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Foreign Technology Acquisition Policy and Firm Performance in Japan, 1957-1970: Macro-aspects of Industrial Policy

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Foreign Technology Acquisition Policy and Firm Performance in Japan, 1957-1970: Micro-aspects of Industrial policy

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Abstract

We examine the determinants and effects of technology acquisition licensing, using firm-level data between 1957 and 1970. Our results indicate that in technology acquisition licensing, the government screened a firm's application based on (i) the industry that the firm belonged to and (ii) its past experience of technology acquisition. As a result, inefficient firms with considerable experience tended to acquire more technologies before deregulation. Despite this screening process, the technology acquisition policy contributes to improve a firm performance: The firms with acquired technology succeeded in capital accumulation, which results in much faster growth of labor productivity. (96 words)

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1. Introduction

The evaluation of Japanese industrial policy has undergone substantial changes since the 1980s. Recent studies by Beason and Weinstein (1996) and Porter, Takeuchi, and Sakakibara (2000) claimed that industrial policy had failed to pick up growing industries and had sustained inefficient sectors. In the 1980s, however, many economists and political scientists thought it to be one of the major sources of the success of the Japanese economy (see Komiya, Okuno, and Suzumura, 1988; Okimoto, 1989; Tyson, 1992; Noland, 1993). Indeed, the evaluation of industrial policy has been inconsistent over time and highly sensitive to the general performance of the Japanese economy.[1]

In this connection, several studies have stressed the importance of the relationship between industrial policy and productivity growth (Beason and Weinstein, 1996; Branstetter and Sakakibara, 1998; Okazaki and Korenaga, 1999).[2] But only a few studies focused on one of the most important but controversial industrial policies that might directly affect the growth in productivity: the foreign technology acquisition policy, which was intensively implemented in the 1950s and 1960s, based on the licensing of foreign technology acquisition by the Ministry of International Trade and Industry (MITI).

Our motivation comes from two strands of research. One is the literature on the

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[1] Some studies stressed that the Japanese industrial policy did not have much effect on firm behavior, including international trade. See Saxonhouse (1983) and Weinstein (1995). Similarly, Okimoto and Saxonhouse (1986) presented evidence that the role of public R&D was quite limited.
[2] Another aspect is the effect of industrial policy on welfare. See Noland (1993).

technology acquisition policy, specifically the licensing of technology acquisition itself. The studies in this area are mainly based on macro and industry level data and descriptive materials. Among them, Ozaki (1972) and Peck and Tamura (1976) provided many significant stylized facts on technology acquisition policy in Japan. According to Ozaki (1972) and Peck and Tamura (1976), the regulations of foreign technology acquisition, which had been strictly implemented in the 1950s, started to be relaxed in the early 1960s. As will be described in the next section, we can identify three periods in the postwar history of technology acquisition policy up until the end of the high economic growth period. In the first period, the government strictly controlled technology acquisition, and licenses were concentrated on intermediate goods industries. In the second period, liberalization of controls started, and acquisitions by consumption and export goods industries increased. Finally, in the third period, liberalization made substantial progress.

The other strand is the microeconometric analysis of technology acquisition. Odagiri (1983) analyzed the correlations among R&D expenditure, patent royalty payments and sales growth, using firm-level data from 1969 to 1980. He found a positive and significant correlation between patent royalty payments and R&D expenditure, with these two expenditures being seen as having a complementary relationship. However, the correlation between patent royalty payments and the growth of sales was not significant. Adopting another approach, Montalvo and Yafeh (1994) analyzed determinants of technology acquisition, based on a model of a firm's decision-making process for technology transfer, using firm-level count data on licensing from 1977 to 1981. They found that a large part of the technological catch-up was driven by large firms, especially those with *keiretsu* relationships.

Both strands of research have made significant contributions to the literature. But the link between the two strands, namely the connection between technology acquisition policy and firm performance has not been fully explored. The first line of study ignored the aspect of firm heterogeneity while the second line did not pay much attention to the role of industrial policy. Firm heterogeneity is particularly important, since, as we will see later in this paper, most firms did not acquire any technologies even in the targeted industries. In other words, the government authorities screened the firms that would be advantaged by the policy tools. To understand the nature and consequences of industrial policy, an analysis of micro aspects is needed.

This paper proposes a framework to integrate these two strands of study. That is, we examine the causes and effects of technology acquisition policy on firm performance with a detailed historical review of the Japanese policy for technology acquisition, using firm-level data. The sample period is between 1957 and 1970, which includes the years when regulation was relaxed as well as the years when strict regulation prevailed. Data used in this paper cover more than 1,100 firms and more than 1,700 acquired technologies.

The paper is organized as follows. The next section presents a historical overview. The third section discusses the data used in our analysis. The fourth section examines the causes and effects of technology acquisition on firm performance, and the final section sets forth our conclusions.

2. Historical Overview

The legal framework of the technology acquisition licensing policy was provided by the Foreign Investment Law of 1950. The Foreign Investment Law aimed at licensing only those capital imports which were "desirable" for the Japanese economy, and at the same time sought to protect foreign investors (The Bureau of Corporations, MITI, 1960). For this purpose, the Law regulated contracts for technological assistance that lasted for longer than one year and that were paid in foreign currencies, as well as acquisition of the stocks of Japanese firms by foreign investors. If a Japanese firm decided to seek foreign technological assistance, it was required to apply for a license from the competent ministers, namely the Minister of Finance and the head of the relevant ministry. The competent ministers screened the applications, consulting with the Foreign Investment Council.

The Foreign Investment Law prescribed the following positive and negative criteria for licensing foreign capital including technology assistance (Article 8). Acquisition would only be approved if it was deemed that it would directly or indirectly contribute to the balance of payments, or the development of important industries or public works. At the same time, acquisition was not approved if it was unfair or illegal, or if it exerted a negative influence on Japan's economic recovery.

Next, the licensing procedure for technology acquisition is described, taking the case of a firm under the jurisdiction of the MITI as an illustration. A firm intending to acquire foreign technology filed an application with the Bank of Japan, which passed the application on to the Industrial Fund Section of MITI. The Industrial Fund Section advised the relevant bureaus of the application and requested their opinions on it. Then, the Industrial Fund Section held a meeting with the applicant firm, the bureau in charge of the applicant, the bureau in charge of the industry that mainly used the products of the applicant, the Institute of Industrial Technology, and the Agency of Patent. Next, the relevant bureaus made their opinions known again to the Industrial Fund Section, which, in turn, coordinated those opinions in order to obtain MITI's viewpoint. Meanwhile, the Ministry of Finance and the Bank of Japan arrived at their respective positions, and these would subsequently come up for discussion at the secretary meeting of the Foreign Investment Council. If the secretary meeting decided to give its approval, it was then passed to the Foreign Investment Council for their endorsement. If the secretary meeting did not approve the application, the meeting advised the applicant to withdraw it. If the applicant refused to withdraw, a formal decision of rejection was made.

The first step towards deregulation was taken in 1961. The positive criteria mentioned above carried with it the implication that only "desirable" foreign technology should be acquired. On the other hand, in the revision of the Foreign Investment Law in 1961, the positive criteria for technology acquisition were abolished, and technology acquisition came to be approved in principle, provided it was not seen as harmful.

Namely, foreign technology acquisition was approved unless it impeded similar domestic technology which had been or would be applied to business, it unduly suppressed small and medium-sized firms, destroyed the order of an industry, or an acquiring firm had not enough capability to assimilate the technology (Year Book of Capital Import, 1962, p.2).

