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Quantitative Analysis on Competition and Productivity[*]

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Abstract

This paper examines the empirical relationship between market competition and corporate productivity using around 2,400 Japanese companies' data. In this analysis, the Share Fluctuation Index (SFI), which is the original index of the Competition Policy Research Center (CPRC) of the Japan Fair Trade Commission (JFTC), and the Herfindahl-Hirschmann Index (HHI) are used as the market competitive indices, and Total Factor Productivity (TFP) is used as the corporate productivity index. Using SFI and HHI as competing indices, our result shows that market competition makes the TFP of the firms increase.

In this research, there are two Japanese data sources, the "Survey of Concentration Ratio on Production and Shipment" in the JFTC, and the "Basic Survey of Japanese Business Structure and Activities" in the Ministry of Economy, Trade and Industry (METI). The former consists of a 6-digit commodity unit monitored by the JFTC and we can calculate the competition indices using these data. The latter consists of a company unit and we can calculate the TFP. Connecting these data sources can help in estimating these relationships.

Through additional analysis, the results show that market competition increases the TFP of small firms more than that of large firms. Furthermore, the results suggest that market competition makes the TFP of firms with high R&D costs increase, and that corporate governance of the firm without a parent firm affects the relationship between the market competition and the TFP.

Key Words: competition, TFP, HHI, SFI, corporate governance, system GMM
JEL Classification Number: C23, D43, K21, L11, L13, O31 and O47

1. Introduction

The Japanese Antimonopoly Act aims to promote free and fair competition, to stimulate the creative initiative of entrepreneurs, to encourage business activities of enterprises, to heighten the level of employment and peoples' real income, and thereby to promote the democratic and wholesome development of the national economy as well as to assure the interests of consumers in general[1]. Previously, the concentration ratio and the profit rate of industries or firms were mainly used to analyze the judgment of free and fair competition and the relationship between competition and economic growth. These researches are based on the view that market control power increases with market concentration so that certain monopolistic profits rise. In many of those early researches, market competition was measured by the profit rate of a firm or the degree of concentration of an industry. This idea stands on the implicit assumption that continuation of static market competition reduces the slack of firms so that dynamic efficiency, such as economic growth, is improved. However, this assumption may be denied by the Schumpeter hypothesis that economic growth that is the result of innovation needs monopolistic profits. As described above, it is worthwhile to analyze the relationship between competition and productivity to provide the foundation for competitive policy.

In this paper, we examined the empirical relationship between the static and dynamic competitive indices and productivity. The investigations presented in this paper indicate that competition improves corporate productivity. We used the Herfindahl Hirschmann Index (HHI) as the static competition index and the Share Fluctuation Index (SFI) as the dynamic index. In addition, the total factor productivity (TFP) used in this paper is the important component for the potential economic growth in the supply side, and is an especially important index that influences the future growth of the Japanese economy that has been decreasing in population because of fewer children. Therefore, it is very important to analyze the influence on TFP from the promotion of competition when the original purpose of competition policy is verified.

The composition of this paper is as follows; first, we describe the theoretical background concerning market competition and productivity, and the precedence research. In Section 3 we explain the data source and competitive indices used in this paper. In Section 4 we show the empirical analysis result from using this data. Finally, as a conclusion, the analysis result for the main subject is summarized and a future research task is described.

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[1] Act Concerning Prohibition of Private Monopolization and Maintenance of Fair Trade Chapter 1 Sec.1 (Tentative Translation)

2. Theoretical Background and Early Study

Total factor productivity is defined as a neutral technical progress other than the production injection of labor and capital, among others, which increase the added value in the economic activity. Therefore, it is innovation for new product development, a new production system, etc. that drives the total factor productivity. Moreover, total factor productivity is caused by the technical spill-over effect. This is because innovation is made more efficient not only by the self-development, but also by using the fruits of others' work, such as the licensing of another company, informal information exchange, and others. The classic economic growth theory defines the technical progress, i.e. the growth of total factor productivity, which causes economic growth, as exogenous. However, the endogenous economic growth theory, which treats this as an endogenous variable, incorporates the spill-over effect of technology into an economic growth model.

Thus, an analysis of the total factor productivity cannot disregard the innovation activity of a company, but another factor is considered here. In particular, it is the concept that market competition activity eliminates the inefficiencies in the company organization typified by X inefficiency and contributes to an increase in productivity. The inefficiencies in an organization can be analyzed based on a contract theory, and Vickers (1995) theoretically surveyed the relation between the inefficiencies and market competition. The following paragraph simply reviews the relation between the inefficiency in company organization and market competition based on Vickers (1995) theory.

(1) Base Model

First, the inefficiency inside a company can be formulated as a Principal-Agent problem in contract theory. Here, the typical model for the Principal (stockholder) and Agent (manager) of a company is shown below.

