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Impact from Productivity and State-ownership of Chinese Agricultural Firms on ODI Decisions

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Abstract: Chinese agricultural outward direct investment has grown rapidly over the last decades. Neo-classical foreign direct investment theories can explain the reasons in motivation perspective reasons for the rapid growth, but cannot explain what types of agricultural firms would be most likely to undertake outward direct investment to together make the rapid growth. We use a Chinese agricultural firm level dataset matched from Chinese industrial enterprises database and Chinese outward direct investment enterprises database to empirically examine the relationship between firm heterogeneity and outward direct investment decisions. We find the estimation results support the Helpman-Melitz-Yeaple hypothesis that as the first firm heterogeneity the total factor productivity has a positive influence on the probability that a firm will undertake outward direct investment, which is in accordance with the past related research especially the recent theoretical research progress of international direct investment. In contrast, we find that as the second firm heterogeneity the state ownership has a negative influence on the probability that a firm will undertake outward direct investment, which is not in accordance with the past research on Chinese overall outward direct investment and could be explained by the domestic support obligations of the state-owned agricultural firms in China. Furthermore, we implement robust estimation and the results shows a significant robustness. Our research shows that firm heterogeneity dose matter and it is important to take this into account in analyzing Chinese agricultural firms' outward direct investment decisions.

Keywords: China, Productivity, Outward Direct Investment, State Ownership

1. Introduction

Chinese agricultural outward direct investment (ODI)[1] has grown rapidly over the last decade. Neo-classical foreign direct investment theories can explain the reason for rapid growth, but cannot explain what types of entities would be most likely to undertake ODI.

Recent theoretical research on outward direct investment has tried to incorporate diverse modes of foreign market access into trade theory by explaining ODI choices in terms of firm heterogeneity. In an empirical study, Helpman, Melitz and Yeaplefound that total factor productivity (TFP) could answer the "which companies" question [1], in that companies with high TFP will choose to engage in ODI. Some research has suggested that state ownership could also influence the ODI choices of Chinese firms [2, 3].

In this paper, we examine the relationship between ODI behavior, and TFP and state ownership, to determine whether these two factors influence ODI choices by Chinese agricultural firms. Following Tian and Yu's research [4], we estimate two logit equations using firm level data. The dataset is constructed by matching industrial enterprises data for 1998 to 2009, compiled by the National Bureau of Statistics. and outward direct investment enterprises' name list data published by the Ministry of Commerce in 2015.

We find that TFP enhances the probability that Chinese agricultural firms will choose to engage in ODI, which supports the HMY hypothesis [1]. We also find that state ownership reduces the probability that firms will choose to engage in ODI. We offer some suggestions as to why this may be case. Our results support the view that firm heterogeneity matters for cross-border behavior, and that private agricultural

1 Also as called outward foreign direct investment (OFDI) in some other literatures; the word ODI or OFDI referenced in this paper has exactly the same meaning.

companies are likely to play a significant role in Chinese agricultural ODI.

2. Background and Literature Review

Chinese agricultural ODI has grown rapidly over the last decade. The annual outflow was just 0.27 billion US dollars (USD) in 2007 but increased to 2.57 billion USD in 2015. The stock of ODI increased from 1.47 billion USD to 11.4 billion USD[2] over the same period, or almost tenfold.

A number of factors have been identified that could explain the transformation from a domestic to a cross-border industry [5]. These include tariff and non-tariff barriers [6], internalization advantages [7], monopoly competition advantages [6-8], and the industry life cycle [7, 9]. Dunning argues that from a firm's perspective the motivation for ODI could be market development, limited domestic natural resources [10], cost saving and profit promoting advantages, and access to strategic assets, such as technology especially for the Chinese firms [11]. These four motivations may apply to Chinese agricultural ODI, but it is difficult to use them to examine empirically which companies will choose to focus on foreign investment.

2.1. TFP and ODI

Recent research on ODI has tried to incorporate diverse modes of foreign market access into new trade theory by explaining investment choices in terms of firm heterogeneity. Melitz reported that only the most productive firms engage in foreign activities [12]. Helpman, Melitz and Yeaple [7][3] developed this idea further to posit that only the most productive firms engage in ODI, the second most productive engage in export and the least productive engage in serving domestic markets. Since that work, many empirical papers have tested this hypothesis. Several of these are summarized in Table 1. We can see that a substantial amount of research supports the HMY hypothesis on which companies choose to pursue ODI.

