Productivity Growth and Competition across the Asian Financial Crisis: Evidence from Korean Manufacturing Firms

Chulwoo Baek

Institute of Economic Research, Hitotsubashi University,
Korea Institute of Science and Technology Evaluation and Planning (KISTEP)

Younggak Kim

Institute of Economic Research, Hitotsubashi University

Hyeog Ug Kwon

Department of Economics, Nihon University, RIETI

Abstract

Using firm level data during 1985-2005, we measured the TFP of Korean manufacturing sector and identified determinants of the TFP growth rate. Given that various institutions for fair competition were introduced in 1988, investigating the difference of the TFP trends before and after the Asian financial crisis is meaningful. With the massive unbalanced panel data, we examined quantitatively whether or not the comprehensive structural reforms have the effect on the Korean economy in terms of productivity.

The data used in this research are financial statements obtained from KIS (Korea Information Service). These cover statutory audit firms and registered firms as well as listed firms in KOSPI and KOSDAQ from 1985 to 2005. Given that statutory audit firms and registration firms are smaller and less competent than listed firms in KOSPI and KOSDAQ and their proportion in the sample amounts to 74.5%, the data used in this paper is expected to lessen the sample bias than previous literatures which only focused on listed firms. When the

coverage of the data used here is compared with the Business Survey by National Statistical Office which covers the whole firms with fifty or more employees, the data used here account for more than 70% of employees, sales and tangible asset, thus the data used in this research has the representativeness to some extent.

It is shown that the TFP growth rate in the period 1985-1992 is negligible, 0.5% per annum, thus the TFP is not the main source of economy growth during this period. However, after steep decline in 1998, the TFP bounced back rapidly with 3.1% growth rate per annum in the period 1999-2005, which implies that the paradigm of economy growth has changes inputs-driven into TFP driven growth. When the TFP growth is decomposed, it is revealed that the output reallocation effect as well as within effect are main sources of the TFP growth. With regard to the determinants of the TFP growth rate, the reinforcement of competition after the Asian financial crisis contributed to the TFP growth rate, justifying introduction of various institutions for fair competition during the crisis. When industries are classified into sub industries by technology intensity, it can be said that the TFP growth has been driven by high technology and medium-high technology, and in high technology industry, the reinforcement of competition during post-crisis period and R&D intensity affected the TFP growth rate positively and significantly.

1. Introduction

This paper investigates the impact of the dramatic structural reforms initiated from 1998 for the purpose of the reinforcement of fair competition in terms of the productivity. Over the past three decades East Asia countries has achieved remarkable economic growth with the almost eight percent of real GDP growth per annum before the Asian financial crisis. It has been argued in the literature that the Total Factor Productivity (TFP) explains one-third of East Asia's rapid growth which is large relative to other economies, both absolutely and as a share of output growth (World bank, 1993), and Korea's successful economic development before the Asian financial crisis has resulted from government-led industrial policy and strategic trade policy (Chang, 1994). However, Krugman (1994), Young (1995) and Rodrik (1995) raised critical view on the economic growth of Asian countries that the rapid growth of Asian countries was attributed to excessive usage of production input factors, not to the enhancement of productivity. As the Asian financial crisis which originated from the sudden depreciation of the Baht in Thailand swept over the East Asian countries in the end of 1977, the debates on East Asia's economy growth including Korea became fiercer.

The presence of economic crisis allowed radical structural reforms based on consensus that new reforms are essential for recovery from the economic crisis and sustainable growth of Korean economy. As the IMF's bailout program began in December of 1997, the IMF asked the Korean government to undertake a series of actions to improve market environment for fair competition cutting off the unreasonable backward management practice from the past. In detail, the financial reform was implemented to restructure the entire financial sector and to improve the efficiency of the operations of financial institutions. As labor market reform, government legalized the usage of temporary agency workers and dismissal of workers through a simple procedure to reduce labor cost and to improve the flexibility of labor market. Regarding corporate sector reform, due to the newly introduced institutions for fair competition, which are mentioned in detail in Section 2, the firms could not rely on the privilege from government as well as could not derive benefits by illegal trade within business group any longer. In addition, restrictions on inflows of FDI were abandoned.

In this study, by using firm level data before and after the Asian financial crisis, we examine how structural reforms in post-crisis Korea affected TFP growth and the efficiency of resource reallocation. To the best of our knowledge, there are almost no quantitative studies on whether the comprehensive structural reforms occurred in Korea have contributed to productivity growth. Compared with the country or industry level, the measurement of TFP at the firm level can consider the heterogeneity among firms and offer rich information on firms' behavior. Moreover, we investigate whether the reinforcement of fair competition contributed to post-crisis TFP growth or not.

We found that aggregate TFP growth is higher after the structural reforms than before. The TFP growth until 1992 is negligible, the 0.5% growth rate per annum, which implies at least the TFP growth is not the main engine of economic growth and supports the arguments of Krugman (1994), Young (1994, 1995) and Rodrik (1995). However, after the Asian financial crisis, we observed the TFP bounced back rapidly with the 3.1% growth rate per annum, which means that the TFP growth has contributed to rapid Korean economic recovery. We also found that the competition has a significant effect on the TFP growth in the post-crisis period.

The remainder of this paper is organized as follows. After brief consideration on the change of competition environment after the financial crisis in section 2, section 3 reviews previous literature. Section 4 explains data and TFP measurement used in analysis. Section 5 presents the sources of aggregate productivity growth and section 6 shows the effect of competition with structural reform on the TFP growth. Finally section 7 summarizes our findings and offers policy implication.

2. The change of competition environments after the financial crisis

In the past, under the government-driven development policies, government offered various benefits in resource distribution to a few "*chaebols*" that are highly diversified, family-controlled conglomerates. Korean governments set the next technology target on the basis of the opinion of business leader, then helped selected firms enter and prosper in targeted industries though credit allocation at below market interest rates, research and development assistance, and temporary protection from domestic and foreign competition. The government tightly regulated and coordinated the investment plans of *chaebols* to assure that investment was of the proper magnitude as well as allocated efficiently (Crotty and Lee, 2001). Moreover, in order to regulate the investment of *chaebols*, the government controlled both the domestic banking system and cross border capital (Cho and Kim, 1994).

The IMF asked the Korean government to undertake a series of action to improve the poor governance and low transparency in Korean firms, in return for the financial rescue packaging (Chang *et al*., 2007). In this vein, Korean government introduced various institutions to improve managerial transparency and financial soundness, and forced *chaebols* to concentrate on core competencies.

In order to improve managerial transparency, combined financial statement became obligatory to the biggest 30 business group (Feb. 1998), the financial accounting standards were revised to be in line with international accounting standards (Dec. 1999), and the government forced the listed firms to assign outside directors totaling as many as over a fourth of their board member (Feb. 1998). These institutions prevented firms from obtaining improper benefits via releasing wrong information and made managerial decision more transparent.

Institutions for *chaebols*' financial soundness also introduced simultaneously. *chaebols* were required to abolish cross-debt guarantees (Apr. 1998) and the ceiling on equity investment was revived (Dec. 1999) to reduce improper transaction within business group. On the basis of the faith that growth strategy depending on excessive loan and expansion was not effective any longer, Korean government forced *chaebols* to lower debt-equity ratio under 200% by the end of

1999, and this resulted in disposal of business sector and asset with low profitability.

Korean government recognized that excessive diversification of *chaebols* caused their unstable financial structure and low profitability. As a consequence, government pushed business exchange, so called *Big Deal*, for concentrating on core competencies, reducing excessive capacity. *Big Deal* was focused on capital intensive industries such as chemicals, semiconductor, motor vehicles and airplanes.

With liberalization of capital market and foreign investment regimes as well as aforementioned institutions, the paradigm of market competition has changed from closed and domestic competition to open and global one since 1999. After partially opening stock market to foreign investors for the first time in 1992, the Korean Stock Exchange (KSE) continually mitigated foreign investment limit and finally opened its market completely to foreign investor as of May, 1998 (Chang *et al.*, 2007).

Under the changed market environments resulting from the newly introduced institutions, firms could not enjoy various privileges from government any longer and they were forced to improve their corporate governance and transparency in line with international standards. In addition, as trade barrier of capital market as well as product market disappeared, firms were exposed fierce global competition. In this vein, this research aims to examine whether the environmental changes fair competition after the Asian financial crisis contributed to the productivity growth or not.

3. Literature review

The previous literature related to this research can be categorized into the change of Korean economy after the Asian financial crisis, the measurement of the TFP, and the effect of competition on the TFP. First, regarding the change of Korean economy after the Asian financial crisis, previous literature offers mixed evidence on the change after the financial crisis. As pessimistic views, Crotty and Lee (2002) claimed that post-crisis neoliberal restructuring which moved Korea towards a globally open and capital market-based financial system, failed to generate sustainable economic recovery and threatens to significantly lower Korea's long-term rate of capital accumulation. In the same vein, Jo (2005) offered empirical evidence that operating profits of *Chaebol* in post crisis stayed at the same level as that in pre crisis in spite of improvement of financial structure by reducing debt. In addition, Park (2001) and Chopra *et al.* (2001) raised criticism on the rapid recovery from the crisis arguing that that the major factors of Korean economic recovery are not the structural reforms, but the expansionary fiscal and monetary policies and a more favorable external environment characterized by depreciated Korean Won. On the other hand, as optimistic views, Kim and In (2004) also insisted average debt-equity ratio of the top 5th firms decreased from 355% in 1997 to 182% in 2001 and that of the top 30th firms decreased more dramatically from 545% to 188% for the same period. According to Chang *el al.* (2007), the information asymmetry of Korean firms is lower after the financial crisis than before, implying that corporate transparency, in effect, improve with the change in business environment.

