Does the “Productivity Paradox” Exist in the Chinese Food Industry?

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The objective of this research is to check if the “productivity paradox” exists in the Chinese food industry and estimate the effect of export scales on the enterprises’ total factor productivity (TFP). The results show the following: first, the “productivity paradox” does not exist in the Chinese food industry; second, within specific optimal intervals, export scale can facilitate the increase in TFP; and third, “learning by exporting” has a time-lag effect on the food industry, which impacts food manufacturing firms the least and beverage manufacturing firms the most.

Keywords: export scale, food industry, total factor productivity

1. Introduction

Since the beginning of the new century, driven by a series of export-oriented policies such as the “Going out” strategy and the Belt and Road Initiative (BRI), Chinese food enterprises have opened up to overseas markets. As the primary pillar sector in China, the food industry generated productivity growth steadily at an average annual rate of 13.7% during 2001 to 2016 (Xu and Chen, 2020). However, dominated by the production patterns of labor intensive and primary processing, the Chinese food industry still develops in an extensive way. With the increasing cost of the physical and human capital accumulation and environmental protection in recent years, accelerating technological progress and enhancing the efficiency of advantageous resources became crucial channels to promote productivity for the food sector.

Using export-led strategies to promote economic growth has been phrased as an effective development strategy, especially in newly industrialized countries and regions in Asia (Chow, 1987). The World Bank research report also pointed out that participation in the export market gives enterprises the best national experience and promotes productivity and growth (World Bank, 1997). After Bernard and Jensen (1995) first used the data of American enterprises from 1976 to 1987, to prove that export enterprises have higher productivity, scholars gradually shifted their research focus from the national and industrial level to the micro enterprise level. Enterprises get the productivity gains from export market is known as “learning by exporting” effect mentioned in the New Trade Theory (NTT) (Melitz, 2003). The firm level trade literature finds exporters are exceptional performers for a wide range of countries. Paradoxically, scholars used the data from domestic manufacturing enterprises to find that pervasive processing trade and low capital–labor ratio (Li, 2010; Dai et al., 2014) lead to an unexceptional exporter performance in China: exporters are less productive than non-exporters, exporters are no longer superior performers. According to the accumulated evidence in the literature, we define the “productivity paradox” for this study as the productivity of exporters is lower than non-exporters without considering the learning effect of exporting.

The objective of this paper is to check if the “productivity paradox” exists in the Chinese food industry, which has the distinctive characteristics of processing trade and is also labor-intensive. The paper also tries to estimate the effect of export scales on total factor productivity (TFP) of enterprises. We further analyze the productivity effect of exporting in the food industry by considering the effects of time-lag on sub-industries.

2. Data and Methodology

1) Data

We used the Chinese Manufacturing Firms Database from 2005 to 2013, which is a firm-level survey, of manufacturing enterprises, conducted by China’s National Bureau of Statistics. The data set has about 80 variables in total and includes, the balance sheet, profit

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and loss statements and cash flow statements of firms. It also provides detailed information on a firm’s identification, export status, employment, capital stock, and so on. These firms contribute 98% to the total exports by Chinese manufacturing companies as seen in the aggregate trade data. In this study, we select the food industry, and include the sub-industries such as Agro-food Processing, Food Manufacture, and Beverages. To clean the data, following Xie et al. (2008) and Wang (2018), we dropped observations that had missing or negative values for any of the following variables: total sales, total revenue, total employment, and export value exceeded 1. We included firms with at least eight employees. Table 1 shows the statistical description of the main variables.

| Variable            | Name          | Unit     | Mean   | Std Dev |
|---------------------|---------------|----------|--------|---------|
| Total output        | lnY           | CNY1,000 | 10.80  | 1.39    |
| Capital stock       | lnK           | CNY1,000 | 8.81   | 1.63    |
| Labor               | lnL /         |          | 4.78   | 1.10    |
| Fixed assets        | lnI           | CNY1,000 | 7.67   | 1.97    |
| Establishment       | Age/Year      |          | 9.15   | 7.76    |

Note: To make the analysis more accurate, this paper refers to the methods in previous research to calculate the real value of the total output and capital stock. The value of the total output is adjusted by the Ex-factory Price Index, and the real capital stock is adjusted by the Price Indices of Fixed Assets Investment. The deflation base period is 2005. Refers to previous studies, we use the perpetual inventory method to calculate the fixed assets investment as previous studies conducted:

Fixed assets investment = current capital stock - (1-depreciation rate) * lag capital stock for one period.
The depreciation rate used is 15%.

