A Study on the Difference of Heterogeneous Firms in Productivity, Production Scale and Production Technology

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Abstract. Lots of empirical researches using firm-level data from several countries have proved that there is substantial difference in productivity, production scale and production technology of firms which are classified into same industry. This document constructs a theoretical model to explain this phenomenon and uses micro-level data in China to testify the theoretical conclusion. The result indicates that foreign export affiliates, foreign affiliates, domestic export firms and domestic firms are significantly different in the production scale, productivity, and production technology.

Introduction

Lots of recent empirical researches using firm-level data from several countries have proved that there is substantial difference in productivity, production scale, production technology of firms which are classified into same industry. Bernard (1995) used U.S. data to analyze the difference between export firms and non-export firms. It indicated that not all firms in the same industry choose to export, and the productivity and production scale of export firms are much bigger that non-export firms [1]. Aw and Hwang (1995) by using data from Taiwan indicated that productivity and production scale of export firms is significant higher than non-export firms' [2].

Dixit and Stiglitz (1977) constructed a monopolistic competition model and brought the heterogeneous goods into theoretical research. Hopenhayn(1992) set up a heterogeneous-firm model with exogenous firm's markups because of symmetric elasticity of substitution between final varieties [3]. Bernard Eaton Henson and Kortum (2000) henceforth BEJK also introduced heterogeneous firms into a theoretical model combined with industry-specific factor comparative advantage, based on Dormbush (1997) and indicated that only firms with higher productivity will serve the foreign market by exporting [4]. Melitz (2003) is another footing stone for heterogeneous-firm researches. Melitz (2003) based on Hopenhayn (1992) incorporated productivity difference between firms and develop the Krugman(1980) and concluded that the firms with highest productivity will export, the firms with second highest productivity will produce domestically and the firms with the lowest productivity will exit the market[5]. Although the assumptions of BEJK model and Melitz (2003) are different, both of them considered that there is difference between firms in the same industry and their strategies are different as well. Then Grossman (2006) based on Melitz (2003) and Yeaple(2003) and constructed a theoretical model on optimal strategies of heterogeneous firms which concluded that firms with least productivity will exit market, firms with middle productivity will produce and sale the final goods domestically, the firms with high productivity will export to foreign market and firms with the highest productivity will choose FDI strategy [6].

This document constructs a theoretical model to explain the difference of firms in same productivity, production scale and production technology, and use micro-level data in China to testify the theoretical conclusion.

Setup of the Model

Production

There are two countries in the world. Home country is abundant with labor, while foreign country is abundant with capital. There are two sectors of producing final goods, one is sector Y producing

homogeneous final goods y, and the other is sector X producing heterogeneous goods. Two kinds of factors are important to production, which are labor and capital. Production of homogeneous good y only needs 1 unit labor input. Heterogeneous good x_i is assembled by intermediate good m_i without any variety cost. Intermediate goods m_i can be produced in both home country and foreign country but only be assembled into final good x_i in home country. Intermediate good m_i is capital intensive and its marginal cost function is

$$C_j = r_j^\tau w_j^{1-\tau}, \ \tau > \frac{1}{2} \quad \text{and} \quad j = H, F \tag{1}$$

where r is capital income and w is labor income. Each heterogeneous firm entering into X sector has pay a fixed cost of f_e and know its productivity θ_i. Production of Intermediate good in foreign country needs fixed cost of f_p. Therefore foreign country has variety cost advantage of producing intermediate good but has an additional fixed cost for production.

Demand

Both countries have the same preference of representative consumer which is

$$U = Y^\beta X^{1-\beta}, \qquad \text{s.t.} \ \ E_j = p_y y + \sum p_i x_i \tag{2}$$

where p_y is the price of homogeneous goods y and p_i is the price of heterogeneous goods x_i in sector X and $X = \left(\sum x_i^\alpha \right)^{1/\alpha}$. E_j is national income of country j. The demand of heterogeneous good x_i in country j is

$$x_i = (1 - \beta)E_j \left(\frac{p_i^j}{P} \right)^{-\sigma} \tag{3}$$

where σ is the elasticity of substitution between any two final heterogeneous goods x_i, $\sigma = \frac{1}{1-\alpha} > 1$ and $P = \left(\sum p_i^{1-\sigma} \right)^{1/(1-\sigma)}$.