After a small change in the regulation in 1966, deregulation began to make substantial progress in 1968. The new procedure for foreign technology acquisition was as follows. Examination of an individual application by the government was required only with respect to the technology related to aircraft, weapons, explosives, nuclear power, space development, computers and the petrochemical industry. With respect to the other technologies, the Bank of Japan approved acquisition, unless the relevant Minister gave a special instruction within one month from the application, on the grounds that the technology acquisition would have a serious influence on the Japanese economy. These criteria were for the acquisition of technology whose price exceeded fifty thousand dollars or was not fixed. Otherwise, the Bank of Japan immediately approved technology acquisition (Year Book of Capital Import, 1968-1969, pp.11-12).

Figure 1 shows the number of firms that acquired technology, and the number of acquired technologies in our data set.[3] Three findings stand out. First, both the number of firms with acquired technologies and the number of acquired technologies increased steadily throughout the period. The number of firms with acquired technologies

[3] A detailed description of the data will be provided in Section 3.

increased from 46 in 1957 to 259 in 1970. Similarly, the number of acquired technologies grew from 70 in 1957 to 686 in 1970.

=== Figure 1 ===

Second, the number of acquired technologies increased dramatically in 1962-63 and 1969-70, which is the period immediately following the relaxation of regulations on technology acquisition. The number of acquired technologies grew from 136 in 1962 to 291 in 1963. Further, it increased from 505 in 1969 to 686 in 1970. These results imply that technology acquisition regulations in Japan effectively constrained firms from acquiring foreign technologies in the 1950s and 1960s.

Finally, some firms acquired many technologies. The growth of the number of firms that were able to acquire technologies was not proportional to the growth of the number of acquired technologies. The number of firms with acquired technologies grew less rapidly than the number of acquired technologies. This fact suggests that limited number of firms could acquire technologies, and there were some firms that acquired many technologies.

Table 1 summarizes the number of acquired technologies and the number of firms that were able to acquire technology, by industry. We split the samples into three periods (1957-61, 1962-68, 1969-70), referring to the deregulations in 1961 and 1968. Table 1 indicates that acquired technologies were concentrated in certain industries.

Major importers were the electric machinery sector, the general machinery sector and the chemical industry. From 1957 to 1970, the number of acquired technologies was 326 for the electric machinery sector, 275 for the general machinery sector, and 301 for the chemical industry, which accounted for 53.0 percent of total acquisitions.

=== Table 1 ===

Note that the relative proportions changed between 1957 and 1970. The share of acquired technologies by these three sectors declined from 57.0 percent in 1957-61 to 49.6 percent in 1969-70. On the other hand, the textiles and wholesale trade sectors grew from 2.6 percent and 3.3 percent in 1957-61 to 4.9 percent and 6.8 percent in 1969-70, respectively. In other words, industries other than the three major importers started acquiring technologies after deregulation.

It should also be noted that most firms did not acquire any technologies in the electric machinery sector, general machinery sector, and chemicals. The technology acquisition rate, which is defined as the proportion of firms with acquired technologies, is 36.3 percent in the electric machinery sector, 30.2 percent in the general machinery sector, and 42.7 percent in chemicals. In addition, the highest technology acquisition rate is observed in drugs and medicines and precision equipment. These results imply that even in the targeted industries most firms have not benefited from 'industrial policy' and the micro-aspects of industrial policy cannot be ignored.

3. Data

Our sample firms are drawn from Japanese firms listed on the Tokyo Stock Exchange in the period 1957-1970. The sample period covers the high economic growth period, and the years when regulation was relaxed as well as the years when strict regulation prevailed. Two main data sources are used. Technology acquisition data come from the Japan Economic Research Institute (1973), *Kigyobetsu Gaishi Donyu Soran* (*Complete List of Capital Imports by Firm*). We define a "technology acquisition" as an import of foreign technology by a Japanese firm listed on the Tokyo Stock Exchange.

Other firm-level data come from the *Financial Database of the Japan Development Bank* (the JDB database), which is compiled from the financial reports of each firm. We merged these two data using the company name as a key.[4] We omit firms that disappeared and subsequently reappeared in the JDB database between 1957 and 1970, and firms for which the number of workers, total wage payments, value-added, tangible assets, and technology acquisition year are not positive or in cases with incomplete replies. After the data were sorted according to the above criteria, the number of firms is 349 in 1957 growing to a figure of 1,150 in 1970 (unbalanced panel). The number of technologies acquired by these firms between 1957 and 1970 is 1,702

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[4] We trace the name of a company using *Tosyo Toukei Nenpou* (*Annual Securities Statistics*) and *Tosyo Yoran* (*Facto Book*) issued by the Tokyo Stock Exchange. The firms that change their names are regarded as the same companies if they are not merged or acquired. The firms that were merged or acquired are dropped from our sample because the JDB database does not allow us to trace back the information on such companies before merger and acquisition.

(Figure 1).

Table 2 indicates the difference of total factor productivity (TFP) and labor productivity between the firms with acquired technologies and the firms without them.[5] This table contains two notable findings. First, the productivity of firms with acquired technologies was substantially higher than that of firms without them. In 1970, firms with acquired technologies were 33.1 percent higher in terms of TFP and 33.9 percent higher in terms of labor productivity than firms without. Second, this productivity difference is observed only after 1961. Before 1960, firms with acquired technologies demonstrated much lower productivity than those without.

=== Table 2 ===

This systematic difference in productivity between firms with and without acquired technologies raises two questions. First, did firms with acquired technologies have higher productivity before they acquired them? Second, did firms with acquired technologies achieve higher productivity growth after they acquired technologies? To address these questions, the following section examines the determinants and the effects of technology acquisition in a dynamic framework.

4. Determinants and Effects of Technology Acquisition

[5] A detailed description of the TFP measurement will be provided in Section 4.2.

4.1. Did good firms acquire technologies?

This section explains a model for firms to acquire technology.[6] Suppose that a firm has to pay some fixed cost to introduce a foreign technology. This cost is a sort of transaction cost. Once a firm succeeded in acquiring a technology, this cost is not required to acquire another technology for a certain period. In other words, the fixed cost is required, only if the firm acquired a technology after a certain period had elapsed since it acquired the preceding technology. We define this period as one year. This implies that we focus on new technology acquisition regardless of the types of contracts.

Denote the fixed cost as C. Denote a dummy variable that takes the value one if the firm acquires technology at year $t-1$ and zero otherwise as Y_{it-1}. In the dynamic framework, the firm decides to acquire a technology if the present value of current profits of technology acquisition (excludes fixed costs) and any discounted increase in the value of the firm when the firm acquires technology in year t is larger than the fixed cost. After controlling for the firm characteristics X_{it} and policy effects G_{it} as factors of current and future profits, the regression equation to examine the determinants of foreign technology acquisition is represented as follows.

$$Y_{it} = \begin{cases} 1 \text{ if } \gamma X_{it} + \lambda G_{it} - C(1 - Y_{it-1}) + \varepsilon_{it} > 0 \\ 0 \text{ otherwise} \end{cases} \tag{1}$$

where ε_{it} is a disturbance term.

[6] Our model is extended from the dynamic model of the decision to export developed by Roberts and Tybout (1997).

Note that, in the binary-choice model with a lagged dependent variable, parameter estimates are biased and inconsistent.[7] There are several estimation strategies for this dynamic binary choice model with unobserved heterogeneity. This paper follows Roberts and Tybout (1997) and employs the probit model with random effects of the form:

$$Y_{it} = \alpha + \beta Y_{it-1} + \gamma X_{it-1} + \lambda G_{it-1} + \eta_i + \mu_{it}, \qquad (2)$$

where η_i is firm specific random effect and μ_{it} is pure disturbance term ($\varepsilon_{it} = \eta_i + \mu_{it}$). To avoid possible simultaneity problems, we assume a one-year lag for all plant characteristics and the government effects.[8]

The dependent variable Y_{it} is a dummy variable that takes the value one if the firm acquires technology at year t and zero otherwise. As for firm characteristics X_{it-1}, we use productivity, size, capital and R&D intensities, liquidity constraint, and past experience of technology acquisition.