The incentive scheme of A: w= $\alpha + \beta$ x

x is the performance of A: x= e + a + ε

In these expressions, “w” is the wage, “e” is the efforts level of A, “a” is the ability of A, and ε is the sum of the indefinite elements, such as economic trend. However, it is assumed that the cost corresponding to performance x of A is $\frac{1}{2}e^2$.

If both Principal P and Agent A are risk-neutral, then

Wage of A: $\max_e \left\{(\alpha + \beta(e + a + \varepsilon)) - \frac{1}{2}e^2\right\} \longrightarrow \quad e^* = \beta$.

Benefit of P: $E(\beta + a + \varepsilon) - (\alpha + \beta(e + a + \varepsilon))$.

Social Welfare (sum of the wage and the benefit):

$$\max_{\beta} E(\beta + a + \varepsilon) - \tfrac{1}{2}\beta^2 \longrightarrow \quad \beta = 1 .$$

In this way the first-best solution is obtained and Social Welfare comes out to a+1/2.

However, if A is risk-averse and the risk aversion is r(r>0), the utility function u(w) =-exp (-rw), and Social Welfare is the following taking into consideration $\tfrac{1}{2}\beta^2 rv$, which is the cost by ε (where, e-N (0, v)),

Social Welfare: $\max_{\beta} E(\beta + a + \varepsilon) - \tfrac{1}{2}\beta^2 - \tfrac{1}{2}\beta^2 rv$.

In this case, $\beta = \frac{1}{1+rv}$, so that the Social Welfare falls short of its first-best level. This Social Welfare loss is $\frac{1}{2}\frac{rv}{1+rv}$.

(2) Market Competition Effect

Competition between two agents in the same market can reduce the Welfare Loss of the Base Model. Here, the performances of two agents are assumed below.

Agent A1: x1= e1 + a1 + ε 1 and

Agent A2: x2= e2 + a2 + ε 2,

where corr(a1 + ε 1, a2 + ε 2)= κ >0.

In this case, we have the assumption below.

The incentive scheme of A1: w1= α + β (x1- κ x2).

In this scheme A1 is compared with the performance of A2 so that A1 takes more effort.

Instead of the variance of x in the base model, the Social Welfare Loss of this model is calculated by the variance of (x1- κ x2). This Social Welfare loss is $\frac{1}{2}\frac{rv(1-\kappa^2)}{1+rv(1-\kappa^2)}$. This expression shows that a smaller variance κ makes the Social Welfare Loss smaller and that if κ equals 1, the Social Welfare Loss equals zero, so the first-best solution is obtained.

As a result, when a competitor is in the market, the uncertainty in the wage of the agent becomes small and the agent makes his effort which is near to first-best level.

(3) More Complex Models

Although previous models are one-shot games, Vickers (1995) also analyzes the reputation and ratchet effects on a repeated game. Some of the analysis results are as follows.

1. When the reputation of a past performance is built in the incentive scheme of an agent, the S/N ratio of the variable for the evaluation reduces, the efforts level of the agent increases, and the Social Welfare Loss reduces.

2. The Market Competition Effect described in part (2) in this section doesn't bring the same result in a repeated game. This is because the agent can make a less effort when he is freely riding on the effort of a competitor.

3. When the reputation of a past performance is built in the incentive scheme of an agent in a repeated game, the ratchet effect can reduce the effort of this term to increase the wage of the next term.

Although these arguments are comparatively simple theoretic models, more various theoretical models, which added another precondition, are analyzed. For example, Scharfstein (1988) showed that an increasing number of companies in the market doesn't necessarily improve the performance of a company. Therefore, when the competition effect is analyzed using a theoretical model, it is necessary to clarify the preconditions and to reflect it in the detailed model.

(4) Empirical Early Study

As mentioned above, theoretical models of the market competition and the performance of a company are developed and these econometrical models are also empirically analyzed. Nickell (1996) presented a serious empirical study using the data from the firm level. He estimated the production function, including the markup percentage of the company level and the market competitive indices, such as the degree of concentration, to analyze the market competition and productivity. Nickell (1996) is grounded in the ideas that market competition settles the holdup problem between a principal and an agent. The result of econometric analysis shows that market competition has a positive influence on the growing rate of the TFP of a firm.

Nickell et al. (1997) added an analysis of the influence of the corporate governance from a debtor or a major external stockholder to this research. Not only the market competition but also the clutch of bankruptcy and monitoring of a major external stockholder add pressure to the productivity of a company. The main result from Nickell et al. (1997) is that when a company gets full pressure from corporate governance, market competition has a weaker influence on the productivity of a company. That is to say, market competition encourages management effort and raises the productivity of a company.

