one if a firm exports merchandized goods. X is a vector of firm characteristics such as age, state-owned enterprise (SOE) dummy, and ownership (OWN) dummy in our regressions. Since the intercept varies across firms a panel model is adopted to take into account of individual (unobserved) heterogeneity problem. We also assume that errors are homoscedastic and serially independent both within and between individuals.

Assuming that all firms have the same intercept, by using OLS, the coefficient on all factor inputs is highly significant. However, firm-specific characteristics may correlate with the regressors; we should therefore use the panel model. The overall significance of the panel regression is good, as shown by the F-test in Table 2. This F test does not include the firm-specific effects, but only the impact of factor inputs. Individual coefficients are also significant and of the expected sign, broadly in line with the OLS estimates. Note that we can reject the null hypothesis that the fixed effects are zero.

Next we have to choose between fixed and random effect. The random effects estimator assumes that intercepts are uncorrelated with the regressors. To test if the average of the fixed and between estimates is the same as the random effects estimate, we can use a Hausman test. The Hausman test is essentially testing whether estimates for the fixed effect model are the same for the between effect model. The result indicates that the fixed and between estimates differ from one another; therefore the fixed effect model should be used. Results are available upon request.

For the second approach, the empirical model can be specified and written as:

$$\ln Y_{it} = a_0 + a_1\text{Import}_{it} + a_2\ln(\text{Capital}_{it}) + a_3\text{Export}_{it} + a_4X_{it} + a_5\text{IndustryD} + a_6\text{YearD} + e_{it}, \quad (2)$$

where Y_{it} denotes a firm's profit and labor productivity. Capital is used to control the size of the firm; X represents firm characteristics including age, ownership dummy, and SOE dummy; IndustryD, and YearD are the industry and year dummies respectively. Equations (1) and (2) are estimated by using the fixed effect panel regression method, which takes into account heterogeneous firm characteristics. We also apply White-corrected standard errors to deal with potential heteroskedasticity.

5. Empirical results and discussion

Table 2 provides the regression results on the relationship between a firm's productivity, export, and import decision.

Table 2. Regressions on the relationship between firm performance and imports of machinery / equipment

Dependent Variables	Ln(Output)		Ln(Profit)		Ln(Profit / Labor)	
	(1)		(2)		(3)	
Constant	2.1291	***	0.2226		0.22257	
Ln (Labor)	0.2955	***	0.3321	***	–0.66792	***
Ln (Intermediate Goods)	0.5566	***	0.4241	***	0.424108	***
Ln (Capital)	0.1708	***	0.2703	**	0.270341	**
Exports of Merchandized Goods	0.0913	**	–0.1644	**	–0.16442	**
Imports of Machinery/Equipment	0.1196	***	0.2142	***	0.214213	***
SOE Dummy	0.0170		–0.0669		–0.06691	
Ownership Dummy	0.1788	***	0.2998	***	0.299777	***
Ln(Age)	–0.2321	***	–0.2612	***	–0.26116	***
Observations	3367		2915		2915	
Adjusted R-squared	0.8606		0.6876		0.4236	

By estimating a panel survey data set from 2000–2002, we find that being a Stated-Owned Enterprise will not trigger on firm performance, while a firm's age and ownership status does matter, which contradicts with Lin and Su (2009). Using data for Chinese publicly listed firms from 1992 to 2002 from Shenzhen Stock Exchange (SZSE) and Shanghai Stock Exchange (SHE), Lin and Su (2009) find evidence that both Chief Executive Officer (CFO) turnover and CEO compensation are related to firm performance, and the possibility of CEO turnover is related to firm performance for non-state-controlled firms, but not for state-controlled firms. The authors suggest that it is one channel through which privatized firms are more efficient than SOE because state ownership is associated with lower pay-performance and it provides lower managerial incentive for CEOs to improve firm productivity. Nevertheless, our study did not find strong evidence that private firms are more efficient that SOE, probability due to the fact that our data set largely consists of small and medium size firms.