Equilibrium in An Open Economy

Therefore profit of heterogeneous firm is $\pi_i = \left(p_i - C_j / \theta_i \right)x_i - f$, and markup of price is $p_i^j = C_j / \alpha\theta_i$. The maximum profit of heterogeneous firm only producing and selling in home country is

$$\pi_i^{HD} = \frac{1}{\sigma} (1 - \beta)\alpha^{\alpha/(1-\alpha)} \Theta_i C_H^{-\alpha/(1-\alpha)} \left(E_H P_H^{\sigma-1} \right) - f_e \tag{4}$$

where $\Theta_i = \theta_i^{\alpha/(1-\alpha)}$. The maximum profit of heterogeneous firm producing in foreign country and selling in home country is

$$\pi_i^{FD} = \frac{1}{\sigma} (1 - \beta)\alpha^{\alpha/(1-\alpha)} \Theta_i C_H^{-\alpha/(1-\alpha)} \left(E_H P_H^{\sigma-1} \right) - f_e - f_p \tag{5}$$

If heterogeneous firms choose to serve the foreign market, they have to bear an additional fixed cost of export f_x for the sake of communication and distribution. International transportation cost is standard iceberg δ, where $(\delta > 1)$, which means you ship δ units of final goods only 1 unit of x_i arrive in foreign country and there is no intermediate transportation cost. When the intermediate is produced in home country, the maximum profit of heterogeneous firm serving both domestic and foreign markets is

$$\pi_i^{HX} = \frac{1}{\sigma}(1-\beta)\alpha^{\alpha/(1-\alpha)}\Theta_i C_H^{-\alpha/(1-\alpha)}\left(E_H P_H^{\sigma-1} + \Delta E_F P_F^{\sigma-1}\right) - f_e - f_x \qquad (6)$$

where $\Delta = \delta^{-\alpha,(1-\alpha)}$. When the intermediate good is produced in foreign country, the maximum profit of heterogeneous firm serving both domestic and foreign markets is

$$\pi_i^{FX} = \frac{1}{\sigma}(1-\beta)\alpha^{\alpha/(1-\alpha)}\Theta_i C_F^{-\alpha/(1-\alpha)}\left(E_H P_H^{\sigma-1} + \Delta E_F P_F^{\sigma-1}\right) - f_e - f_p - f_x \qquad (7)$$

Heterogeneous firms based on the expectation of profit choose the optimal strategies on whether serving foreign market and the location of producing intermediate goods.

Comparing equation (4) to (5), firm only serving domestic market, whose productivity is lower than $\Theta_{HD}^{FD} = \dfrac{f_p}{\Pi E_H P_H^{\sigma-1}\left(C_F^{1-\sigma} - C_H^{1-\sigma}\right)}$[1] will choose produce intermediate good in home country and firm whose productivity is higher than Θ_{HD}^{FD} will choose produce intermediate good in foreign country. Comparing equation (6) to (7), firm serving both markets, whose productivity is lower than

$\Theta_{HX}^{FX} = \dfrac{f_p}{\Pi\left(E_H P_H^{\sigma-1} + \Delta E_F P_F^{\sigma-1}\right)\left(C_F^{1-\sigma} - C_H^{1-\sigma}\right)}$[2] will choose produce intermediate good in foreign market, and firm whose productivity is higher than Θ_{HX}^{RX} will produce intermediate good in foreign country.

