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市場集中程度對企業生產力之影響 – 以中國規模以上工業企業為例

Effects of Market Concentration on Firm-Level Productivity – Evidence from Above-Scale Chinese Industrial Firms

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Abstract

This study examines the effects of market concentration on firm-level productivity using data on Chinese above-scale industrial firms from 2001 to 2007. Productivity is identified as total factor productivity (TFP) and estimated using the Olley-Pakes three-step estimation in order to avoid simultaneity and selection biases. Using data on around 590,000 industrial firms, empirical results indicate that the less concentrated the market, the higher the productivity generally. However, a few industries are identified to have opposite direction; that is, the more concentrated, the more productive are the firms. In some industries, there is no significant relationship between market concentration and firm productivity.

Keywords**:** market concentration; firm-level productivity; Olley-Pakes three-step estimation; total factor productivity

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1. Introduction

Since the economic reform initiative in 1978, China's industrial structure has been under vigorous transformation. A considerable amount of effort has been dedicated to introducing the model of market economy into China. Since then, the Chinese economy witnessed a rapid expansion in the private sector and establishments of numerous new firms. This, in turn, results in increase competition in many of the Chinese industries.

Today, China stands as one of the largest economies in the world. Numerous studies has found substantial increase in firm productivity since its economic reforms. From 1992 to 2007, the Chinese industrial growth mounts to as much as 12.6% annually. At the micro-level, Jefferson *et al.* (2008) found that the rapid expansion has contributed much to productivity growth as well. This productivity growth is, however, not universal and varies across industries. Similar to most countries, large productivity dispersion has been ubiquitous in the Chinese industrial sector. This phenomenon poses an interesting question regarding the impact of market structure, specifically, the degree of competition on firm productivity.

It is believed that competition pressures firms to reduce cost, generates incentives to organize production more efficiently, and stimulates innovation. This widespread belief has important implications in countries across the globe and has geared most policy formulations toward a single direction. Theoretical foundations of the benefits of competition is, however, continuously in discussion. On the one hand, it is possible for a firm facing severe competition to utilize its resources in a more efficient manner, thus leading to higher productivity. However, it has been argued that a monopoly has just as much incentive to do the same. On top of that, a monopoly has more resources and a large sum of rent to invest in innovation activities, which lays the groundwork for higher productivity in the future.

Although most people believe that competition has positive impacts on markets, to what extent do the effects of characteristics and structure of markets have on firm performance remains a question. To test these opposing hypotheses, this study is concerned with the impact of competition on performance of firms. More specifically, the present study examines the effects of market concentration on firm's total factor productivity in the Chinese industrial sector from years 2001 to 2007.

The next section briefly introduces different methods used in estimating productivity and delve further into prior approaches in micro-level productivity estimation. In addition, I also review suggested measures of market concentration and their relationships to productivity, examined in other studies. The third section summarizes the estimation methodology used in this study. Section 4 presents the empirical results obtained and Section 5 concludes.

2. Literature Review

This section first briefly reviews prior methodologies in the estimation of productivity. Secondly, the section identifies specific challenges, namely the simultaneity problem and selection bias, in estimating firm-level productivity and introduces a semi-parametric approach proposed by Olley and Pakes (1996) to accommodate these problems. Then, a review of some of the proposed indices in measuring market concentration and their properties are given. Lastly, I look at prior studies and their conclusions on the impact of market concentration on firm productivity.

2.1 Measuring Productivity

Productivity is a measure of efficiency in which inputs convert to output during the production process. In light of the fact that firms might face different factor prices, researchers often use the concept of total factor productivity (henceforth TFP), as single-factor productivity measures are subjected to the influence of the intensity of usage of other factors. Factor-price changes would only be shifts along the isoquant a given level of TFP stands for. Consider a Hicks-neutral production function

$$Y_{it} = A_{it}\, F(K_{it}\, , L_{it}\, , M_{it}) \tag{2.1}$$

where Y_{it} is output, K_{it}, L_{it}, M_{it} are capital stock, labor, and intermediate output. In this formulation, TFP is A_{it}, where it captures output variations not explained by inputs choices. Thus, TFP is often understood as a residual.

While the concept of productivity is relatively easy to comprehend, measurement of productivity poses a greater challenge. Classic productivity estimation starts off from estimating the production function. In view of the numerous ways to estimate production function, methods to estimate productivity varies as well. Del Gatto *et al.* (2008) distinguish between frontier and non-frontier approaches as well as deterministic and econometric methodologies, which is further grouped into parametric and semi-parametric estimations. Another distinction one should keep in mind when estimating productivity is between the different methodologies used when conducting macro and micro studies.

Macro-level studies are mostly concerned with changes in TFP followed from economic growth. This strand of literature began with Solow growth theory in which productivity growth accompanies technological progress. The first deterministic methodology is known as the *growth accounting*, which dates back to Solow (1957). It measures the contribution of factors to growth and computes the rate of technological progress (i.e. Solow residual). *Growth regression* differs from growth accounting in that it uses a parametric approach.

The distinction between frontier and non-frontier approaches lies in the different assumptions made with regard to production efficiencies. Frontier approaches can be applied to both macro and micro studies. They assume that production units do not always produce efficiently, hence productivity growth results from both technological changes and technological efficiency changes. *Data envelopment analysis* (DEA), which dates back to Farrell (1957) and Charnes *et al*. (1978), constructs a feasible or efficient production frontier using observed input-output relations of firms and the concept of distance function. By comparing the distance of a firm's actual input-output relations to the feasible frontier, TFP growth can be decomposed into technological inefficiency and technological progress. *Stochastic frontier analysis (SFA)*, a parametric approach, makes similar assumption as that of DEA, but takes into account the potential deviations from potential output due to random shocks that are beyond the control of firms.