2) Total factor productivity (TFP)
China’s food industry is still labor-intensive and the productivity of labor-intensive enterprises is measured by the average value of the labor added. This naturally tends to underestimate the productivity of enterprises. Therefore, TFP is used as a proxy for enterprise productivity in this paper. TFP reflects the level of “surplus” productivity after deducting factor contribution, and can generally be understood as the contribution of unproductive input factors such as technological progress, institutional change, and so on. We choose the OP approach to estimate the production function, which is currently the popular method of estimation.

This method was proposed by Olley and Pakes (1996). The advantage of the OP method is that it can effectively overcome the simultaneity bias and the selectivity bias. It is based on the Cobb–Douglas production function, and can be represented as below:

\[
\ln Y_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \text{age}_{it} + \\sum_m \delta_m \text{year}_{im} + \sum_n \theta_n \text{reg}_{in} + \sum_k \phi_k \text{sub}_{ik} + \text{exit} + \varepsilon_{it}
\]

where \( \ln Y_{it} \) refers to total output of firm \( i \) in year \( t \); \( \ln K_{it} \) and \( \text{age}_{it} \) are the state variables for total value added and the age of the firm \( i \) respectively; \( \ln L_{it} \) is the free variable which represents the number of employees of firm \( i \); \( \text{year}_{im} \) is the control variable; \( \text{reg}_{in} \) is the dummy variable which represents the region to which the firm belongs; \( \text{sub}_{ik} \) represents the sub-industry of firm \( i \). exit represents the exit variable which is generated based on whether the enterprise exists in the database.

3) Generalized propensity score (GPS)
When discussing the actual impact of the increase in export on productivity, it is considered that, while export may affect the productivity, high productivity enterprises may choose to take part in the international market. This means that there is a “two-way causality” relationship between export and productivity, and the differences in the individual characteristics of enterprises may also affect their productivity. These factors tend to cause a mixed bias in measurement. To overcome these biases, this paper chooses the generalized propensity score (GPS) proposed by Hirano and Imbens (2004).

In this paper, we control the covariates to estimate the conditional probability of density distribution of the continuous treatment variable (quantity and intensity of export), to calculate the GPS of the sample enterprises according to the estimation results. Finally, we estimate the average treatment effect of outcome TFP at each level of the treatment variable to precisely estimate the effect of “learning by exporting” on the Chinese food industry. Based on previous studies, we choose employment, establishment, capital-intensive, and wage
as covariates to estimate the GPS. The definitions and summary statistics of covariate variables for propensity score estimation are reported in Table 2.

### Table 2. Covariate variable definitions and summary statistics

| Covariate variable          | Definition                                                                 | Std Dev. | Mean   | Obs.  |
|----------------------------|----------------------------------------------------------------------------|----------|--------|-------|
| ln(Employment)             | logarithm of number of employees                                          | 1.12     | 4.65   | 198293 |
| Establishment              | Current year - year of establishment + 1                                  | 7.96     | 9.07   | 198293 |
| ln(capital-intensive)      | logarithm of (total assets /employment) in real value                      | 1.33     | 4.06   | 198293 |
| ln(wage)                   | logarithm of (salary payable/employment)                                  | 0.81     | 2.53   | 146075 |

Note: All monetary values are in real term.