With respect to the measurement of the TFP of Korea, Aw *et al.* (2000, 2003), Hahn (2000, 2004), Ahn *et al.* (2004), Ahn (2006), Pyo *et al.* (2006), Kim (2006), Kwack (2007), Jung (2008) and Oh *et al.* (2009) measured the TFP of Korean manufacturing using micro level data. While Jung (2008) used firm level data, others used plant level data. Previous literatures offer somewhat different TFP growth rates before and after the Asian financial crisis. For example, Ahn (2006) showed that the annual TFP growth rate is 1.7% in the period 1990-1997 and 4.9% in the period 1997-2003, which implies the growth rate in post crisis is higher than that in pre crisis. On the other hand, Kwack (2007) showed 2.2% in the period 1988-1996 and 2.1% in the period 2000-2004 implying that there is not significant TFP increase after the crisis.

In the relation of market competition and TFP, Nickell (1996) 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. The results presented that market competition has a positive influence on the growing rate of TFP at the firm level. In the sequential study, Nickell *et al.* (1997) showed that when a firm received strong pressure from corporate governance, market competition has a weaker influence on the productivity of a firm, which implies market competition encourages management effort and improve the productivity. Besides Funakoshi *et al.* (2006) examined the empirical relationship between market competition and corporate productivity using around 2,400 Japanese firm data. This showed that market competition increased the TFP of small firms more than that of large firms and enhanced the TFP of R&D intensive firms.

4. Data and the productivity measurement

4.1. Data

Considering the difficulties in measuring inputs and outputs of service sectors and the heterogeneity among service sectors, we confine this analysis to manufacturing sectors. The data used in this research are financial statements obtained from KIS (Korea Information Service). These cover statutory audit firms and registered firms as well as listed firms in KOSPI and KOSDAQ from 1985 to 2005[1]. Given that statutory audit firms and registration firms are smaller and less competent than listed firms in KOSPI and KOSDAQ and their proportion in the sample amounts to 74.5%, the data used in this paper is expected to lessen the sample bias than previous literatures which only focused on listed firms[2]. When the coverage of the data used here is compared with the Business Survey by National Statistical Office which covers the whole firms with fifty or more employees, the data used here account for more than 70% of employees, sales and tangible asset as shown in Table 1, thus the data used in this research has

1 Listed firms in KOSPI consist of large and well established firms and listed firms in KOSDAQ are relatively young firms with high technology. Statutory audit firms are the firms whose total asset is more than 7 billion Korean Won so that external audit is mandatory by laws. Registered firms are firms which are registered in Financial Supervisory Service to transact securities.

2 As mentioned Section 3, Jung (2008) is the only previous literature which used firm level data. However, Jung (2008) covered only listed firm in KOSPI and KOSDAQ, excluding statutory audit firms and registration firms, thus his result has the possibility to overestimate the TFP of manufacturing via aggregation.

the representativeness to some extent.

[Table 1 here]

The standard of ICPA (International Comparison of Productivity among Asian Countries) is adopted for industry classification. According to ICPA standards, the total industry can be classified into 33 sub industries and the 6^{th} to 25^{th} sub industries among them are classified as manufacturing sector. As shown in Table 2, the total number of observations is 59,002 and electrical machinery, non-electrical machinery, chemicals and motor vehicles sectors hold 17.2%, 12.1%, 10.7% and 10.1%, respectively.

[Table 2 here]

The price indexes for output and inputs and depreciation rate are calculated from EU KLEMS Growth and Productivity Account. The information on Korea in EU KLEMS data is based on the National Account from the Bank of Korea and several labor statistics from National Statistical Office and Ministry of Labor. By using the nominal and real value of inputs and output as well as depreciation and labor hour in EU KLEMS data, price indexes, depreciation rate and average labor hour are derived.

4.2.The measurement of TFP

Following Good, Nadiri and Sickles (1996) and subsequent empirical studies including Kim (2007) and Fukao *et al.* (2006), firm level TFP was estimated by the chained-multilateral index number approach. It is derived from translog production function with satisfying four desirable properties: transitivity for cross sectional and time series comparison, superlativity for second order local approximation, allowance for technological change over time and no assumption on perfect competition. TFP level for firm *f* in year *t* in a certain industry is defined in comparison with the TFP level of a hypothetical representative firm in the base year in that industry as follows:

$$\ln TFP_{f,t} = (\ln Q_{f,t} - \overline{\ln Q_t}) - \sum_{i=1}^{n} \frac{1}{2}(S_{i,f,t} + \overline{S_{i,t}})(\ln X_{i,f,t} - \overline{\ln X_{i,t}})$$
$$+ \sum_{s=t}^{t_0-1}(\overline{\ln Q_s} - \overline{\ln Q_{s+1}}) - \sum_{s=t}^{t_0-1}\sum_{i=1}^{n} \frac{1}{2}(\overline{S_{i,s}} + \overline{S_{i,s+1}})(\overline{\ln X_{i,s}} - \overline{\ln X_{i,s+1}})$$

for $t<t_0$,

$$\ln TFP_{f,t} = (\ln Q_{f,t} - \overline{\ln Q_t}) - \sum_{i=1}^{n} \frac{1}{2}(S_{i,f,t} + \overline{S_{i,t}})(\ln X_{i,f,t} - \overline{\ln X_{i,t}}) \quad (1)$$

for $t=t_0$, and

$$\ln TFP_{f,t} = (\ln Q_{f,t} - \overline{\ln Q_t}) - \sum_{i=1}^{n} \frac{1}{2}(S_{i,f,t} + \overline{S_{i,t}})(\ln X_{i,f,t} - \overline{\ln X_{i,t}})$$
$$+ \sum_{s=t_0+1}^{t}(\overline{\ln Q_s} - \overline{\ln Q_{s-1}}) - \sum_{s=t_0+1}^{t}\sum_{i=1}^{n} \frac{1}{2}(\overline{S_{i,s}} + \overline{S_{i,s-1}})(\overline{\ln X_{i,s}} - \overline{\ln X_{i,s-1}})$$

for $t>t_0$.

where $Q_{f,t}$, $S_{i,f,t}$, and $X_{i,f,t}$ denote the gross output of firm *f* in year *t*, the cost share of factor *i* for firm *f* in year *t*, and firm *f*'s input of factor *i* in year *t*, respectively. Variables with an upper bar denote the industry average of that variable. The representative firms for each industry are defined as a hypothetical firm whose output, inputs, and cost shares of all production factors are identical with the industry average.

The first two terms on the right hand side of equation (1) denote the gap between firm *f*'s TFP level in year *t* and the representative firm's TFP level in that year. The third and fourth term denote the gap between the representative firm's TFP level in year *t* and the representative firm's TFP level in base year t_0. Therefore, $\ln TFP_{f,t}$ in equation (1) denotes the gap between firm *f*'s TFP level in year *t* and the representative firm's TFP level in the base year. As in the previous literature, constant returns to scale is assumed on the production function whose input factors are capital input, labor input and real intermediate input.

In calculating equation (1), base year t_0 is set to be 2000. As usual with micro-level data, it is often pointed out that since some observation may have extraordinary values in their inputs or output, values of inputs and output of representative firm may be affected. For this reason, we take two-step calculation method. As the first step, the multilateral TFP is calculated in a normal way. Then, the outliers are screened out by excluding the observation whose TFP index deviates from the industry average of TFP in the year farther than three times standard deviation. As the second step, multilateral TFP is calculated again with recalculated industry average value. See the Appendix for more detailed description on variables.

The result of aggregate TFP measurement is shown in Table 3 and Figure 1. The aggregate TFP of Korean manufacturing has increased 29.5% in the period 1985-2005 with annual growth rate of 1.3%. The decline in 1998 due to the Asian financial crisis is remarkable. In 1998 the TFP decreased to the level of 1985, but next year it quickly recovered to the level of 1997. Remarkable result is that aggregate TFP growth rate is higher after the structural reforms than before. The TFP growth in the period 1985-1992 is negligible, the 0.5% growth rate per annum, which implies at least the TFP growth is not the main engine of economic growth and is consistent to the arguments of Krugman (1994), Young (1994, 1995) and Rodrik (1995). After small increase of annul growth rate of aggregate TFP, 1.6% in the period 1993-1997, the TFP bounced back rapidly with the 3.1% growth rate per annum in the period 1999-2005, which means that TFP growth has contributed to rapid Korean economic recovery and the paradigm of economy growth has changed from inputs-driven into TFP-driven growth. Another remarkable result is that the increasing gap between weighted and unweighted mean implies the movement of market share toward more productive firms.