Micro-level studies are interested in scrutinizing firm-level performance. Major challenges in estimating productivity in this realm involve the problems of simultaneity and selection. To individual firms, observed inputs are chosen as a function of factors that are known to the firms, but unobserved by the researcher. As such, the OLS assumptions of no correlation between input demands and unobserved productivity fails to hold and OLS estimation gives inconsistent and biased estimates. This is the classic simultaneity problem first analyzed by Marschak and Andrews (1944). Standard approach to the problem involves using a fixed effect or within estimator to control for simultaneity assuming that firm productivity is constant over time. Under this assumption, standard fixed effect estimation gives consistent estimates of the coefficients. However, this assumption is likely to fail; individual firm productivity is subjected to change over the years, especially during periods of structural changes. To this end, a dynamic model that allows idiosyncratic productivity changes over time is needed.

Next, consider the problem of selection bias caused by firm shutdowns. At the beginning of each period, each firm decides whether to stay in business or exit the market. It continues operation if it expects its future profits to exceed sell-off value. Assuming that a firm's ability to generate future profits is positively related to its capital stock at a given current productivity level, then a firm with larger capital stock is willing to continue operation with lower productivity realizations. Therefore, exit behavior implies that the expected productivity conditional on firm survival is decreasing in capital stock, thus generates negative bias in the capital coefficient. Traditional approach to avoid accounting for this problem involves using a balanced panel data set. But this approach contains deficiencies and produces biased estimates. Olley and Pakes (1996) proposed an algorithm that accommodates for the aforementioned challenges in estimating productivity, a semi-parametric approach that uses data on firm-level investment as a proxy for productivity. Olley and Pakes used this approach to scrutinize the impact of technological advancements and regulatory environment changes on the productivity distribution of American telecommunication equipment market. They found that deregulations is accompanied by increases in productivity growth rate and this growth is primarily a result of capital reallocation toward more efficient firms. Their estimation algorithm produce less implausible estimates of production function coefficients. Built upon this approach, Levinsohn and Petrin (2003) relied on intermediate inputs as the proxy variable for productivity, not investment, because they argued that it is highly probable that firms have zero-investment, which undermines the Olley-Pakes method.

2.2 Measures of Concentration

Market concentration is the size distribution of firms in a particular industry. It plays an important role in determining market power and firm behavior. Economists have long seek to measure this market power and numerous measures have been suggested to do so.

Lerner (1934) proposed using the difference between marginal cost and price divided by price to see the derivation of price from perfectly competitive level. Kaldor (1935) suggested to use cross-elasticities of demand and Rothschild (1942) suggested a measure derived from the angel between the segments of kinked demand curve. Alternative to these theoretical measures, it has been suggested to use the size distribution of firms to measure market power. Hannah and Kay (1977) proposed a list of seven desirable characteristics for concentration measures:

i. Ranking firms in descending order of size, an increase in the cumulative share of the i^{th} firm implies an increase in concentration.
ii. The principle of transfers should hold, that is, an increase of the share of a firm at the expense of a smaller firm should increase the concentration.
iii. Entry of new firms below the average size of incumbent firms should reduce concentration, while the exit of those below the average size should increase concentration.
iv. Concentration should increase as a result of mergers.
v. Consumer random brand-switching should reduce concentration.
vi. If s_j is the share of a new firm, then as a smaller scale of s_j becomes should have smaller effect on the concentration ratio.
vii. Measured concentration should be increase by random factors in the growth of firms.

The most commonly used measures of concentrations included the N-firm concentration ratio, Herfindahl index, Hannah and Kay index, and the entropy index.

The N-firm concentration ratio is defined as the cumulative share of the N^{th} firm. The ratio is given by

$$\mathrm{CR}N = \sum_{i=1}^{N} s_i \tag{2.2}$$

where s_i is the market share of the i^{th} firm. The choice of N is arbitrary and often takes the value between 3 and 8. However, an inappropriate choice of N can lead to failure to satisfy the desired properties above, specifically, the principle of transfer. That is, an increase of the market share of a firm outside the largest N-firms at the expense of a smaller firm has no effect on the concentration ratio. The Herfindahl index, used by Herfindahl (1950), (henceforth H-index), measured as the sum of squared values of firms' market shares, avoids the violation of principle of transfer by including all firms' shares in the index. The H-index fulfills all of the Hannah and Kay axioms. Based on the seven axioms proposed, Hannah and Kay suggested an index calculated as the sum of the firms' shares raised to the power of θ, which measures the extent to which larger firms affect the index. The Hannah-Kay index is given by

$$\mathrm{HK}(\theta) = \left(\sum_{i=1}^{N} s_i^{\theta}\right)^{1/(1-\theta)} \tag{2.3}$$

As such, the H-index is simply the reciprocal of the Hannah-Kay index of $\theta = 2$. There is no guideline as to which values of θ to choose, so a range of values are usually used. Another measure of concentration is the entropy index, given by

$$\mathrm{E} = -\sum_{i}^{N} s_i \log s_i \tag{2.4}$$

If the value of entropy index is large, it implies a low concentration in the industry and vice versa.

2.3 Market Competition and Firm Performance

The theory of industrial organization is concerned with the interactions among firm behavior, market structure, and performance and the relationship between market competition and firm performance has long been the center of interest. Competing theories has been proposed regarding this lane of research. Early thinking in this realm was built upon the structure–conduct–performance paradigm, in which industrial structure is assumed to modulate the conduct of firms involved. Similarly, the X-efficiency hypothesis says that the lack of competition consequently results in slack and other inefficiencies such as opportunistic behavior, which in turn lead to higher costs. Modern theory suggests alternative interpretations. For instance, firms that acquired successful innovation may grow and gain a higher portion of market share, leading to increased industry concentration, as Nickell (1996) pointed out '*high performing companies may, eventually, gain a position of market power'*. In which, welfare losses caused by the lack of competition within highly concentrated market may be compensated by gains due to investment opportunities and economies of scale. A competitive environment is suitable for static resource allocation, but a large firm in a highly concentrated market is the source of output growth. The logic behind is that monopoly rents provide resource for innovation.