2.2. State Ownership and ODI

China has a large number of state owned companies, and this applies in the agricultural field. Some research suggests that state ownership could be an important element in explaining the cross-border behavior of Chinese enterprises [3, 10, 11, 31-33]. Two potential aspects of the impact of state ownership have been identified. First, it could enhance financial capability and credit availability so that state-owned firms are able to access finance at lower cost and to undertake greater investment risk than private firms [2, 3, 34]. This may lead to a higher probability of profitability from cross border investments by state owned companies. Second, state owned companies may have to make some investment decisions for political or diplomatic reasons, rather than simply for business reasons. These motivations may also prompt host countries to erect barriers to protect domestic industries and to restrict foreign investment [3].

2.3. Implications

On the basis of the discussion above we can conclude that both TFP and state ownership could be important elements for ODI choices by Chinese agricultural enterprises. A reasonable hypothesis would be that Chinese agricultural enterprises with high TFP or under state ownership would be more likely to undertake ODI than those with lower TFP or without state ownership. In this paper, we test this hypothesis empirically based on firm level data.

3. Data Illustration

To conduct the analysis we merge two sources together into one panel dataset via cleaning and matching.

The first source is the Chinese industrial enterprises database (CIED), which is an annual survey of all Chinese industrial enterprises above a minimum size conducted by the National Bureau of Statistics from 1998 to 2009[4]. This includes all the companies' basic information including name, start year, address, industry sector etc., and annual financial information. Only companies with sales of at least 5 million CNY (about 0.72 million USD), are included in the annual survey. In our analysis we only consider those companies that have undertaken ODI, and exclude those that have not.

The second data source is the Chinese outward direct investment enterprises' name list (CODIENL) published annually by the Ministry of Commerce. This includes the company's registration number, domestic name, enterprise name in the host country, host country, industry category, and years for which ODI was undertaken. We use the list published in December 2015, which covers all the companies that invested outside China from 1983 to 2015[5].

3.1. CIED Data

From the CIED database, we selected all the companies related to agriculture based on their industry code. The names are listed in appendix A1. Using the similar data cleaning method in Dai, Maitra and Yu's framework [35], we dropped the observations in which there was a missing or negative value for any of following variables: total sales, total employment, fixed capital, current assets, and state ownership.

After data cleaning, the effective sample size by year is

2 Data Source: National Bureau of Statistics of China. flow data: data.stats.gov.cn/easyquery.htm?cn=C01&zb=A060G01; stock data: data.stats.gov.cn/easyquery.htm?cn=C01&zb=A060G02.

3 The theoretical framework was based on the proximity-concentration tradeoff [23]. The empirical test only included a sample involving horizontal integration [24, 25]; without observations involving vertical integration [26, 27]. The limitation that theoretically the HMY hypothesis [7] does not apply to every ODI case has been pointed out by Engel and Procher's work [28].

4 Actually, there are some CIED data until the year of 2012, but questions have been raised about the quality of some of the data. In this paper, we only use the data up to 2009.

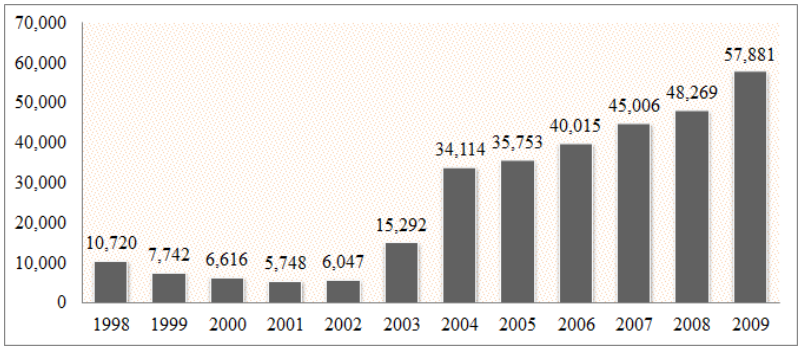
5 The data can be accessed at: http://femhzs.mofcom.gov.cn/fecpmvc/pages/fem/CorpJWList.html.

shown in figure 1. We have 313,203 observations in total, or about 88% of the original 354,678 observations. From figure 1 we can see that sample size was at a maximum of 57,881 in 2009 and at a minimum of 5,748 in 2001. We can also see that the number of Chinese agricultural companies with ODI tended to decline in the first five years of the sample period, but expanded rapidly thereafter.