[Table 3 here]

[Figure 1 here]

In addition, on the basis of methodological work at the OECD, manufacturing industries were classified into four different categories of technological intensity; high, medium-high, medium-low and low technology industry.[3] As shown in Figure 2, aggregate TFP growth of manufacturing was driven mainly by high and medium-high technology industries while aggregate TFP of low and medium-low technology industries have been hardly improved over time.

[Figure 2 here]

The weighted means of lnTFP for major industries are presented in Figure 3. Electrical machinery industry marked the highest increase of TFP, 44.8%, and then instruments industry ranked the second highest increase, 42.7%. The TFP of motor vehicles industry during the financial crisis declined most seriously to the level of 1985 although all the industries experienced commonly the TFP decline during this period. This is partly due to the sensitivity of motor vehicles to the business cycle and domestic market demand. In the case of primary metal industry, it shows U-shaped curve distinctively because POSCO, the largest steal company in Korea, constructed new work phase in Gwangyang to expand its production capacities twice from 1987 to 1992, which seems to have caused the decline of productivity.

[Figure 3 here]

5. The sources of aggregate productivity growth

In order to identify the source of aggregate productivity growth, we decompose aggregate TFP using cross-sectional decomposition methodology utilized by Olley and Pakes (1996) and Griliches and Regev (1995). To begin with, an aggregate productivity in a given industry can be represented by a weighted average of each individual firm' productivity as follows;

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[3] Refer to the research of Schaaper (2004) for more detailed standard of categorization.

$$\ln TFP_t = \sum_{f \in F} \theta_{f,t} \ln TFP_{f,t} \tag{2}$$

where $\theta_{f,t}$ denotes firm *f*'s gross output share in year *t* in that industry. *F* is the set of all the firms existed in year *t* in the industry. Then, as Olley and Pakes (1996) showed, we can decompose the manufacturing sector's TFP in year t into the following two factors.

$$\ln TFP_t = \overline{\ln TFP_t} + \sum_f (\theta_{f,t} - \overline{\theta_t})(\ln TFP_{f,t} - \overline{\ln TFP_t}) \tag{3}$$

where an upper bar over a variable represents the cross-sectional unweighted mean across all firms in the same industry. Therefore an aggregate productivity can be decomposed into two parts: The unweighted aggregated productivity and the total covariance between firm's share of industry output and its productivity. In this decomposition, covariance term reflects gains in productivity resulting from high productive firms' expanding output shares or from low productive firms' shrinking output shares, that is output reallocation effect.

The decomposition results for major industries are presented in Table 4. In most industries, the covariance terms have positive sign which means output reallocation effect contributed to the aggregate productivity. Especially, major industries in Korea such as electrical machinery and motor vehicles have positive sign of covariance term over the whole period and their proportions to the aggregate productivity are relatively high.

[Table 4 here]

The Olley and Pakes decomposition indicates whether or not more productive firms are gaining at the expense of the less productive firms. But it does not differentiate between the individual contribution of resource reallocation and factors that are not related to resource reallocation on productivity growth. This can be captured by the Griliches and Regev decomposition (Dimova, 2008).

Griliches and Regev (1996) suggested that the change in a firm's contribution to the total can be decomposed as follows:

$$\theta_t \ln TFP_t - \theta_{t-i} \ln TFP_{t-i} = \theta(a) d \ln TFP + (d\theta) \ln TFP(a) \qquad (4)$$

where $x(a) = (x_t + x_{t-i})/2$ designates the period average for a variable and $dx = x_t - x_{t-i}$ its change. This decomposition is meaningful for continuing firms in that it makes possible to separate the contribution of within-firm productivity growth from the between-firm shifts in the relative weight of high – versus low-productivity firms.

The result of Griliches and Regev decomposition is shown is Table 5 and Figure 4. Except apparel and transportation industries, between effects contributed to the productivity positively during 1999-2002, and especially in fifteen industries within effect during 1999-2002 was higher than during 1993-1996. In the case of major industries in Figure 3, the between effects of chemicals, non-electrical machinery, electrical machinery and motor vehicles were enhanced after the financial crisis. Similarly, the within effects of primary metal, non-electrical machinery, electrical machinery and motor vehicles were also improved after the financial crisis.

[Table 5 here]

[Figure 4 here]

In order to identify output reallocation effect more intuitively, firms are divided into four quartiles from the lowest quartile (Q1) to the highest quartile (Q4) according to the productivity level by year and industry as shown in Figure 5. It is remarkable that the output share of the top 50% (Q3+Q4) tends to increase over time and exceeds 70% except chemical industry since 1993. In the case of chemical industry, the output share of the top 50% is not high around 40% compared with other industries, but since 1999 it began to increase rapidly to around 70%. This trend of chemical industry is closely related to the trend of lnTFP in Figure 3 in that the productivity of chemical industry was stagnant until 1999, then, it increased rapidly.

[Figure 5 here]

The results of the decompositions by equation (3) and (4) implies commonly that the output reallocation effect that more productive firms take up higher market share has contributed to the increase of the TFP and Figure 5 is the ex-post evidence for this effect. Moreover, Griliches and Regev decomposition provides additional information that firms' effort to improve their productivity, i.e. within effect, is another source of productivity increase.

6. Market competition and productivity growth

It is revealed that within effect is one of the sources of productivity growth in section 5, and Korean government introduced various institutions for fair competition after the Asian financial crisis. In this vein, this section investigates whether or not the change of competition environment after the Asian financial crisis contributed to firm's productivity growth. Thus, as a measure of market competition at the industry level, the index Aghion *et al*.(2002) suggested is used as follows:

$$c_{jt} = 1 - \frac{1}{N} \sum l_{it} \qquad (5)$$

where i indexes firms, j indexes industry, t indexes time, N_{jt} is the number of firms in the industry j in year t, and l_{it} is defined as (operating profit – financial cost)/sales [4]. A value of 1 indicates perfect competition, i.e. price equals marginal cost while values below 1 indicate some

[4] The financial cost is the multiplication of capital cost and capital stock. The capital cost is assumed to be the bond rate and the capital stock is measured using the perpetual inventory method. See the Appendix for detailed information on the bond rate and the perpetual inventory method.

degree of market power.

To examine the effect of market competition on the productivity growth rate, pooled OLS model is used as follows;

$$d\ln TFP_{ijt} = f(\ln TFP_{ijt-1}, X_{ijt-1}, \mathrm{c}_{jt-1}, \mathrm{crisis}_{it}, \mathrm{c}_{jt-1}*\mathrm{crisis}_{it}, \mathrm{year}_{t}, \mathrm{industry}_{j}) \qquad (6)$$

where i indexes firms, j indexes industry, t indexes time, $d\ln TFP_{ijt}$ is the TFP growth rate (=$\ln TFP_{ijt}$ - $\ln TFP_{ijt-1}$), X_{ijt-1}, is control variable for firm i at time t-1, c_{jt-1}, is the competition index of industry j at time t-1, and crisis_{it} is post-crisis dummy which has value 1 if year>1998, otherwise 0. The interaction term between competition and post-crisis dummy is expected to capture the effect of competition environment' change after the financial crisis on the productivity growth rate, and industry and year dummy are added to control the industry characteristics and macro-economic effect. With regard to control variable X_{ijt-1}, firm size (=log(total asset)), firm age, group dummy which has value 1 if a firm belongs to business group, debt ratio (=debt/total asset), no R&D dummy which has value 1 if a firm do not invest on R&D, R&D intensity (=R&D/sales) and export/output defined as the ratio of industry export to industry output.[5] Descriptive statics for variables are presented in Table 6.

[Table 6 here]

However, the presence of unmodeled heterogeneity among firms, such as manager's capability and the skill of the employees can make the coefficient from pooled OLS biased. Thus the fixed effect model is also used to remove systematic heterogeneity from the error term by adding firm specific constant term as follows.

$$d\ln TFP_{ijt} = \alpha_i + f(\ln TFP_{ijt-1}, X_{ijt-1}, \mathrm{c}_{jt-1}, \mathrm{crisis}_{it}, \mathrm{c}_{jt-1}*\mathrm{crisis}_{it}, \mathrm{year}_{t}) \qquad (7)$$

[5] There is a criticism that depreciated Korean won during crisis period provided favorable environment for export, and this might contributed to the recovery from the crisis (Park; 2001, Chopra et al.; 2001). To control export effect, we added the ratio of export to output at industry level.

Estimation of fixed effect model sacrifices a lot of degree of freedom. And with so many firms and short time period, these intercepts may be picking up on a lot of random error and thus be quite inconsistent. Therefore, we convert variables for each observation into a deviation from the mean in each firm. This sweeps out the unit effect and we no longer need to include an intercept term.

[Table 7 here]

The regression results of pooled OLS and fixed effect model presented in Table 7 implies as follows. First, the reinforcement of market competition after the financial crisis stimulated for firms to increase their productivity. Although post-crisis dummy has positive and statistically significant value in model 1 and 3, it turns to negative (Model 2) or lessened (Model 4) when interaction term is added, and interaction term has positive and statistically significant value both in pooled OLS and fixed effect model. Although the TFP growth due to the favorable export environment during post-crisis period is controlled by inserting export/output ratio at the industry level, the interaction term of (A) and (B) has significant and positive effect on the TFP growth rate.

