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Are Picked-up Losers Really Losers?: Evidence from Scrapping Policies in the Japanese Spinning Industry, 1965-79

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Are Picked-up Losers Really Losers? : Evidence from Scrapping Policies in the Japanese Spinning Industry, 1965-79*

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Abstract

Scrapping policy induces or forces firms to dismantle and dispose of “excessive” machines, and was a typical policy tool for depressed or declining industries in postwar Japan. This paper examines the effects of this policy on the Japanese spinning industry from 1965-79 using firm-level data. After clarifying features in the policy scheme, I first calculated the productivity and (capital) profitability of a specified machine targeted by the scrapping policy by estimating the production function with data from the production stage. Then, several forms of (dis)investment functions were estimated to examine the direct effect on investment under policy implementation and the indirect effect on post-policy investment through the firm’s revelation of the expected long-term return on investment. The former effect crucially depended upon whether scrapping was compulsory or voluntary, as well as on the coverage of targeted machines. Compulsory scrapping distorted a firm’s investment decisions more than voluntary scrapping. Regarding the latter effect, firms picked up by voluntary scrapping in a certain period were shown to be losers still investing less or disinvesting in the post-treatment period. Firm exits also had a certain role in cutting down the unprofitable machines. Distortions by another related policy (a scrap-and-build constraint on investment) was also observed. As a result, this skillfully-designed policy scheme was, on the whole, far from a welfare-enhancing scheme.

Keywords: Industrial Policy, Regulation, Scrapping, Textiles, Spinning Industry, Japan
JEL classification: L52, N45

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1. Introduction

Almost all industries face or will face the possibility of decline in the long run. This problem has been more than just one in particular periods for many developed countries. In the case of postwar Japan, stagnation or decline of specific industries often became the subject of heated policy debates. Examples include coal mining during heavy chemical industrialization and energy conversion since the late 1950's, and shipbuilding and textiles during trade and capital liberalization since the early 1960's.

This paper focuses on the Japanese spinning industry in 1965-1979, and examines the effects of scrapping policies using firm level data. The spinning industry belongs to the textile industry, which was a typical example of depressed or declining industries during the period. Scrapping of production facilities was one of the typical policy tools used in the textile industry and, in the spinning industry, it was implemented three times (1968-69, 1972-73, and 1978-79) with a different backgrounds and schemes respectively.

There has been a large body of literature on industrial policies of Japan toward depressed or declining industries during this period, along with related public policies[1]. The overall picture of such policies can be characterized by at least the following features. First, as a whole, the policy targets were mainly not high growth but low growth or declining industries. Beason and Weinstein (1996) examined the effects of industrial policy on industry level TFP growth and found that many of the policy measures were used to aid low growth or declining sectors.

Secondly, however, evaluations of each policy measure are often ambiguous and different among researchers. The main reason is simple in that there were competing powers between measures. While one measure was used to recover the industry's competitiveness or simply mitigate economic deterioration and social instability in the particular industry or regions, other measures were also implemented at the same time to facilitate shifts of economic resources from the industry to other industries. Then both cancelled out each other, and the effect of the policy highly depended upon other policies. The same can be said of scrapping policy in Japanese textile industry. For example, Yonezawa (1981) examined industrial policies toward the textile industry mainly based on the industry level performance indices, and suggested that scrapping policy in 1968-69 could not resolve excess capacities in the spinning industry, due to the opposite effect

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[1] As for basic reference to general policy framework, see Komiya et al. (1988), Peck et al. (1987), Sekiguchi and Horiuchi (1988), MITI (1993), and Tan and Shimada (1994). For textile industry, basic references are,Yonezawa (1978, 1981), Yamazawa (1981, 1988), Watanabe (2010), MITI et al. (1977) and MITI (1984) on textile and clothing; JSA (1962, 1969, 1979) on spinning; Horiuchi (1985) on synthetic fibers. Such experiences have been often cited in reports on industrial policy (Noland and Pack, 2003).

of other policies and the lack of market competition. On the other hand, Peck et al. (1987) examined the degree of achievement in the target industries in the late 1970's scrapping policy and pointed out that inefficiency due to disposal of production facilities could be small in two spinning industries, where many small firms exited by "picking losers," according to their own words.