The ownership status of the observations is summarized in figure 2. Given the situation in China, firms that fall under the national holding and local state holding categories can be considered to be under state ownership. All other types (including private holding, Hong Kong Macau and Taiwan holding, foreign holding and other holding) can be considered as being under private ownership.

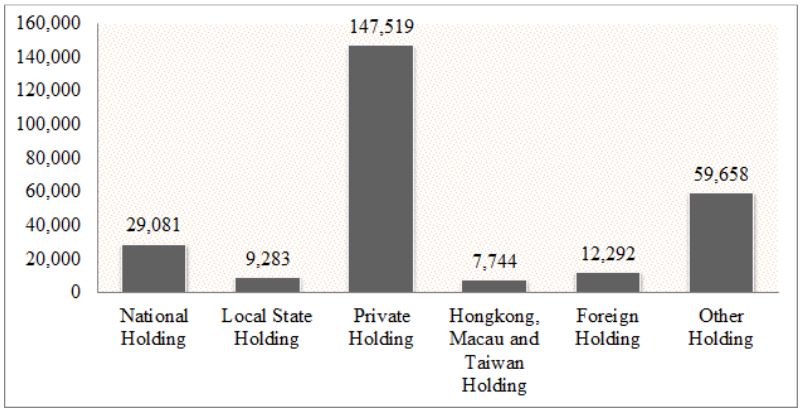
Table 1. *Some empirical tests of the HMY hypothesis in recent years.*

Literature	Sample Country	Sample Period	Samples Industry	Empirical Method	HMY Hypothesis: Yes or No?
Girma et al. [13]	UK	1990-1996	Manufacturing	Nonparametric KS Test[6]	Yes
Murakami [14]	Japan	1998	Manufacturing	OLE[7]	Yes
Wagner [15]	German	1995	Manufacturing	Nonparametric KS Test	Yes
Kimura and Kiyota [16]	Japan	1994-2000	Manufacturing and Service Industry	OLE	Yes
Castellani and Zanfei [17]	Italia	1994-1996	Manufacturing	Nonparametric KS Test	Yes
Yeaple (2009) [18]	USA	1994	Manufacturing	OLE	Yes
Chen and Moore [19]	France	1993-2001	Manufacturing	OLE	Yes
Arnold and Hussinger [20]	German	1996-2002	Manufacturing	Nonparametric KS Test	Yes
Todo [21]	Japan	1997-2005	Manufacturing	OLE	No
Hagemejer and Kolasa [22]	Poland	1996-2005	All industries	Nonparametric KS Test	Yes
Tian and Yu [4]	China	2006-2008	All industries	OLE (Fixed effect)	Yes
Engel and Procher [28]	France	2004	All industries except agriculture	Nonparametric KS Test	Yes
Tanaka [29]	Japan	1997-2009	Retailing	OLE	Yes
Shepherd [30]	119 Developing Countries	2006-2011	Service Industry	OLE	Yes



Source: CIED Database.

Figure 1. *Annual Chinese Agricultural Firms Sample 1998-2009.*



Source: CIED Database.

Figure 2. *Ownership Status of the Agricultural Firms Sample 1998-2009.*

6 The nonparametric KS test in this paper means the Kolmogorov-Smirnov test, which is based on the concept of stochastic dominance.
7 Ordinary Linear Estimation.

3.2. CODIENL Data

In order to test our hypothesis at the firm level, we have to know which agricultural companies have invested outside China. On the basis of the CODIENL data published in December 2015, we delete the observations with no company name information and finally we have 41,713 observations on Chinese companies that have undertaken ODI, of which 3,587 are agriculture related.

3.3. Data Matching and Merging

After cleaning the CIED data we have observations on Chinese agricultural companies above the minimum scale identified earlier, and their financial performance during the period 1998 to 2009. From the CODIENL after-cleaning dataset, we have the names of 3,587 Chinese agricultural companies that have undertaken ODI. In a matching and merging process, we combined the CIED and CODIENL data into a single dataset. We also generate the dependent variable "ODI" to define whether a company has undertaken ODI or not.