Green and Mayes (1991) found that degree of competition is among the most essential variables to explain the dispersion in efficiency. Nickell (1996), using data on British firms, showed that a firm's productivity is enhanced when faced with an increased number of rival firms or when rents decreases. Nickell *et al.* (1997) showed that as the market share of a firm increases, its productivity decreases. Kato (2009) regressed level and growth of output, measured as value added on market competition and corporate governance variables, and found that smaller market share is associated with higher productivity growth. This effect is more prominent in less concentrated markets.

A competing theory with regard to the relationship between concentration and productivity. Gopinath *et al.* (2004) focused on the productivity-industrial concentration relationship in the US manufacturing sector and found that concentration is positively correlated to productivity, with diminishing effects in the overall manufacturing industry. That is, the more concentrated the market, the higher productivity. Tomaskovic-Devey (1988) discussed about the productivity variation among US industries and similar results, that is, more concentrated industries have higher productivity.

3. Methodology

3.1 Olley-Pakes Estimation

To circumvent the simultaneity problem and selection bias engendered in the OLS approach, this study adopts the three-stage estimation proposed by Olley and Pakes. First, assume that each firm has a production function with Cobb-Douglas technology. The capital accumulation and firm's age equations are given by

$$K_{t+1} = (1 - \delta)\, K_t + i_t \quad \text{and} \quad \alpha_{t+1} = \alpha_t + 1 \tag{3.1}$$

where α_t is a firm's age in period *t*, K_t its capital stock, and δ the depreciation rate.

The firm's production function is given by

$$y_{it} = \beta_0 + \beta_\alpha \alpha_{it} + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it} \tag{3.2}$$

where y_{it}, k_{it} , and m_{it} are the logs of firm *i*'s output, capital stock, and intermediate input in year *t*. α_{it} is the age of the firm, ω_{it} its productivity, and η_{it} is measurement error or unexpected productivity shock beyond the firm's control. Both ω *and* η are unobserved, however, the distinction is that the former is a state variable involved in the firm's decision making process, while the latter has no effect on the decision.

At the beginning of each period, each firm decides whether to exit or stay in the market. If it chooses to continue operation, it will decide on a level of variable inputs and investment. On the other hand, if it decides to liquidate, it receives a sell-off value of Φ dollars and never to return to the market again. Assuming that the firm maximizes its expected value of discounted net future cash flows, both exit and investment decisions depend on the firm's expected future productivity in period *t* +1. As such, the firm's exit rule is given by

$$\chi_t = \begin{cases} 1 & \text{if } \omega_t > \underline{\omega}_t(\alpha_t, k_t) \\ 0 & \text{otherwise} \end{cases} \tag{3.3}$$

where $\chi_t = 1$ if the firm continues to operate and $\chi_t = 0$ if it exits the market. $\underline{\omega}_t$ is threshold productivity level in which the firm will continue operation if its expected future productivity is higher than $\underline{\omega}_t$.

Assuming that the firm's input decision making process involves the consideration of its age α, capital stock k, and productivity ω, we obtain the investment demand function

$$i_t = i_t\ (\alpha_t, k_t, \omega_t) \tag{3.4}$$

The first stage of Olley-Pakes estimation aims to eliminate the simultaneity problem. Provided that $i_t > 0$, equation (3.4) is strictly increasing in ω. Thus, under the monotonicity assumption, we can invert equation (3.5) to obtain

$$\omega_t = i_t^{-1}\ (i_t, \alpha_t, k_t) = h_t\ (i_t, \alpha_t, k_t) \tag{3.5}$$

which is strictly increasing in i_{it}.

Substituting equation (3.5) into (3.2) yields

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \emptyset_t\ (i_{it}, \alpha_{it}, k_{it}) + \eta_{it} \tag{3.6}$$

where

$$\emptyset_t\ (i_{it}, \alpha_{it}, k_{it}) = \beta_0 + \beta_\alpha \alpha_{it} + \beta_k k_{it} + h_t\ (i_t, \alpha_t, k_t) \tag{3.7}$$

Suppose that labor and intermediate inputs are the only variable inputs, an OLS estimation on equation (3.6) allows us to identify β_l and β_m, but does not separate the effects of β_α and β_k on output from their effects on investment decisions. We use a third-order polynomial expansion to estimate $\emptyset_t\ (i_{it}, \alpha_{it}, k_{it})$[1].

The selection bias arises from traditional balanced panel approach to account for entry and exit of firms. A firm's exit decision depends on its expected future productivity, which is in part determined by current productivity. Therefore, the use of balanced panel leads to an overestimation of firm productivity. To encounter selection bias and to identify the effects of β_α and β_k, Olley and Pakes use survival probabilities in addition to the estimates of β_l, β_m, and $\emptyset_t\ (\cdot)$ from equation (3.6).

The probabilities are given by

[1] Olley and Pakes (1996) used fourth order polynomial expansion in $\emptyset_t\ (\cdot)$, but found no difference between the third and fourth order approximation. Here, we use the third order approximation.

$$
\begin{aligned}
& Pr\left\{\chi_{t+1} = 1 \mid \underline{\omega}_{t+1}(k_{t+1}, a_{t+1}), J_t\right\} \\
& = Pr\left\{\omega_{t+1} \geq \underline{\omega}_{t+1}(k_{t+1}, a_{t+1}) \mid \underline{\omega}_{t+1}(k_{t+1}, a_{t+1}), \omega_t\right\} \\
& = \wp_t\left\{\underline{\omega}_{t+1}(k_{t+1}, a_{t+1}), \omega_t\right\} \qquad (3.8) \\
& = \wp_t\{i_t, \alpha_t, k_t\} \\
& \equiv P_t
\end{aligned}
$$

where J_t is the information available in period *t*. The fourth row in equation (3.8) follows from (3.5) and (3.1). As such, we can estimate productivity in period *t* + 1 based on productivity in period *t*. A probit estimation gives an estimate of a firm's survival probability P_t.