Finally, although some previous studies examined the function and effect of policy theoretically, and others offered empirically based policy evaluation on industry level's performance indices, such as profitability, firm size and distribution, market shares, and evolution of entries and exits, there are still relatively few micro-econometric studies using firm or plant data, especially on scrapping policy[2]. The purpose of this paper is to fulfill the gap in this research strand.

In another close, but different stream of micro-econometric studies of policies on the Japanese spinning industry, studies most related to this paper are Okazaki and Korenaga (1999a, 1999b) and Kiyota and Okazaki (2010). Since the early 1950's, this industry had been controlled by a set of policy tools skillfully designed for specific purposes. The former two studies examined the determinants and effects of foreign exchange allocation policy under import control in the 1950's wool spinning industry. The latter study focused on anticompetitive output control policy through restriction of machine use under the registration system for production facilities in 1955-64 cotton spinning industry, and examined its effect on the industry and firm productivity. The common interests across these studies are to examine the effects of policy, and then offer some evidence on features in its institutional framework such as government capability to policy making and implementation, or the coordination between government and firms. In this context, this paper focuses on anticompetitive output control policy under a different scheme in the late 1960's, which is next to the scheme studied by Kiyota and Okazaki (2010), and the liberalization period after the abolition of the registration system in 1970, sharing similar interests with them.

In making a research design, I started investigating the features in the policy scheme. Firstly, in relation with the Anti-monopoly law, scrapping policies in the spinning industry during that period, as a whole, were positioned along the extended line of anticompetitive output control policies. The product markets the industry faces are fairly competitive

[2] The remarkable exception is Okazaki studies in the official history of MITI (2012). He examined policy effects of several temporary laws that were enacted since the late 1970's to assist the specified industries, regions or firms, and obtained positive evaluation in many cases. Among them, the effects of the 1978 law are also covered in this paper. But the performance variables he used were ROA, TFP growth rate and labor productivity, and the results were based on the estimated coefficient of industry level dummy. So direct comparison to this paper is impossible.

because (i) there are many firms, (ii) the product, which is spun yarn, is basically homogeneous, and (iii) trade policies are relatively open, which made it difficult for firms to sustain collusive behavior. Since scrapping is a negative investment or disinvestment for production facilities, and its production capacity is the upper bound of output, scrapping means decreasing the long-term output. The coordination between firms and government authority also occurred in the process of policymaking and implementation.

Second, however, firms' behaviors under the policy were characterized by the specific rules of policy, and difficulty in making strategic relationships among many firms. This was not what we can expect from the phrase "cartel" and "collective action." The timetable for players can be sketched as follows. At first, the government tries to pick up firms by setting the purchasing price for scrapped machine and several requirements (compulsory or voluntary; with or without penalties to violators; who pays the expenses). Next, each firm observes the purchasing price, calculates the expected long-term return on investment from the subsequent periods along with other factors, compares it with the price, and then chooses the amount of machine scrapped.

The weak degree of strategic relationship between firms also enables us to use a less complicated analytical framework and to narrow down the key factors taken into consideration. Although it is well known that the long-term decision on investment under incomplete information in dynamic oligopoly could make multiple equilibrium paths depending upon the firms' strategies, if we can assume the absence of strategic relationship, the remaining key factors for investment decision are financial costs and the expected long-term return on investment, which further depend upon fundamentals, such as production costs and the overall evolution of the product market.

