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Abstract

This paper analyzes the relationship between the use of stock options and productivity by employing firm-level panel data from the Basic Survey of Japanese Business Structure and Activities. According to the analysis, the use of stock options has a positive impact on firm productivity. Productivity steadily increases after the adoption of stock options. In addition, we found suggestive evidence that R&D investment increases after the introduction of stock options. These results imply that the deregulation on the use of stock options in 1997 and the subsequent legal reforms have had positive contributions to the productivity performance of Japanese firms.

Keywords : stock options, productivity, R&D investment

JEL classifications : D22, D24, G34, M52

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1. Introduction

This paper presents an empirical analysis on the relationship between stock options and productivity in Japanese firms. Stock options are pecuniary incentives that give executives and employees the right to buy the firm's stocks at a predetermined price during a prescribed period of time. The effect of stock options is generally understood to provide effects such as mitigating agency problems caused by the separation of ownership and management, promoting risk-taking by business managers, and enhancing the effort of executives and employees. This is a long-standing system in the United States, but was only introduced to Japan in 1997 after an amendment of the Commercial Act. A proper tax treatment for stock options was introduced in 1998. Further, at the beginning of the 2000s, the following revisions of the Commercial Act were made: removal of the upper limit of stock options, expansion of the coverage of people who are entitled to stock options, simplification of the legal procedures for granting stock options, etc.

The Ministry of Economy, Trade and Industry (METI) has conducted a survey on the adoption of stock options for about 30,000 large and medium-sized Japanese firms in "the Basic Survey of Japanese Business Structure and Activities" since fiscal year 1997 when stock options were widely introduced. The number of firms which adopted stock options continued to increase by the mid 2000s and since that time has remained the same or decreased slightly. The recent figure is about 1,500 firms, which is about 5-6% of the total firms surveyed (see Table 1). As described later, listed firms comprised a little less than half of the total firms adopting stock options and a considerable number of unlisted firms adopted stock options. METI added a survey item on the coverage of the people granted stock options in the Survey between 1998 and 2005. According to the survey results, 70% or more of the total firms which adopt stock options have granted stock options to both executives and employees.

If stock options enhance incentives for executives and employees and promote resource allocation by business managers on profitable investments, they are likely to contribute to productivity growth in firms as a result. They may also provide effects to expand relatively high-risk investments including R&D investment.

Although there have been some studies on the determinants and the effects of stock options in Japan, to the author's knowledge an analysis on the relationship between stock options and productivity has not yet been conducted. Moreover, past studies have used financial data of only listed firms and the large scale data collected in the Basic Survey of Japanese Business Structure and Activities were not fully utilized. Based upon this background, this paper analyzes the relationship between stock options and productivity (total factor productivity (TFP) and labor productivity (LP)) based on the panel data from the Survey mentioned above. Furthermore, we will analyze the relationship between stock options and R&D investments which is a typical high-risk investment, compared to ordinary equipment investment.

The results of the analysis can be summarized as follows: 1) Adoption of stock options increases TFP by 5-8% and LP by 5-10%, when the firm fixed-effects and endogeneity of the stock options are controlled for. 2) A comparison with the period before and after stock options were introduced demonstrates that the productivity growth rate before the introduction of stock options was not high compared to that for firms that did not introduce stock options. However, the productivity growth rate accelerated after the introduction of stock options and continued to increase every year since then. 3) R&D intensity (R&D investments / total sales) increases after the introduction of stock options. These results imply that withdrawal of the ban on stock options in the late 1990s and subsequent improvement of their systems made a contribution to the performance of Japanese firms.

The rest of this paper is structured as follows. Section 2 briefly surveys past studies. Section 3 describes the data used and the method of analysis. Section 4 presents the results, and Section 5 concludes with policy implications.

2. Literature Review

As Core et al. (2003) and Hanazaki and Matsushita (2010) present a detailed survey on theoretical and empirical studies on stock options, we only briefly review past studies that are closely related to the analysis in this paper. A large number of studies have been

conducted on the effects of stock options in Europe and the U.S., such as 1) the effects on share price (Brickley et al., 1985, etc.), 2) the effects on accounting profits (DeFusco et al., 1990; Chen and Lee, 2010, etc.), and 3) the effects on risk taking behavior (DeFusco et al.1990; Rajgopal and Shevlin, 2002; Chen and Lee, 2010, etc.). Recent research often investigates the effects of broad-based stock options not limited to executive but available for all employees (Core and Guay, 2001; Oyer and Schaefer, 2005; Hallock and Olson, 2010, etc.). Core et al. (2003) present a comprehensive survey of theoretical and empirical studies on a compensation plan for executive and employees based on shares including stock options and conclude that there is no theoretical or empirical consensus on how stock options and managerial equity ownership affect firm performance. They suggest that the optimum level of incentives for executives may vary by firms and that the current level of incentives may be too high or too low depending on the firm characteristics.