3. Data Source and Competition Index

(1) Data Source

To construct the new data set, we used the market share in Japan from the "National Survey of Concentration Ration on Production and Shipment"[2] as a data source. Using the dates on the market share, we calculated competitive indices for each market level. However, since diversified firms deal on many markets, we need to calculate the competitive indices in each firm level. Therefore, we calculated the competitive indices in each firm level using a weighted average with the sales of each market and the competitive indices in each market level. For another source of data, we used the "Basic Survey of Japanese Business Structure and Activities"[3]. We collected data on the variable in each firm level using this data source. After calculating the indices, we matched the variables from both data sources in each firm level. We can use about 1,500 firms' unbalanced panel data from 1994 to 2001.

(2) Competitive Index

Various competition measures have been put forward in literature. The conventionally used measures are the price-cost margin, the concentration ratio, the market share, and the Herfindahl Hirschmann Index (HHI). They are indirect indices derived from Structure Conduct Performance (SCP) paradigm. Additionally, they were static indices at that time. In this research, we selected HHI because it consists of the two elements of the number of firms and the variance of the market share and is used most widely as the degree of concentration.

As compared with these static indices, some dynamic measures of competition, which are calculated directly at the multiple points of time, are developed. For example, Joskow (1960) proposed the rank correlation coefficient. Hymer and Pashingian (1962) proposed an index that summed the absolute value of the market share's changes. Caves and Porter (1978) and Sakakibara and Porter (2001) defined a smaller index of market share's changes. On the other hand, Bain (1970), Mueller and Hamm (1974),

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[2] This survey is published biennially by the Japan Fare Trade Commission (JFTC). JFTC collects data on the production and shipment of about 350 goods and services to calculate the market shares, and we monitor the oligopoly markets. We can use the market data for 6-digit industries in Japan from 1975.

[3] This survey is published annually by the Ministry of Economy, Trade and Industry (METI). METI collects the data from firms the METI collects the data on from all firms who have more than 50 employees and whose capital is more than 30 million yen in Japan from 1994 annually. There are about 25,000 firms.

and many other studies used changes in the concentration ratio. According to Davies and Geroski (1997), however, changes in concentration conceal much of the nature of the underlying competitive processes.

We developed a new dynamic competitive index, the Share Fluctuation Index (SFI). This index is the average of the sum of the square of the difference of market shares. The SFI for a five-year period is calculated as follows.

$$SFI_{it} = \frac{\sum_{s=t-4}^{t-1} \sum_{j=1}^{n} (share_{is+1}^{j} - share_{is}^{j})^2}{4}$$

In this expression, the share is the market share, “i” is the market subscript, “s” and “t” are the time subscripts, “j” is the firm subscript, and “n” is the number of firms in the market. When SFI is calculated for too short a period, it can move largely by the impact at a certain period. However, when it is calculated for too long a period, the competition of past periods affects the SFI more than necessary. In this paper, we calculated this dynamic competitive index for five years.

4. Empirical Analysis

In this section, in order to analyze the relation between the market competition and the productivity, the production function, including the market competition index, is estimated according to the framework set forth by Nickel (1996). We used HHI and SFI as the market competitive indices. In particular, using each analytical method from OLS, the Fixed Effect Model, and System-GMM, the Cobb-Douglas type production function is estimated with the Japanese panel data of the company unit.

(1) Static Model

a) Model of Estimation

The basic model follows the Cobb-Douglas type production function, in which the relation between the TFP, residual error of the capital injection and labor injection, and the market competitive indices, are estimated. In addition, it is assumed that “u”, which is the residual error term in estimation [1], consists of various elements shown in estimation [2].

$$\ln VA_{it} = \alpha \ln L_{it} + \beta \ln K_{it} + \gamma comp_{it} + u_{it} \qquad \textbf{[1]}$$

$$u_{it} = a_{it} + e_{it} + \varepsilon_{it} \qquad \textbf{[2]}$$

In these expressions, VA is the value-added output, L is the total labor input, K is the capital stock input, comp is the market competition index of the company unit, specifically HHI or SFI, dummy is the year dummy variable and the industrial dummy variable, “i” is the firm subscript, and “t” is the time subscript. In addition, VA is realized by the deflator of the gross domestic product according to the economic activity in 2001, and K is realized by the deflator of the gross domestic fixed capital formation of the private enterprise equipment in 2001. Moreover, the element that constitutes an error term “u” is as follows. It is assumed that “a” is the factor of others explaining the productivity at the company level (for example: manager's capability, employee's motivation, product development capability, etc.), “e” is the factor of the exogenous economic ambience (for example: macro economy shock, trend of an exchange rate, etc.), “ε “ is the data error, as well as other random shocks. Furthermore, in this analysis, “a” is assumed to be fixed through a period ($a_{it} = a_i$) since it is short panel data. If “e” is a macro economy shock, it is controllable with the dummy variable of the year, and the dummy variable of the industry. Therefore, “e”, which is the factor of the exogenous economic ambience, was controlled by putting year and industrial dummies in estimation [1].