With data matching, we have 529 Chinese agricultural companies, which are reported to have undertaken ODI from the CODIENL data that are also found in the CIED data. This implies that during the sample period roughly 15% of Chinese agricultural companies which have invested outside China are above scale firms. This implies that many Chinese agricultural companies which have invested outside China are small or medium enterprises.

The variable ODI takes on a value of 1 when a company's name is included in both the CIED and CODIENL data, and that the company is recorded as having undertaken ODI in a given year. The value of 0 applies when these conditions are not met. For example, suppose there are three companies A, B and C which can be found in both CIED and CODIENL data. If company A has undertaken ODI in all years since 1998, then the value of the ODI variables for the 12 observations will be 1. If company B has not undertaken ODI since 1998 its 12 observations will have a value of 0. If company C has undertaken ODI since 2003 the value of the ODI variable for the first five observations from 1998 to 2002 will be 0 and those for the seven observations from 2003 to 2009 will be 1.

4. Empirical Methods

4.1. Empirical Equations

As shown in Table 1, many researchers have used a fixed effect model to test the HMY hypothesis. For example, Tian and Yu [4] used this approach on firm level data for all industries in China from 2006 to 2008. Following that approach we construct two logit[8] equations as follows:

First, by considering the data as panel data:

$$Pr(ODI_{\mathrm{it}} = 1|X_{it}) = \beta_0 + \beta_1 ln^{TFP} + \beta_2 Ownership + \beta_3 FRG + \beta_4 Age_{it} + \varepsilon_{it} \quad (1)$$

Second, by considering the data as pooled cross-sectional data:

$$Pr(ODI_{\mathrm{it}} = 1|X_{it}) = id_i + year_t + \beta_0 + \beta_1 ln^{TFP} + \beta_2 Ownership + \beta_3 FRG + \beta_4 Age_{it} + v_{it} \quad (2)$$

Fixed effect logit estimation is efficient when the within group variance of the dependent variable is non zero, but in our data there are many companies that have never invested outside China. Consequently, the within group variance of the variable ODI could be 0 for many observations. This would require the deletion of a large number of observations. To deal with this problem we use both fixed and random effect logit estimation by treating the data as panel data. This allows us to control directly the company id and year variables. A priori we cannot know whether a fixed or random effects model is more suitable, so we use the Likelihood Ratio and Hausman tests to determine this.

4.2. The Variables

In the equations, X denotes the sample companies, i is the index for each sample company, t is the sample year. The variable ODI has a value of 1 if the company undertook ODI otherwise the value is 0.

The variable "id" is the unique identification code for each company. It has no actual numerical meaning but is used here to control for fixed effects among diverse companies. Some uncommon elements may influence a company's ODI decision but it is hard to obtain information or precise data to reflect these. These elements can include such things as the foreign language capability of the company's managers or non-business preferences.

The variable "year" is used to control for fixed effects across different years, for example, differences in domestic or international macroeconomic conditions. For example, the global financial crisis of 2007-08 may have influenced the investment behavior of companies, leading some to suspend plans for cross-border activity.

The variable "TFP" denotes a company's Total Factor Productivity, calculated using the OP method [35, 37, 38]. Two major considerations underlie the choice of this method (see appendix A2). First, other methods for calculating TFP based on micro data (e.g., the classical OLS method) tend to be less efficient. Second, most recent research based on CIED data has found OP to be more effective and stable than alternatives. Lu and Lian examined several methods and concluded that the OP method generated the most plausible and stable estimates of TFP from CIED data [39].

The variable "Ownership" is a dummy variable that is equal to 1 if a firm is state owned and 0 otherwise. The variable "FRG" is a dummy variable with a value of 1 if the company itself has received foreign investment. If a company has been the target of FDI it is likely to be more open to international

8 Compared to using probit estimation, logit estimation can be more stable and avoid non-consistency when involving fixed effects [36].

activity. Companies that have received foreign capital may have greater access to international business contacts, information, and expertise if they want to go outward. The variable "Age" reflects the age of the company (number of years that it has been operating). The longevity of the company and the experience of its management people may influence investment behavior, e.g., through attitudes to risk.

5. Result and Discussion

5.1. Estimation Result

After estimation we obtain the results in Table 2. The Likelihood Ratio and Hausman test results are summarized in Table 3.