A small number of studies that focus on the relationship between stock options and productivity include Jones et al. (2010) and Sesil and Lin (2011).[1] Jones et al. (2010) estimate a Cobb-Douglas production function by fixed-effect estimation using panel data of listed firms in Finland (1992~2002), and conclude that no statistically significant relationship was identified between stock options for employees and productivity. Sesil and Lin (2011) also estimate a Cobb-Douglas production function to evaluate the effects of stock options for executives and those for employees on productivity in the current year and the following 5 years, based on the panel data collected from 632 high-tech firms in the United States. Their results show that stock options for executives have positive effects (+18%) on productivity in the year of the introduction of stock options, that those effects lasted for 5 years, and that broad-based stock options for people including employees have a positive effect (+9%) on productivity in the year of the introduction of stock options but that the effect does not persist. Based on these results, they conclude that although the adoption of stock options is beneficial for the productivity of firms, it is necessary to grant broad-based stock options to employees as frequently as stock options for executives in order to sustain a long-term effect from broad-based stock options. Furthermore, Bulan et al. (2010) analyze the relationship between the sensitivity of compensation for managers including stock options to business performance and productivity among manufacturers in the U.S. and indicate

[1] Palia and Lichtenberg (1999) analized the relationship between managers' ownership of shares and TFP (but not stock options).

that when the value of stock options for managers is more sensitive to the volatility of stock return, TFP of the firm is higher. In other words, they suggest that stock options prevent a decline in productivity due to managers' risk aversion.

In Japan, Nagaoka (2005) and Uchida (2006) empirically analyze the determinants of the introduction of stock options using firm-level data after the withdrawal of the ban on stock options in 1997 by the amendment of the Commercial Act. Nagaoka (2005), using data for 3,176 listed firms (including 391 firms that introduced stock options) between 1997 and 2000, finds that the R&D intensity of the firms which adopted stock options is high at the time of the introduction of stock options and the growth rate of the number of employees is very high. Nagaoka (2005) also estimates a probit model and a multinomial model. The results indicate that stock options are used more often by fast-growing young firms and less in regulated industries and by the firms with concentrated ownership structure, and that there is no significant relationship between R&D intensity and the introduction of stock options. Uchida (2006) analyzes the determinants (firm characteristics) of the adoption of stock options by estimating a probit model based on a data between 1997 and 2000 collected from firms listed in the First Section of the Tokyo Stock Exchange. The results suggest that there is a negative relation between leverage and the probability of firms' use of stock options, that such a relation is more marked for firms in a certain affiliated group (*Keiretsu*) or associated with main banks, and that independent firms which are more concerned about the shareholder wealth are more likely to use stock options. Although these studies analyze the determinants of the introduction of stock options, the effects of stock options on business performance are not examined.

Kubo and Saito (2008) analyze the sensitivity of compensation for presidents, including stock options, of Japanese firms, to the firm value based on a panel data for 115 firms between 1977 and 2000. The results indicate that the sensitivity of compensation for presidents of Japanese firms to the firm value is not only significantly low compared to the U.S. firms but decreased after 1990. They state that these results do not stem from the movements in overall share price. Their results imply that stock options have not been effective enough as an incentive for managers of the Japanese firms.

With respect to the effects on firm performance, Kato et al. (2005) analyzed the effects of stock options on share price and accounting performance based on the data

collected from about 350 listed firms which adopted stock options between 1997 and 2001. They present evidence that the adoption of stock options in Japanese firms had positive effects on share price and ROA. However, the periods of their research was until around 2000, which are not long enough to identify the medium- and long-term effects of stock options. Recent research by Hanazaki and Matsushita (2010) comprehensively analyze the determinants of the introduction of stock options and the effects of stock options on firm profits and risk-taking behaviour based on a panel data of Japanese listed firms between 1997 and 2006. The results show that firms of which large foreign ownership and firms of which have relatively low leverage are more likely to adopt stock options. The results also show that the use of stock options has limited effects on the firm's profitability (ROA and ROE) and that the effect of stock options on the firm's risk-taking is not observed. From these results, they concluded that the adoption of stock options in Japanese firms does not have either significant positive effects or negative side effects.

To summarize, the results of past Japanese studies on the effects of stock options on firm' profits are divided. There has been no empirical study on the relationship between stock options and productivity in Japan. In addition, although a small number of studies have been done on the effects on productivity even in Europe and the U.S., the conclusions are not uniform across studies. This paper aims to analyze empirically the medium- and long-term effects of the introduction of stock options on firm productivity and risk-taking (proxied by R&D investments) using a large sample of firms covering both listed and unlisted firms.

3. Data and Methodology

The analysis in this paper uses a panel data between 1994 and 2009 from the Basic Survey of Japanese Business Structure and Activities conducted by METI. The Basic Survey of Japanese Business Structure and Activities, an annual survey begun in 1991, accumulates representative statistics on Japanese firms with 50 or more regular employees, including those engaged in mining, manufacturing, electricity and gas, wholesale, retail, and several service industries. Over 25,000 firms are surveyed every

year. The purpose of this survey is to capture a comprehensive picture of Japanese firms, including their basic financial information, composition of businesses, R&D activities, IT usage, and foreign direct investments. As the sample firms are coded by using perpetual numbers, it is easy to construct a firm-level longitudinal data set. This Survey collects information on the adoption of stock options each year from 1997 to the present.[2] The specific questionnaire is very simple: "Are stock options introduced in your firm?" In this paper, a dummy variable (*sopt*) is used as an independent variable, which takes a value 1 for firms answering "Yes" for the above question.