The third stage estimation takes the estimates from previous stages to obtain the estimates of β_α and β_k by running a nonlinear least squares on the following equation[2]

$$y_{t+1} - \beta_l l_{t+1} = \mathrm{c} + \beta_\alpha \alpha_{t+1} + \beta_k k_{t+1} + \sum_{j=0}^{3-n} \sum_{n=0}^{3} \beta_{nj} \hat{h}_t^n \hat{P}_t^j + e_t \qquad (3.9)$$

where $\hat{h}_t = \hat{\phi}_t - \beta_\alpha \alpha_t + \beta_k k_t$.

Finally, having obtained all the necessary estimates, we can calculate firm-level productivity as

$$p_{it} = \exp(y_{it} - \beta_l l_{it} - \beta_m m_{it} - \beta_\alpha \alpha_{it} - \beta_k k_{it}) \qquad (3.10)$$

3.2 Fixed Effects Model

The Olley-Pakes estimation algorithm allows us to advert the simultaneity problem and selection bias and obtain the estimates of the parameters of a firm's production function. As such we are able to estimate the productivity of the firm. The purpose of this study is to examine the effect of market's structure on the productivities of the firms in the market. Given the nature of the data available, we use the fixed effects model. The model is given by

[2] Again, Olley and Pakes (1996) used fourth order polynomial expansion in (P_t, h_t), but found no difference between the third and fourth order approximation.

$$\ln p_{it} = \beta_0 + \beta_c mktcon_{it} + \beta_a antitst_{it} + \beta_s share_{it} + dT + a_i + \varepsilon_{it} \quad (3.11)$$

where $\ln p_{it}$ is the log of firm productivity, $mktcon_{it}$ are measures of market concentration, $antitst_{it}$ is antitrust index, and $share_{it}$ is the market share. dT is a full set of time dummy variables, a_i is the unobserved time-invariant firm-specific fixed effect, and ε_{it} is error term. The fixed effects model eliminates fixed effects by demeaning the variables using within transformation. This allows us to control for fixed characteristics specific to each firm that affect its productivity. Some examples of such fixed effects include the firm's geographic location and its registration type (state-owned or private).

3.3 Data Description and Variables

The data used in this study is acquired from China's Annual Survey of Industrial Firms conducted by the National Bureau of Statistics. The survey covers data from all State-owned firms and above-scale non-State-owned industrial firms. Firms classified as "Mining and quarrying", "Manufacturing", and "Power, gas, and water production and supply" in the Chinese Industrial Classification (CIC). Above-scale firms refers to those whose main source of annual revenue exceeds five million Chinese dollars, Renminbi (RMB). The survey covers a wide range of data on firms, including output, assets, accounts receivables, debt and liabilities, inputs, employment, and capital stock. This study uses data on two-digit CIC firms from years 2001 to 2007.

Despite the extensive coverage, the database nonetheless contains missing or unreasonable values, mainly due to typographical errors or remissness. Therefore, I exclude records that contain negative or missing values on output, value-added, revenue, employment, intermediate output, and net fixed capital. I also exclude observations that have unreasonable establishment dates and then calculate firm's age by subtracting establishment date from year. Data on investment are not available in the original survey database, therefore, investment is derived from the increment of net capital stock with 5% depreciation rate. To conform to the strict monotonicity assumption between productivity and investment in the Olley-Pakes method, observations with negative or zero investment are omitted. In the Olley-

Pakes estimation, a total of 598,877 observations are used. Table 3.1 lists the variables used in the Olley-Pakes estimation and Table 3.2 gives the descriptive statistics of these variables.

Table 3.1 Variables Description (in OP estimation)

output	output in year *t* (in ten thousands RMB)
labor	employees (in person)
imdte	intermediate output (in ten thousands RMB)
fa_net	net capital stock (in ten thousands RMB)
age	age of firm (in years)
inv	investment (in ten thousands RMB)
exit	= 0 if exit, 1 otherwise

Table 3.2 Summary Statistics (in OP estimation)

Variable	Mean	Standard Deviation	Minimum	Maximum
output	115,357.3	967,135.5	0	153,714,768
labor	346.43	1,698.41	0	156,965
imdte	76,930.11	616,548	0	101,687,576
fa_net	51,806.7	720,929	0.7839448	122,929,832
age	11.111929	11.97185	1	403
inv	12,104.89	201,716.3	0.0022047	60,409,972
exit	0.1963625	0.3972462	0	1
Number of observations = 598,877				

After obtaining the firm-level productivity estimates, I regress the log of productivity estimates on each of the concentration measures together with a few control variables to examine the effects of market concentration on firm-level productivity.

Concentration Measures

In this study, I use four different measures of market concentration, namely the *N*-firm concentration ratio, the Herfindahl index, the Hannah-Kay index, and the entropy index.

For the *N*-firm concentration ratio, I use the most commonly used 4-firm concentration ratio, in which the market shares of the four largest firms in each market are summed. The Herfindahl index is the sum of squared market share of each firm in the market. The advantage of the H-index is that it weights all the firms in the market. A more generalized form of the H-index is the Hannah-Kay index. I use four different values for θ, namely 0.5, 1.5, 2.0, and 2.5. The larger θ is, the more weight is given to the larger firms.

Control Variables

Regulation. The extent to how the market is regulated can have significant impact on the market as well as individual firms. Poorly regulated markets can distort the market and reduce firm productivity. On the other hand, deregulation can reverse such effects. To take into account the regulatory impacts on the markets, I include antitrust index, ranging between 0 and 1, constructed from antitrust cases in each province.