Comparing equation (4) and (6), firm producing intermediate good in home country, whose productivity is lower than $\Theta_{HD}^{HX} = \dfrac{f_x}{\Pi C_H^{1-\sigma}\Delta E_F P_F^{\sigma-1}}$[3] will only serve domestic market, and firm whose productivity is higher than Θ_{HD}^{HX} will serve both markets. Comparing equation (5) and (7), firm producing intermediate good in foreign country, whose productivity is lower than $\Theta_{FD}^{FX} = \dfrac{f_x}{\Pi C_F^{1-\sigma}\Delta E_F P_F^{\sigma-1}}$[4] will only serve domestic market, and firm whose productivity is higher than Θ_{HD}^{HX} will serve both markets. We take these analysis above together[5], see figure 1.
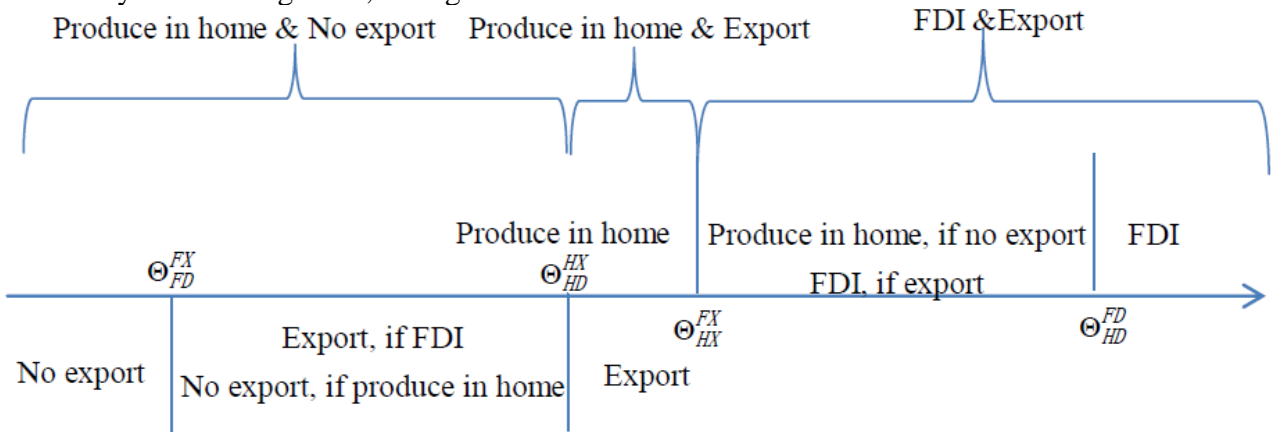

Figure 1. The strategied of heterogeneous firms with different productivity

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[1] Θ_{HD}^{RD} is the productivity shreshold when $\pi^{FD} = \pi^{HD}$.

[2] Θ_{HX}^{RX} is the productivity shreshold when $\pi^{FX} = \pi^{HX}$, and it is easy to know that $\Theta_{HX}^{RX} < \Theta_{HD}^{RD}$.

[3] Θ_{HD}^{HX} is the productivity shreshold when $\pi^{HX} = \pi^{HD}$.

[4] Θ_{FD}^{FX} is the productivity shreshold when $\pi^{FX} = \pi^{FD}$, and it is easy to know that $\Theta_{FD}^{FX} < \Theta_{HD}^{HX}$.

[5] In this document, we assume that fixed cost of producing intermediate good abroad is dominantly larger than fixed cost of export, which means $\dfrac{f_p}{f_x} > \dfrac{\left(E_H P_H^{\sigma-1} + \Delta E_F P_F^{\sigma-1}\right)\left(C_F^{1-\sigma} - C_H^{1-\sigma}\right)}{C_H^{1-\sigma}\Delta E_F P_F^{\sigma-1}}$.

As we can see in figure 1, firm whose productivity is higher than Θ_{HX}^{RX} will choose FDI strategy producing intermediate good in foreign and export. Firm whose productivity is between Θ_{HD}^{HX} and Θ_{HX}^{RX} will choose produce intermediate good in home country and export. Firm whose productivity is lower than Θ_{HD}^{HX} will choose produce intermediate good in home country and only serve domestic market.

To sum up, although firms are classified into same industry, there is significant difference in their strategies, which is affected by their productivity, production scale and fixed cost of export and FDI. Firms with highest productivity will choose vertical FDI and export to foreign market. Firms with middle productivity will export to foreign market. Firms with least productivity will only serve domestic market. It also means that firms that choose to FDI and export have highest productivity and largest production scale. Firms that choose export to foreign market have middle productivity and production scale. Firm only serving domestic market have lowest productivity and smallest production sclae.

Estimation

Firm-level Data Description

This document will use micro-level data in China to estimate the theoretical prediction. The data used in this document comes from a questionnaire survey carried out by World Bank among accountants and personnel managers of firms located in china. It covers 1500 firms in manufacturing sector including apparel and leather goods, electronic equipment, electronic components, consumer products, and vehicles and vehicle parts and mainly scatters over 5 cities including Bei Jing, Cheng Du, Guang Zhou, Shang Hai and Tian Jin.