Firstly, the relationship between stock options and productivity was analyzed based on the above data set. Value-added based TFP and labor productivity (LP) are our main dependent variables, where value-added, capital (total tangible assets), labor (total hours), and cost of shares of capital and labor are used for constructing these productivity measures. The TFP is calculated in a nonparametric manner that uses a hypothetical representative firm as reference. Specifically, the input and output of a hypothetical representative firm are calculated as the geometric means of those of all firms and the cost shares of labor and capital are calculated as arithmetic means at the base year (2001). The TFP for each firm are calculated relative to the hypothetical representative firm. This is called as the index number method which is often used for TFP measurement in recent studies.[3] LP is measured as value-added output per hour (used as a logarithmic form). When LP is used as dependent variable, the capital intensity (*lnkl)* is used as a control variable. Although LP is an incomplete productivity indicator compared to TFP, it has an advantage that measurement errors are relatively small.

The baseline estimation methods employ pooled OLS and fixed-effect (FE) estimators. The firm size (the log of the number of regular employees: *lnemp*) and year dummies are used as control variables. In addition, three-digit- industry dummies are used in the OLS

[2] A questionnaire on the subjects granted stock options (executives and/or employees) were added between the 1998 and the 2005 surveys.

[3] The formula for calculating value-added is as follows: 'Value added = Operating profit + Rental expense + Total labor cost + Depreciation expense + Taxes and dues' which is adopted in the report of the Basic Survey of Japanese Business Structure and Activities (taxes and dues are not included in 1994 as such data is unavailable). Working hours by industry and employment type are taken from the Monthly Labor Survey. Value-added deflator in "National Accounts" is used for creating real value-added and deflator on gross capital formation is used for creating real capital stock.

estimations. To summarize, the baseline equation to be estimated is expressed below. The equation (1) shows OLS estimation and the equation (2) shows FE estimation. The period of the analysis is from 1994 to 2009. Although stock options were introduced only after 1997, we use data back to 1994 in order to analyze the productivity before the introduction of stock options.

$$y_{it} = \alpha + \beta\, sopt_{it} + \gamma\, X_{it} + d_k \Sigma_k\, industry\ dummies + \lambda_t + \varepsilon_{it} \quad (1)$$

$$y_{it} = \alpha + \beta\, sopt_{it} + \gamma\, X_{it} + \lambda_t + \eta_i + \varepsilon_{it} \quad (2)$$

In these equations, y_{it} denotes productivity indicators (TFP, LP), X_{it} denotes control variables (firm size and capital intensity), λ_t denotes year dummies, η_i denotes firm fixed-effects, and ε_{it} is an i.i.d. error term.

In addition to the baseline estimation, the interaction term between stock options and listing is added in order to observe the different effects of stock options on whether the firm is listed or not. Needless to say, the effectiveness of stock options as an incentive device depends on the market value of the stock. Therefore, the effectiveness may be limited unless the firm is listed or is expected to be listed in the near future. As data about the listing status of firms is unavailable in the Basic Survey of Japanese Business Structure and Activities, the variable for listing dummy is constructed by using a converter of the Survey and the securities identification codes of listed firms.[4] Securities identification codes in the "Corporate Financial Data Bank" by the Research Institute of Capital Formation of Development Bank of Japan are used. The listed firms include all listed firms on the first and the second sections and emerging markets of the Tokyo, Osaka and Nagoya Stock Exchange, and other local stock exchanges.

There are often problems in relation to whether a causal relationship can be inferred from regression analysis due to endogeneity in variables related to corporate

[4] A converter for firm numbers and securities identification codes in the Basic Survey of Japanese Business Structure and Activities was provided by the Quantitative Analysis and Database Group of RIETI. The number of listed firms which corresponded to securities identification codes was about 2,500.

governance.[5] However, generally, it is very difficult to find an appropriate instrument. The effect of stock options is not an exception for the causality issue. This paper tries to check the robustness of the results of the baseline estimation, using stock options in the previous year as an instrumental variable for estimation.

Next, we analyze the effects of the adoption of stock options on firm's risk-taking behavior, using R&D investment as a proxy for high-risk investment. It is a well-known fact that R&D investments have higher risk and higher return than ordinary equipment investments. For example, Coles et al. (2006) suggest that the sensitivity of compensation for CEOs to the volatility of share price has a positive effect on R&D investments. Himmelberg and Petersen (1996) indicate the high sensitivity to internal funds (cash flow) of R&D investments, of which risk and profitability are hard to evaluate from outside. Specifically, we use R&D investments and equipment investments divided by firm sales as dependent variables in the regressions. The same explanatory variables and estimation methods as those for productivity regressions (see equations (1) and (2)) are used.