Market share. The relative position of a firm in a market might have an impact on its productivity. A firm with a smaller share might be pressured to allocate its resources in the most efficient manner possible to compete with other firm, thus having a higher productivity. To control for this effect, I also include market share as a control variable.

Table 3.3 lists all the variables used in the fixed effects model and Table 3.4 gives the summary statistics on these variables. It is shown in the summary statistics that productivity estimates have very large standard deviations, which indicate a large difference in productivity levels across firms, a phenomenon documented by numerous studies. The measures of concentration also show large variations, indicating the divergence between industries.

Table 3.3 Variables Description (in fixed effects model)

p	Productivity estimates
cr4	4 - firm concentration ratio
h-idx	Herfindahl index
hk(0.5)	Hannah - Kay index with $\theta = 0.5$
hk(1.5)	Hannah - Kay index with $\theta = 1.5$
hk(2.0)	Hannah - Kay index with $\theta = 2.0$
hk(2.5)	Hannah - Kay index with $\theta = 2.5$
etpyt	Entropy index
share	Market share
antitst	Antitrust index

Table 3.3 Summary Statistics (in fixed effects model)

Variable	Mean	Standard Deviation	Minimum	Maximum
p	8.828635	905.0855	1.02075	488337.3
cr4	0.0709251	0.0434811	0.0138061	0.9676757
h_idx	0.0035205	0.0063199	0.0003362	1
hk(0.5)	5453.411	3659.645	1	14839.74
hk(1.5)	1241.265	1005.992	1	4840.577
hk(2.0)	637.3776	578.4807	1	2974.155
hk(2.5)	393.4152	373.5297	1	1980.939
etpy	7.555478	0.9184376	0	9.003411
share	0.0002516	0.0025997	0	1
antitst	0.1264033	0.0501926	0.0314282	0.2188847

Number of observations = 598,877

4. Empirical Analysis

4.1 Productivity Estimation

In conducting Olley-Pakes estimation, labor is the only variable input. Intermediate input, capital stock, and age are state variables. The results of the three-step estimation are provided in Table 4.1. Column 1 shows the coefficient estimates using the Olley-Pakes method and Column 2 shows the OLS results for comparison. As previously mentioned, OLS estimates are likely to generate upwardly biased estimates of the input coefficients, namely labor and intermediate inputs. On the other hand, OLS approach produces negative bias in the capital coefficient. These biases are evident when comparing results from the two columns. The Olley-Pakes method amends these biases and gives lower labor coefficient estimate and higher capital stock coefficient estimate. Notably, the marginal contribution of intermediate inputs are comparably higher in both estimation. As shown in the table, labor, capital, and intermediate inputs each account for 6.5%, 7.0%, and 84.7% of total output.

Table 4.1 OP Estimation Results, Dependent Variable: ln(*output*)

	(1) Olley-Pakes	(2) OLS
ln (*labor*)	0.0653486*** (0.0012231)	0.0679424*** (0.0010702)
ln (*imdte*)	0.8471021*** (0.002114)	0.8543051*** (0.0018404)
ln (*fa_net*)	0.0697418*** (0.0020095)	0.0548271*** (0.000741)
age	- 0.0006506*** (0.0001365)	-0.0024793*** (0.0000607)
Observations	598,877	598,877
R^2		0.9380

p < 0.10 * p < 0.05** p < 0.01***

Table 4.2 gives the productivity estimates for each of the 37 industries from 2001 to 2007. For the lack of valid observations, I excluded two industries from the analysis, namely, (11) other mining and quarrying and (43) waste resources and materials recovering.

In general, average productivity increases with the passing of time, but fluctuates with in a vigorous manner. At the industry-level, some industries demonstrate constant steady growth and others fluctuates. For instance, average productivities of (25) petroleum processing industry in 2005 and 2006 are tremendously higher than in the previous years. The same can be observed in (44) power, heat production and supply in 2006 and (15) manufacturing of beverage. Other industries demonstrates fluctuations to the lesser extreme. The dispersion of average productivity across and within industries is case-specific. These differences could be results of characteristics and government policies specific to each industry. A thorough analysis of each industry and investigation of the idiosyncratic differences is beyond the scope of this study.

Table 4.2 Average Productivity Estimates from 2001 to 2007, by industry

CIC	Industry	2001	2002	2003	2004	2005	2006	2007
Mining and quarrying								
06	Mining of coal and lignite	2.5830	2.5304	2.7352	3.2594	3.7613	4.3073	4.3978
07	Extraction of crude petroleum and natural gas	3.4763	3.5303	3.8384	5.1532	5.0143	5.4537	5.2118
08	Mining of ferrous metals	2.5014	5.6920	2.7666	3.3676	3.2575	4.1984	3.5637
09	Mining of nonferrous metals	2.3882	2.4575	2.6597	3.1414	3.2418	3.5019	3.7369
10	Other Non-metal ores mining	2.4984	2.6572	2.6436	2.9208	2.9917	3.2691	3.3121
Manufacturing								
13	Processing of foods	3.0538	2.8520	2.9238	3.1372	3.5389	11.6451	4.2950
14	Food	3.1684	2.5263	2.5777	2.6448	2.8395	3.7355	7.6337
15	Beverage	2.5811	2.4749	6.2935	2.8113	2.7788	3.8524	3.3380
16	Tobacco products	3.2298	3.3808	3.7158	5.0485	3.9634	4.1169	4.1446
17	Textiles	2.4405	2.4898	2.5202	2.5146	2.8721	4.8049	3.4263
18	Apparel, footwear, and caps	2.9491	3.0160	2.6515	5.3652	3.7047	3.4518	3.5001
19	Leather	3.2509	2.4871	2.5058	3.1980	2.8239	3.6149	3.1961
20	Timber processing	2.8707	2.9303	3.2432	3.5899	4.5577	7.4395	7.2899
21	Furniture	2.4678	2.6550	2.7999	2.9586	3.6118	5.4575	6.2603
22	Papermaking	2.3866	2.5148	5.2203	3.3973	4.9549	5.5510	4.0900
23	Print, reproduction of media	2.7107	2.6510	2.7425	3.2217	3.5197	3.6773	4.8401
24	Articles for culture, education, and sports	4.2468	2.7166	2.8528	5.7584	3.4172	3.5000	3.9088