The aim of this section of this document is that using micro-level data to estimate whether there is the significant difference in productivity, production scale and technology of firms that classfied into same industry. We classify these 1500 firms into 4 groups which are domestic firms only serving domestic market(denoted by hd), domestic firms serving foreign market(denoted by hx), foreign affiliates only serving dometic market (denoted by fd) and foreign affiliates serving foreign market(denoted by fx). Based on Feenstra and Hanson(2003), we consider firm that is owned by foreign firms bigger than 25% as the foreign affiliates.

Empirical Result

We use the total employment and total sales as the proxy of production scale of firms and use total sales per capita($\frac{total slaes}{total employment}$) to represent the productivity of firms. empolyment of skilled labor and R&D expenditure are used to represent the technology of firms. The empirical test equation is

$$\mathrm{y}_i = c + \alpha_{hd}hd + \alpha_{hx}hx + \alpha_{fd}fd + \mathrm{sector}_i + \varepsilon_i \tag{8}$$

where y_i is dependent variable represents the total employment, total sales, production scales, the total sales per capita, empolyment of skilled labor and R&D expenditure. hd hx fd and fx are dummy variables represent 4 groups of firms. We should know that the constant c represents the coefficient of fx. The OLS result can be seen in table 1.

As we can see in table 1, there is a significant difference in the total sales among these 4 gorups. And coefficients of fx, fd, hx and hd are 756910.9, -488177.4, -560187 and -652557.9. The absolute value of these coefficients does not matter, but the relative value is very important to prove that total sale of fx is significantly highest, followed by fd's, hx's and total sale of hd is the smallest, which coincides with the theoretical prediction. The total employment of fx is significantly larger than fd's, and total employment of fx and fd are not significantly higher than domestic firms, which means there is not significantly different between foreign affiliats and domestic firms in total employment scale.

The total sales per capita is significant for all kinds of firms. The coefficient of fx is 800.7538, which is the higest value followed by fd's (-34.82065), hx's(-395.2397) and hd's(-571.0774), which proves that the productivity of foreign affiliates serving foreign market is the higest. The productivity of foreign

affiliates only serving domestic market is the second largest. Productivity of domestic firms serving foreign market is higher than the firms only serving domestic market.

The difference in technology represented by R&D expenditure among 4 groups of firms is significant. R&D of fx is 49999.83 which is bigger than fd's -39583.90, which is bigger than hx's -40810.47 and hd's -48421.06. This result coinsides with the theoretical preditions that the production technology of fx that choose FDI and export strategy is the highest, followed by the fd's hx's and hd's. Skilled labor input is only significant in coefficient of fx, which means there is not significant difference in skilled labor input among fd, hx and hd.

Table 1 the Result of OLS Estimation (*** $p < 0.01$; ** $p < 0.05$,*$P<0.1$)

coefficient	hd	hx	fd	fx
Production Scale measured by total employment	-348.0263 (-1.645672)	107.0656 (0.436573)	-530.8158* (-1.682858)	846.0178*** (4.345581)
Production Scale measured by total sales	-652557.9*** (-6.002868)	-560187*** (-4.445912)	-488177.4*** (-2.985013)	756910.9*** (7.567188)
Total slaes per capita	-571.0774*** (-4.758559)	-395.2397*** (-2.839986)	-34.82065 (-0.194531)	800.7538*** (7.247973)
R&D	-48421.06*** (-3.612214)	-40810.47*** (-2.642479)	-39583.90** (-2.006003)	49999.83*** (4.049773)
Skilled labor input	-9.664940 (-0.701190)	18.12991 (1.134247)	-14.78328 (-0.719085)	49.40828*** (3.893800)

Summary

Lots of empirical researches using firm-level data from several countries have proved that there is substantial difference in productivity, production scale and production technology of firms which are classified into same industry. This document constructs a theoretical model to explain this phenomenon and uses micro-level data in China to testify the theoretical conclusion. Based on the theoretical model, firms that choose FDI and export have highest productivity and production scale so as production technology. Firms that choose export have middle productivity and production scale so as production technology. Firms that only serving domestic market have lowest productivity and production scale so as production technology. The result of empirical research to a great extent has proved the prediction of theoretical model and indicates that foreign export affiliates, foreign affiliates, domestic export firms and domestic firms are significantly different in the production scale, productivity, and production technology. Foreign export affiliates have the largest production scale either measured by employment or by total sales, productivity measured by total sales per capita, R&D expenditure and employment of skilled labor. The foreign affiliates and follow by the foreign affiliates, domestic export firms and domestic firm in the decreasing order.