Productivity

We use productivity as a key factor affecting the profit of a firm. Since TFP and labor productivity are highly correlated, we use TFP in our analysis to avoid multicoliniality.[9] In computing TFP, we employ deterministic (non-stochastic) method in computing TFP developed by Caves, Christensen, and Diewert (1982) and extended

[7] See Nickell (1981).
[8] For more detail, see Bernad and Jensen (1999, p.12 and footnote 19).
[9] For a summary of the statistics and correlation of variables, see Appendix Tables 1 and 2.

by Good, Nadiri, Roller, and Sickles (1983). This index uses a hypothetical firm that has the arithmetic mean values of log output, log input, and input cost shares over firms in each year. Each firm's output and inputs are measured relative to this hypothetical firm. The hypothetical firms are chain-linked over time. Hence, the index measures the TFP of each firm in year t relative to that of the hypothetical firm in year 0 (initial year). In our analysis, 1957 is the reference year and TFP of the hypothetical firm in 1957 equals one. A detailed explanation of the methodology and the data is in the Appendix.

Firm size

Firm size can be an important factor in acquiring a technology. The level of sales is one way of measuring firm size (Montalvo and Yafeh, 1994). However, it is difficult to compare the value of sales across industries, since this is highly industry dependent. We thus use market share in a given industry rather than the value of sales itself so that we can examine the relative importance of each firm in the industry.[10] Sales data are from the JDB database.

Capital and R&D intensities

As Cohen and Levinthal (1989) argued, R&D plays an important role not only in the innovation but also in the development of absorptive capacity that includes the

[10] We define an industry at the two-digit level. This is because large firms are more likely to produce many products across industries but the two-digit level can generally cover most products that a firm produces.

firm's ability to exploit outside knowledge of a more intermediate sort. This in turn implies that R&D facilitates the adoption of new technologies by a firm. Similarly, capital stock appeared to play a similar role during the 1960s. To control the difference of absorptive capacity, we use capital and R&D intensities. Capital intensity is defined as the capital sales ratio while R&D intensity is defined as the R&D sales ratio.[11] All variables are from the JDB database.

Liquidity constraint

Montalvo and Yafeh (1994) pointed out the importance of liquidity in the firm's decision to acquire a technology. Firms without liquidity constraints are more likely to have the chance to acquire a new technology. In order to examine the effects of liquidity constraint, we use cash flow, defined as the sum of profits and depreciation costs divided by sales. All the data come from the JDB database.

Past experience

A technology dummy having a one-year lag might not fully capture the effects of past experience since experience can be accumulated over time. Hence, we also test the alternative specification that uses the cumulative number of acquired technologies instead of the technology acquisition dummy. The cumulative number of acquired

[11] R&D stock is a more appropriate measure to ascertain the effects of R&D. However, it is not an easy task to construct appropriate R&D stock, especially at the firm level. Following Wakasugi (1997), we use R&D expenditure rather than R&D stock as the first approximation.

technologies is defined as the sum of acquired technologies starting from 1957. Data were obtained from the Japan Economic Research Institute (1973).

Policy variables

As for policy variables, G_{it-1}, we focus on industry targeting and deregulation of technology acquisition. To capture the impacts of industry targeting, we use subsidies and the JDB loans, following Beason and Weinstein (1996).[12] The subsidies are obtained from the Economic Planning Agency (1991), while the JDB loans are obtained from the Development Bank of Japan (2002). Since we did not get these variables at firm level, we employ the ratio of the policy variables relative to the value added in that industry.

The effect of deregulation is captured by the deregulation period dummy. This variable captures the effects of deregulation on the technology acquisition and takes one if regulation is relaxed and zero otherwise. Since deregulation was carried out twice, in 1961 and 1968, two dummy variables are employed. One is a dummy variable that takes the value one for the period 1962-68 and zero otherwise. The other takes the value one for the period 1969-70 and zero otherwise. If regulation works effectively, deregulation contributes to the firm's capacity to acquire an increasing number of new technologies.

We also investigate the cross-effects of deregulation and firm characteristics. If the government focuses on a range of firm characteristics in its screening process, the

[12] Horiuchi and Sui (1993) also emphasized the role of the JDB loans as one of the industrial policy tools.

firm characteristics will show different impacts before and after regulation. We assume that the government focused on productivity, firm size and past experience in the screening process, and examine the coefficients of a cross-term between these variables and the deregulation dummy.

=== Table 3 ===

Table 3 presents the regression results of equation (2) with the random-effects model. Major findings are summarized as follows. First, the coefficients of deregulation period dummies indicate positive and significant signs. Further, the coefficient is larger for the period 1969-70 than 1962-68. This result implies that firms could acquire more technologies after 1962, particularly after 1969. In other words, even after we control various firm characteristics and industry effects, the significant effect of regulation is confirmed.

Second, TFP does not have any effect on technology acquisition, as the coefficients are not statistically significant. However, once we introduce a cross-term between the TFP and deregulation period dummy, we observe significantly positive impacts of TFP on technology acquisition for 1962-68. Productivity became a significant factor after regulation was relaxed.

Third, the cumulative number of technology acquisitions has positive and significant effects, as the coefficients on the cumulative number of technology acquisition show positive and statistically significant signs. However, the coefficients of the cumulative number of technologies reversed after 1962. We observe negative and significant coefficients on a cross-term between the cumulative number of technology acquisitions and period dummies. These results imply that even firms that lack past experience of technology acquisition could acquire technologies after deregulation. This result can be interpreted as an evidence of changes in industrial policy. Past experience in technology acquisition became less important in the screening process after deregulation.

Fourth, the large market share is also an important factor even after deregulation. The coefficients of market share present positive and significant signs. This result might suggest that the government approves acquisitions mainly for large firms in a particular industry. In other words, the focus of foreign technology acquisition policy might be directed to some large firms.[13]

Finally, cash flow shows positive and significant signs. This result implies that the liquidity is a factor in acquiring technology, which is consistent with the findings of Montalvo and Yafeh (1994).

4.2. Did good firms acquire many technologies?

The analyses have thus far concentrated on whether a firm acquired technologies or not. There is yet another side to this analysis, that is, how many technologies a firm

[13] Alternative interpretation is that only large firms apply for approval to acquire technologies. This interpretation can be true when sunk costs depend not on the past experience but on the firm scale.

acquired. As we confirmed from Figure 1, some firms acquired technologies frequently. Why did some firms acquire a large number of technologies? To address this question, we examine the determinants of the number of technologies acquired by a firm. We assume that the relationship between characteristics of a firm and the number of technologies it acquired is similar to equation (2), substituting the dummy variables in the left hand side for the number of acquired technologies.

Note that the dependent variable has the following characteristics: discrete, non-negative and often takes a value of zero. As was discussed in relation to Montalvo and Yafeh (1994), the Poisson regression is a possible approach to deal with this type of data since the Poisson regression is designed to investigate the relationship between a dependent variable that represents the number of events that occurred within a given period and the exogenous variables that determine its frequency.