An estimating model [1] by OLS usually presumed that factors, such as a manager's capability and an employee's motivation, affects the labor injection, the capital stock, and the market competition, as well as the TFP. For example, the company has such good intangible assets, such as manager's capability and the skill of the employee etc., that cannot be observed, that it can perform more labor and capital injections. The residual “*a”* correlates with L and K positively and it is assumed that these coefficients have upper bias. Thereby, although the market competition index can be an exogenous variable, the variable also has bias by the other explaining variables.

In order to remove these biases, we can use the fixed effect model, which is as follows:

$$\ln VA_{it} = \alpha \ln L_{it} + \beta \ln K_{it} + \gamma comp_{it} + dummy_t + dummy_i + a_i + \varepsilon_{ti} \quad \textbf{[3]}$$

$$\overline{\ln VA_i} = \alpha \overline{\ln L_i} + \beta \overline{\ln K_i} + \gamma \overline{comp_i} + dummy_i + a_i + \bar{\varepsilon}_i \quad \textbf{[4]}$$

Therefore, taking deviations from the group means removing the heterogeneity:

$$\ln VA_{it} - \overline{\ln VA_i} = \alpha(\ln L_{it} - \overline{\ln L_i}) + \beta(\ln K_{it} - \overline{\ln K_i}) + \gamma(comp_{it} - \overline{comp_i}) + dummy_t + \varepsilon_{it} - \bar{\varepsilon}_i \quad \textbf{[5]}$$

b) Result of Estimation

The result of estimation using OLS and the fixed effect model is shown in Table 1.

Table 1. Static Model estimated by OLS (POOL) and Fixed Effect Model (FE)

	HHI		SFI	
	POOL (1)	FE (2)	POOL (3)	FE (4)
lnL	0.824 (79.64)**	0.466 (13.43)**	0.819 (76.82)**	0.469 (12.95)**
lnK	0.247 (29.75)**	0.011 (0.52)	0.251 (29.12)**	0.002 (0.09)
HHI	-0.501 (3.24)**	-0.319 (2.02)*		
SFI			2.109 (2.83)**	0.764 (1.23)
Constant	3.838 (10.01)**	5.841 (20.96)**	0.665 (1.76)	5.840 (20.27)**
Observations	4504	4504	4397	4397
R-squared	0.96	0.12	0.96	0.11
Number of id		951		941

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

When the results of models (1) and (2), as well as those of (3) and (4), are compared in Table 1, the coefficient of the labor and capital injections of the fixed effect model fall greatly. In the OLS estimation with “a”, such as manager's capability, employee's motivation, product development capability, etc., explain that the variables correlate with “a” so that these coefficients have upper bias. Therefore, in this analysis, the Fixed Effect Model is more suitable than OLS.

The overview of the analysis result by the Fixed Effect Model is that HHI is negatively significant and SFI is positively insignificant. However, the coefficient of capital is not statistically significant and there are also some problems in the estimation of the Fixed Effect Model. In particular, since capital stock is realized by the deflator of the gross domestic fixed capital formation of the private enterprise equipment, the data error can be influenced. Then, since the error of the explaining variable gives a lower bias to the coefficient (Griliches and Hausman, 1984), it is presumed that the coefficient becomes small as a result of the error of the explaining variable. This influence affects other coefficients through the covariance structure of the explaining variables, so that these results should be restrictively appreciated.

(2) Dynamic Model

a) Model of Estimation

The fixed effect model [5] requires that the explaining variables must be exogenous. However, the added value is affected by the past input factors of production. For example, if new capital goods are purchased, it may take a considerable amount of time before the new machines are fully operational. Therefore, serial correlation can cause downward biases of the coefficients of the explaining variables.

In order to eliminate these biases we added a lagged dependent variable as an explaining variable to model [3]. This model [6] is as follows.

$$\ln VA_{it} = \lambda \ln VA_{it-1} + \alpha \ln L_{it} + \beta \ln K_{it} + \gamma comp_{it} + a_i + dummy_t + dummy_i + \varepsilon \qquad \textbf{[6]}$$

As well as model [3] in the preceding paragraph, estimating model [6] by OLS causes the residual "*a*" correlated to lagged VA, L, and K positively. In addition, these coefficients have upper bias. In order to remove these biases, we can use the fixed effect model which is as follows:

$$\ln VA_{it} = \lambda \ln VA_{it-1} + \alpha \ln L_{it} + \beta \ln K_{it} + \gamma comp_{it} + dummy_t + dummy_i + a_i + \varepsilon_{ti} \qquad \textbf{[7]}$$

$$\overline{\ln VA_i} = \lambda \overline{\ln VA_{it-1}} + \alpha \overline{\ln L_i} + \beta \overline{\ln K_i} + \gamma \overline{comp}_i + dummy_i + a_i + \bar{\varepsilon}_i \,. \qquad \textbf{[8]}$$