References

[1]   Benard A B. And J. B. Jensen, Export, Jobs and wages in U.S. Manufacturing, 1976-1987, Brooking papers on Economic Ativity, Microeconomis, (1995) 67-119.

[2]   Aw, Bee Yan, and Amy Hwang, Productivity and the export Market: A Firm-Level Analysis., Journal of Development Economics 47(1995) 313-332.

[3]   Hopenhayn, Hugo., Enry, Exit, and Firm Dynamics in Long-Run Equilibrium., Econometrica 60(1992) 1127-1150

[4]   Benard A. B., and J Eaton, J.B. Jensen and S. Kortum, Plants and Productivity in International Trade, American Economic Review, 93(2003) 1268-1292.

[5]   Melitz M.J., The Impact of Trde on Intra-Industry Realloctions and Aggregate Industry

Productivity, Eonomica, 71(2003) 1695-1725.

[6]   Grossman, G. M., Helpman, E. and Szeidl, A, Optimal Integration Strategies for the Multinational Firm, Journal of International Economics, 70(2006) 216-238.

[7]   Aizenman, J. and Nancy M., The Merits of Horizontal Versus Vertical FDI in the Presence of Uncertainty, Journal of International Economics, 62(2004) 125-148.

[8]   Antràs, Pol., Firms, Contracts, and Trade Structure, Quarterly Journal of Economics, 118(2003) 1375-1418.

[9]   Antràs, Pol. and Helpman, E., Global Sourcing, Journal of Political Economy, 112(2004) 552-80.

[10]   Aw, Bee Yan, Sukkyun Chung and Mark J. R., Productivity and Turnover in the Export Market: Micro-Level Evidence from the Republic of Korea and Taiwan (China), World Bank Economic Review, 14(2000) 65-90.

[11]   Baldwin, J. R. and Wulong G., Export- Market Participation and Productivity Performance in Canadian Manufacturing, Canadian Journal of Economics, 36(2003) 634-57.

[12]   Berman, E., Bound, J. and Machin, S., Implications of Skill-biased Technological Change: International Evidence, Quarterly Journal of Economics, 113(1998) 1245-1279.

[13]   Bernard, A. and Jensen, J. B. "Exporters, Skill Upgrading and the Wage Gap, Journal of International Economics, 42(1997) 3-32.

[14]   Bernard, A. and Jensen, J., Exceptional exporter performance: cause, effect, or both?, Journal of International Economics, 47(1999) 1-25.

[15]   Brainard, S. L., A Simple Theory of Multinational Corporations and Trade with a Trade-off between Proximity and Concentration, NBER Working Paper No. 4269, 1993.

[16]   Brainard,L.S., An Empirical Assessment of the Proximity Concentration Trade between Multinational Sales and Trade, American Economic Review,87(1997) 520-544.

[17]   Carr, D.L., Markusen, J. R. and Maskus, K.E., Estimating the Knowledge-Capital Model of the Multinational Enterprise, The American Economic Review, 91(2001) 693-708.

[18]   Helpman, E., Melitz, M. J. and Yeaple, S. R., Export versus FDI with Heterogeneous Firms, American Economic Review,94(2004) 300-316.

[19]   Hummels,D., Rapoport, D. and Kei-Mu,Yi , Vertical Specialization and the Changing Nature of World Trade, Federal Reserve Bank of New York Economic Policy Review, 4(2001) 79-99.

[20]   Markusen, J. R., Multinationals, Multi-Plant Economies, and the Gains from Trade, Journal of International Economics, 16(1984) 205-226.

[21]   Markusen, Maskus, Estimating the Knowledge-Capital Model of the Multi- national Enterprise, American Economic Review,91(2001) 693-708.

[22]   Lawrence, E., A Firm Level Analysis of Trade, Technology and Employment in South Africa, Journal of International Development, 16(2004) 45 -61.

[23]   Machin, S. and Van Reenen, J., Technology and Changes in Skill Structure: Evidence from Seven OECD Countries, IFS Working Papers, No.W98 /04.1998.

[24]   Mazumdar, J. and Quispe -Agnoli M., Trade and the Skill Premium in Developing Countries: the Role of Intermediate Goods and Some Evidence from Peru, Federal Reserve Bank of Atlanta Working Paper, No. 2002 -11.