25	Petroleum processing	1.7854	1.6899	1.8915	2.0687	7.4539	6.1341	1.9819
26	Raw chemical	2.6623	3.4394	9.4198	2.8511	3.6064	8.3143	3.1272
27	Medical	2.6752	2.7978	2.8063	2.6832	5.3718	7.8190	3.5623
28	Chemical fibers	2.3797	2.6084	2.6409	2.5173	2.6553	2.7143	2.8077
29	Rubber	2.4707	2.5735	2.7036	4.9340	2.7004	4.1630	6.6989
30	Plastics	2.5425	2.6658	6.2358	3.5232	4.1275	4.0726	3.5141
31	Nonmetallic mineral	2.8929	3.9642	5.5281	5.5143	4.8185	9.5386	6.4467
32	Pressing of ferrous metals	2.4061	2.6045	6.2295	2.6018	2.7339	2.4602	3.0167
33	Pressing of nonferrous metals	2.4266	3.0202	2.5317	2.7777	2.7119	2.6810	9.9111
34	Metal products	2.7860	2.7219	2.4577	3.1258	4.1677	4.0150	3.5268
35	General purpose machinery	2.5402	3.4587	2.9113	3.1030	3.8175	6.0208	13.6411
36	Special purpose machinery	2.5542	2.7098	3.1771	3.4905	6.9619	7.0597	4.4191
37	Transport equipment	2.5591	2.7141	2.9819	2.9393	4.0570	4.0066	3.1692
39	Electrical machinery and equipment	2.4603	2.6650	7.5540	3.8238	5.9112	8.7921	5.4710
40	Computers and other	6.0827	9.9131	5.4114	6.4156	6.3527	9.7088	13.4504
41	Instruments	2.8501	2.8947	3.3456	3.7938	9.0744	6.7627	9.1625
42	Handicraft article and other manufacturing	2.7221	2.8343	3.0278	4.0462	4.2502	3.7093	3.9041
Power, gas, and water production and supply								
44	Power, heat production and supply	3.0795	3.0228	2.9263	3.7058	5.6464	9.2324	6.4322
45	Gas production and supply	2.4452	2.3887	2.4215	5.7584	2.9693	6.3193	3.5634
46	Water production and supply	2.5488	2.4859	2.5317	3.2888	2.9680	3.1163	3.0830

4.2 Effects of Concentration on Productivity

To investigate the relationship between market concentration and firm productivity, I regress the log of productivity estimates on each of the concentration indicators, antitrust index, market share, and a full set of time dummies. The results are summarized in Table 4.3. The empirical results show that market concentration has a negative relationship to firm productivity in most of the two-digit CIC industries. For instance, in the (14) food manufacturing industry, it is shown that as the CR4 concentration increases by 0.1 point, productivity decreases by 62.3%. Other measures of concentrations demonstrate the same direction. In manufacturing of (40) computers and other, a 0.1 unit increase in CR4 ratios is associated with 42.4% decrease in productivity. This relationship between concentration and productivity is unanimous to Nickell (1996) and many of the past findings.

On the other hand, the results show that the manufacturing of (16) tobacco products, (32) pressing of ferrous metals, and (44) power, heat production and supply industries have the opposite direction. In the manufacturing of tobacco products, a 0.1 unit increase in the CR4 concentration ratio is associated 13.5% increase in productivity. Other measures of concentration indicate the same relationship. Productivity of the pressing of ferrous metals industry also increases as concentration increases, but at a lesser magnitude compared to tobacco production. For instance, a 0.1 unit increase in the CR4 concentration ratio in pressing of ferrous metals industry is associated to 4.6% increases in productivity. The third industry that demonstrates a statistically positive relationship is the industry of power, heat production and supply. A 0.1 unit increase in CR4 ratio increases productivity by 12.5 %, nearly as much as the tobacco products manufacturing. Manufacturing in (39) electrical machinery and equipment and (25) petroleum processing industries also possess positive concentration coefficients, but they are statistically insignificant.

In some of the industries, different concentrations measures show different direction of effects on productivity. These industries are manufacturing of (17) textiles, (18) apparel, footwear, and caps, (22) papermaking, and (30) plastics, (33) pressing of nonferrous metals, manufacturing of (34) metal products, and (46) water production and supply. In the manufacturing of textiles, all the measures indicate a positive effect of concentration on productivity except for *hk(0.5)* and the entropy index, which show the opposite. Both the manufacturing of plastics and of apparel, footwear, and caps have their CR4 ratios indicating statistically significant positive impact on productivity but the remaining measures saying otherwise. In the papermaking industry, *hk(0.5)*, *hk(1.5)*, and entropy index indicate negative relationship, whereas the rest show the opposite. Changing directions of concentration measures can also be observed in a few other industries. The reason as to why these measures changes signs is ambiguous.

In brief, concentration is associated to lower firm productivity, as shown in most of the industries. However, this is not conclusive. In some industries, the coefficients demonstrate opposite direction. In a few cases, the results show changing signs of the coefficients of concentration measures. Lastly, in two of the industries, there is no significant relationship between concentration and frim productivity. The antitrust index coefficients unanimously indicate a negative relationship, suggesting the less regulated a market, the higher the firm-productivity. The market share coefficients, on the other hand, generally show positive correlation to productivity.