Therefore, taking deviations from the group means removing "a":

$$\ln VA_{it} - \overline{\ln VA_i} = \lambda(\ln VA_{it-1} - \overline{\ln VA_{it-1}}) + \alpha(\ln L_{it} - \overline{\ln L_i}) + \beta(\ln K_{it} - \overline{\ln K_i}) + \gamma(comp_{it} - \overline{comp}_i) + dummy_t + \varepsilon_{it} - \bar{\varepsilon}_i \,. \qquad \textbf{[9]}$$

However, for panels where the number of time periods available is small, the fixed effect model [9] causes the lagged VA term to correlate with the ε term. The lagged VA term is that

$$\ln VA_{it-1} - \overline{\ln VA_{it-1}} = \ln VA_{it-1} - \frac{1}{T-1}(\ln VA_{i1} + \ldots + \ln VA_{it} + \ldots + \ln VA_{iT-1}) \,, \qquad \textbf{[10]}$$

whilst the ε term is that

$$\varepsilon_{it} - \bar{\varepsilon}_i = \varepsilon_{it} - \frac{1}{T-1}(\varepsilon_{i2} + \ldots + \varepsilon_{it-1} + \ldots + \varepsilon_{iT}) \quad . \qquad [11]$$

The $-\frac{\ln VA_{it}}{T-1}$ element in equation [10] is negatively correlated with ε_{it} in equation [11], and the $-\frac{\varepsilon_{it-1}}{T-1}$ element in equation [11] is also negatively correlated with the $\ln VA_{it-1}$ element in equation [10]. These negative correlations are relatively larger than the positive correlations between other elements, such as $-\frac{\ln VA_{it-1}}{T-1}$ and $-\frac{\varepsilon_{it-1}}{T-1}$, so that the correlation between equations [10] and [11] can be shown to be negative. The fixed effect model [9] with small time periods is biased downwards. It is useful that these two estimators are biased in opposite directions. We can select a consistent estimator that will be between the OLS and the fixed effect model.

The Generalized Method of Moment (GMM) is widely used for estimating a dynamic model, such as in equation [6]. GMM provides a convenient framework for obtaining asymptotically efficient estimators in these models. In particular, the AB method (hereinafter, difGMM) developed by Arrelano and Bond (1991) adjusts the data errors, endogenous explaining variables, and time series correlation of explained variables. This method was used in the precedence research conducted by Nickell (1996) and Okada (2004) among others. Specifically, this estimation model is the following model [12], which is simply a difference from model [6].

$$\Delta \ln VA_{it} = \lambda \Delta \ln VA_{it-1} + \alpha \Delta \ln L_{it} + \beta \Delta \ln K_{it} + \gamma \Delta comp_{it} + dummy_t + \Delta \varepsilon_{it} \qquad \textbf{[12]}$$

This method was used in various estimations of the production function in the early studies. However, Blundel and Bond (1998) showed that if $\Delta \ln VA_{it}$ is persistent (i.e. parameter λ approaches 1) or the variance of the fixed effect “a” becomes large, $\Delta \ln VA_{it-1}$ weakly correlates with $\ln VA_{it-2}$. Therefore, the instrument variable $\ln VA_{it-2}$ in this model reduces the effectiveness and the instrumental variable estimators can be subject to serious finite sample downward biases.

In order to eliminate these biases, a new method named system GMM (hereinafter, sysGMM) was recommended by Blundel and Bond (1998).[4] The instrumental variable of sysGMM is not only the lagged level of the explaining variables in the first differences equations, but also the lagged differences of the explaining

[4] System GMM was set up by Arellano and Bover (1995), and theories, such as the applicable condition, were elaborated by Bond and Brundell (1998).

variables in the level equations.

b) Result of Estimation

Table 2 shows the results from estimating this model using system GMM, comparing it with OLS, the fixed effect model (FE), and difGMM.