5.2. Discussion

On the basis of Tables 2 and 3, we note the following major characteristics:

From Table 3, we can see that both the LR and Hausman tests suggests that random effect logit estimation is more suitable for our case when viewing the data as panel data. Also from the effective sample amount "N" in Table 2, we can see that the application of the condition that the within group variance of the dependent variable should not be zero results in a substantial reduction in sample size. Thus the fixed effect logit estimation based on panel data is not suitable for our case.

From Table 2, we can see that in both the random effect logit panel estimation and the pooled logit estimation, the coefficients for TFP are strongly positive. This suggests that TFP matters for Chinese agricultural firms' ODI choices; companies with higher TFP have a higher probability of engaging in ODI. This provides support for the HMY hypothesis in Chinese agricultural firms.

Table 2. *Estimated Coefficients.*

	(1-Fixed Effect Panel Logit)	(2-Random Effect Panel Logit)	(3-Pooled Logit)
	ODI	**ODI**	**ODI**
TFP	2.050***	1.921***	1.316***
	(3.56)	(9.78)	(21.85)
Ownership	0.968	-0.661*	-0.825***
	(1.61)	(-2.37)	(-4.78)
FRG	1.754*	1.068***	-0.152
	(2.55)	(4.36)	(-1.16)
Age	0.639***	0.00343	-0.000948
	(10.39)	(1.06)	(-0.21)
id			-0.00000846***
			(-5.34)
year			0.470***
			(16.33)
_constant		-25.05***	-954.3***
		(-26.06)	(-16.52)
N	907	310107	310107

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3. *Likelihood Ratio and Hausman Test Results.*

	Chibar2	P-value
LR Test	59609.79***	0.000
Hausman Test	3169.37***	0.000

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. *Robust IV Estimation Results.*

	(2 - Random Effect Panel Logit)	(3 - Pooled Logit)
	ODI	**ODI**
L_tfp	2.029***	1.353***
	(9.57)	(20.02)
ownership	-0.650*	-0.922***
	(-1.96)	(-4.71)
frg	0.861**	-0.143
	(3.08)	(-1.01)

	(2 - Random Effect Panel Logit)	(3 - Pooled Logit)
	ODI	**ODI**
age	0.00101	-0.00413
	(0.17)	(-0.81)
id		-0.00000761***
		(-4.02)
year		0.415***
		(12.86)
_constant	-28.17***	-845.3***
	(-28.16)	(-13.03)
N	202462	202462

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Also from Table 2, we can see that in both random effect logit panel estimation and pooled logit estimation, the coefficients of ownership are negative and statistically significant, which suggests that state-ownership matters for Chinese agricultural firms but with the opposite effect from that found in past research (Cui and Jiang, 2012). Our results suggest that if an agricultural company is state-owned, it will have a smaller probability of engaging in ODI. The reason for this may involve two aspects. First, Chinese state owned agricultural firms are required to take on significant financial obligations to support domestic agricultural development. Many have to incur deficits to engage in market intervention through schemes such as the "minimum purchase prices policy" and "temporary purchases and storage policy"[9] which require state owned companies to purchase domestic grain production at prices higher than for imported grain. This financial commitment may limit the ability of state owned companies to expand their domestic business, let alone invest abroad. Second, in recent years, Chinese state owned agricultural companies may have had to face restrictions and barriers to investing abroad as a result of political constraints in host countries. In our sample, only 87 state owned companies have undertaken ODI or 8% the total of 1089 companies which undertook ODI in 1998 - 2009.

5.3. Robust Estimation

The estimates obtained lend support to the hypothesis stated earlier about the relationship between TFP and state ownership for ODI by Chinese agricultural firms. However, there could be endogeneity in the estimation. Companies which undertake ODI may experience spillover benefits, also called a learning effect by some researchers [39]. For example, a processing company that has invested overseas to build a new plant, may learn from that experience in terms of optimizing the use of its technology, and the application of that experience domestically can induce gains in TFP.

To deal with this possibility, we use the TFP from previous year (L_tfp) as an instrumental variable (IV) of TFP. The estimation results are reported in Table 4.

The results in Table 4 suggest that even allowing for endogeneity in TFP, the results in Table 3 are still supported. Consequently, we can conclude that we have a robust outcome from the application of our empirical framework.