Second, the productivity tends to converge strongly. A firm which has higher value in the TFP or size or age at previous year is likely to have lower TFP growth rate next year. Given that it is general for the TFP level and size of a firm to increase gradually as time goes on, the negative coefficients of lnTFP, log(total asset) and age support the convergence of productivity among firms. This trend becomes stronger when the heterogeneity among firms is controlled.

Third, the firms affiliated with business groups have higher productivity. Tangible and intangible support within the same business group can contribute to enhance the productivity. This fact is consistent with many previous studies which claimed that affiliation with a business group improves firm performance (Carney et al. 2008, Ma et al., 2006, Khanna and Palepu, 2000, Blanchard et al., 2004)

Fourth, R&D investment contributes to the TFP growth rate. The coefficient of R&D intensity in Pooled OLS implies that 10% increase in R&D intensity results in 1.9% increase in the TFP growth rate. Non-R&D performer has lower TFP growth rate than R&D performer, but this is not statistically significant.

Fifth, the TFP growth rate is affected by the export environment. When the export proportion of certain industry to which a firm belongs increases, a firm's TFP growth rate also increases. This effect may be valid during post-crisis period when Korean firms had advantage in trade due to the depreciated Korean won.

The determinants of the TFP growth rate are also considered by technology intensity following OECD standards. Except low technology industry, the reinforcement of competition after the Asian financial crisis contributed to TFP growth rate significantly, and its effect is the largest in high technology industry. Moreover, the effect of R&D intensity on the TFP growth rate is positive and significant only in high technology and medium-high technology industries. It is also remarkable that group dummy is not significant only in high technology industry, which implies that the reinforcement of core competency by R&D is more important than tangible and intangible support within business group in high technology industry.

[Table 8 here]

7. Concluding remarks

Using firm level data during 1985-2005, we measured the TFP of Korean manufacturing sector and identified determinants of the TFP growth rate. Given that various institutions for fair competition were introduced in 1988, investigating the difference of the TFP trends before and after the Asian financial crisis is meaningful. With the massive unbalanced panel data, we examined quantitatively whether or not the comprehensive structural reforms have the effect on the Korean economy in terms of productivity.

It is shown that the TFP growth rate in the period 1985-1992 is negligible, 0.5% per annum, thus the TFP is not the main source of economy growth during this period. However, after steep decline in 1998, the TFP bounced back rapidly with 3.1% growth rate per annum in the period 1999-2005, which implies that the paradigm of economy growth has changes inputs-driven into TFP driven growth. When the TFP growth is decomposed, it is revealed that the output reallocation effect as well as within effect are main sources of the TFP growth. With regard to the determinants of the TFP growth rate, the reinforcement of competition after the Asian financial crisis contributed to the TFP growth rate, justifying introduction of various institutions for fair competition during the crisis. When industries are classified into sub industries by technology intensity, it can be said that the TFP growth has been driven by high technology and medium-high technology, and in high technology industry, the reinforcement of competition during post-crisis period and R&D intensity affected the TFP growth rate positively and significantly.

However, this study raises many issues as future research. First, the dynamic characteristics of firms such as entry and exit should be considered. By using the information on entry and exit, the more detailed sources of the TFP growth can be provided. Second, the usage of more accurate competition index is required. Competition index used in this study assumes that the degree of competition is in the relation of reciprocal proportion with average mark-up. However, the degree of competition which firms face can be affected by market structure, import penetration, regulation etc. More accurate competition index is expected to improve the reliability of the research.

Appendix. Main variables to measure TFP[6]

Output

For output, gross sales after adjusting for inventory are used. Gross output is deflated by output deflators derived from EU KLEMS data.

Capital Stock

The perpetual inventory method is used to calculate real capital stock.

$$K_t = (1-\delta)K_{t-1} + \frac{NOMI_t}{PK_t} \qquad \text{(A.1)}$$

$$NOMI_t = KNB_t - KNB_{t-1} + DEP \qquad \text{(A.2)}$$

where PK_t is the price index for the capital asset, KNB_t is the book value of tangible fixed asst minus land and construction in-progress, DEP_t is the accounting depreciation during the period, $NOMI_t$ is the nominal investment, and δ is depreciation rate derived from EU KLEMS data.

The perpetual inventory method is sensitive to initial capital stock. Especially when the tangible asset data prior to starting year of analysis is not available, initial capital stock ignore previously installed capital input, thus it may cause the underestimation of initial capital stock. To adjust initial capital stock, we calculated $\sum K / \sum KNB$ for KOSPI listed firms by year and industry, then multiplied them to initial capital stock.

Intermediate inputs

Intermediate input is calculated as follows:

Intermediate input = Sales cost +Selling & general administrative expenses –Wage – Depreciation – R&D expenses (A.3)

[6] For variable selection and detailed calculation, we referred Kim(2007) and Fukao *et al.*(2006).

Intermediate inputs are deflated by intermediate input deflators derived from EU KLEMS data.

Labor input

Man-hours are used as labor input. Industry average man-hours are derived from EU KLEMS data then man-hours are calculated by multiplying the number of employees and industry average man-hours.

Capital Cost

Capital cost is measured as follows:

$$c_k = \frac{1-z}{1-u} p \left\{ \lambda r + (1-u)(1-\lambda)i + \delta - \left(\frac{\dot{p}}{p} \right) \right\} \quad \text{(A.4)}$$

where u is the effective corporate tax rate, λ is the own-capital ratio, r is the long-term bond rate, i is the prime rate, δ is depreciation rate, p is the price index, $\dot{p}$ is the five year moving average of price index, and z is the expected present value of tax savings due to depreciation allowances on a won of investment in capital goods. z is calculated as follows:

$$z = (u \bullet \delta) / \left[\left\{ \lambda r + (1-u)(1-\lambda)i \right\} + \delta \right] \quad \text{(A.5)}$$

Capital cost is calculated by multiplying c by the capital stock.

Effective tax rate

In Korea, taxes imposed on firms consist of corporate and local tax. Corporate tax is determined as the multiplication of profit and tax rate. Local tax consists of the one proportional to the amount of corporate tax and the other imposed uniformly in the same profit range.

However, the latter is negligible compare with the former. Considering aforementioned tax system, the effective tax rate can be determined as follows:

$$\tau_t = \tau_t^N (1 + \tau_t^L) \quad \text{(A.6)}$$

where τ_t^N and τ_t^L are tax rate of corporate tax and local tax in time t, respectively.

Long-term bond rate

The government bond more than five year has issued since mid 1990s, thus it is not appropriate as long-term bond rate. However, Korean government has issued several bonds in the relation with constructing house and road and so on. Among these, Housing bond has been one of the largest bond and has been traded for long time with stability. Therefore interest rate of 5 year Housing bond is used as a long-term bond rate.

Prime rate

Although the prime rate has been used since 1988, the movement of prime rate was so inflexible that usual interest rate was less than prime rate since 1999. Ultimately the prime rate is not used any longer in 2000s. As an alternative, Industrial Financial Debentures issued by the Korea Development Bank is used. It has been issued since 1954, and used as a standard for a long-term fixed debt.

References

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2002), "Competition and Innovation: An Inversed U Relationship", NBER Working Paper Series 9269.

Ahn, S. (2006), "Internationalization of Production and Change of Productivity: Evidence from Micro Data and International Comparison", KDI Research Report 2006-5. (in Korean)

Ahn, S., K. Fukao and H. Kwon (2004), "The Internationalization and Performance of Korean and Japanese Firms: An Empirical Analysis Based on Micro Data." Seoul Journal of Economics Vol. 17, pp. 439-482.

Aw, B.Y., S. Chung and M.J. Roberts (2000), "Productivity and Turnover in the Export Market: Micro Evidence from Taiwan and South Korea", World Bank Economic Review Vol. 14, pp. 65-90.

Aw, B.Y., S. Chung and M.J. Roberts (2003), "Productivity, output, and failure: A Comparison of Taiwanese and Korean Manufacturers", The Economic Journal Vol. 113, pp. 485-510.

Blenchard, P., J.P. Huiban and P. Sevestre (2004), "R&D and Productivity in Corporate Groups: An empirical Investigation Using a Panel of French Firms", Discussion Paper.

Carney, Michael, D. Shapiro and Y. Tang (2008), "Business Group Performance in China: Ownership and Temporal Consideration", Management and Organization Review, forthcoming.

Chang, Hajoon (1994) *The Political Economy and Industrial Policy*, Macmillan, London and Basingstoke.

Chang, Jinho, Young Jun Cho, and Hyun-Han Shin (2007), "The change in corporate transparency of Korean firms after the Asian Financial crisis: an analysis using analysts' forecast data" Corporate Governance Vol 15, No. 6, pp.1144-1167.

Chopra, Ajai, Kenneth H. Kang, Meral Karasulu, Hong Liang, Henry P. Ma and Anthony J. Richards (2001) "From Crisis to Recovery in Korea: Strategy, Achievements, and Lessons, IMF Working Paper WP 01-154.