Moreover we find that foreign owned firms perform better than their domestically owned counterparts, and this finding is consistent with most earlier empirical findings. For example, Alan and Steve (2005) reveal the fact that UK corporations owned by foreigners performs much better than domestically owned firms. Our findings, however, complement the existing literature by examining the evidence from a developing country.

Model 1–3 shows that imports of machinery/equipment are negatively and significantly associated with a firm's output, profit, and labor productivity. Based on cross countries data, some studies claim that a firm can benefit from technological spillover by importing machinery from developed countries, and hence improving productivity (Eaton, Kortum 2001; Caselli, Wilson 2004; EKCW thereafter). Our empirical evidence is consistent with those of EKCW. Fan and Hu (2008) use the same set of data covering the time period 1998–2000, and reach the same conclusion that importing machinery could improve firm performance. However, our study complements the existing literature by using latest data set, and more importantly, by comparing and contrasting the role of exports, and examining the effects of exports and importing machinery on a firm's performance. Several important observations are made. First, the overall result indicates that export activities do not improve firm performance; it contradicts the evidence of existing literature[5]. Second, the import of machinery and equipment improves firm performance and this result is consistent with existing literature[6].

The first conclusion is inconsistent with the former finding of Greenaway and Yu (2004), which may be attributed to the aggregation bias. Greenaway and Yu (2004) investigate interactions between exporting and productivity at the firm level, using a panel of firms in the UK chemical industry. They find that exporters are more productive than non-exporters. Further research is needed for the current study to examine the effect of export activities on firm performance by industry. We suspect that the aggregation bias is caused by a different degree of capital intensity for different industries because only the highly technology-intensive exporting sector may benefit from exporting. For the later observation, we find evidence for improving firm performance by importing machinery and equipment, however, we still cannot draw conclusion on which sector benefits the most from importing behavior.

The second conclusion, however, has a similar effect on productivity to that of trade openness. Topalova and Khandelwal (2011) examine the effect of trade liberalization on firm productivity in India. The authors use a panel data of about 4,100 individual manufacturing Indian firms spanning from 1989 to 2007, which covers 116 industries. This research exploits the 1991 liberalization episode in India as a response to the requirement of the International Monetary Fund (IMF) in assisting India's severe balance of payment crisis in 1919. Therefore, it gives a natural experiment to solve the endogeneity problem about the causality effect of tariff reduction and firms' productivity. Using a dynamic panel regression the authors find evidence that reductions in trade protection led to higher levels of productivity.

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[5] For cross countries studies, see for example, Sachs and Warner (1995), Edwards (1998), and Frankel and Romer, 1999. For firm specific level studies, see for example, Bernard and Jensen (1997), Kraay (1999), and Zhang (2005).

[6] See for example, Eaton and Kortum (2001), Liu *et al.* (2002), Lupez and Shnchez (2005), and Narayanan (2006).

6. Conclusion

In this paper, we have evaluated the links between imports, exports, and productivity at the firm level, focusing on Chinese enterprises, which have experienced high profitability growth over the last decade. We find that exporters are not more efficient than non-export enterprises and this finding may come from aggregation bias. Moreover, we find that the association between imports of machinery and equipment and firm performance is positive and significant.

Further studies may extend to two ways. Firstly, it can take into account the spillover effect of FDI and the organizational culture difference between domestic and foreign capital firms. Furthermore, the crowd out effect whereby once the foreign capital has acquired the local company's stake, the foreign capital firm may start to expand the domestic market share (Tvaronavičienė, Degutis 2007; Tvaronavičienė, Grybaitė 2007).

Secondly, a firm's decision on financial channels may affect productivity. Ayyagari *et al.* (2010) use a firm-level survey database from the World Bank, covering 48 countries, to investigate how financial and institutional development affects financing of large and small firms, and they find that small firms and firms in countries with poor institutions use less external finance, especially bank finance.

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