Table 4.3 Fixed Effects Estimates, Dependent Variable: ln(*P*)

Industry		Concentration Measures						
		cr4	*h-index*	*hk(0.5)*	*hk(1.5)*	*hk(2)*	*hk(2.5)*	*etpy*
06	Mining of coal and lignite	-5.79758*** (0.22946)	-46.00405*** (1.82078)	0.00019*** (7.36e-06)	0.00244*** (0.00010)	0.00458*** (0.00018)	0.00638*** (0.00025)	0.29292*** (0.01159)
07	Extraction of crude petroleum and natural gas	-3.24708*** (0.36737)	-6.92272*** (0.78323)	0.02510*** (0.00284)	0.07826*** (0.00885)	0.10240*** (0.01159)	0.12579*** (0.01423)	0.83985*** (0.09501)
08	Mining of ferrous metals	-2.77758*** (0.23779)	-31.35100*** (2.68393)	0.00026*** (0.00002)	0.00065*** (0.00006)	0.00095*** (0.00008)	0.00128*** (0.00011)	0.19695*** (0.01686)
09	Mining of nonferrous metals	-12.34801*** (0.95888)	-48.10889*** (3.73586)	0.00039*** (0.00003)	0.00218*** (0.00017)	0.00568*** (0.00044)	0.01132*** (0.00088)	0.25383*** (0.01971)
10	Other Non-metal ores mining	-7.06996*** (1.22505)	-112.7152*** (19.53078)	0.00026*** (0.00005)	0.00071*** (0.00012)	0.00114*** (0.00020)	0.00165*** (0.00029)	0.31490*** (0.05456)
13	Processing of foods	-6.94723*** (0.75995)	-163.8644*** (17.92489)	0.00002*** (2.21e-06)	0.00010*** (0.00001)	0.00022*** (0.00002)	0.00039*** (0.00004)	0.13969*** (0.01528)
14	Food	-6.23601*** (1.32729)	-53.76752*** (11.44405)	0.00004*** (9.05e-06)	0.00023*** (0.00005)	0.00048*** (0.00010)	0.00080*** (0.00017)	0.11057*** (0.02354)
15	Beverage	-3.67478*** (0.76831)	-62.63346*** (13.09521)	0.00010*** (0.00002)	0.00061*** (0.00013)	0.00190*** (0.00040)	0.00671*** (0.00140)	0.17459*** (0.03650)
16	Tobacco products	1.35397*** (0.31855)	6.56994*** (1.54571)	-0.00196*** (0.00046)	-0.00484*** (0.00114)	-0.00667*** (0.00157)	-0.00868*** (0.00204)	-0.16764*** (0.03944)
17	Textiles	4.18067*** (0.21350)	101.8656*** (5.20202)	0.00001*** (7.15e-07)	-0.00096*** (0.00005)	-0.00015*** (7.71e-06)	-0.00019*** (9.69e-06)	0.18418*** (0.00941)
18	Apparel, footwear, and caps	98.76400*** (8.24096)	-862.3421*** (71.95463)	0.00004*** (3.14e-06)	0.00026*** (0.00002)	0.00122*** (0.00010)	0.00510*** (0.00043)	0.28517*** (0.02380)
19	Leather	-5.55691*** (0.68134)	-88.69215*** (10.87469)	0.00006*** (6.70e-06)	0.00017*** (0.00002)	0.00031*** (0.00004)	0.00052*** (0.00006)	0.15201*** (0.01864)

p < 0.10 * p < 0.05** p < 0.01***

20	Timber processing	-22.0820*** (0.86972)	-229.0787*** (9.02242)	0.00018*** (6.90e-06)	0.00070*** (0.00003)	0.00203*** (0.00008)	0.00554*** (0.00022)	0.41596*** (0.01638)
21	Furniture	-17.24227*** (1.27001)	-206.4159*** (15.2039)	0.00027*** (0.00002)	0.00068*** (0.00005)	0.00105*** (0.00008)	0.0015***1 (0.00011)	0.41455*** (0.03053)
22	Papermaking	22.60935*** (1.09697)	746.6565*** (36.2265)	0.00017*** (8.35e-06)	0.02058*** (0.00100)	-0.00734*** (0.00036)	-0.00958*** (0.00047)	0.95445*** (0.04631)
23	Print, reproduction of media	-13.19752*** (0.74334)	-181.2116*** (10.20661)	0.00022*** (0.00001)	0.00051*** (0.00003)	0.00079*** (0.00004)	0.00113*** (0.00006)	0.41829*** (0.02356)
24	Articles for culture, education, and sports	-17.92075*** (1.00745)	-225.7195*** (12.68922)	0.00023*** (0.00001)	0.00071*** (0.00004)	0.00125*** (0.00007)	0.00202*** (0.00011)	0.40906*** (0.02300)
25	Petroleum processing	0.60761 (0.50494)	2.70423 (2.24732)	-0.00245 (0.00203)	-0.00452 (0.00375)	-0.00648 (0.00538)	-0.00859 (0.00714)	-0.14413 (0.11977)
26	Raw chemical	-3.40226*** (0.27150)	-77.12593*** (6.15460)	0.00002*** (1.62e-06)	0.00018*** (0.00001)	0.00042*** (0.00003)	0.00074*** (0.00006)	0.16311*** (0.01302)
27	Medical	-12.3250*** (1.52631)	-159.0348*** (19.69462)	0.00012*** (0.00001)	0.00053*** (0.00007)	0.00109*** (0.00014)	0.00196*** (0.00024)	0.29202*** (0.03616)
28	Chemical fibers	-2.19364*** (0.59238)	-15.74215*** (4.25104)	0.00027*** (0.00007)	0.00229*** (0.00062)	0.00308*** (0.00083)	0.00348*** (0.00094)	0.19279*** (0.05206)
29	Rubber	-86.98361*** (12.45466)	-147.7932*** (21.16163)	0.00019*** (0.00003)	0.00294*** (0.00042)	0.00962*** (0.00138)	0.02442*** (0.00350)	0.31079*** (0.04450)
30	Plastics	312.7444*** (11.92886)	-530.9378*** (20.2513)	0.00005*** (1.92e-06)	0.00019*** (7.38e-06)	0.00046*** (0.00002)	0.00107*** (0.00004)	0.31404*** (0.01198)
31	Nonmetallic mineral	-16.81799*** (0.34878)	-742.7793*** (15.4039)	0.00005*** (1.12e-06)	0.00014*** (2.86e-06)	0.00019*** (3.88e-06)	0.00024*** (5.00e-06)	0.56318*** (0.01168)
32	Pressing of ferrous metals	0.45878*** (0.14899)	4.50197** (1.46197)	-0.00004** (0.00001)	-0.00032** (0.00011)	-0.00054** (0.00018)	-0.00076** (0.00025)	-0.04366** (0.01418)
33	Pressing of nonferrous metals	0.93072 (0.58723)	-27.80923 (17.54636)	0.00002 (0.00001)	0.00023 (0.00015)	0.00106 (0.00067)	-0.00762 (0.00481)	0.03521 (0.02221)