Suppose that the number of acquired technologies z_{it} is drawn from a Poisson distribution with parameter γ_{it}, which is related to the firm characteristics, X_{it}, and policy tools, G_{it}. Suppose that the relationship between γ_{it}, X_{it} and G_{it} is described as the log linear form: $\ln \gamma_{it} = \beta X_{it} + \lambda G_{it}$. The Poisson density function is

$$\Pr(Z_{it} = z_{it}) = \exp(-\gamma_{it-1}) \frac{\gamma_{it}^{z_{it}}}{z_{it}!}, \quad \text{where } \gamma_{it} = \exp(\beta X_{it} + \lambda G_{it}) \tag{3}$$

The firm characteristics are the same as those used in the estimation of equation (2). Similar to the previous regression, we take one-year lag for the regressors to avoid the possible simultaneity problem.

The determinants of the number of acquired technologies are presented in Table 4 (random-effects Poisson regressions). Similar to Table 3, the coefficients of deregulation period dummies indicate positive and significant signs. Furthermore, the coefficient is larger for the period 1969-70 than 1962-68. This result implies that regulation effectively constrained the number of acquired technologies before 1968, especially before 1961.[14]

=== Table 4 ===

The coefficients of TFP, market share, cumulative number of technologies, and cash flow show significant signs that are the same as those in Table 3. Namely, the TFP came to have a bearing in acquiring technologies in conjunction with deregulation, while the positive effect of the market share continued throughout the period. The past technology acquisition experience become less important in the screening process after deregulation. Liquidity has a significant influence on the firm’s decision to acquire technologies.

Significantly negative signs are more likely to be observed in the coefficients of the JDB loans. In other words, the JDB loans had a negative effect on technology

[14] One may argue that technology acquisition may increase unproportionally possibly because firms that had earlier been denied government approval rush to acquire technologies. From Figure 1 we can observe a jump in 1963 that would appear to support this supposition. To test the hypothesis, we introduce a new dummy variable that is equal to one in 1963 only and these results are presented in the Appendix Tables 3 and 4. The results indicate that, although the coefficients of year 1963 dummies are positive, they are not always significant.

acquisition. Since the coefficients of the JDB loans and subsidies capture the within-industry inter-temporal effect, the result suggests that the JDB loans might be used not for the support of technology acquisition, but for other purposes such as adjustment of declining industries. There were several major tools for industrial policy in Japan, including technology licensing, the JDB loans and subsidies. Technology licensing was allocated a purpose different from those of the JDB loans and subsidies. We will return to this issue later.

Finally, the coefficients of the cumulative number of technologies do not present statistically significant signs. Although past experience had a strong effect on whether a firm acquired a technology or not, as we saw above, it did not have any significant effect on how many technologies a firm acquired.

4.3. Effects of Technology Acquisition on Firm Performance

Let us now check the opposite causal direction, namely whether the technology acquisition has positive effects on firm performance or not. To test the effects of technology acquisition on dynamic corporate performance, following the method of Bernard and Jensen (1999), we run a simple regression of changes in performance measures, X_{it-1}, on technology acquisition status, and other exogenous factors.

$$\begin{aligned}\%\Delta X_{it} &= \frac{1}{T}\left(\ln X_{it} - \ln X_{it-1}\right) \\ &= \alpha + \beta Y_{it-1} + \gamma \text{Char.s}_{it-1} + \lambda G_{it-1} + \varepsilon_{it},\end{aligned} \tag{4}$$

where Y_{it-1} is a dummy variable that takes the value one if the firm acquires technology, and zero otherwise.[15] $Char.s_{it-1}$ is a vector of firm characteristics at the initial period and G_{it-1} is a vector of the government effects.[16] Hence, the coefficient β represents the gaps in the annual average growth rate of the performance between firms with and without acquired technologies. We introduce a cross-term between the technology acquisition dummy and deregulation period dummies for 1962-68 and 1969-70, in order to capture the effects of deregulation. The other firm characteristics for the initial year are the same as those used in section 4.1.

Table 5 shows the results of regression equation (4) with the random-effects model. The coefficients of technology acquisition present significantly positive signs for labor productivity, value-added, capital-labor ratio and R&D sales ratio before deregulation. On the other hand, we could not confirm the significant effect on TFP growth. These results imply that firms with acquired technologies achieved much faster growth in labor productivity, value-added, capital and R&D intensities than firms without. However, these positive effects are only confirmed for the period prior to 1961. Along with deregulation, the positive effects of technology acquisition disappeared, as the coefficients of cross-terms present negative and significant signs.

=== Table 5 ===

[15] The effects might appear a few years after the technology acquisition for some industries. However, to control such effects requires detailed data on the quality of technologies that is not available. We thus assume that the effects of technology acquisition appear from the next year in this analysis.

[16] Firm characteristics include TFP, the number of workers, average wages, capital-labor ratio, R&D sales ratio, and cash flow, while government effects include the JDB loans and subsidies. Year dummies and industry dummies are also included.

The results of the effects equation can be interpreted as the capital-augmenting effect of technology acquisition.[17] However, the gap between firms with acquired technologies and firms without with regard to these effects disappeared after the 1961 deregulation. One of the possible reasons is the change in the quality of acquired technologies. While the technologies acquired before deregulation had capital-augmenting effects, the technologies acquired after deregulation had much greater labor or other factor-augmenting effects.

5. Concluding Remarks

In conclusion, we would like to summarize the major results and discuss their implications on the industrial policy debate. Our results can be summarized as three points. First, until deregulation in 1968, government regulation effectively constrained technology acquisition in Japan. As a matter of fact, after deregulation, the number of acquired technologies sharply increased. Second, the characteristics of the firms that acquired technologies were substantially different between the regulated and deregulated periods. Whereas firms with considerable experience in technology acquisition, which did not have an advantage in terms of productivity, were more likely to acquire technologies before deregulation, firms with higher productivity but that

[17] This is because the firm with acquired technologies increases capital stock (not employment). Therefore, the firm's labor productivity (not TFP) improves. Accordingly, payments of capital (not wages) and value-added grew. We appreciate the contribution made by the referee for the interpretation of this result.

lacked experience came to acquire more technologies after deregulation. Finally, although we could not find the positive effects of technology acquisition on TFP, the technology acquisition policy at least contributes to the capital accumulation of the firms. The firms with acquired technologies succeeded in capital accumulation much faster than firms without such technologies during the regulated periods.

These results imply that in technology acquisition licensing, the government screened a firm's application, based on (i) the industry which the firm belonged to and (ii) its past experience of technology acquisition, and that as a result, large but relatively inefficient firms tended to acquire more technologies before deregulation. In other words, if it had not been for technology acquisition licensing, more efficient firms that lacked past experience would have acquired more technologies.

Despite this screening process, technology acquisition policy worked relatively well. During the regulated period, the firms with acquired technology could succeed in capital accumulation, which contributes to the faster growth of labor productivity. This in turn implies that the government successfully picked up the firms that could assimilate acquired technology. Of course, this does not necessarily mean that the government picked up the firms with the largest potential, but at least the screening of the acquiring firms by the government did not result in a serious failure.

The role of subsidies and the JDB loans in technology acquisition should be interpreted carefully. The subsidy and the JDB loans did not play an important role for firms in acquiring technologies. In particular, the JDB loans have negative and significant impacts on technology acquisition. Similarly, Beason and Weinstein (1996) argued that Japanese industrial policy failed to pick up the winner based on the negative correlation between subsidies/the JDB loans and the TFP growth. However, these negative impacts do not necessarily mean that the industrial policy was a failure. These policy tools were mainly applied for purposes other than promoting growing industries, including adjustment of declining industries and construction of social infrastructure. In the 1950s and 1960s, such industries as mining, transportation and electricity continued to receive a large share of the total JDB loans (Development Bank of Japan, 2002, pp.854-855). To put it differently, the policy tools depended upon the development phases of industries. While technology acquisition licensing was applied to the industries in the growing phase, the JDB loans and subsidies were mainly applied to the industries in the matured and declining phases.