However, the estimation method described above is based on the assumption that the effects of stock options are stable regardless of the number of years after the adoption. In addition, a higher growth rate in productivity trends and a higher increase in R&D intensity of the firms which adopt stock options may overstate the estimated effects of stock options. For these reasons, in this paper, the year when each firm introduced stock options is used as the base year and the figures of productivity and R&D investments during the 3 years before that year and each year after the introduction are analyzed. In this case, fixed-effect estimator is employed.

$$y_{it} = \alpha + \beta\, soptyear_{it} + \gamma\, X_{it} + \lambda_t + \eta_i + \varepsilon_{it} \qquad (3)$$

The dummy variable $soptyear_{it}$ denotes the number of years after the introduction of stock options. The dummy $soptyear_{i0}$=1 for the firm-year when stock options is first introduced, and $soptyear_{i1}$=1 for the firm-year when the firm continues to adopt stock

[5] See Roberts and Whited (2011) for problems of endogeneity related to research on corporate governance.

options in the next year. In presenting estimation results, 1, 2, 3, 4, and 5 or more years after the introduction of stock options will be expressed as *sopt1*, *sopt2*, *sopt3*, *sopt4*, *sopt5+*. For example, for a firm which introduced stock options in 2001, *sopt1* and *sopt2* are the dummies for 2002 and 2003 of the firm. As the objective of this estimation is to compare the performance trends before and after the time of the introduction of stock options, the dummies for 1, 2, and 3 years before the introduction of stock options are also used (expressed as *sopt_1*, *sopt_2*, *sopt_3*). The specific year of the introduction of stock options varies depending on the firm. For example, for a firm which introduced stock options in 2001, *sopt_1, sopt_2, sopt_3* are dummies for 1998, 1999, and 2000 of the firm.

4. Results

Before presenting the regression results, the basic characteristics of the firms which introduce stock options and those which do not introduce stock options are compared based on the data set from 1997 to 2009 (see Table 2). The firms which introduced stock options are larger in size, higher in productivity (TFP, LP) and higher in the ratio of R&D investments-sales ratio and equipment investments-sales ratio, compared to those which did not introduce stock options. There are statistically significant differences at the 1% level in all these attributes. It is also found that the firms that introduced stock option have a higher foreign ownership ratio (8.38%) than those which did not introduce stock options (1.64%). On the other hand, the average year of the foundation of the firms that introduce stock options is 1960, while that of those which do not introduce stock options is 1957. Although the difference is statistically significant at the 5% level, the difference is quantitatively small. We do not find a strong tendency of introducing stock options among younger firms. In fact, a large number of traditional large firms introduced stock options.

Listed firms comprise about 45% of the firms which introduced stock options in the sample. The remaining 55% are unlisted firms.[6] As stock options have little value if

[6] As described already, as the data of whether the firm is listed or not is unavailable in the Basic Survey of Japanese Business Structure and Activities, the information which corresponds to

shares are non-marketable at the time of the exercise of the right, it is expected that the majority of the firms which introduced stock options would be listed firms. However, in reality, there are quite a few unlisted firms which introduced stock options.

4-1. Stock Options and Productivity

This subsection presents estimation results obtained from the regression equations described in the previous section. The relationship between stock options and productivity is shown in Table 3. The result of OLS estimate show that the TFP of the firms that adopted stock options is 8.7% higher after controlling for the firm size, industrial sector, and year dummies, while the result of FE estimate show that the TFP of such firms is 4.6% higher. The coefficient of the FE result is about half of that of the OLS estimate, which implies that the unobserved firm characteristics which adopted stock options are positively related to productivity: more productive firms tend to use stock options. The labor productivity advantages of firms that adopted stock options are 9.3% in the OLS estimate and 5.4% in the FE estimate. The size of the estimated coefficients is almost the same as that of the TFP. When three-digit industry dummies are added to the FE estimation (not reported in the table), the coefficients of stock options are 0.042 in TFP and 0.049 in LP.[7]

When the sample firms are divided into manufacturing and non-manufacturing firms, the estimated effects of stock options on TFP and LP are both about 1% higher in manufacturers than in non-manufacturers. However, a positive relationship between stock options and productivity is observed both in manufacturing and non-manufacturing firms (see Table 4).

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securities identification codes is used. As the matching may not be perfect, listed firms with the ratio of 45% may be an underestimate.

[7] Value-added includes wages. If stock options are granted instead of wages to employees, the calculated productivity will be lower. In this case, the effects on stock options can be underestimated.

As mentioned already, there are quite a few unlisted firms among the firms that adopted stock options. In order to detect if there are any differences in the effects of stock options on productivity in relation to whether the firms are listed or unlisted, a dummy for listed firms and the interaction term of stock options and the dummy for listed firms are added as independent variables in the FE estimations. The results indicate that the coefficients of the interaction terms are significant and relatively high positive value (see Table 5 and Figure 1). The effects of stock options on TFP is about 3% for non-listed firms and about 7% for listed firms (LP is about 3% for non-listed firms and about 8% for listed firms). The effects of stock options on productivity performance are stronger for listed-firms. However, it should be noted that the introduction of stock options has a positive effect on productivity even for non-listed firms.

Next, the results of instrumental variable estimation (IV) and IV fixed-effects estimation (IVFE) are presented, where the adoption of stock options for the previous year is used as an instrument for the current stock options. Once stock options are introduced, they often continue to be adopted for the following several years. Therefore, the explanatory power of the first stage regression to explain the adoption of stock options is high.[8] As shown in Table 6, the coefficients are relatively larger than those without instrumental variable. The results of IVFE show that the adoption of stock options increased TFP by about 8% and LP by about 10% (Table 6, columns (3) and (4)). When the sample firms are divided into manufacturing and non-manufacturing firms, the effects of the adoption of stock options on TFP are about 10% for manufacturers and about 7% for non-manufacturers, and the effects on LP are about 11% for manufacturers and about 9% for non-manufacturers. The effects on productivity in manufacturing firms are somewhat larger than those in the simple FE estimates (see Table 7).