6. Conclusions and Implications

Our empirical study used Chinese agricultural firm level data to study the relationship between outward direct investment behavior, focusing on total factor productivity and state ownership. Through logit estimation we find support for the HMY hypothesis [7], that is agricultural firms with higher TFP are more likely to have invested overseas. We also find that companies that have attracted foreign capital are more likely to have engaged in outward direct investment than those which have purely domestic capital in their financial structure.

We also found that agricultural firms under state ownership are less likely to engage in outward direct investment. This is counter to results obtained for other sectors. There are two potential reasons. First, state owned firms in the agricultural sector are expected to contribute to the development of agriculture through various types of expenditure, potentially leaving them with limited funds to allocate to ODI. Second, sensitivity to foreign investment in agriculture in host countries may make it difficult for state owned agricultural companies' to engage in cross-border investment. Further research would be needed to explore the factors that underlie ODI behavior of state-owned firms across different industries. This could be important for determining the future role of state-owned versus privately-owned firms in Chinese ODI and for understanding how China will participate in globalization. Finally, while our results lend support to the HMY hypothesis, they also indicate that firm heterogeneity can play a major role in cross-border investment behavior, and that it is important to take this into account.

9 Information about these two policies is contained in a report about grain and feed in China by the US Department of Agriculture: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_Beijing_China%20-%20Peoples%20Republic%20of_5-11-2015.pdf.

Appendix

Appendix 1 Table. Agriculture Related Industry Codes: Any Observation Having Either One of These Codes Was Selected into Our Sample

A	Agriculture, forestry, animal husbandry and fishery
01	Agriculture
011	Grain and other crops
0111	Grain cultivation
0112	Potato cultivation
0113	Oil plantings
0114	The cultivation of beans
0115	Cotton cultivation
0116	Bast Fiber cultivation
0117	Sugar plantings
0118	Tobacco cultivation
0119	Other crops are grown
012	Vegetables, horticultural crops
0121	Vegetable cultivation
0122	Flower planting
0123	Other horticultural crops
013	Fruit, nuts, beverages and spice crops
0131	Fruit, nuts cultivation
0132	Tea and other beverage crops
0133	Spice crop cultivation
0140	Chinese herbal medicine cultivation
02	forestry
021	Cultivation and planting of trees
0211	Breeding and nursery
0212	afforestation
0213	Tending and management of trees
022	Timber and bamboo harvesting
0221	Timber harvesting
0222	Bamboo harvesting
0230	Collection of forest products
03	Animal husbandry
0310	Livestock breeding
0320	Feeding of pigs
0330	Feeding of poultry
0340	Hunting and catching animals
0390	Other animal husbandry
04	Fisheries
041	Marine fisheries
0411	Marine cultivation
0412	Marine fishing
042	Inland fisheries
0421	Inland farming
0422	Inland fishing
05	Agriculture, forestry, animal husbandry and fishery services
051	Agricultural Services
0511	Irrigation services
0512	Agricultural products processing services
0519	Other Agricultural Services
0520	Forestry services
053	Livestock services
0531	Veterinary services
0539	Other livestock services

0540	Fishery services
C	Manufacturing
13	Agricultural and sideline food processing industry
1310	Grain grinding
1320	Feed processing
133	Vegetable oil processing
1331	Edible vegetable oil processing
1332	Processing of non - edible vegetable oils
1340	Sugar
135	Slaughtering and meat processing
1351	Livestock slaughter
1352	Meat products and by-products processing
136	Aquatic Products Processing
1361	Frozen aquatic products processing
1362	Surimi products and aquatic products dry pickled processing
1363	Aquatic feed manufacturing
1364	Fish oil extraction and the manufacture of products
1369	Other aquatic products processing
1370	Vegetables, fruits and nuts
139	Other agricultural and sideline products processing
1391	Starch and starch products manufacturing
1392	Soybean products manufacturing
1393	Egg processing
1399	Other unclassified agricultural and sideline products processing
14	Food industry
141	Manufacture of bakery products
1411	Pastry, bread making
1419	Biscuits and other bakery products
142	Candy, chocolate and candied fruit
1421	Candy, chocolate manufacturing
1422	Candied fruit production
143	Convenient food manufacturing
1431	Rice, flour products manufacturing
1432	Frozen food manufacturing
1439	Instant noodles and other convenient food manufacturing
1440	Liquid milk and dairy products manufacturing
145	Canning
1451	Meat, poultry canned manufacturing
1452	Canned aquatic products
1453	Vegetables, fruit canned manufacturing
1459	Other canned food manufacturing
146	Spices, fermented products manufacturing
1461	Monosodium Glutamate (MSG) manufacturing
1462	Soy sauce, vinegar and similar products
1469	Other condiments, fermented products manufacturing
149	Other food manufacturing
1491	Nutrition, health food manufacturing
1492	Frozen drinks and edible ice
1493	Salt processing
1494	Food and feed additives manufacturing
1499	Manufacture of other food products not elsewhere specified
15	Beverage Manufacturing
1510	Alcohol production
152	The manufacture of wine
1521	Liquor manufacturing
1522	Beer manufacturing
1523	Yellow wine manufacturing