We can derive some implications for developing countries, from the results of this paper. Among others, it is confirmed that technology acquisition licensing was a powerful policy tool to affect on inter-firm as well as inter-industry allocation of capital in the 1950s and 1960s. This very fact requires the government which applies this policy tool, to screen licensees carefully. In the case of Japan, the government attached importance to a firm’s past experience of technology acquisition. It is a conservative policy, which excluded young and more efficient firms from the opportunities to acquire foreign technologies. However, given the limited ability of the government to screen firms, it might be the second-best approach to administer foreign technology acquisitions.

However, our results do not necessarily support application of the technology acquisition licensing policy to developing countries, since we did not confirm the significantly positive effects on TFP growth. Furthermore, a part of the investment-enhancing effect of technology acquisition in the regulated period might be due to the first mover advantage or the rent based on restricted access to the foreign technologies, as benefits of technology acquisition disappeared after deregulation. Controlling for the type and the quality of technologies in detail could be one possible avenue to discriminate these possibilities. Application of the technology acquisition licensing policy to developing countries, thus, should be discussed more carefully.

Finally, we should also note that the effects of aggregated factors, or the effects of supply side such as the increases in the world supply of new technologies, are not covered in our analysis.[18] Additionally, because of the limited data availability, it is difficult to examine the detail of the contracts because some contracts might involve a set of patents rather than single patent. These problems are future topics for exploration.

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[18] For an analysis that takes into account supply side effects, see Wakasugi (1997) as one example.

of the authors and in no way represent the views of the University of Tokyo, Yokohama National University, or RIETI.

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Appendix: Construction of Multilateral TFP Index

Methodology

The multilateral index measures the TFP of each firm in year t relative to that of a hypothetical firm in year 0 (initial year). The hypothetical firm is the firm that has the arithmetic mean values of log output, log input, and input cost shares over firms in each year. Suppose that the TFP of this hypothetical firm is equal to one. The TFP index for firm i in year t relative to that of the hypothetical firm in the initial year is defined as

$$\ln\theta_{it} \approx \left(\ln Q_{it} - \overline{\ln Q_t}\right) + \sum_{\tau=2}^{t}\left(\overline{\ln Q_\tau} - \overline{\ln Q_{\tau-1}}\right) - \sum_{j=1}^{J}\frac{1}{2}\left(s_{ijt} + \bar{s}_{jt}\right)\left(\ln X_{ijt} - \overline{\ln X_{jt}}\right) - \sum_{\tau=2}^{t}\sum_{j=1}^{J}\frac{1}{2}\left(\bar{s}_{j\tau} + \bar{s}_{j\tau-1}\right)\left(\overline{\ln X_{j\tau}} - \overline{\ln X_{j\tau-1}}\right),$$

where $\ln Q_{it}$, $\ln X_{ijt}$, and s_{ijt} are the log output, log input of factor j, and the cost share of factor j for firm i, respectively. $\overline{\ln Q_t}$, $\overline{\ln X_{jt}}$, and $\bar{s}_{jt}$ are the values of the hypothetical firm in year t and are equal to the arithmetic means of corresponding variables over all firms in year t. The first term on the right hand side variable indicates the deviation of the firm's output from the output of the hypothetical firm in year t, and the second term means the cumulative change in the output the hypothetical firm between year t and year, $t = 0$. The same operations are applied to each input j, weighted by the average of the cost shares. Since our initial year is 1957, we set TFP of the hypothetical firm in 1957 as one. In this connection, all related variables are adjusted as 1957 constant prices.

Data

Output

There are two ways to define output: gross output and net output, or value-added. In terms of production technologies, gross output is more appropriate than value-added. However, it is difficult to obtain price deflators for the inputs and outputs of non-manufacturing sectors. Since our observations cover non-manufacturing as well as manufacturing firms, we define value-added as outputs. The value-added deflator is obtained from the Economic Planning Agency (1991).[19]

Inputs

Inputs are consists of labor and capital. Labor is defined as man-hour. Working hour data are from the Ministry of Health, Labour and Welfare (various years). Capital

[19] For details on industry mapping between the JDB database and Economic Planning Agency (1991), see Okazaki and Kiyota (2003).

stock is estimated from tangible assets of the JDB database, following Nishimura, Nakajima, and Kiyota (2005).

Costs

Labor cost is defined as total wage payments. Capital cost is defined as real capital stock, K_{it}, times user cost, p_{Kt}. The user cost is defined as follows.

$$p_{Kt} = p_{It}\left(\frac{1-\tau_t\phi_i}{1-\tau_t}\right)\left(r_t + \delta_{it} - \frac{\dot{p}_{It}}{p_{It}}\right),$$

where p_{It} is the investment goods deflator, τ_t is corporate tax on business income, ϕ_i is the present value of the depreciation deduction on unit nominal investment, r_t is interest rate, and δ_{it} is depreciation rate. The investment goods deflator was obtained from Toyo Keizai (2002), while corporate tax is from the Ministry of Finance website (2003). The variable ϕ_i is derived so that the following equations are satisfied:

$$\phi_i = \sum_{t=1}^{T} \frac{(1-\delta_{it})^{t-1}\delta_{it}}{(1+r_t)^{t-1}} \quad \text{and} \quad (1-\delta_{it})^T \approx 0.1$$

The second equation means that the end point of the depreciation period is defined as the time when the accumulated depreciation cost approximately equals 90 percent of the initial investment. Interest rate is defined as bond yield (annual average) from the Bank of Japan (1967) for 1957-65, and the Bank of Japan (1976) for 1966-1970. Depreciation data are from the KEO Data Base.[20]

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20 Although capital cost and depreciation rates are certainly different by company, depending on its

management situation and production technology, the limitation of data availability forces us to assume that capital cost is common to all firms and a depreciation rate is differentiated only between industries. The KEO Data Base (KDB) has been developed at the Keio Economic Observatory. We thank Koji Nomura for the provision of information about KDB. For details on industry mapping between the JDB database and KDB, see Okazaki and Kiyota (2003).

Figure 1. Number of Firms, Number of Firms with Acquired Technologies, and The Number of Acquired Technologies, 1957-70