The unobservable time-invariant firm characteristics are controlled in FE estimates. However, regardless of whether the firm introduced stock options or not, there may be a trend difference in the productivity growth rates between the firms which adopted stock options and those which did not adopt stock options. To investigate this possibility, productivity performance during the period of 3 years prior to the introduction of stock options is compared to that of the several years after the introduction. The results are

[8] As described later, the effects on productivity become larger as the time passed after the introduction of stock options. This suggests that there are lagged effects of stock options on productivity. Therefore, the lagged stock options may not be an ideal instrument.

shown in Table 8 and Figure 1. They show that although the growth rate of productivity was not very high before the introduction of stock options, it increased after the introduction and continued to increase as the years passed. Productivity in the firms which introduced stock options more than 5 years before experience about 11-13% increases. This suggests that the firms which introduced stock options are not those which already had higher trend productivity growth, but that the growth rate of productivity accelerated by the introduction of stock options. Although this analysis does not completely eliminate the possible endogeneity bias that the firms introduce stock options by anticipating an increased growth rate of their productivity, it strongly implies a causal relationship between the introduction of stock options and productivity performance.

As Kubo and Saito (2008) indicated, the sensitivity of executive compensation including stock options of Japanese firms to business performance is very low. However, the effects of incentives depend both on 1) the sensitivity of compensation to business performance, and 2) the sensitivity of efforts made by executives and employees to changes in compensation structure. In addition, stock options can have effects to promote risk-taking by increasing not only the sensitivity of compensation to the level of business performance but also the sensitivity to the volatility of business performance (equity risk) (Guay, 1999; Coles et al., 2006, etc.). Although this paper does not directly test these arguments, it implies that the sensitivity of efforts to compensation can be high and/or stock options can have effects to change behavior of risk-averse managers.

4-2. Stock Options and R&D Investment

This subsection reports the results on whether the adoption of stock options has effects on the increase of corporate risk-taking by focusing on R&D investments. The results of the OLS estimates show that R&D intensity (the ratio of R&D investments to sales) is 0.77% higher for firms which adopted stock options whereas the results of FE estimates indicate a value of 0.09% which is relatively low (see Table 9, columns (1) and (2)). However, the sign of the coefficients is positive and highly significant from statistical

standpoint.[9] The reason that the coefficients in OLS and FE are very different seems to stem from the firm characteristics that the level of R&D intensity of the firms which adopted stock options is high without the adoption. Although the figure 0.09% seems small, it should be noted that the sample mean of the R&D intensity is 0.55%. The figure 0.09% in FE estimates indicates that the adoption of stock options increases R&D investments by about 15% on average, which is economically sizable. However, the fitness of the whole regression is not good, implying that the factors which determine R&D investments are not fully incorporated in this equation.

In contrast to the results for R&D investment, for ordinary equipment investments, although the results of OLS estimates show that the equipment investments is high in firms which adopted stock options, the results of FE estimates show that there is no significant relationship between these two variables and the sign of the coefficient is negative (see Table 9, columns (3) and (4)). This indicates that taking firm fixed-effects into account, the adoption of stock options does not increase ordinary equipment investments.

When estimation is conducted by including the interaction terms between the adoption of stock options and the dummy for listed firms, the coefficient for the interaction term is positive and significant for R&D equation, but the coefficient of stock options becomes insignificant (see Table 10, column (1)). This indicates that the effects of stock options on R&D investments are limited only to the listed firms.

In order to remove possible endogeneity bias, we conduct IV and IVFE estimations using the lagged stock options as an instrumental variable for current stock options. The results show that the coefficient of stock options is about twice larger than that in the simple FE estimates (see Table 11), and that the adoption of stock options increases R&D intensity by about 0.2 %, which is 33.5% to R&D intensity of the sample mean.

Finally, similar to the productivity estimations, changes in R&D intensity before and after the introduction of stock options are estimated, taking into account that the firms

[9] When the sample firms are divided into manufacturing and non-manufacturing firms, the coefficient in FE estimates is 0.0014 for manufacturers and 0.0005 for non-manufacturers, and the coefficient in IVFE estimates is 0.0031 for manufacturers (all of these are statistically significant at the 1% level) and in 0.0006 for non-manufacturers (insignificant at the 10% level). This indicates that the effects of stock options on R&D investments are larger for manufacturing firms.

which adopted stock options had not only a high level of R&D intensity but a high trend growth of R&D intensity before the adoption of stock options. The results are shown in Table 12. The slightly increasing trends in productivity were observed before the adoption of stock options. Although it is not as clear as the case of productivity due to large fluctuations by years, R&D intensity increases in the following year of the adoption and 5 or more years after the adoption.

The results described above imply that the adoption of stock options can have effects to promote R&D investments, which have higher risk and higher return compared to ordinary equipment investments.

5. Conclusion

This paper presents an empirical analysis on the relationship between stock options and productivity based on the panel data of the Basic Survey of Japanese Business Structure and Activities. The first objective of this study is to investigate factors that affect differences in firm-level productivity. The second objective is policy evaluation about the effects of legal reforms. In Japan, stock options were introduced in 1997 after a revision of the Commercial Act. Since then, METI has been committed to improve the stock option systems for more than 10 years. This is an empirical study to investigate into the effects of such reform of the system on Japanese firms. The novelty of this research is that we analyse the medium- to long-term effects of the adoption of stock options on productivity using a large firm-level panel data covering both listed and unlisted firms.