$p < 0.10$ * $p < 0.05$** $p < 0.01$***

34	Metal products	9.36967** (3.27464)	-410.6136** (143.507)	0.00002** (5.05e-06)	0.00008** (0.00003)	0.00032** (0.00011)	-0.01128** (0.00394)	0.10913** (0.03814)
35	General purpose machinery	-25.45184*** (0.74589)	-425.4066*** (12.46689)	0.00003*** (8.69e-07)	0.00024*** (7.16e-06)	0.00078*** (0.00002)	0.00177*** (0.00005)	0.28473*** (0.00834)
36	Special purpose machinery	-159.1132*** (5.75168)	-764.7326*** (27.64382)	0.00009*** (3.17e-06)	0.00093*** (0.00003)	0.00302*** (0.00011)	0.00515*** (0.00017)	0.50323*** (0.01819)
37	Transport equipment	-1.32237*** (0.09015)	-16.58987*** (1.13099)	0.00006*** (3.74e-06)	0.00067*** (0.00005)	0.00124*** (0.00008)	0.00180*** (0.00012)	0.17009*** (0.01160)
39	Electrical machinery and equipment	0.12881 (0.27975)	1.82204 (3.95726)	-1.90e-06 (4.13e-06)	-0.00001 (0.00003)	-0.00003 (0.00007)	-0.00006 (0.00013)	-0.00876 (0.01903)
40	Computers and other	-4.24026*** (0.55081)	-34.30931*** (4.45680)	0.00007*** (8.45e-06)	0.00064*** (0.00008)	0.00128*** (0.00017)	0.00204*** (0.00026)	0.15577*** (0.02023)
41	Instruments	-3.25967*** (0.34854)	-42.3581*** (4.52913)	0.00023*** (0.00002)	0.00144*** (0.00015)	0.00239*** (0.00026)	0.00327*** (0.00035)	0.34754*** (0.03716)
42	Handicraft article and other manufacturing	-6.32411*** (0.40593)	-145.4385*** (9.33532)	0.00016*** (9.99e-06)	0.00051*** (0.00003)	0.00077*** (0.00005)	0.00108*** (0.00007)	0.45719*** (0.02935)
44	Power, heat production and supply	1.24546*** (0.14909)	13.46381*** (1.61171)	-0.00179*** (0.00021)	-0.00047*** (0.00006)	-0.00079*** (0.00010)	-0.00131*** (0.00016)	-0.20957*** (0.02509)
45	Gas production and supply	-2.62954** (0.79592)	-15.7277** (4.76051)	0.00136** (0.00041)	0.00409** (0.00124)	0.00588** (0.00178)	0.00779** (0.00236)	0.28739* (0.08699)
46	Water production and supply	8.46229*** (0.95966)	-1260.201*** (142.9115)	-0.00203*** (0.00023)	0.00794*** (0.00090)	0.07532*** (0.00854)	-0.03287*** (0.00373)	1.80608*** (0.20482)

$p < 0.10$ * $p < 0.05$** $p < 0.01$***

5. Conclusion and Recommendations

Market structure has been identified to be one of the most essential factors to affect the performance of the firms in the industry. Following the economic reforms in China, initiated in 1978, establishments of numerous new firms prevailed the Chinese industrial sector. The vigorous transformation of the industrial market structures brought about increased competition, which is believed to improve firm-level productivity. The issue concerned here is the effects of market competition, measured by the concentration ratios, on firm-level productivity.

To obtain unbiased estimates of firm-level productivity, Olley-Pakes three-step estimation was used to circumvent the simultaneity and selection biases engendered in the OLS approach. The results of the average productivity estimates show idiosyncratic differences and in some industries, fluctuate severely. This phenomenon is a result of heterogeneity of characteristics of industries and policy adoption.

Whether competition is beneficial to firm productivity has continuously been in discussion. Evidence on both hypotheses have been found. This study examines the effects of market concentration on firm-level productivity using data on the Chinese industrial sector from 2001 to 2007. The results show that in most industries, the higher the concentration of the market, the lower the firms' productivities. However, positive relationships between concentration and productivity are also observed in a few industries. This is true in manufacturing of tobacco products, pressing of ferrous metals, and power, heat production and supply industries. The same relationship is observed in manufacturing of electrical machinery and equipment and petroleum processing, but coefficients are statistically insignificant, thus no conclusion could be drawn between concentration and productivity in these industries. In general, evidence show that competition or lower concentration is associated with higher firm-productivity. Nonetheless, one must be cautious to articulate this for all industries, as it is not necessarily true in some.

Due to the limitation of data available at hand, other variables that might affect firm productivity are not included here. Some of these variables are identified by Syverson (2011) and various other studies. In addition, further research and study could be conducted to investigate the factors that caused the heterogeneity in industry productivities. This might require industry-specific investigation as properties and policies vary across industries.

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