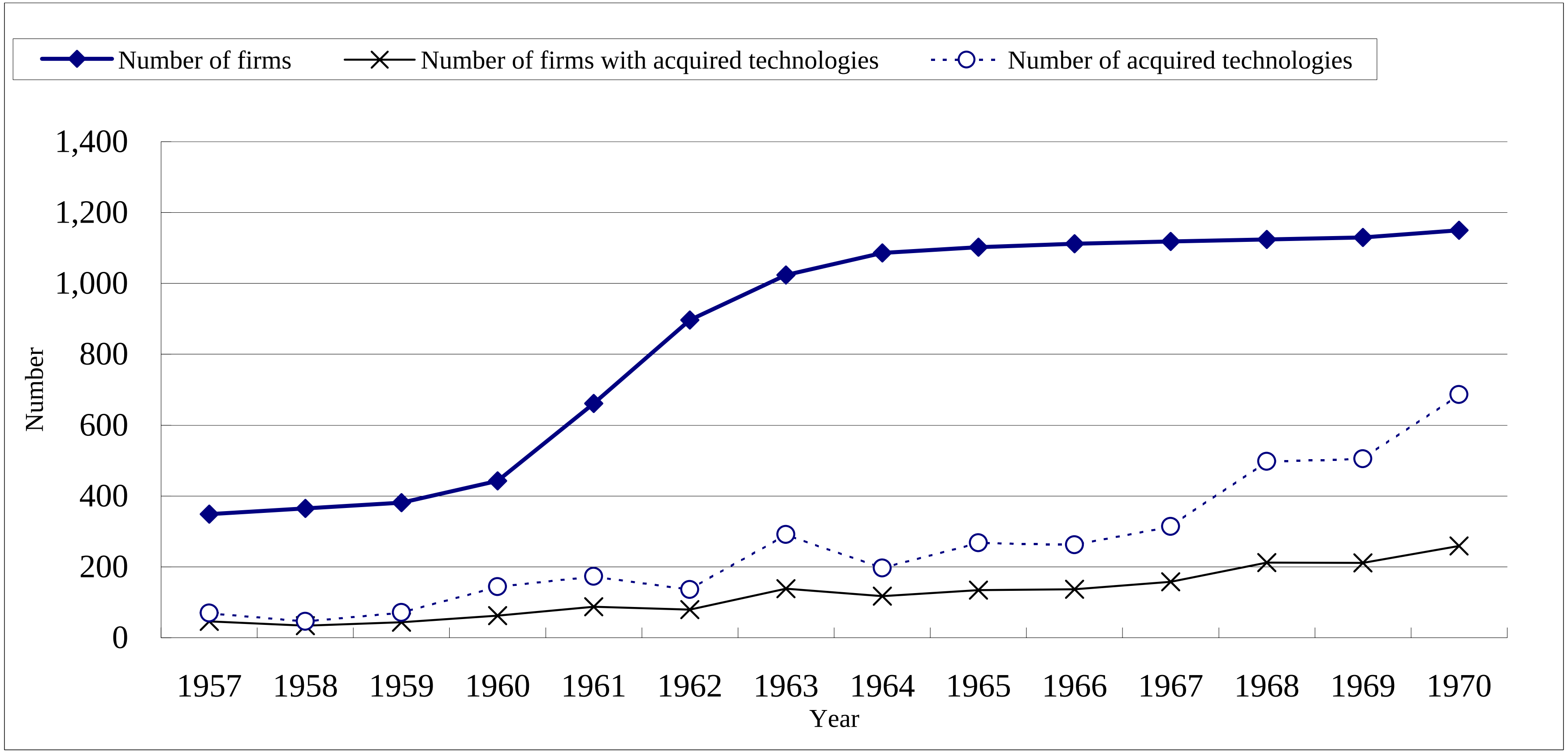

Table 1. Number of Acquired Technologies and Number of Firms with Acquired Technologies

	Number of acquired technologies				Share (%)				Number of firms			Share of firms		
									with acquired technologies, 1957-70	without acquired technologies, 1957-70	Total	with acquired technologies, 1957-70	without acquired technologies, 1957-70	Total
Industry	1957-61	1962-68	1969-70	1957-70	1957-61	1962-68	1969-70	1957-70						
Food products and beverages	4	10	10	24	1.5%	1.3%	1.5%	1.4%	4	69	73	5.5%	94.5%	100.0%
Textiles	7	31	33	71	2.6%	4.1%	4.9%	4.2%	12	51	63	19.0%	81.0%	100.0%
Pulp and paper products	11	19	21	51	4.1%	2.5%	3.1%	3.0%	6	31	37	16.2%	83.8%	100.0%
Chemicals	57	131	113	301	21.1%	17.3%	16.7%	17.7%	41	55	96	42.7%	57.3%	100.0%
Drugs and medicines	12	20	24	56	4.4%	2.6%	3.6%	3.3%	12	16	28	42.9%	57.1%	100.0%
Rubber products	8	10	12	30	3.0%	1.3%	1.8%	1.8%	5	9	14	35.7%	64.3%	100.0%
Glass, Cement and its products	6	31	21	58	2.2%	4.1%	3.1%	3.4%	8	50	58	13.8%	86.2%	100.0%
Iron and steel	10	22	19	51	3.7%	2.9%	2.8%	3.0%	8	30	38	21.1%	78.9%	100.0%
Non-ferrous metals	21	40	30	91	7.8%	5.3%	4.4%	5.3%	13	19	32	40.6%	59.4%	100.0%
Fabricated metal products	2	6	4	12	0.7%	0.8%	0.6%	0.7%	2	35	37	5.4%	94.6%	100.0%
General machinery	37	133	105	275	13.7%	17.6%	15.5%	16.2%	42	97	139	30.2%	69.8%	100.0%
Electric machinery	60	149	117	326	22.2%	19.7%	17.3%	19.2%	41	72	113	36.3%	63.7%	100.0%
Transport equipment	14	52	56	122	5.2%	6.9%	8.3%	7.2%	21	59	80	26.3%	73.8%	100.0%
Precision equipment	8	37	24	69	3.0%	4.9%	3.6%	4.1%	9	12	21	42.9%	57.1%	100.0%
Other manufacturing	3	11	21	35	1.1%	1.5%	3.1%	2.1%	7	23	30	23.3%	76.7%	100.0%
Construction	1	10	11	22	0.4%	1.3%	1.6%	1.3%	5	81	86	5.8%	94.2%	100.0%
Wholesale trade	9	44	46	99	3.3%	5.8%	6.8%	5.8%	17	46	63	27.0%	73.0%	100.0%
Retail trade	0	0	9	9	0.0%	0.0%	1.3%	0.5%	4	29	33	12.1%	87.9%	100.0%
Total	270	756	676	1,702	100.0%	100.0%	100.0%	100.0%	257	784	1,041	24.7%	75.3%	100.0%

Note: Sectoral classification is based on SNA with some modification.
Source: See main text.

Table 2. The Difference of Economic Performance Between Technology Importers and Non-importers

(Mean)

Year	TFP		Labor productivity	
	Firms with tech.	Firms without	Firms with tech.	Firms without
1957	2.43	3.13	2,694	3,643
1958	0.98	3.32	1,365	3,831
1959	0.93	2.85	1,225	3,558
1960	0.95	2.77	1,552	3,662
1961	2.72	2.27	4,235	3,174
1962	5.16	2.12	7,034	3,096
1963	2.40	2.15	3,750	3,215
1964	3.06	2.02	4,832	3,317
1965	2.76	2.04	4,618	3,433
1966	3.79	1.93	6,343	3,297
1967	2.74	2.24	5,019	3,839
1968	3.00	2.28	5,495	4,140
1969	3.52	2.29	6,967	4,277
1970	3.22	2.42	6,595	4,925

Notes: 1) TFP is an index (the TFP of hypothetical firm in 1957 = 1).
2) Firms with tech: firms with acquired technologies.
Firms without: firms without acquired technologies.