The results suggest that the adoption of stock options have a positive effect on firm's productivity and that the quantitative magnitude on TFP and LP is about 5-10%. The increasing trends are also observed in productivity as the time passed after the introduction of stock options. There are quite a few unlisted firms among the firms which adopted stock options. With respect to whether there are any differences in effects of stock options on productivity between listed and unlisted firms, larger effects in listed firms are observed. The firms which adopted stock options increase R&D

investments, while such relationship is not found in ordinary equipment investments. This implies that the firms increase high-risk investments, triggered by the introduction of stock options. Generally speaking, as R&D investments lead to productivity growth for medium- and long-term, the increase in R&D investments can be one of the important channels which enhance firm productivity.

According to past studies, the optimum incentives level for executives and employees, including stock options, is not uniform across firms and depends on the firm characteristics. The implication is that the adoption of stock options is determined as a result of a rational choice of the optimum contract for each firm, thus it is unrelated to business performance. However, the analysis of this paper shows that stock options have positive effects on productivity performance in Japanese firms. Possible reasons include the fact that the introduction of stock options, which were banned before 1997, allowed firms suitable for using such incentives to adopt stock options actively. If managers of Japanese firms were overly risk-averse, use of compensation scheme which promote risk-taking of managers have desirable effects on firm performance.

Regarding policies, the reforms of the laws and regulations related to corporate governance including the revision of the Commercial Act and the introduction of the tax system for stock options during the past 15 years have provided an opportunity to make use of incentive schemes for managerial risk-taking and investment for productivity growth.

It should be noted that there are some limitations to the analysis in this paper. Firstly, the firms that adopted stock options may have implemented various managerial reforms in parallel with the introduction of stock options. Therefore, the relationship between stock options and productivity observed in this paper may include the effects of other managerial reforms omitted in the analysis. Secondly, although we have checked for possible endogeneity bias of the results by employing IV estimations, the instrumental variable used is a lagged endogenous variable, which is not an ideal instrument. Thirdly, the measure of stock options used here is a dummy variable of whether stock options are adopted or not, and we do not consider the size of stock options granted due to the data limitation. Finally, the analysis in this paper focuses only on stock options, but incentives for executives and employees include the ownership of shares–the ownership of shares by executives, Employee Stock Ownership Plans (ESOPs), etc.–aside from

stock options. In spite of the need for further research, we believe the analysis in this paper helps to deepen our understanding on the effects of stock options.

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Table 1. The number of firms adopting stock options

Fiscal year	Number of firms with stock options	Ratio to total firms
1997	544	2.1%
1998	639	2.4%
1999	827	3.2%
2000	1093	4.0%
2001	1188	4.2%
2002	1483	5.4%
2003	1492	5.6%
2004	1729	6.1%
2005	1701	6.1%
2006	1626	5.8%
2007	1613	5.5%
2008	1590	5.6%
2009	1505	5.4%

(Note) Author's calculation from the Basic Survey of Japanese Business Structure and Activities (METI).

Table 2. Characteristics of firms which adopt stock options and those which do not adopt stock options

	Firms with stock options	Firms without stock options	
Ln (Number of employees)	5.863	5.157	***
TFP	0.143	−0.070	***
LP	−2.968	−3.174	***
R&D investments/sales	0.015	0.005	***
Equipmentment investment/sales	0.040	0.033	***
Foreign ownership ratio	8.38	1.64	***
Year of establishment	1959.5	1957.2	**

(Note) *** Significant at 1%; ** significant at 5%; * significant at10%.

Table 3. Stock options and productivity

	(1) TFP		(2) TFP		(3) LP		(4) LP	
	OLS		FE		OLS		FE	
sopt	0.0867	***	0.0456	***	0.0928	***	0.0535	***
	(0.0043)		(0.0039)		(0.0042)		(0.0038)	
lnemp	0.0499	***	−0.1438	***	0.0697	***	−0.2155	***
	(0.0008)		(0.0024)		(0.0008)		(0.0024)	
lnkl					0.1156	***	0.0793	***
					(0.0006)		(0.0013)	
year dummies	yes		yes		yes		yes	
industry dummies	yes		no		yes		no	
Number of obs	377,760		377,760		377,760		377,760	
R-squared	0.1849		0.0443		0.2500		0.0955	

(Note) OLS and FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Adjusted R-squared for OLS estimates, R-squared (within) for FE estimates.