Lastly, other kinds of policy tools were also implemented along with scrapping policy. The government started offering tax incentives and financial assistance for modernization and rationalization of production activities in the late 1960"s, which could potentially change a firm's productivity. A specific type of constraint on investment was also imposed during the late 1960's. It was called scrap-and-build rule, and forced a firm to scrap suspended machines in return for permission to install new machines. Moreover, another type of anti-competitive policy, the short-term suspension of machine, was intermittently implemented under the government-approved cartel, which was called the recession cartel.

Given the above evidence on policy scheme, this paper focuses on the following research questions. The first question is on the direct effects of scrapping policy: What type of firm scraps more machines under the policy? In other words, how is a firm's (dis)investment decision under the policy different from that without the policy? The second question is on the indirect policy effect: How does a firm having scrapped more change their performance in the post-policy period? Specifically, is a firm picked up by policy actually a loser in the post-policy period?

As for identification of such policy effects, the following analytical frameworks are employed. First, this paper will take the approach of modeling a firm's investment decision. The first merit of this approach is that a firm profit maximization problem under scrapping policy can give theory-based parameter restrictions on the estimated equation. Another merit is that the scrap-and-build constraint can be treated explicitly in the estimated equation by parameterizing the Lagrange multiplier. The effect of the recession cartel is also adjusted.

Second, departing from Tobin's Q theory, this paper employs investment function with adjustment cost, and uses as capital profitability the short-term return on investment to a specific machine, which is the spinning machine that was designated as the policy target. Third, the production function is also estimated using data on spinning production stage, by which the short-term return on investment to the spinning machine can be estimated as marginal product of the machine. The merit of this approach is that we can directly examine the relationship between scrapping and the marginal returns of the last and possible excessive one unit of the machine, while empirically we often can only use the firm-level average Q instead of the marginal Q. It can be also suggested that using firm-level profitability could get less appropriate in declining or matured industries where firms diversify their business to other fields. Another merit of estimating production function is that we can capture the effects of other policies affecting firm productivity.

Fourth, since the common policy variable is not available in the whole period, I split it into sub-periods and estimated investment function in the form of a saturated model with policy-implementation year dummies to measure treatment effect.

Finally, to examine the indirect policy effect of voluntary scrapping scheme in a certain period, I also use, as the indicator of the expected long-term return on investment, the presence or absence of a firm's participation in this policy scheme, along with the short-term return noted above. The hypothesis is that joining voluntary scrapping scheme was the revelation of the expected long-term return on investment because more profitable firms are less likely to join this policy. If this is true, this policy variable negatively correlates with the investment rate in the subsequent period, which implies that a firm picked up by policy is actually a loser in the post-policy period.

The composition of this paper is as follows. In the next section, I provide an overview of the scheme of scrapping policies, and clarify their features based on previous studies and primary documents. In section 3, after a panel estimation of production function, I measure the industry's productivity change and capital profitability, and discuss the scale of incentives offered by policy. In section 4, I firstly examine direct effects on investment behaviors under the policy by panel estimation. Then, in a case of voluntary scrapping in 1968-69, the indirect effects of the policy on post-policy investment behaviors are also examined. Appendices for data and theoretical model of investment function are at the end of the paper.

2. Overview of the industry and the policy scheme for scrapping

The Japanese cotton spinning industry had once attained global competitive edges in the prewar era (Odagiri and Goto, 1996)[3]. After compulsory shrinking during World War II, the industry restarted with a few incumbents called *Judaibo* (Ten Large Spinners) and the subsequent two groups of new entrants called *Shinbo* (New Spinners) and *Shinshinbo* (New-New Spinners), respectively. The industry experienced restoration under government control of material imports and production facility use since the early 1950s[4]. The direct control of production facility use was implemented under the *Sen'i kogyo setsubi rinji sochi ho* (Old Law on Temporary Measures for Textile Industry Equipment; enacted in 1956 and amended in 1960; hereafter the Old Textile Law). The law introduced the registration system for production facilities, and also provided a couple of measures for its use, which were the short-term and the long-term production adjustments through the suspension of machines (JSA, 1962, p.67-94). Kiyota and Okazaki (2010) showed that this anticompetitive output control policy constrained the reallocation of resource, resulting in negative productivity growth in the industry.