Cho, Yoon-je and Joon Kyung Kim (1994), "Credit Policies and the Industrialization of Korea," World Bank Working Paper, No.286.

Crotty, James and Kang-Kook Lee (2001), "Economic Performance in Post-Crisis Korea: A Critical Perspective on Neoliberal Restructuring," Political Economy Research Institute of University of Massachusetts Amherst, Working Paper Series no.23.

Crotty, J. and K. Lee (2002), "Is Financial Liberalization good for Developing Nations?: The case of South Korea in the 1990s", Review of Radical Political Economics 34, 327–334.

Dimova, R. (2008), "The Impact of Labour Reallocation and Competitive Pressure on TFP Growth: Firm-level Evidence from Crisis and Transition ridden Bulgaria", International Review of Applied Economics, Vol. 22, No. 3, pp.321-338.

Fischer, S. (1998), The Asian crisis: A view from the IMF, press release.

Fukao, K., Y. Kim, and H.U. Kwon (2006), "Plant Turnover and TFP Dynamics in Japanese Manufacturing", Hitotsubashi University, Hi-Stat Discussion Paper Series No.180.

Funakoshi, M., K. Motohashi and A. Tohei (2006), "Quantitative Analysis on Competition and Productivity", Competition Policy Research Center of Fair Trade Commission of Japan, CPRC Discussion Paper Series CPDP-21-E.

Good, D.H., M.I. Nadiri, and R. Sickles (1996), "Index Number and Factor Demand Approaches to the Estimation of Productivity", NBER Working Paper 5790.

Griliches, Z. and H. Regev (1995), "Firm Productivity in Israeli Industry 1979-1988", Journal of Econometrics Vol. 65, pp. 175-203.

Hahn, C.H. (2000), "Entry, Exit and Aggregate Productivity Growth: Micro Evidence on Korean Manufacturing", OECD Economics Department Working Papers 272.

Hahn, C.H. (2004), "Exporting and Performance of Plants: Evidence from Korean Manufacturing" NBER Working Paper 10208.

Jo, S.W. (2001), Empirical Analysis on Performance of Policies on Chaebol after Financial Crisis, KDI Policy Research 2001-15. (in Korean)

Jung. M. (2008), "Productivity (TFP) and Catching Up of Korean Firms with the Japanese Firms: SIS (Sectoral Innovation System) and Firm Level Learning", Ph.D. Dissertation, Seoul National University, Korea.

Khanna, T. and K. Palepu (2000), “Is Group Affiliation Profitable in Emerging Markets? An Analysis of Diversified Indian Business Groups”, The Journal of Finance, Vol. 55, No. 2, pp. 867-891.

Kim, C (2006), “Firm Dynamics and Productivity in Korean Manufacturing”, Ph. D. Dissertation, Seoul National University, Korea. (in Korean).

Kim, J.K., and J.I. In (2004), Performance Evaluation of Restructuring after Financial Crisis: Profitability and Financial Soundness, KDI Policy Forum 168, 2004-01. (in Korean)

Kim, Younggak (2007), “Estimating Production Functions with R&D Investment and Endogeneity”, Hitotsubashi University, Hi-Stat Discussion Paper Series No.229.

Krugman, Paul (1994), “The Myth of Asia’s Miracle,” Foreign Affairs, Vol. 73, No.6, pp.62-78.

Krugman, Paul, (1998), What Happened to Asia, Conference Paper in Japan.

Kwack, S (2007), “Knowledge Capital and Export Growth in Korean Manufacturing Industries”, KIET Korea Institute for Industrial Economics & Trade) Occasional Paper No. 65.

Ma, X., X. Yao and Y. Xi (2006), “Business Group Affiliation and Firm Performance in a Transition Economy: A Focus on Ownership Voids”, Asia Pacific Journal of Management Vol. 23, pp. 467-483

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

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

Oh, I., A. Heshmati, C. Baek. and J. Lee, (2009), "Comparative Analysis of Plant Dynamics by Size: Korean Manufacturing" Japanese Economic Review (forthcoming).

“Comparative Analysis of Firm Dynamics by Size: Korean Manufacturing.” Ratio Working Papers 94.

Olley, G.S., and A. Pakes (1996), “The Dynamics of Productivity in the Telecommunications equipments Industry”, Econometrica, Vol. 64(6), pp. 1263-1297.

Park, Yung Chul (2001) “The East Asian Dilemma: Restructuring Out or Growing Out?” Princeton Essays in International Economics no.223.

Pyo, H, K. Rhee and B. Ha (2006), “Growth Accounting and Productivity Analysis by 33 Industrial Sectors in Korea (1984-2002)”, Hi-Stat Discussion Paper Series of Institute of Economic Research, Hitotsubashi University.

Radelet, S., and S. Jeffrey, 1998, “The Onset of the East Asian Crisis”, NBER Working Paper.

Rodrik, D. (1995), “Getting Interventions Right: How South Korea and Taiwan Grew Rich.” Economic Policy Vol. 10, pp. 54–107.

Schaaper, M. (2004), “An emerging knowledge-based economy in China? Indicators from OECD databases”, OECD STI working paper 2004/4.

Young, A. (1994), “Lessons from the East Asian NICs: A Contrarian View.” European Economic Review Vol. 38, pp. 964–973.

Young, A. (1995). “The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience”, Quarterly Journal of Economics Vol. 110, pp. 641–680.

World Bank (1993), “The East Asian Miracle: Economic Growth and Public Policy,” Oxford University Press, New York, NY.

Table 1. The coverage of data used, as of 2005

	no of firms	employees	sales (bil. Won)	tangible asset (bil. Won)
The whole firms with 50 or more employees and with 300 million Won of capital stocks (A)	6,144	1,539,465	712,316	259,873
Data used in this research (B)	5,141	1,131,349	537,519	196,900
(B)/(A)	0.84	0.73	0.75	0.76

(A) is referred from the Business Survey by National Statistical Office.

Table 2. Firm distribution by industry and year

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Food and kindred products	96	100	109	113	121	125	145	149	152	146	147	175	175	195	186	183	176	206	208	231	216	3,354
Textile mill products	46	52	60	67	80	84	101	105	104	94	99	106	120	132	115	117	123	142	152	140	129	2,168
Apparel	24	28	30	35	44	46	57	63	65	64	71	77	80	87	75	60	63	70	88	93	85	1,305
Lumber and wood	4	4	5	6	6	5	8	9	8	8	8	11	14	21	30	28	27	28	29	34	32	325
Furniture and fixtures	7	7	7	7	9	10	11	13	13	13	15	20	27	26	28	35	37	42	44	46	46	463
Paper and allied	36	42	47	50	54	58	67	70	68	74	83	86	85	88	83	91	91	109	122	115	97	1,616
Printing, publishing and allied	25	25	31	35	40	50	66	71	68	77	84	103	107	130	123	110	146	205	214	219	202	2,131
Chemicals	152	167	181	201	229	237	275	292	288	285	310	332	341	365	334	319	355	420	421	435	391	6,330
Petroleum and coal products	10	10	13	11	12	13	15	15	13	14	14	16	17	20	27	23	23	27	28	28	24	373
Leather	10	10	14	16	19	20	24	24	24	23	23	25	24	27	26	25	21	21	28	32	26	462
Stone, clay, glass	61	72	78	85	89	96	114	123	118	117	121	148	152	174	151	157	172	189	213	227	208	2,865
Primary metal	68	75	78	90	109	123	154	159	154	167	188	210	244	272	287	284	316	395	387	408	374	4,542
Fabricated metal	41	49	55	74	87	85	100	111	99	106	116	160	186	221	233	258	295	340	350	360	348	3,674
Machinery, non-elec	40	47	72	82	96	105	139	150	139	156	188	336	407	502	511	534	624	714	758	810	734	7,144
Electrical machinery	105	121	150	158	182	196	236	251	252	280	313	404	489	570	623	679	834	1,003	1,074	1,125	1,024	10,069
Motor vehicles	51	73	91	104	127	133	171	176	177	199	228	245	291	323	401	434	468	559	581	589	559	5,980
Transportation equipment & ordnance	9	7	10	11	13	13	15	20	22	22	28	47	69	78	83	90	91	111	115	120	117	1,091
Instruments	16	17	21	25	26	29	38	38	38	40	48	77	88	111	131	122	143	167	181	190	179	1,725
Rubber and misc plastics	22	29	37	46	55	54	74	78	73	76	89	116	149	186	187	197	217	268	299	312	273	2,837
Misc. manufacturing	9	10	13	13	17	16	19	21	19	18	17	27	31	42	40	39	36	41	42	43	35	548
Total	832	945	1,102	1,229	1,415	1,498	1,829	1,938	1,894	1,979	2,190	2,721	3,096	3,570	3,674	3,785	4,258	5,057	5,334	5,557	5,099	59,002