Table 2. Dynamic Model estimated by system GMM, OLS, FE, and difGMM

	HHI				SFI			
	POOL	FE	diffGMM	sysGMM	POOL	FE	diffGMM	sysGMM
l.lnVA (lag of lnVA)	0.755 (69.47)**	0.297 (17.97)**	0.042 (0.74)	0.575 (5.06)**	0.751 (67.47)**	0.296 (17.70)**	0.008 (1.05)	0.583 (5.26)**
lnL	0.211 (20.45)**	0.433 (11.81)**	-0.108 (0.33)	0.344 (2.86)**	0.213 (20.09)**	0.443 (11.79)**	0.08 (0.25)	0.332 (2.88)**
lnK	0.06 (10.99)**	-0.067 (2.74)**	-0.08 (0.85)	0.131 (3.53)**	0.064 (11.30)**	-0.079 (3.22)**	-0.121 (1.55)	0.131 (3.41)**
HHI	**-0.343 (5.18)****	**-0.461 (2.97)****	**-0.186 (0.61)**	**-0.394 (3.71)****				
SFI					**1.302 (3.27)****	**0.084 (0.15)**	**-0.934 (1.33)**	**1.09 (1.97)***
Sargan test p-value			46.07 0.17				43.02 0.26	
Hansen J Statistics p-value				50.80 0.22				49.82 0.25
AB test m1 p-value			-3.10 0.00	-4.50 0.00			-3.11 0.00	-4.59 0.00
AB test m2 p-value			-1.52 0.12	-1.06 0.29			-1.91 0.05	-0.97 0.33
Observations	3466	3466	1994	3466	3403	3403	1967	3403
Number of id		797	549	797		788	544	788

t statistics in parentheses
* significant at 5%; ** significant at 1%

Comparing the results of each method, the coefficients of explaining the variables of sysGMM is between those of FE and OLS. At this point the results are consistent with foregoing explanations, which were about the biases of these methods. However, all difGMM coefficients are not significant and less than that of FE. The possible causes are weak instruments when the individual series have near unit root properties[5].

The overview of the analysis result by system GMM is that HHI is negatively significant and SFI is positively significant. Here, HHI is so low and SFI is so high that the market is competitive. In addition, the other coefficients are positively significant. These results are consistent with the theoretical background, as shown in preceding chapter.

[5] Blundell, Bond, and Windmeijer (2000) suggested that this is also likely to be a concern in multivariate models when the individual series are highly persistent.

Table 3 shows the result of estimating model [12], classified by the size of firms using system GMM. The sales from small firms are less than 100 billion yen and the sales from large firms are more than 100 billion yen.

Table 3. Dynamic Model classified by size of firms

	HHI			SFI		
	All firms	Small firms	Large firms	All firms	Small firms	Large firms
l.lnVA (lag of lnVA)	0.575 (5.06)**	0.576 (5.00)**	0.590 (6.45)**	0.583 (5.26)**	0.576 (5.69)**	0.558 (5.19)**
lnL	0.344 (2.86)**	0.313 (2.95)**	0.439 (3.89)**	0.332 (2.88)**	0.302 (3.16)**	0.471 (3.14)**
lnK	0.131 (3.53)**	0.127 (3.18)**	0.041 -0.88	0.131 (3.41)**	0.125 (3.16)**	0.038 -0.67
HHI	-0.394 (3.71)**	-0.475 (2.88)**	-0.470 (2.52)*			
SFI				1.090 (1.97)*	1.252 (1.97)*	1.944 (1.53)
Hansen J Statistics p-value	50.80 0.22	46.23 0.38	48.53 0.29	49.82 0.25	43.39 0.49	47.88 0.31
AB test m1 p-value	-4.50 0.00	-4.12 0.00	-3.42 0.00	-4.59 0.00	-4.46 0.00	-3.34 0.00
AB test m2 p-value	-1.06 0.29	-0.74 0.45	-0.93 0.35	-0.97 0.33	-0.71 0.47	-0.76 0.45
Observations	3466	2170	1296	3403	2121	1282
Number of id	797	550	273	788	542	272

t statistics in parentheses
* significant at 5%; ** significant at 1%
Small firms: sale<\100billion, Large firms: sale≧\100billion

The overview of the analysis result is that although the SFI of small firms is positively significant, the SFI of large firms is positively insignificant and the HHI of small firms is more significant than that of large firms.

Tables 4 and 5 show the results of HHI and SFI estimating model [12], classified by R&D intensity, parent company, and foreign capital, using system GMM. In this classification, the ratio of R&D cost to sale is more or less than 2%, if the firm has parent company or not, and if the firm has foreign capital or not.