### 3. Result and Discussion

1) **“Productivity paradox”**

To check if the “productivity paradox” exists or not, in other words, the exporters in the Chinese food industry are less productive or more, we estimated the TFP of both exporters and non-exporters. Additionally, we list value-added, fixed assets, investment, scale and employment for investigating the firms’ performance. To make the comparative results more reliable, two TFP results, one estimated by the traditional Ordinary Least Squares (OLS) method and the other, by the mainstream Olley and Pakes (OP) approach are shown together in Table 3.

| Food Industry | Agro-food processing | Food manufacture | Beverages |
|---------------|----------------------|------------------|-----------|
| Exporter      | Non-Exporter         | Exporter         | Non-Exporter | Exporter | Non-Exporter |
| ln(Total value-added) | 8.84 | 8.17 | 8.73 | 8.10 | 9.90 | 8.25 | 9.12 | 8.35 |
| ln(Fixed assets)    | 9.21 | 8.74 | 8.99 | 8.61 | 9.44 | 8.79 | 9.84 | 9.17 |
| ln(Investment)     | 7.83 | 7.47 | 7.66 | 7.37 | 7.98 | 7.49 | 8.40 | 7.86 |
| ln(Enterprise scale) | 5.05 | 4.55 | 4.96 | 4.44 | 5.21 | 4.72 | 5.15 | 4.76 |
| ln(Employment)     | 5.13 | 4.54 | 5.05 | 4.43 | 5.26 | 8.38 | 5.21 | 4.75 |
| ln(TFP): OP        | 4.69 | 4.69 | 5.89 | 5.64 | 4.87 | 4.81 | 5.32 | 4.88 |
| ln(TFP): OLS       | 3.32 | 3.09 | 3.44 | 3.23 | 3.16 | 2.99 | 3.01 | 2.71 |

Note: All monetary values are in real term. The table reports mean of the variables taking logarithm.

It can be seen that by both OP approach and OLS estimation, the productivity of exporters is higher than that of non-exporters, the “productivity paradox” does not exist in the Chinese food industry. As is shown in previous evidence for a wide range of countries, the exporters in the Chinese food industry are still superior performers. One possible reason mainly lies in the different range of data selection, in particular, our findings only focus on the food industry. Although, the Agro-food processing firms with an obvious characteristic of processing trade is accounted for a great majority in the food sector, the proportion of processing trade enterprises with low productivity in the food industry is much less than that in the whole manufacturing industry. Another possible explanation is that food exporters are more easily restricted by food safety regulations made by foreign buyers (Bontemps et al., 2012). Thus exporters are forced to promote TFP for adjusting intense global market competition, rather than the non-exporters.

2) **The effect of export on productivity**

We dropped the samples of enterprises whose export value was equal to 0. We selected export quantity and intensity as indicators to measure export scale, and analyze the impact of export scale on productivity. As previous researches proposed, export quantity is measured by the export value from the database, and
export intensity is measured by the ratio of export value to gross value-added. In the estimation, assuming that the impact of the export scale on firm productivity may lag, we use relevant research to set the outcome variable (the enterprise TFP) with a lag period, while the treatment variables and covariates are considered at the current value. The dose–response function of the export quantity on TFP and export intensity on TFP are shown in Figures 1 and 2 respectively.

As Figure 1 shows, with the increase in export quantity, the TFP of food enterprises shows a downward trend at first. When the ln(export value) is 4, the effect turns positive and the TFP rises. The optimal interval of the effect is [9,16], which means that the export quantity within this interval has the most obvious positive effect on TFP. The possible reason lead to the trend is food products have a rigid demand domestically and most of the profits of food industry are from the domestic market. In addition, the industrial level of food firms in China are mostly at the middle and low-end of the global value chain, which means that the food firms which have recently engaged in foreign trade, suffer from export inhibition effects such as increases in coordination cost and control cost. Also, some low productivity firms could take advantages of preferential policies for boosting export expansion implemented by the government making them pursue production but ignore technological innovation. With the increase in market share, international competition is becoming increasingly fierce, and enterprises must pay more attention to reform and innovation, to improve technical efficiencies. Food safety is another factor for the low competitiveness in food trade. Although the absolute value of export products is increasing, so is the stimulating effect of Technical Barriers to Trade (TBT). Firms are hence required to strengthen supervision and improve technical efficiencies.