1524	Wine making
1529	Manufacture of other wines
153	Soft drink manufacturing
1531	Carbonated beverage manufacturing
1532	Bottles (cans) installed drinking water production
1533	Fruit and vegetable juice and fruit and vegetable juice beverage manufacturing
1534	Milk beverage and plant protein beverage
1535	Solid beverage manufacturing
1539	Tea drinks and other soft drinks manufacturing
1540	Refined tea processing
16	Tobacco Products Industry
1610	Tobacco re-baking
1620	Manufacture of cigarettes
1690	Other tobacco products processing
20	Wood processing and wood, bamboo, rattan, brown, grass products industry
201	Sawn timber, wood processing
2011	Sawn timber processing
2012	Wood processing
202	Wood - based panel manufacturing
2021	Manufacture of plywood
2022	Fiberboard manufacturing
2023	Manufacture of particleboard
2029	Other wood-based panels, wood manufacturing
203	Wood products manufacturing
2031	Wood and wood components for construction
2032	Wood container manufacturing
2039	Cork products and other wood products manufacturing
2040	Bamboo, rattan, brown, grass products manufacturing
262	Fertilizer manufacturing
2621	Nitrogen fertilizer manufacturing
2622	Phosphate fertilizer manufacturing
2623	Potash manufacturing
2624	Manufacture of compound fertilizers
2625	Organic fertilizer and microbial fertilizer manufacturing
2629	Manufacture of other fertilizers
263	Pesticide manufacturing
2631	Chemical pesticide manufacturing
2632	Biochemical pesticides and microbial pesticide manufacturing
2730	Pieces of Chinese medicine processing
2740	Chinese medicine manufacturing
2750	Veterinary drug manufacturing
2760	Biological, biochemical products manufacturing
3423	Manufacture of metal tools for agricultural and garden use
363	Food, beverages, tobacco and feed production of special equipment manufacturing
3631	Food, beverages, tobacco industry-specific equipment manufacturers
3632	Agricultural and sideline food processing equipment manufacturing
3633	Special equipment for feed production
367	Agriculture, forestry, animal husbandry, fishing special machinery manufacturing
3671	Manufacture of tractors
3672	Mechanized agriculture and horticultural machinery manufacturing
3673	Forest and wood harvesting machinery manufacturing
3674	Livestock machinery manufacturing
3675	Fishery machinery manufacturing
3676	Agriculture, forestry, animal husbandry and fishery machinery parts manufacturing
3679	Other farming, forestry, animal husbandry and fishery machinery manufacturing and mechanical repair
5810	Grain, cotton and other agricultural products storage
H	Wholesale and retail trade

631	Wholesale of agricultural and livestock products
6311	Grain, beans and potato wholesale
6312	Seeds, feed wholesale
6313	Cotton, hemp wholesale
6314	Wholesale livestock
6319	Other agricultural and livestock products wholesale
632	Food, beverages and tobacco products wholesale
6321	Rice, flour products and edible oil wholesale
6322	Cakes, sweets and sugar wholesale
6323	Fruits, vegetables wholesale
6324	Meat, poultry, eggs and aquatic products wholesale
6325	Salt and condiments wholesale
6326	Beverages and tea wholesale
6327	Wholesale of tobacco products
6329	Other food wholesale
636	Mineral products, building materials and chemical products wholesale
6366	Fertilizer wholesale
6367	Pesticide wholesale
6368	Agricultural film wholesale
637	Machinery and equipment
6371	Wholesale of agricultural machinery
652	Food, beverages and tobacco products specialized retail
6521	Grain and oil retail
6522	Pastry, bread retail
6523	Fruit, vegetable retail
6524	Meat, poultry, eggs and aquatic products retail
6525	Beverages and tea retail
6526	Retail of tobacco products
6529	Other food retail
7312	Agricultural machinery leasing
M	Scientific research, technical services and geological prospecting
7530	Agricultural Science Research and Development

Appendix 2-Addition Explanation of the OP Method for Calculating TFP

We use a similar method to Yasar, Raciborski and Poi's work [38] for estimating TFP in this paper, employing the Opreg programming order package which was developed by these authors for the software Stata. The basic concept of this method is as follows.