Table 4. Dynamic Model of HHI

		R&D intensity		Parent company		Foreign capital	
	All firms	high	low	yes	no	yes	no
l.lnVA (lag of lnVA)	0.575 (5.06)**	0.701 (6.42)**	0.566 (4.44)**	0.808 (5.56)**	0.542 (5.36)**	0.686 (7.88)**	0.662 (4.87)**
lnL	0.344 (2.86)**	0.379 (2.81)**	0.381 (3.07)**	0.173 (1.24)	0.391 (3.48)**	0.281 (2.98)**	0.306 (2.35)*
lnK	0.131 (3.53)**	-0.021 (0.48)	0.146 (2.98)**	0.092 (1.62)	0.131 (3.44)**	0.088 (2.14)*	0.08 (1.87)
HHI	-0.394 (3.71)**	-0.516 (2.00)*	-0.202 (1.57)	-0.241 (1.01)	-0.377 (3.15)**	-0.39 (2.45)*	-0.325 (2.15)*
Hansen J Statistics p-value	50.80 0.22	46.56 0.36	52.52 0.17	52.68 0.17	49.76 0.25	45.02 0.42	43.21 0.50
AB test m1 p-value	-4.50 0.00	-2.99 0.00	-3.81 0.00	-2.84 0.00	-4.58 0.00	-4.42 0.00	-3.33 0.00
AB test m2 p-value	-1.06 0.29	-0.48 0.63	-1.21 0.22	0.22 0.82	-1.84 0.06	0.17 0.86	-1.18 0.24
Observations	3466	1079	2387	835	2631	1672	1794
Number of id	797	315	713	195	602	345	452

t statistics in parentheses
* significant at 5%; ** significant at 1%

Table 5. Dynamic Model of SFI

		R&D intensity		Parent company		Foreign capital	
	All firms	high	low	yes	no	yes	no
l.lnVA (lag of lnVA)	0.583 (5.26)**	0.74 (6.86)**	0.57 (4.50)**	0.778 (5.49)**	0.542 (5.18)**	0.717 (7.81)**	0.672 (4.91)**
lnL	0.332 (2.88)**	0.339 (2.72)**	0.377 (3.08)**	0.199 (1.48)	0.378 (3.34)**	0.235 (2.52)*	0.31 (2.35)*
lnK	0.131 (3.41)**	-0.022 (0.49)	0.148 (2.98)**	0.101 (1.63)	0.143 (3.55)**	0.091 (2.22)*	0.076 (1.80)
SFI	1.09 (1.97)*	0.432 (0.45)	0.974 (1.35)	1.082 (0.83)	0.841 (1.29)	0.564 (1.00)	1.06 (1.23)
Hansen J Statistics p-value	49.82 0.25	47.14 0.34	52.41 0.18	55.84 0.10	48.92 0.28	46.48 0.37	43.78 0.48
AB test m1 p-value	-4.59 0.00	-3.00 0.00	-3.86 0.00	-2.83 0.00	-4.50 0.00	-4.38 0.00	-3.33 0.00
AB test m2 p-value	-0.97 0.33	-0.57 0.56	-1.09 0.27	0.26 0.79	-1.81 0.07	0.24 0.81	-1.13 0.26
Observations	3403	1074	2329	819	2584	1652	1751
Number of id	788	313	706	193	595	342	446

t statistics in parentheses
* significant at 5%; ** significant at 1%

The overview of the analysis result of HHI is that when R&D intensity is high, parent company is no, and foreign capital yes and no, the coefficients are negatively significant. However all classification of SFI is positively not significant.

5. Conclusions

The object of this research was to obtain the empirical relationship between market competition and corporate productivity using Japanese companies' data. We used HHI as the static competition index and SFI as the dynamic competition index. When we estimated the relationship using the production function, including the market competition index, many kinds of biases were assumable. To eliminate all of the assumable biases we used a dynamic model and selected system GMM from several methods.

The results of estimating with all the samples consisted of our assumption that market competition raises corporate productivity. Coefficients of both of the static and dynamic competitive indices (HHI and SFI) were statistically significant. Both the static market competition without oligopoly and dynamic market competition, which resulted in a change in market share, reduce the slack of firms so that market competition improves dynamic efficiency, which is the productivity growth. The result is negative for the Schumpeter hypothesis that economic growth which is the result of the innovation needs monopolistic profits.

Through additional analysis, the results from HHI and SFI show that market competition increases the TFP of small firms more than that of large firms. Small firms may react more quickly from the shock of market competition than large firms so that they may reduce slack and change their processes.

Furthermore, the results from HHI suggest that the TFP of a firm whose R&D cost is high increases when the market becomes more competitive and that corporate governance of the firm without a parent company positively affects the relationship between the market competition and the TFP. From these results, static market competition may cause R&D competition, and monitoring corporate governance of its child company by a parent company, reduces the slack of the child company.

In this research, the results showed not only static competition in the early studies, but also dynamic competition using new indices reduced the slack of firms and their productivity growth was improved. Since the correlation coefficient (=-0.15) of HHI and SFI is low, each index has a different meaning. In the future, we think that it is necessary to theoretically consider what HHI and SFI mean as competitive indices and to analyze them empirically.