This result also very similar with the finding by Qian et al. (2016) who investigated that there is a U-shaped relationship between the diversification of export markets and firm productivity. As firms begin to export, they face higher costs (and thus lower productivity) initially because they lack the experience and knowledge. Gradually, as diversification of the export market moves beyond a threshold level and investments cumulate, export market expansion results in lower long-run average costs and thus higher productivity owing to the learning curve and economies of scope, as well as economies of scale.

Figure 1. “Dose–response” function of food enterprise export quantity and TFP

Figure 2 shows the specific impact of export intensity on the TFP for food enterprises. As opposed to Figure 1, there is an approximate “N-shape” relationship between export intensity and the TFP for food enterprises. That is, with the continuous increase of export intensity, the productivity of enterprises shows a trend of “rising–falling–rising.” Compared to the effect of export quantity, the export intensity has a more restrictive effect on the TFP of food enterprises. When the export intensity is 70.5%, it begins to show a significant positive impact on TFP. This is because, as soon as some enterprises enter the international market, they have enough power to improve efficiency and productivity. However, once they occupy a share of the international market, they become inert and reduce the speed of innovation. Productivity gradually deteriorates with the increase of export intensity (Li, 2010). However, in the long run, with the increase of export intensity, crisis-consciousness compels firms to pay attention to technological innovation and again improve TFP.

Figure 2. “Dose–response” function of food enterprise export intensity and TFP
3) Time-lag effect

To do a robustness check of the above results and a dynamic analysis of the effect of export scale on TFP, we use the second lag-term and third lag-term of the TFP of enterprises to estimate the average treatment effect at each level of export scale. It is found that the dose–response function trends of the second lag-term TFP and third lag-term TFP were similar. Therefore, only the dose–response functions of export scale and the second lag-term TFP (as shown in Figure 3) are described below.

We then sorted the “lowest inflection point” and its estimated coefficient by the lags as shown in Table 4 to explore the persistence of the average treatment effect of export scale on the TFP of enterprises.

Figure 3 shows that the conclusion is the same as before: to begin with, the export quantity has a bit of an inhibitory effect on the TFP of enterprises. When the logarithm value of export value is 3.9, the productivity will fluctuate and rise with its increase. The relationship between export intensity and productivity is still follows an “N-shape,” which means with the export intensity increasing, the TFP of enterprises will rise at first, then decline and finally rise. Furthermore, Table 4 shows that the minimum inflection points of these three lag-terms of TFP are very close to one another. The effect of export scale on TFP can last for three lag-terms and the average treatment effect in the second lag-term reaches the maximum level and weakens in the third lag-term.

![Figure 3. Results of the time-lag effect on the dose–response function](image)

Figure 3. Results of the time-lag effect on the dose–response function

| Source | Chinese Manufacturing Firms Database. |
|--------|----------------------------------------|

| Table 4. Results of the time-lag effect: “lowest inflection point” and estimated coefficient |
|---------------------------------------------------------------|
| Export quantity | Export intensity |
|                 | First lag | Second lag | Third lag | First lag | Second lag | Third lag |
| Lowest inflection point | 3.7 | 3.9 | 4.1 | 69.4 | 70.8 | 71.4 |
| Effect coefficient | 0.11 | 0.15 | 0.08 | 2.99 | 3.25 | 1.06 |

4) Further discussion

After analyzing all samples of the food enterprises in China, we moved on to the three sub-industries. In order to visually examine the heterogeneity of the impact of export scale on TFP on the three sub-industries, we look at the range of coefficients and optimal intervals in the dose–responses function representing the effect of export scale on TFP of enterprises for all three sub-industries as shown in Table 5.