Table 3. The result of lnTFP measurement

year	no of obs	weighted mean	unweighted mean	min	max	std dev
1985	821	-0.016	-0.040	-0.569	0.489	0.119
1986	929	-0.016	-0.027	-0.649	0.414	0.116
1987	1,079	-0.002	-0.006	-0.704	0.398	0.119
1988	1,216	-0.007	-0.001	-0.551	0.630	0.122
1989	1,386	0.014	0.005	-1.076	0.545	0.142
1990	1,470	0.022	0.024	-0.924	0.857	0.153
1991	1,804	0.029	0.026	-1.393	0.810	0.183
1992	1,902	0.019	0.016	-1.069	0.580	0.174
1993	1,860	0.023	0.012	-1.381	0.600	0.171
1994	1,939	0.053	0.021	-0.667	0.623	0.160
1995	2,158	0.076	0.031	-0.781	1.013	0.166
1996	2,677	0.077	0.051	-0.720	0.727	0.168
1997	3,055	0.087	0.060	-0.929	0.971	0.181
1998	3,519	-0.014	0.001	-1.019	0.803	0.214
1999	3,625	0.091	0.073	-1.199	1.103	0.181
2000	3,745	0.173	0.103	-0.929	0.880	0.171
2001	4,222	0.167	0.118	-0.719	0.934	0.173
2002	5,011	0.223	0.127	-0.918	0.924	0.187
2003	5,274	0.247	0.140	-0.780	0.868	0.193
2004	5,137	0.274	0.144	-0.794	1.046	0.197
2005	4,728	0.279	0.164	-0.697	1.098	0.197

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Table 4. The result of Olley and Pakes decomposition

Industry	year	aggregate productivity	unweighted mean	covariance	Industry	year	aggregate productivity	unweighted mean	covariance
Food and kindred products	1985	-0.026	-0.040	0.014	Textile mil products	1985	-0.030	-0.035	0.005
	1990	-0.026	-0.037	0.011		1990	0.016	-0.001	0.017
	1995	-0.014	-0.070	0.056		1995	-0.054	-0.093	0.039
	2000	0.011	-0.050	0.062		2000	-0.062	-0.039	-0.023
	2005	0.052	-0.038	0.091		2005	-0.025	-0.042	0.016

Apparel	1985	-0.008	-0.027	0.019	Lumber and wood	1985	0.001	0.019301	-0.018
	1990	0.109	0.081	0.028		1990	0.000	0.017894	-0.018
	1995	0.097	0.023	0.074		1995	-0.121	-0.09541	-0.026
	2000	0.119	0.071	0.048		2000	-0.082	-0.03731	-0.045
	2005	0.154	0.139	0.015		2005	-0.015	0.007072	-0.022
Furniture and fixtures	1985	0.057	-0.015	0.072	Paper and allied	1985	0.024	-0.023	0.047
	1990	0.237	0.272	-0.035		1990	0.050	0.037	0.013
	1995	0.187	0.152	0.035		1995	0.078	0.046	0.033
	2000	0.153	0.104	0.049		2000	0.048	0.010	0.038
	2005	0.180	0.146	0.034		2005	0.032	-0.018	0.051
Printing and publishing and allied	1985	0.056	-0.037	0.093	Chemicals	1985	-0.024	-0.054	0.030
	1990	0.150	0.006	0.144		1990	-0.013	0.021	-0.034
	1995	0.146	0.055	0.090		1995	-0.045	-0.031	-0.014
	2000	0.199	0.125	0.074		2000	0.086	0.083	0.004
	2005	0.063	0.026	0.037		2005	0.144	0.099	0.044
Petroleum and coal products	1985	-0.017	-0.031	0.014	Leather	1985	-0.029	-0.016	-0.014
	1990	-0.010	0.009	-0.019		1990	0.030	0.032	-0.002
	1995	-0.009	-0.028	0.019		1995	0.055	0.006	0.049
	2000	-0.042	-0.069	0.027		2000	0.009	0.004	0.004
	2005	0.035	-0.041	0.075		2005	0.033	0.046	-0.013
Stone, clay, glass	1985	-0.035	-0.061	0.026	Primary metal	1985	-0.019	-0.037	0.017
	1990	-0.017	-0.005	-0.012		1990	-0.162	-0.024	-0.137
	1995	0.009	0.028	-0.019		1995	-0.066	0.005	-0.071
	2000	0.062	0.028	0.034		2000	0.013	0.036	-0.022
	2005	0.090	0.072	0.017		2005	0.144	0.038	0.106
Fabricated metal	1985	-0.124	-0.043	-0.080	Machinery, non-elec	1985	-0.035	-0.027	-0.008
	1990	0.034	0.017	0.017		1990	0.153	0.115	0.038
	1995	-0.001	-0.065	0.064		1995	0.218	0.164	0.054
	2000	-0.047	-0.087	0.040		2000	0.204	0.175	0.029
	2005	-0.033	-0.085	0.052		2005	0.296	0.266	0.030
Electrical machinery	1985	-0.007	-0.042	0.035	Motor vehicles	1985	0.002	-0.028	0.030
	1990	0.063	0.018	0.045		1990	0.088	0.025	0.064
	1995	0.254	0.064	0.190		1995	0.182	0.094	0.088
	2000	0.380	0.224	0.155		2000	0.218	0.142	0.075
	2005	0.441	0.350	0.090		2005	0.233	0.201	0.032
Transportation equipment & ordinance	1985	0.043	-0.035	0.079	Instruments	1985	-0.021	-0.052	0.031
	1990	0.214	0.171	0.042		1990	0.158	0.161	-0.003
	1995	0.214	0.176	0.038		1995	0.268	0.259	0.009
	2000	0.264	0.180	0.084		2000	0.394	0.293	0.101
	2005	0.290	0.273	0.017		2005	0.407	0.339	0.067
Rubber and misc plastics	1985	0.007	-0.017	0.024	Misc. manufacturing	1985	0.044	-0.034	0.078
	1990	0.058	-0.021	0.078		1990	0.183	0.144	0.039
	1995	0.010	-0.032	0.042		1995	0.133	0.133	0.000
	2000	-0.001	-0.018	0.018		2000	0.209	0.183	0.027
	2005	0.050	0.003	0.047		2005	0.138	0.154	-0.015

Table 5. The result of Griliches and Regev decomposition

Industry	1993-1996			1999-2002			2002-2005		
	within	between	Total	within	between	Total	within	between	Total
Food and kindred products	0.019	0.010	0.029	-0.008	0.008	0.000	0.021	0.001	0.022
Textile mill products	-0.003	0.004	0.001	0.046	0.018	0.064	-0.012	0.028	0.016
Apparel	-0.022	0.016	-0.006	0.054	-0.020	0.034	0.033	0.011	0.044
Lumber and wood	-0.004	-0.011	-0.015	0.080	0.001	0.081	-0.008	0.011	0.003
Furniture and fixtures	0.008	0.004	0.012	0.013	0.017	0.031	0.008	-0.005	0.004
Paper and allied	-0.030	-0.004	-0.034	0.060	0.000	0.060	0.001	-0.001	0.000
Printing, publishing and allied	0.012	0.017	0.030	-0.059	0.006	-0.053	0.048	0.025	0.073
Chemicals	0.036	0.001	0.038	0.017	0.013	0.030	0.008	0.009	0.017
Petroleum and coal products	0.024	-0.009	0.015	0.001	0.000	0.001	0.001	0.003	0.004
Leather	0.001	0.009	0.011	0.004	0.019	0.023	0.033	0.014	0.047
Stone, clay, glass	-0.004	0.005	0.001	0.047	0.007	0.053	-0.004	0.006	0.003
Primary metal	0.028	0.009	0.037	0.042	0.005	0.047	0.010	0.008	0.017
Fabricated metal	-0.021	0.014	-0.007	0.008	0.001	0.009	0.003	-0.004	-0.001
Machinery, non-elec	0.008	0.007	0.015	0.017	0.019	0.036	0.011	0.019	0.030
Electrical machinery	-0.037	0.006	-0.031	0.107	0.036	0.143	-0.014	0.009	-0.005
Motor vehicles	0.030	-0.005	0.025	0.058	0.010	0.067	-0.018	-0.003	-0.020
Transportation equipment & ordnance	-0.007	-0.002	-0.009	0.031	-0.003	0.028	0.024	-0.003	0.021
Instruments	0.028	0.015	0.043	0.005	0.009	0.014	0.010	0.018	0.027
Rubber and misc plastics	-0.015	0.007	-0.009	0.008	0.004	0.012	0.015	0.005	0.020
Misc. manufacturing	-0.018	0.014	-0.005	-0.016	0.010	-0.006	-0.010	0.031	0.022

Table 6. Descriptive statistics

	level	mean	median	min	max	std. dev.
TFP growth rate	firm	0.016	0.013	-1.380	1.527	0.124
lnTFP	firm	0.079	0.076	-1.393	1.103	0.189
log(total asset)	firm	16.519	16.298	9.832	24.646	1.435
age	firm	13.991	11.000	0.000	109.000	11.343
group dummy	firm	0.571	1.000	0.000	1.000	0.495
debt ratio	firm	0.669	0.691	0.000	15.412	0.263
no R&D dummy	firm	0.435	0.000	0.000	1.000	0.496
R&D intensity	firm	0.008	0.000	-0.035	1.056	0.024
export/output	industry	0.450	0.389	0.011	2.918	0.448
crisis	firm	0.555	1.000	0.000	1.000	0.497
competition	industry	0.997	0.989	0.937	1.255	0.036