6. Data Appendix

Valuables taken from "Basic Survey of Japanese Business Structure and Activities"

Value added (VA): Cost of employees + profits before tax + depreciation + interest payments. This is normalized on an industry-classified deflator of Japan's SNA

Employment (L): Number of employees.

Capital (K): This is normalized on capital deflator of Japan's SNA

Valuables taken from "Survey of Concentration Ratio on Production and Shipment"

Market share : The market share is calculated as sales in firm in year t ÷ total sales in each 6-digit industry.

Herfindahl Hirschmann Index (HHI) : This index is the sum of the square of the market shares.

Share Fluctuation Index (SFI) : This index is the average of the sum of the square of the difference of market shares.

Data conversion

The competitive indices such as HHI and SFI were 6-digit industry classified, so that we converted them to the indices in each firm level using a weighted average with the sales of each industry and the competitive indices in each industry level. For example HHI is converted as follows.

$$HHI_j = \sum_{\forall i \in j} \left(\frac{tsale_i}{\sum_{\forall i \in j} tsale_i} HHI_i \right)$$

In this expression, the *tsale* is total sales in each industry, "i" is the industry subscript, "j" is the firm subscript, and " $\forall i \in j$ " are all industries of the firm productions.

7.References

Arellano, M. and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and Application to Employment Equations", *Review of Economic Studies*, Vol.58, pp.277-297

Arellano, M and O. Bover (1995), "Another Look at the Instrumental Variable Estimation of Error-Components Models", *Journal of Econometrics*, Vol.68, pp.29-51

Bain, J. S. (1970), "Changes in Concentration in Manufacturing Industries in the United States, 1945-1966: Trends and Relationships to the Levels of 1954 Concentration", *The Review of Economics and Statistics*, Vol. 52, pp.411-416

Blundell, R. and S. Bond (1998), "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models", *Journal of Econometrics*, Vol.87, pp.115-143

Blundell, R., S. Bond and F. Windmeijer (2000), "Estimation in Dynamic Panel Data Models: Improving on the Performance of the Standard GMM Estimator in B. Baltagi(ed)", *Advances in Econometrics, Vol.15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels*, Netherlands, JAI Press Inc.

Blundell, R. Griffith, R. and J. Van Reenen (1999), "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms", *Review of Economic Studies*, Vol. 66. pp. 529-554

Caves, R. E. and M. E. Porter (1978), "Market Structure, Oligopoly, and Stability of Market Shares", *The Journal of Industrial Economics*, Vol. 26, pp.289-313

Davies, S. W. and P. A. Geroski (1997), "Changes in Concentration, Turbulence, and the Dynamics of Market Shares", *The Review of Economics and Statistics*, Vol. 79, pp.383-391

Geroski, P. (1996), *Market Structure, Corporate Performance and Innovative Activity*, United Kingdom, Oxford University Press

Griliches, Z. and Hausman, JA (1986), "Errors in Variables in Panel. Data", *Journal of Econometrics*, Vol.31, pp.93-118

Hausmann, J., B. Hall and Z. Griliches (1984), "Econometric Models for Count Data with an Application to the Patents-R&D Relationship", *Econometrica*, Vol. 52, pp.909-938

Hymer, S. and P. Pashigian (1962), "Turnover of Firms As a Measure of Market Behavior", *The Review of Economics and Statistics*, Vol. 44, pp.82-87

Joskow, J (1960), "Structural Indicia: Rank-Shift Analysis as a Supplement to Concentration Ratios", *The Review of Economics and Statistics*, Vol. 42, pp.113-116

Motohashi, K., M. Funakoshi and A. Tohei (2005), "Quantitative Analysis on Competition, Innovation and Productivity", *The Report of Competition Policy Research Center, Fair Trade Commission of Japan,* CR 02-05, pp.15-38

Mueller, W. F. and L. Hamm (1974), "Trends in Industrial Market Concentration, 1947 to 1970", *The Review of Economics and Statistics*, Vol. 56, pp.511-520

Nickell, S. (1996), "Competition and Corporate Performance", *Journal of Political Economy*, Vol. 104, pp. 724-746

Nickell, S., Nicolitsas, D and N. Dryden (1997), "What Makes Firms Perform Well?", *European Economic Review,* Vol.41, pp. 783-796

Okada, Y (2005), "Competition and Productivity in Japanese Manufacturing Industries", *Journal of the Japanese and International Economies*, Vol.19, pp.586-616

Sakakibara, M. and M. E. Porter (2001), "Competing at Home to Win Abroad: Evidence from Japanese Industry", *Review of Economics and Statistics*, Vol.83, pp.310-322

Scharfstein, D. (1988), "Product-Market Competition and Managerial Slack", *Rand J. Econ.* Vol.19, pp.147-155

Vickers, J. (1995), Concepts of Competition, *Oxford Economic Papers*, Vol. 47, pp. 1-23