As seen from the table 5, the agro-food processing accounts for the largest proportion in the food industry, while the beverage industry accounts for the least proportion. In terms of the effect of the export scale on firms’ TFP, within three sub-industries, the range of the optimal interval of the food manufacturing industry is the shortest while the range of the coefficient of beverage industry is the largest. To sum up, the export scale has the weakest positive effect on food manufacturing firms, and has most obvious stimulating effect on beverage manufacturing firms.
Table 5. Effect of export scale on enterprise TFP in different sub-industries

|                          | Proportion (%) | Export quantity Range of coefficient (CNY1,000) | Export intensity Range of coefficient (%) | Optimal interval |
|--------------------------|----------------|-----------------------------------------------|------------------------------------------|------------------|
| Agro-food processing     | 61.57%         | 0.24-0.67                                      | 0.15-1.23                                | 5-16             |
| Food manufacturing       | 28.89%         | 0.08-0.02                                      | 1.33-1.89                                | 1.51-2.41        |
| Beverage                 | 9.54%          | 0.34-1.31                                      | 0.19-0.81                                | 7-16             |

Source: Chinese Manufacturing Firms Database.

4. Conclusion

This paper examines the existence of the “productivity paradox” in the Chinese food industry. It also estimates the effect of export scales on the TFP of enterprises using the firm-level panel data in China. The results show that there is no “productivity paradox” in the Chinese food industry; the productivity of exporter is higher than that of the non-exporter. With the increase in export quantity, the TFP of the enterprises in the Chinese food industry declines at first and rises after. For the export intensity, there is an approximate “N-shaped” relationship between the export intensity and TFP of the food enterprise. Export also has a time-lag effect on the food industry, and food enterprises get the most enhancement in the second lag-term; however, this enhancement will weaken in the long run. Finally, the export scale has the weakest effect on food manufacturing enterprises, while it has the most obvious stimulating effect on beverage manufacturing enterprises.

From the view of the effect of export behavior on firms’ productivity, this study does not directly investigate the impact of firms’ export strategy as well as the share change in both domestic and global markets on productivity gains. This also makes sense to evaluate the productivity effect of exporting. These can be fruitful areas for future research.

Acknowledgement: This study was supported by JSPS KAKENHI Grant Number JP19H00960.

References

Bernard A. B., J. B. Jensen, and R. Z. Lawrence (1995) Exporters, Jobs, and Wages in U.S. Manufacturing: 1976-1987, Brookings Papers on Economic Activity Microeconomics 67-119.

Bontemps, C., C. Nauges, and M. Simioni (2012) Food Safety Regulation and Firm Productivity: Evidence from the French Food Industry, University of Toulouse.

Chow, P. C. (1987) Causality between Export Growth and Industrial Development: Empirical Evidence from the NICs, Journal of development Economics 26(1): 55-63.

Dai, M., M. Yu, and M. Madhura (2014) The Mystery of Productivity of Chinese Export Enterprises: The Role of Processing Trade, China Economic Quarterly 2: 675-698.

Hirano, K. and G. W. Imbens (2004) The Propensity Score with Continuous Treatments, Applied Bayesian Modeling and Causal Inference from Incomplete - Data Perspectives, Wiley-Blackwell, 73-84.

Li, C. D. (2010) Is There a “Productivity Paradox” in Chinese Exporter? A T-test Based on the Chinese Manufacturing Enterprises, World Economy 7: 64-81.

Melitz, M. J. (2003) The Impact of Trade on Intra-Industry and Aggregate Industry Productivity, Econometrica 71: 1695-1725.

Olley, G. S. and A. Pakes (1996) The Dynamics of Productivity in The Telecommunications Equipment Industry, Econometrica 64: 1263-1297.

Qian, X. F. and M. Yaşar (2016) Export Market Diversification and Firm Productivity: Evidence from a Large Developing Country, World Development 82: 28-47.

Wang, G. D. (2018) Calculation on TFP of Manufacturing Enterprises in China during 1996-2013, China Economic Studies 4: 88-99.

World Bank (1997) The State in a Changing World. New York, Oxford University Press.

Xu, B. W. and X. L. Chen (2020) Production Efficiency Measurement and Regional Differences of Food Industry: Based on Cumulative LHM-TFP Index, Jiangsu Agricultural Science 48 (11): 313-319.

Xie, Q. L., T. G. Rawski, Y. F. Zhang (2008) Growth and Convergence of Industrial Productivity in China, China Economic Quarterly 3: 809-826.