Table 3. Determinants of Technology Acquisition I: Technology Acquisition Dummy

Dependent variable: technology acquisition dummy in year t						
Independent variables in year t-1						
TFP	0.001	-0.001	0.004	0.000	0.001	-0.001
	[0.27]	[0.14]	[0.91]	[0.10]	[0.17]	[0.15]
TFP * period 1 (1962-68)		0.009*		0.008*		0.010*
		[1.75]		[1.66]		[1.84]
TFP * period 2 (1969-70)		0.011		0.007		0.012
		[1.20]		[0.74]		[1.27]
Market share	7.624***	6.831***	5.715***	4.793***	7.711***	6.983***
	[12.53]	[10.30]	[10.19]	[7.59]	[12.66]	[10.49]
Market share * period 1 (1962-68)		6.602***		4.521***		6.692***
		[7.96]		[5.20]		[8.04]
Market share * period 2 (1969-70)		14.646***		10.375***		14.784***
		[6.60]		[4.32]		[6.64]
Capital intensity	0.119	0.099	-0.058	-0.040	0.125	0.107
	[0.97]	[0.83]	[0.60]	[0.39]	[1.00]	[0.87]
Cash-flow	1.089**	0.895*	1.178***	1.013**	1.092**	0.894*
	[2.13]	[1.77]	[2.73]	[2.28]	[2.10]	[1.75]
Subsidy	1.030	1.148	0.830	0.171	1.031	1.165
	[1.08]	[1.23]	[1.07]	[0.20]	[1.06]	[1.23]
JDB loans	-10.040*	-8.751	-1.863	-1.540	-10.716*	-9.262
	[1.67]	[1.47]	[0.34]	[0.28]	[1.78]	[1.55]
Research and development	0.054	0.063	0.047	0.058	0.053	0.063
	[1.21]	[1.45]	[1.17]	[1.42]	[1.19]	[1.43]
Technology acquisition dummy	0.119**	0.096*				
	[2.09]	[1.69]				
Cumulative number of acquired technologies			0.141***	0.210***		
			[12.93]	[6.87]		
Cumulative number * period 1 (1962-68)				-0.099***		
				[3.40]		
Cumulative number * period 2 (1969-70)				-0.094***		
				[2.86]		
Period 1 (1962-68)	0.700***	0.422***	0.243***	0.170**	0.732***	0.443***
	[10.06]	[5.69]	[3.55]	[2.37]	[10.71]	[6.03]
Period 2 (1969-70)	1.178***	0.823***	0.493***	0.411***	1.230***	0.858***
	[14.31]	[9.40]	[5.76]	[4.62]	[15.55]	[10.05]
Constant	-4.279***	-3.211***	-3.258***	-2.547***	-4.367***	-3.255***
	[9.54]	[10.01]	[9.10]	[9.61]	[9.55]	[10.09]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	9,415	9,415	9,415	9,415	9,415	9,415
Akaike's information criteria	2.66	2.64	2.64	2.63	2.66	2.64
Log-likelihood	-3112.26	-3058.45	-3033.88	-3007.19	-3114.44	-3059.87

Notes: 1) Random-effect probit model is used for estimation.
2) ***, **, * indicate level of significance at 1%, 5% and 10%.
3) Figures in brackets indicate z-statistics.
4) For the definition of variables and sources, see main text.

Table 4. Determinants of Technology Acquisition II: Number of Acquired Technologies

Dependent variable: number of acquired technologies in year t						
Independent variables in year t-1						
TFP	-0.005	-0.009	-0.006	-0.009	-0.005	-0.009
	[0.82]	[1.20]	[0.91]	[1.17]	[0.80]	[1.19]
TFP * period 1 (1962-68)		0.018***		0.017***		0.018***
		[3.06]		[2.80]		[3.05]
TFP * period 2 (1969-70)		0.024***		0.022***		0.024***
		[3.54]		[3.15]		[3.52]
Market share	5.792***	6.867***	6.232***	6.633***	5.609***	6.838***
	[9.91]	[10.89]	[10.16]	[10.15]	[9.73]	[10.89]
Market share * period 1 (1962-68)		3.598***		5.060***		3.647***
		[6.98]		[7.02]		[7.16]
Market share * period 2 (1969-70)		4.974***		7.055***		5.090***
		[6.93]		[7.54]		[7.35]
Capital intensity	0.209	0.222	0.200	0.239	0.212	0.223
	[1.32]	[1.42]	[1.27]	[1.53]	[1.33]	[1.43]
Cash-flow	1.472**	1.418**	1.613**	1.190*	1.468**	1.414**
	[2.24]	[2.17]	[2.45]	[1.81]	[2.22]	[2.16]
Subsidy	-0.533	-0.274	-0.346	-0.832	-0.605	-0.285
	[0.59]	[0.30]	[0.38]	[0.92]	[0.67]	[0.32]
JDB loans	-11.808*	-9.527	-9.729	-11.031*	-12.215**	-9.666
	[1.95]	[1.57]	[1.61]	[1.78]	[2.01]	[1.59]
Research and Development	-0.029	-0.031	-0.030	-0.029	-0.032	-0.031
	[0.62]	[0.67]	[0.64]	[0.62]	[0.68]	[0.68]
Number of acquired technologies	0.018**	0.005				
	[2.37]	[0.61]				
Cumulative number of acquired technologies			0.004***	0.025***		
			[3.33]	[3.48]		
Cumulative number * period 1 (1962-68)				-0.025***		
				[3.76]		
Cumulative number * period 2 (1969-70)				-0.027***		
				[3.94]		
Period 1 (1962-68)	0.798***	0.551***	0.777***	0.496***	0.827***	0.555***
	[12.13]	[7.66]	[11.75]	[6.83]	[12.76]	[7.73]
Period 2 (1969-70)	1.486***	1.187***	1.442***	1.157***	1.544***	1.197***
	[20.16]	[14.96]	[19.04]	[14.45]	[22.15]	[15.38]
Constant	-4.849***	-4.874***	-4.863***	-3.346***	-4.871***	-3.338***
	[8.67]	[8.65]	[8.69]	[6.96]	[8.68]	[6.93]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	9,415	9,415	9,415	9,415	9,415	9,415
Akaike's information criteria	1.09	1.08	1.09	1.08	1.09	1.08
Log-likelihood	-5099.56	-5055.28	-5096.81	-5047.48	-5102.36	-5055.46

Notes: 1) Random-effects Poisson model is used for estimation.
2) ***, **, * indicate level of significance at 1%, 5% and 10%.
3) Figures in brackets indicate z-statistics.
4) For the definition of variables and sources, see main text.

Table 5. Effects of Technology Imports on the Performance of Firm

Dependent variables: 1-year growth	TFP	Labor productivity	Value-added	Number of workers	Average wage	Capital-labor ratio	R&D-sales ratio
Technology acquisition policy variables							
Technology import dummy	0.099	2.868**	3.540**	0.188	-0.302	3.099***	0.034*
	[0.07]	[2.02]	[2.56]	[0.23]	[0.27]	[2.95]	[1.67]
Tech. Acq. dummy * period 1 (1962-68)	-1.347	-4.563***	-3.914**	0.901	-0.206	-3.947***	-0.019
	[0.83]	[2.89]	[2.55]	[1.03]	[0.17]	[3.39]	[0.82]
Tech. Acq. dummy * period 2 (1969-70)	-1.956	-4.497**	-4.061*	0.655	0.190	-1.993	-0.067**
	[0.89]	[2.10]	[1.94]	[0.55]	[0.11]	[1.26]	[2.20]
Observations	9,415	9,415	9,415	9,415	9,415	9,415	9,415
R-squared (overall)	0.050	0.040	0.050	0.110	0.050	0.070	0.130
Dependent variables: 3-year growth	TFP	Labor productivity	Value-added	Number of workers	Average wage	Capital-labor ratio	R&D-sales ratio
Technology import dummy	-0.592	1.279*	1.410**	-0.121	-0.476	2.323***	0.017*
	[0.87]	[1.93]	[2.05]	[0.27]	[0.86]	[4.09]	[1.74]
Tech. Acq. dummy * period 1 (1962-68)	-0.157	-1.974***	-1.462*	0.591	0.307	-2.324***	-0.003
	[0.21]	[2.68]	[1.92]	[1.20]	[0.50]	[3.69]	[0.29]
Observations	7,453	7,453	7,453	7,453	7,453	7,453	7,453
R-squared (overall)	0.140	0.100	0.080	0.160	0.110	0.110	0.370

Notes: 1) Random-effect model is used for estimation.
2) ***, **, * indicate level of significance at 1%, 5% and 10% and figures in brackets indicate z-statistics.
3) Estimated coefficients indicate the gaps of growth rate between foreign-owned and domestically-owned firms.
4) Year dummies and industry dummies are included (not reported).
5) We also include firm characteristics as control variables. See main text, for more detail.