First, we assume the following production function:

$$Y_{it} = F(E_{it}, K_{it}, a_{it}, \omega_{it}) \ (a)$$

We can derive the following equation based on the Cobb-Douglas technology assumption:

$$y_{it} = \beta_0 + \beta_e e_{it} + \beta_k k_{it} + \beta_a a_{it} + u_{it} \ (b)$$

$$u_{it} = \omega_{it} + \sigma_{it} \ (c)$$

In equation (b), y_{it} is log output for firm i in period t. e_{it}, k_{it} and a_{it} are the log values of total employment, fixed capital, and age of the firm i. ω_{it} is the productivity shock which is observed by the decision maker in the firm but not by the econometrician and σ_{it} is an unexpected productivity shock which is not observed by both decision maker and the econometrician. This means that ω_{it} has an effect on the firm's decision making process and can lead to biased estimation, while σ_{it} does not.

Olley and Pakes [37] define the decision making process as follows:

$$x_{it} = \begin{cases} 1 \ if \ \omega_{it} \geq \underline{\omega}_{it}(k_{it}, a_{it}) \\ 0 \ otherwise \end{cases} \ (d)$$

Which indicates that firm I would decide to stay in the market ($x_{it} = 1$) or exit the market ($x_{it} = 0$) if its productivity is greater than or less than a threshold determined by the firm's capital stock and age. Then we can derive the firm's decision to increase future investment IN_{it} as follows (in_{it} is the log value of IN_{it} which is identified by the current assets of the firm i in period t in this paper):

$$in_{it} = I \ (\omega_{it}, k_{it}, a_{it}) \ (e)$$

We can apply this in the former equations to control for the correlation between the productivity shock error term and inputs.

One more thing has to be emphasized here is that we assume that future productivity is strictly increasing with respect to ω_{it}, which means that firms with an observed positive productivity shock in period t will invest more in that period while keeping k_{it} *and* a_{it} the same. We can derive the

inverse function of ω_{it} as follows:

$$\omega_{it} = I^{-1}(in_{it}, k_{it}, a_{it}) = g(in_{it}, k_{it}, a_{it}) \ (f)$$

Substituting equations $(c)\ and\ (f)$ into (b) we have:

$$y_{it} = \beta_e e_{it} + \varphi(in_{it}, k_{it}, a_{it}) + \sigma_{it} \ (e)$$

$$\varphi(in_{it}, k_{it}, a_{it}) = \beta_0 + \beta_k k_{it} + \beta_a a_{it} + g(in_{it}, k_{it}, a_{it}) \ (g)$$

Moreover, similar to Yasar, Raciborski and Poi' work [38], we assume that $\varphi(\cdot)$ and $h(\cdot)$ approximate a second-order polynomial series. Estimating the parameters using OLS we calculate TFP from the following equation:

$$TFP^{OP}{}_{it} = y_{it} - \hat{\beta}_e e_{it} - \hat{\beta}_k k_{it} \ (i)$$

To obtain the parameter estimate $\hat{\beta}_k$, we posit that the probability of survival in period t for firm i depends on the relation between $\omega_{i,t-1}$ and $\underline{\omega}_{i,t-1}$ which can be expressed by the age, capital and investment in period t-1 (a deduction of the Bellman equation in the work of Olley and Pakes (1996)). Yasar, Raciborski and Poi (2008) used a probit model to calculate the predicted probabilities $\hat{P}_{it}$ with the final equation as follows:

$$y_{it} - \hat{\beta}_e e_{it} = \beta_k k_{it} + \beta_a a_{it} + h\left(\hat{\varphi}_{t-1} - \beta_k k_{i,t-1} - \beta_a a_{i,t-1}, \hat{P}_{it}\right) + \sigma_{it} \ (h)$$

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