Table 7. The determinants of the TFP growth

	Pooled OLS				Fixed effect model			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
constant	-0.0375	*	-0.0071		0.2006	***	0.2416	***
	(-1.70)		(-0.29)		(7.05)		(7.94)	
lnTFP(t-1)	-0.4023	***	-0.4026	***	-0.6174	***	-0.618	***
	(-117.48)		(-117.53)		(-143.21)		(-143.29)	
log(total asset)(t-1)	-0.0015	***	-0.0015	***	-0.0115	***	-0.0115	***
	(-3.14)		(-3.15)		(-9.26)		(-9.25)	
age(t-1)	-0.0003	***	-0.0003	***	-0.0097	***	-0.0099	***
	(-6.08)		(-6.06)		(-4.33)		(-4.39)	
group dummy(t-1)	0.0054	***	0.0054	***				
	(4.75)		(4.74)					
debt ratio(t-1)	-0.0009		-0.0009		0.0206	***	0.0204	***
	(-0.39)		(-0.42)		(6.43)		(6.36)	
no R&D dummy(t-1)	-0.001		-0.0011		-0.001		-0.0011	
	(-0.90)		(-0.91)		(-0.65)		(-0.68)	
R&D intensity(t-1)	0.1939	***	0.1931	***	0.0781	**	0.0764	**
	(7.68)		(7.65)		(2.02)		(1.97)	
export/output(t-1)	0.0089	**	0.0095	**	0.0078	*	0.0079	*
	(2.35)		(2.50)		(1.91)		(1.93)	
post-crisis dummy (A)	0.0415	***	-0.0752	*	0.2769	***	0.1258	**
	(10.83)		(-1.84)		(6.80)		(2.21)	
competition(t-1) (B)	0.0367	*	0.006		0.0055		-0.0354	
	(1.77)		(0.26)		(0.27)		(-1.55)	
(A)*(B)			0.1186	***			0.157	***
			(2.87)				(3.82)	
Year dummy	Included		Included		Included		Included	
Industry dummy	Included		Included					
Adj. R-squared	0.280		0.28		0.291		0.291	
no of obs	45,929		45,929		45,929		45,929	

The values in the parenthesis are t-values. *** , ** and * indicate significance at the 1, 5, 10 percent levels, respectively. Dependent variable is the growth rate of TFP (=lnTFP(t)-lnTFP(t-1)), and postfix (t-1) means the one-year lags.

Table 8. Determinants of TFP growth rate by technology intensity

sample	high tech.		medium-high		medium-low		low tech.	
constant	0.4979	***	0.0358		0.1517	***	0.0164	
	(5.59)		(0.85)		(3.62)		(0.24)	
lnTFP(t-1)	-0.4465	***	-0.4631	***	-0.4137	***	-0.3595	***
	(-50.66)		(-80.93)		(-61.93)		(-47.10)	
log(total asset)(t-1)	-0.0035	**	0.0008		-0.0012		-0.002	*
	(-2.52)		(1.12)		(-1.39)		(-1.75)	
age(t-1)	-0.0003	*	-0.0006	***	-0.0005	***	-0.0002	**
	(-1.91)		(-6.52)		(-4.62)		(-2.27)	
group dummy(t-1)	-0.0022		0.0061	***	0.0099	***	0.0077	***
	(-0.66)		(3.59)		(4.95)		(2.95)	
debt ratio(t-1)	-0.0029		-0.015	***	-0.0102	**	0.0058	
	(-0.47)		(-3.92)		(-2.48)		(1.33)	
no R&D dummy(t-1)	0.0035		-0.0036	**	-0.0003		-0.0015	
	(0.94)		(-2.02)		(-0.17)		(-0.61)	
R&D intensity(t-1)	0.1248	***	0.212	***	-0.0861		0.0339	
	(2.78)		(5.05)		(-0.84)		(0.48)	
export/output(t-1)	-0.0031		-0.0197	***	-0.0251	*	0.0219	
	(-0.34)		(-3.59)		(-1.83)		(1.40)	
post-crisis dummy (A)	-0.4798	***	-0.0699		-0.2493	*	0.3809	***
	(-2.81)		(-1.19)		(-1.91)		(3.21)	
competition(t-1) (B)	-0.389	***	0.0612		-0.1197	***	0.0057	
	(-4.19)		(1.45)		(-3.11)		(0.09)	
(A)*(B)	0.6023	***	0.1543	***	0.2902	**	-0.367	***
	(3.42)		(2.66)		(2.28)		(-3.12)	
Year dummy	Included		Included		Included		Included	
Industry dummy	Included		Included		Included		Included	
Adj. R-squared	0.288		0.336		0.309		0.224	
no of obs	7,966		17,448		11,065		9,450	

The values in the parenthesis are t-values. *** , ** and * indicate significance at the 1, 5, 10 percent levels, respectively. Dependent variable is the growth rate of TFP(=lnTFP(t)-lnTFP(t-1))