In the 1960's, the industry gradually lost its competitive advantage and was often hit by the depression, facing import increases from developing countries, while the overall wage rose due to other industries' progress. Meanwhile, government control was deregulated in a stepwise manner. Control of material imports was abolished in 1961 but the scheme for control of production facilities use was revised in the mid-1960's, and remained until June 1970. Table 1 shows the evolution of outputs and inputs of firms in

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[3] The spinning industry is mainly engaged in the process of drawing out and twisting yarn from staple of fibers by a spindle, and usually classified into cotton spinning, wool spinning, hemp spinning, chemical and synthetic fiber spinning, and so on. (The Textile Machinery Society of Japan, 1987). Hereafter, I mainly review the cotton spinning industry. Those firms were originally engaged in cotton spinning but launched into staple rayon spinning and then synthetic fiber spinning since the 1950"s.

[4] Since the Japanese yen had lost its convertibility until the late 1950's, the government controlled the imports of almost all item through the foreign exchange allocation. As for textile material import, see Korenaga (2000) for cotton spinning and Okazaki and Korenaga (1999) for wool spinning.

the Japan Spinner Association (hereafter, JSA)[5]. The evolution of production facilities is also depicted in Figure 2. In the mid-1970's, the industry entered a declining stage, which was triggered by rapid appreciation of the yen due to the transition into the floating exchange-rate system. In addition, a steep rise in energy prices was triggered by the first oil crisis.

During 1965-79 covered in this paper, a various form of policy assistance were implemented under gradual liberalization of the textile trade (Yonezawa, 1981; Yamazawa, 1988). Those policies were sometimes called structural adjustment policy or adjustment assistance policy. As a whole, the central policy goals changed around the mid-1970's. Until the early 1970's, both strengthening international competitiveness and facilitating shifts of economic resources to other industries were pursued. After the mid-1970's, the emphasis gradually shifted to the latter goal. Scrapping of production facilities had been one of the main policy measures throughout the whole period, and the spinning industry implemented this type of policies three times (1968-69, 1972-73, and 1978-79) for the different backgrounds.

Scrapping policy in 1968-69

In a case of 1968-69, the scrapping scheme was introduced by the enactment of the law in 1967 to solve the problem, which remained an issue with the existing policy measures. In 1964, the Old Textile Law was replaced by the *Sen'i kogyo setsubi rinji sochi ho* (New Law on Temporary Measures for Textile Industry Equipment (enacted in 1964 and extended to 1970; hereafter, New Textile Law). This law was proposed as a step toward deregulation of the spinning industry (JSA, 1979, p.57-64). First, the clause on the short-term production adjustment was deleted and thereafter replaced by the recession cartels approved by the Japanese Fair Trade Commission. Second, the suspension of the textile machines, which was used as the long-term production adjustment, was directed only one time (in December 1964) right after the enforcement of law. Third, the law prescribed that the registration system for production facilities would be abolished in September 1967 (extended to June 1970 after its 1967 revision). Fourth, the so-called scrap-and-build (open) clause was added (hereafter, S & B). This rule was a kind of constraint on investment, and allowed firms having disposed of suspended machines to install new machines (or return remaining suspended ones to an operable state) up to half the value of disposed machines.

The amount of operable equipment increased in 1965 due to the S & B rule, which had

[5] JSA was one of the major trade associations that made up a significant part of the cotton, rayon and synthetic fiber spinning industry, as explained later.

the potential to increase yarn production. The cotton spinning industry started the recession cartel in December 1965 and extended it several times (Oct. 1965 - Mar. 1966, Apr. 1966 - Dec. 1966, Jan. 1967 - Jun. 1967 (stopped in Mar. 1967)). The S & B clause was temporarily discontinued under the cartel (JSA, 1979, p.242).