Table 4. Stock options and productivity (manufacturing vs. non-manufacturing firms)

	(1) TFP		(2) TFP		(3) LP		(4) LP	
	FE		FE		FE		FE	
	Manufacturing		Non-manufacturing		Manufacturing		Non-manufacturing	
sopt	0.0519	***	0.0420	***	0.0586	***	0.0505	***
	(0.0060)		(0.0049)		(0.0059)		(0.0047)	
lnemp	−0.1049	***	−0.1507	***	−0.1675	***	−0.2308	***
	(0.0042)		(0.0028)		(0.0042)		(0.0028)	
lnkl					0.0875	***	0.0714	***
					(0.0023)		(0.0014)	
year dummies	yes		yes		yes		yes	
Number of obs	190,833		186,927		190,833		186,927	
R-sq: within	0.0824		0.0330		0.1301		0.0917	

(Note) FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5. Stock options and productivity (listed vs. unlisted firms)

	(1) TFP		(2) LP	
	FE		FE	
sopt	0.0302	***	0.0332	***
	(0.0050)		(0.0048)	
sopt_list	0.0387	***	0.0508	***
	(0.0077)		(0.0075)	
list	−0.0184	*	0.0053	
	(0.0103)		(0.0101)	
lnemp	−0.1439	***	−0.2157	***
	(0.0024)		(0.0024)	
lnkl			0.0793	***
			(0.0013)	
year dummies	yes		yes	
Number of obs	377,760		377,760	
R-sq: within	0.0444		0.0956	

(Note) FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6. Stock options and productivity (IV estimation)

	(1) TFP		(2) LP		(3) TFP		(4) LP	
	IV		IV		IVFE		IVFE	
sopt	0.1088	***	0.1176	***	0.0838	***	0.0989	***
	(0.0060)		(0.0059)		(0.0080)		(0.0078)	
lnemp	0.0514	***	0.0720	***	−0.1411	***	−0.2134	***
	(0.0009)		(0.0009)		(0.0026)		(0.0026)	
lnkl			0.1162	***			0.0835	***
			(0.0007)				(0.0014)	
year dummies	yes		yes		yes		yes	
First-stage F static	2935.97	***	2915.64	***	6074.00	***	5718.20	***
Number of obs	321,823		321,823		321,823		321,823	
R-squared	0.1855		0.2551		0.0336		0.0777	

(Note) Lagged stock options are used as instrumental variable. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7. Stock options and productivity (IV estimation, manufacturing vs. non-manufacturing firms)

	(1) TFP		(2) TFP		(3) LP		(4) LP	
	IVFE		IVFE		IVFE		IVFE	
	Manufacturing		Non-manufacturing		Manufacturing		Non-manufacturing	
sopt	0.1008	***	0.0711	***	0.1116	***	0.0890	***
	(0.0117)		(0.0109)		(0.0114)		(0.0106)	
lnemp	−0.1033	***	−0.1515	***	−0.1638	***	−0.2331	***
	(0.0044)		(0.0031)		(0.0045)		(0.0031)	
lnkl					0.0959	***	0.0733	***
					(0.0026)		(0.0016)	
year dummies	yes		yes		yes		yes	
First-stage F static	3535.61	***	2388.18	***	3327.80	***	2249.01	***
Number of obs	165,430		156,393		165,430		156,393	
R-sq: within	0.0636		0.0340		0.1041		0.0883	

(Note) Lagged stock options are used as instrumental variable. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8. Productivity before and after the introduction of stock options

	(1) TFP		(2) LP	
	FE		FE	
sopty_3	0.0127	**	0.0140	**
	(0.0058)		(0.0057)	
sopty_2	0.0152	***	0.0169	***
	(0.0059)		(0.0057)	
sopty_1	0.0255	***	0.0295	***
	(0.0061)		(0.0059)	
sopty0	0.0231	***	0.0285	***
	(0.0053)		(0.0052)	
sopty1	0.0527	***	0.0627	***
	(0.0068)		(0.0066)	
sopty2	0.0716	***	0.0838	***
	(0.0081)		(0.0079)	
sopty3	0.0851	***	0.0959	***
	(0.0095)		(0.0093)	
sopty4	0.1000	***	0.1116	***
	(0.0113)		(0.0110)	
sopty5+	0.1109	***	0.1256	***
	(0.0093)		(0.0091)	
lnemp	−0.1445	***	−0.2164	***
	(0.0024)		(0.0024)	
lnkl			0.0792	***
			(0.0013)	
year dummies	yes		yes	
Number of obs	377,760		377,760	
R-sq: within	0.0447		0.0960	

(Note) FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9. Stock options and R&D investments

	(1) R&D		(2) R&D		(3) Equipment		(4) Equipment	
	OLS		FE		OLS		FE	
sopt	0.0077	***	0.0009	***	0.0052	***	−0.0001	
	(0.0001)		(0.0001)		(0.0006)		(0.0007)	
lnemp	0.0029	***	0.0004	***	0.0035	***	0.0060	***
	(0.0000)		(0.0001)		(0.0001)		(0.0004)	
year dummies	yes		yes		yes		yes	
industry dummies	yes		no		yes		no	
Number of obs	437,895		437,895		384,517		384,517	
R-squared	0.1632		0.0007		0.0848		0.0035	

(Note) OLS and FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Adjusted R-squared for OLS estimates, R-squared (within) for FE estimates.