Appendix Table 1. Basic Indicators of Variables

	N	Mean	S.D.	Minimum	Maximum
Technology acquisition dummy	9,415	0.15	0.35	0.00	1.00
Number of acquired technologies	9,415	0.29	1.08	0.00	22.00
Cumulative number of technologies	9,415	1.40	5.44	0.00	165.00
Capital intensity	9,415	0.48	0.32	0.00	2.52
Market share	9,415	0.02	0.05	0.00	0.72
TFP	9,415	2.31	7.49	0.05	118.04
Cash-flow	9,415	0.10	0.06	-0.36	0.50
Subsidy	9,415	0.06	0.09	0.01	0.52
JDB loans	9,415	0.00	0.01	0.00	0.04
Research and development	9,415	0.16	0.51	0.00	9.01

Note: For the definition of variables and sources, see main text.

Appendix Table 2. Correlation Matrix of Variables

N = 9415	Tech. D	Tech. Acq.	Cum. Tech.	Capital intensity	Market share	TFP	Cash-flow	Subsidy	JDB	R&D
Technology acquisition dummy [Tech. D] (t)	1.00									
Number of acquired technologies [Tech. Acq.] (t)	0.64	1.00								
Cumulative number of acquired technologies [Cum. Tech.] (t-1)	0.37	0.75	1.00							
Capital intensity (t-1)	0.05	0.03	0.06	1.00						
Market share (t-1)	0.23	0.31	0.31	0.00	1.00					
TFP (t-1)	0.03	0.02	0.00	-0.30	0.12	1.00				
Cash-flow (t-1)	0.08	0.05	0.04	0.37	0.01	-0.26	1.00			
Subsidy (t-1)	-0.06	-0.04	-0.04	-0.14	-0.03	-0.04	-0.12	1.00		
JDB loans (t-1)	0.05	0.01	0.00	0.27	-0.03	-0.14	0.21	-0.17	1.00	
Research and Development [R&D] (t-1)	0.06	0.03	0.05	0.19	-0.04	-0.07	-0.04	-0.02	0.08	1.00

Note: For the definition of variables and sources, see main text.

Appendix Table 3. Determinants of Technology Acquisition I with 1963 Year Dummy

Dependent variable: technology acquisition dummy in year t				
Independent variables in year t-1				
TFP	0.001	-0.001	0.004	0.000
	[0.26]	[0.14]	[0.88]	[0.10]
TFP * period 1 (1962-68)		0.009*		0.008
		[1.74]		[1.61]
TFP * period 2 (1969-70)		0.011		0.007
		[1.20]		[0.73]
Market share	7.616***	6.831***	5.658***	4.752***
	[12.53]	[10.30]	[10.12]	[7.56]
Market share * period 1 (1962-68)		6.595***		4.355***
		[7.93]		[4.99]
Market share * period 2 (1969-70)		14.641***		10.269***
		[6.60]		[4.28]
Capital intensity	0.124	0.100	-0.050	-0.034
	[1.02]	[0.83]	[0.52]	[0.34]
Cash-flow	1.051**	0.890*	1.094**	0.951**
	[2.05]	[1.76]	[2.53]	[2.14]
Subsidy	0.949	1.136	0.642	-0.002
	[0.99]	[1.21]	[0.82]	[0.00]
JDB loans	-11.700*	-8.985	-5.795	-4.511
	[1.85]	[1.43]	[1.00]	[0.77]
Research and development	0.055	0.064	0.049	0.059
	[1.24]	[1.45]	[1.23]	[1.46]
Technology acquisition dummy	0.123**	0.096*		
	[2.15]	[1.69]		
Cumulative number of acquired technologies			0.144***	0.215***
			[13.20]	[7.03]
Cumulative number * period 1 (1962-68)				-0.101***
				[3.46]
Cumulative number * period 2 (1969-70)				-0.098***
				[2.96]
Period 1 (1962-68)	0.689***	0.421***	0.208***	0.146**
	[9.72]	[5.61]	[2.98]	[2.01]
Period 2 (1969-70)	1.173***	0.822***	0.473***	0.398***
	[14.22]	[9.38]	[5.54]	[4.49]
Year 1963 dummy	0.065	0.009	0.169**	0.130*
	[0.85]	[0.12]	[2.34]	[1.76]
Constant	-4.274***	-3.210***	-3.237***	-2.520***
	[9.54]	[10.00]	[9.10]	[9.56]
Industry dummies	Yes	Yes	Yes	Yes
N	9,415	9,415	9,415	9,415
Akaike's information criteria	2.66	2.64	2.64	2.63
Log-likelihood	-3111.90	-3058.45	-3031.20	-3005.66

For notes, see Table 3.

Appendix Table 4. Determinants of Technology Acquisition II with 1963 Year Dummy

Dependent variable: number of acquired technologies in year t				
Independent variables in year t-1				
TFP	-0.006	-0.010	-0.006	-0.009
	[0.86]	[1.20]	[0.95]	[1.18]
TFP * period 1 (1962-68)		0.018***		0.017***
		[3.05]		[2.79]
TFP * period 2 (1969-70)		0.024***		0.022***
		[3.54]		[3.15]
Market share	5.816***	6.865***	6.258***	6.634***
	[9.95]	[10.89]	[10.19]	[10.15]
Market share * period 1 (1962-68)		3.584***		5.027***
		[6.90]		[6.92]
Market share * period 2 (1969-70)		4.958***		7.033***
		[6.87]		[7.50]
Capital intensity	0.225	0.225	0.216	0.243
	[1.42]	[1.44]	[1.37]	[1.55]
Cash-flow	1.365**	1.402**	1.513**	1.168*
	[2.07]	[2.14]	[2.29]	[1.77]
Subsidy	-0.663	-0.297	-0.471	-0.868
	[0.73]	[0.33]	[0.52]	[0.95]
JDB loans	-14.746**	-9.993	-12.541**	-11.753*
	[2.31]	[1.55]	[1.98]	[1.80]
Research and Development	-0.027	-0.031	-0.028	-0.028
	[0.58]	[0.66]	[0.60]	[0.61]
Number of acquired technologies	0.019**	0.005		
	[2.52]	[0.63]		
Cumulative number of acquired technologies			0.005***	0.025***
			[3.42]	[3.49]
Cumulative number * period 1 (1962-68)				-0.026***
				[3.78]
Cumulative number * period 2 (1969-70)				-0.027***
				[3.95]
Period 1 (1962-68)	0.778***	0.548***	0.758***	0.493***
	[11.58]	[7.54]	[11.24]	[6.70]
Period 2 (1969-70)	1.476***	1.187***	1.434***	1.155***
	[19.97]	[14.94]	[18.87]	[14.40]
Year 1963 dummy	0.107	0.016	0.104	0.026
	[1.48]	[0.22]	[1.44]	[0.35]
Constant	-4.843***	-4.873***	-4.858***	-3.342***
	[8.66]	[8.64]	[8.68]	[6.95]
Industry dummies	Yes	Yes	Yes	Yes
N	9,415	9,415	9,415	9,415
Akaike's information criteria	1.09	1.08	1.09	1.08
Log-likelihood	-5098.49	-5055.26	-5095.80	-5047.42

For notes, see Table 4.