In 1967, the *Tokutei sen'i kogyo kozo kaizen rinji sochi ho* (Law on Temporary Measures for Structural Improvement of Specified Textile Industry; hereafter the 1967 law) was enacted and scrapping proceeded under this law[6]. First, firms holding certain type of spinning machines, which had been registered as the first segment (cotton, rayon, or synthetic fiber spinning) in the registration system under the New Textile Law, were designated as the *Tokutei boseki gyo* (Specified Spinning Industry). Second, the 1967 law prescribed the formulation of the Basic Plan for the [Old] Structural Improvement in the designated industries. This plan called for the disposal of excess capacities, along with tax incentives and financial assistance for modernization of equipment and rationalization of firm size. Third, the *Sen'i kogyo kozo kaizen jigyo kyokai* (Textile Industry Restructuring Agency; TIRA) was launched in 1967 to be in charge of operation in the above plan, and was co-funded by the government and the industry.

Then, under concerted actions directed by the Minister of International Trade and Industry, disposing of specified spinning machines, including suspended ones (the coverage of which was almost the same as the first segments in the New Textile Law just mentioned above, with some exceptions) was implemented from October 1968 until March 1969. JSA and 2 other trade associations participated in this action. JSA's shares was 53.7% (131 of 244) in the number of firms, but accounted for 90.2 % (= 9,760,117/10,824,104) in the number of targeted spinning machines.

The rules in the scheme were documented by MITI and the industry and can be summarized as follows (JSA, 1969, p.51-63, 74-82, 90-93).

> (1) Compulsory disposal by all participants
>
> 6.35% of the number of specified spinning machines, which each participant has and which has been registered as of 10th August 1968, are compulsory disposed of on a pro rata basis over firm's size. The planned goal is about 600,000 spindles. TIRA purchases the disposed machines and the purchasing price per spindle is 3,000 yen for an operable

[6] In the process of making the 1967 law, coordination between the government and firms occurred. In 1965, JSA released a report titled *Nihon sen'i sangyo no shorai to kokyu taisaku* (The future and permanent measures in Japanese textile industry) and requested a policy scheme for disposal of machines as a permanent measure for stabilizing the balance between demand and supply. When the Textile Industry Council in MITI started discussions at the end of that year, the above JSA report was used as a basis for discussion (JSA 1979, p.98). Korenaga (2002) reviewed the roles of JSA in the coordination process during the late 1960's and 1970's using JSA documents.

machine (or 1,000 yen for a suspended one) plus the resale value as scraps.

(2) Voluntary disposal by JSA firms

In addition to measures listed above, JSA make an appeal for voluntary disposal to only JSA companies. The planned goal is about 400,000 spindles. TIRA purchases operable or suspended machines as well, but JSA gives incentive of 2,000 yen to its members, so the purchasing price per spindle is raised to 5,000 yen for an operable one (or 3,000 yen for a suspended one) plus the resale value as scraps[7].

(3) Disposal by exiting firms

TIRA also purchases machines from firms planning to exit from the specified textile industries. The purchase price per spindle is 6,000 yen for an operable one (or 2,000 yen per spindle for a suspended one) plus the resale value as scraps.

(4) Penalties on deviators from the concerted actions

Penalties of 1,000 or 3,000 yen per spindle, or 50,000 yen per case are charged to deviators from the concerted actions.

(5) The expenses

The expenses for compulsory disposal are financed by bank loan through TIRA and then TIRA collects 289.5 yen per spindle from incumbent participants on a pro rata basis. The same expenses apply for voluntary disposal, but the additional incentives are incurred by the incumbent JSA firms and they pay additional 39 yen per spindle on a pro rata basis. As for disposal by exiting firms, half of the expenses is subsidized by the government and TIRA collects the other half (1.05 yen per spindle) from incumbent participants on a pro rata basis. Pro rata was over the number of the remaining machines in all cases.