Figure 1. The mean of lnTFP

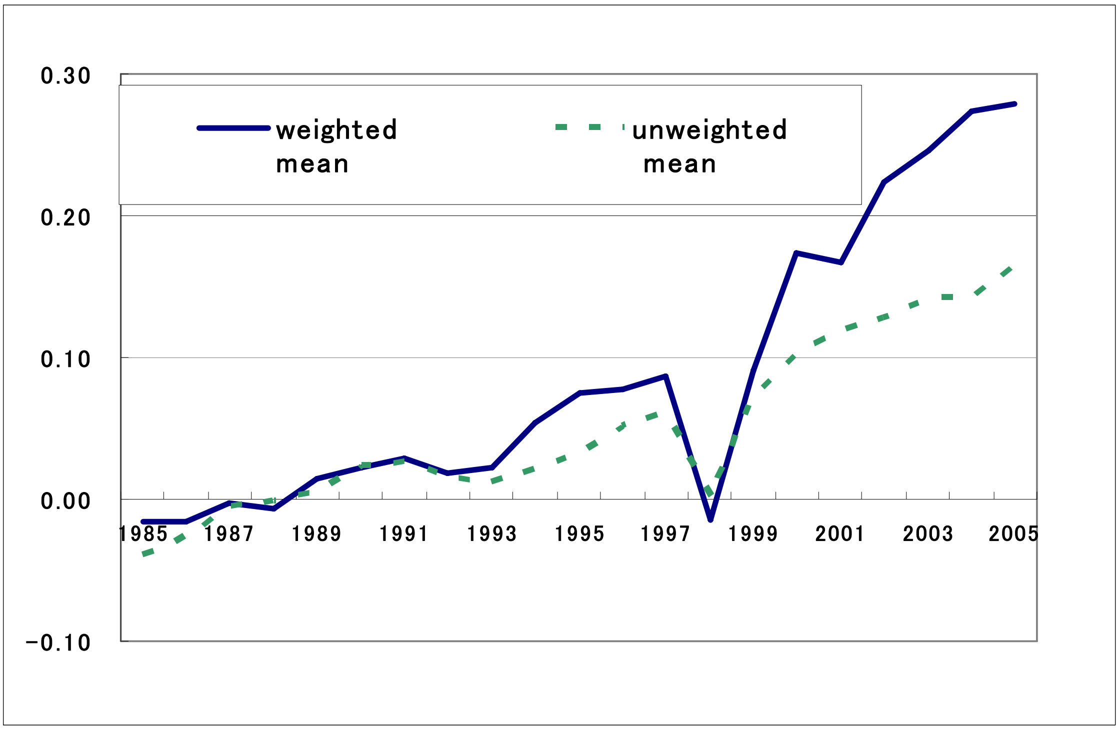

Figure 2. The mean of lnTFP by technology intensity

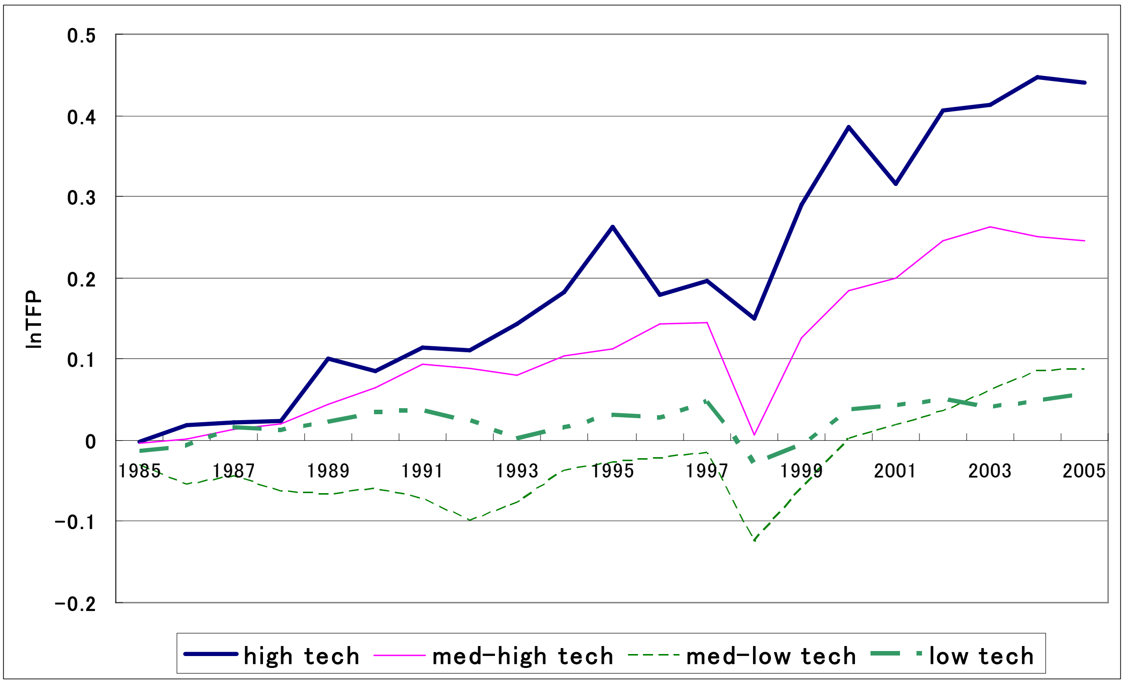

Figure 3. Gross output weighted mean of lnTFP by major industry

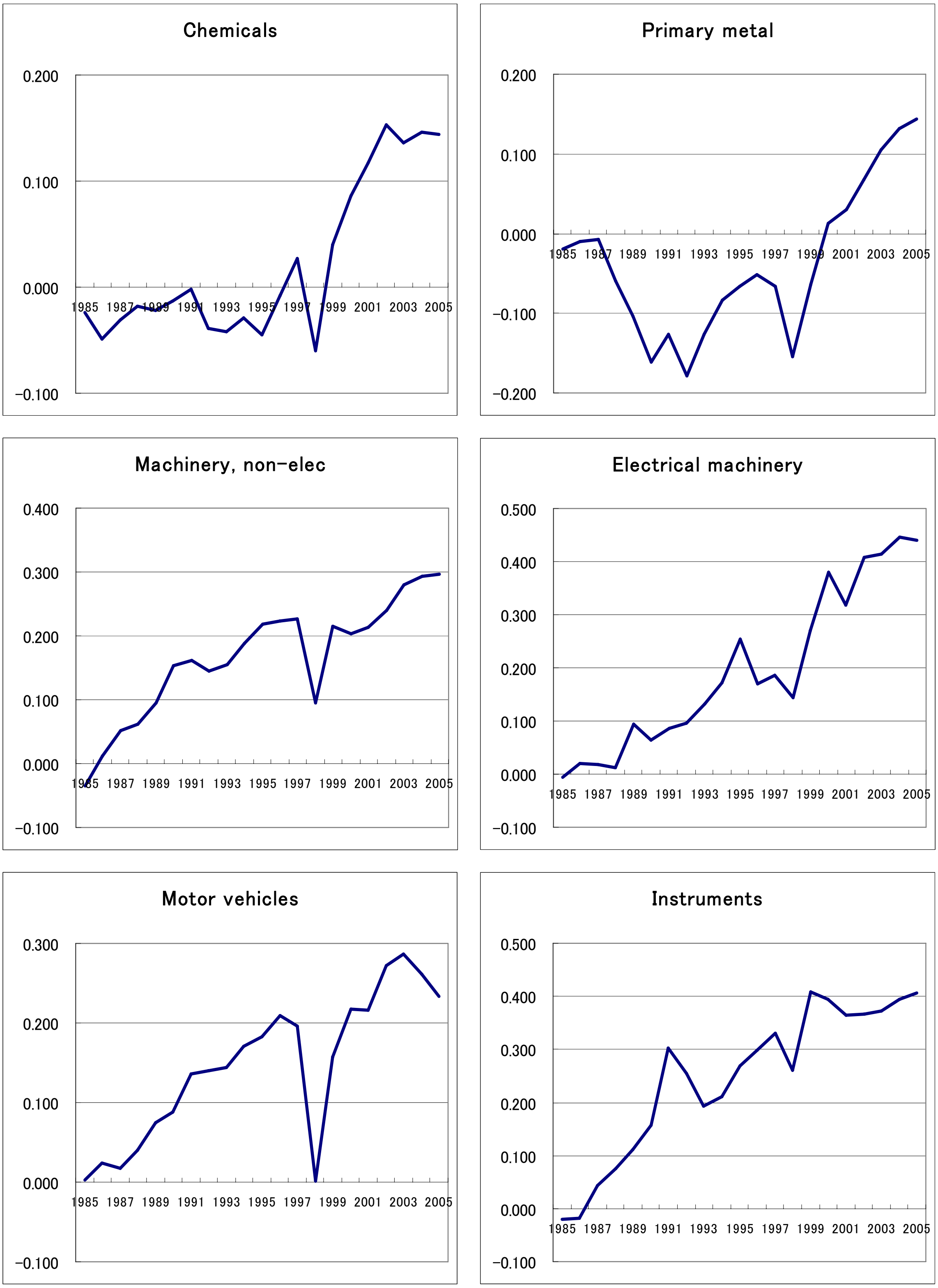

Figure 4. Griliches and Regev decomposition by major industry

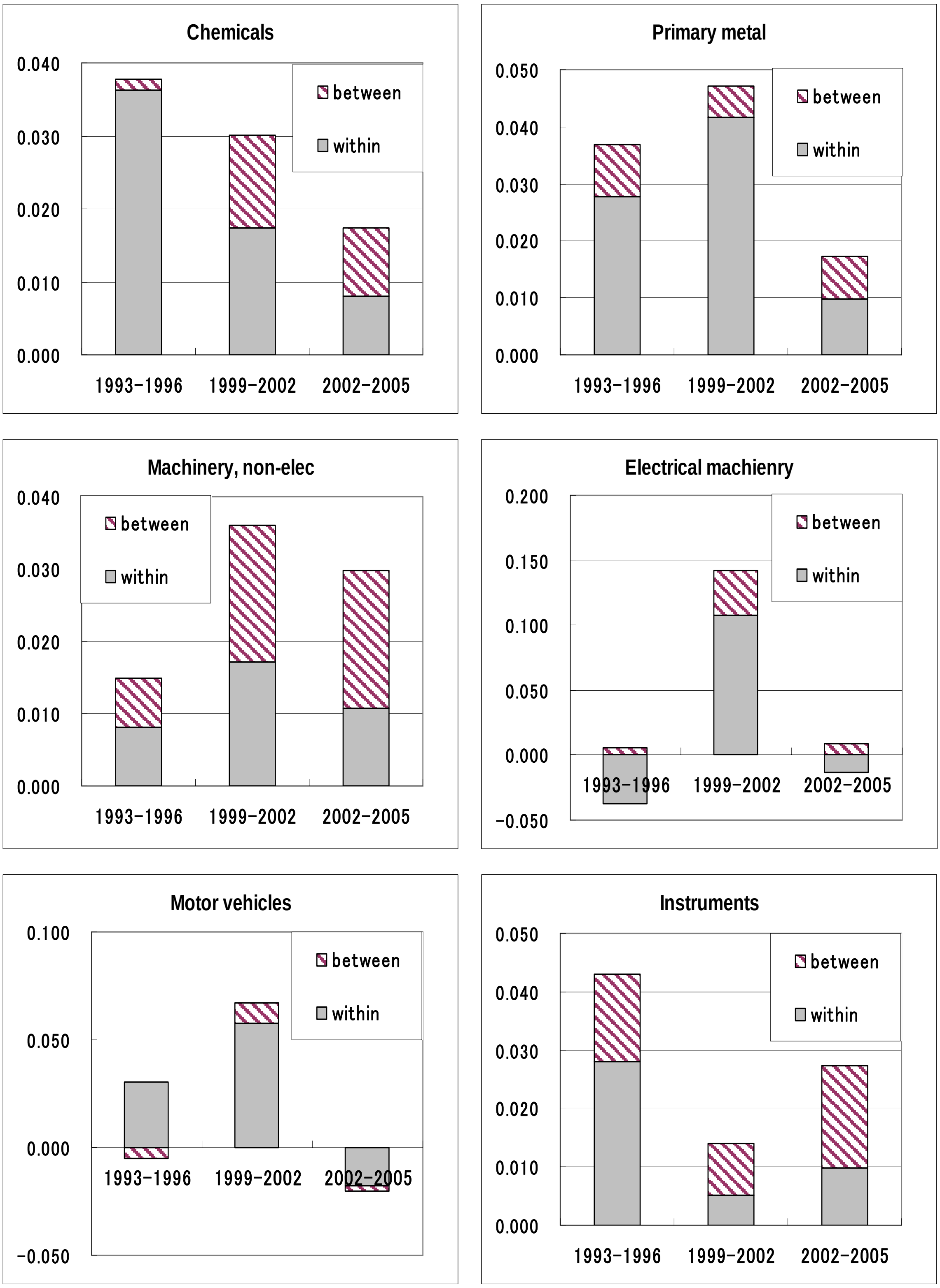

Figure 5. Output share by quartile of lnTFP : major industries