Table 10. Stock options and R&D investments (listed vs. unlisted firms)

	(1) R&D		(2) Equipment	
	FE		FE	
sopt	0.0000		−0.0005	
	(0.0002)		(0.0009)	
sopt_list	0.0025	***	0.0009	
	(0.0003)		(0.0013)	
list	−0.0020	***	0.0071	***
	(0.0003)		(0.0016)	
lnemp	0.0004	***	0.0060	***
	(0.0001)		(0.0004)	
year dummies	yes		yes	
Number of obs	437,895		384,517	
R-squared	0.0009		0.0035	

(Note) FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 11. Stock options and R&D investments (IV estimation)

	(1) R&D IV		(2) R&D IVFE	
sopt	0.0100	***	0.0019	***
	(0.00021)		(0.00028)	
lnemp	0.0030	***	0.0003	***
	(0.00003)		(0.00009)	
year dummies	yes		yes	
First-stage F static	3606.21	***	7228.51	***
Number of obs	373,887		373,887	
R-sq: within	0.1744		0.0007	

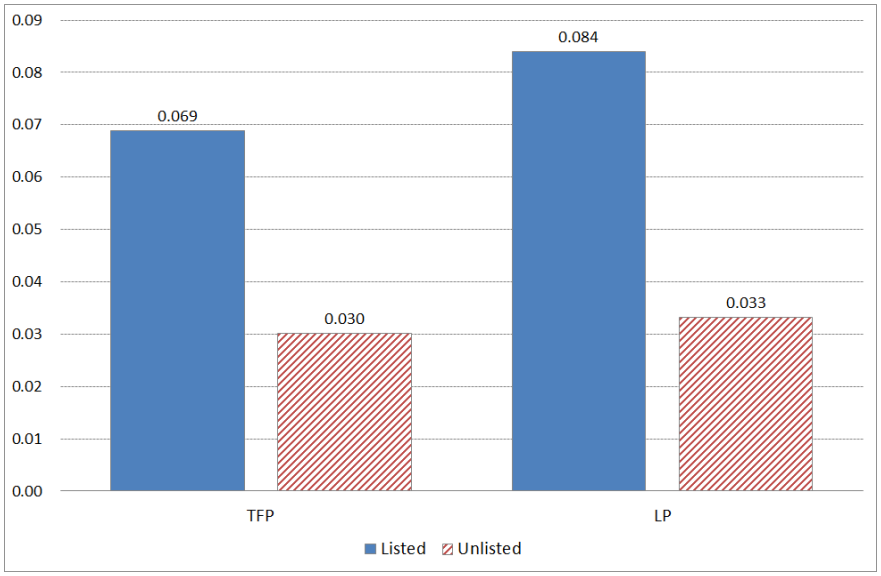
(Note) Lagged stock options are used as instrumental variable. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 12. R&D intensity before and after the introduction of stock options

	(1) R&D FE		(2) Equipment FE	
sopty_3	−0.0008	***	0.0015	
	(0.0002)		(0.0010)	
sopty_2	−0.0007	***	0.0028	***
	(0.0002)		(0.0010)	
sopty_1	−0.0003		0.0019	*
	(0.0002)		(0.0011)	
sopty0	0.0000		0.0024	***
	(0.0002)		(0.0009)	
sopty1	0.0015	***	0.0005	
	(0.0002)		(0.0012)	
sopty2	0.0010	***	0.0021	
	(0.0003)		(0.0014)	
sopty3	0.0003		−0.0026	*
	(0.0003)		(0.0016)	
sopty4	0.0013	***	−0.0065	***
	(0.0004)		(0.0018)	
sopty5+	0.0025	***	−0.0019	
	(0.0003)		(0.0015)	
lnemp	0.0004	***	0.0060	***
	(0.0001)		(0.0004)	
year dummies	yes		yes	
Number of obs	437,895		384,517	
R-sq: within	0.0009		0.0036	

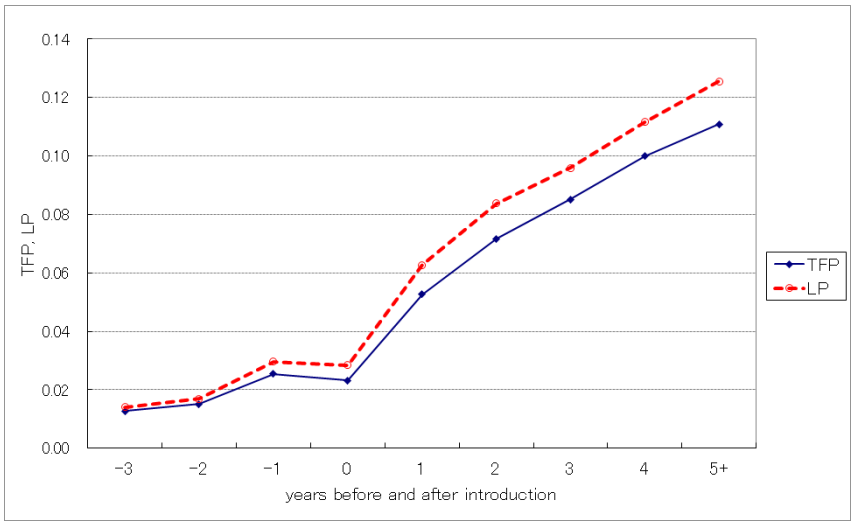
(Note) FE estimates with standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 1. Productivity effects of stock options (listed vs. unlisted firms)



(Note) FE estimation results. Firm size and year dummies are controlled. The vertical axis indicates productivity (log points).

Figure 2. Productivity before and after the introduction of stock options



(Note) FE estimation results. Firm size and year dummies are controlled. The vertical axis indicates productivity (log points).