The actual achievements were 850,160 spindles in total, 7.9% of the target spinning machines, of which 671,117 (595,705) were by compulsory disposal, 175,823 (163,659) by incumbents' voluntary disposal, and 3,220 by exits (the operable marked in the parentheses). The JSA's achievements were 797,578 (719,692) spindles in total, where 621,949 (556,497) were by compulsory disposal, 175,629 (163,465) by voluntary disposal, and 0 by exits. The JSA's participants in compulsory and voluntary disposal were 101 and 66 firms.

Since the primary documents do not give us precise information on the incentives offered by the policy, I built a model of a firm's investment decision in Appendix 2. Then, the following six points list the features in the above scheme. First, the 1967 law gave firms new monetary incentive to scrap spinning machines, while the existing S & B constraint granted firms disposing the suspended machines a simple permission to increase the amount of operable machines. Moreover, at least theoretically, S & B constraint could force a firm with high return on investment to cut down the suspended machines (Appendix 2).

Second, although the policy seemed to make a more profitable firm scrap less by naive

[7] A couple of non-JSA firms also voluntarily scrapped a very small amount of operable machines, but its subtotal was only 167 spindles.

conjecture, the possible pattern of scrapping has more variety than expected, due to the following couple of incentives offered by the policy (Appendix 2). The one incentive is that because of higher purchasing price for an operable machine, voluntary disposal is always preferred to a compulsory one although a firm is required to join the latter scheme. The other incentive is that under nonlinear pricing to different states of machines in each scheme, a slight change in the difference between the relative purchasing price of the operable one to the suspended one, and its relative opportunity cost (that is, the relative return on investment) can switch the priority order among two states of machines a firm scraps in each scheme.

Third, while penalties for deviators were provided, the coordination to make the rule enforceable for participants also occurred. Before the concerted actions for disposal were directed, JSA had several meetings with other textile trade associations to reach an agreement on the coverage of machines in compulsory disposal and to persuade opponents (JSA, 1969, p.47-51)[8]. This suggests that there existed a trade-off between enforceability and effectiveness in policy implementation. Fourth, the voluntary disposal offered by JSA could simultaneously give firms the opportunity to consider their long-term return on investment in comparison to the purchasing prices. The scale of incentive will be examined in section 3.

Fifth, however, it is not clear whether the scrapping enhanced economic welfare, although we can point out several positive factors that the purchasing price could act as the opportunity cost in the presence of the sunk cost of spinning machine and that an improvement of balance between supply and demand could raise its utilization rate. Lastly, policy measures for modernization and rationalization in the Structural Improvement Plan could have the opposite effects against the disposal[9]. So we should care about the overall policy implication for economic welfare. Productivity changes could also happen during the period, which will be examined in section 3.

Scrapping policy in 1972-73

In a case of 1972-73, scrapping of production facilities for textiles was proceeded as one of the Temporary Special Measures for the Textile Industry, which were offered to

[8] The other coordination was that MITI and TIRA allowed a firm to be exempt from compulsory disposal if another firm scrapped the same amount of machine in their agreement instead (JSA, 1969, p.64-66).

[9] While it was said that the program achieve certain progress with sufficient financial supports (MITI et al., 1977; JSA, 1979), Yonezawa (1981) suggested that, due to the opposite effect and the lack of market competition, excess capacities were not resolved fundamentally under scrapping in 1968-69. Policy assistance for laid-off workers was also introduced under the 1967 law, but not effective due to the low benefit (Yonezawa, 1978).

compensate for the loss the industry could incur from exports control in Japan-US textile negotiations (JSA, 1979, 142-51). The negotiation started in the mid-1950s, but trade friction got intensified in the late 1960s. The Japanese textile industry, led by 22 trade associations including JSA, collectively made an appeal against imports control by the U.S., and started to voluntarily restrain exports to the U.S. in July 1971. But eventually, Japan- US agreement on trade of textile products was signed in January 1972.

The Japanese government approved budgets to compensate for both the voluntary export restraints and the Japan-US agreement during 1971. MITI announced the implementation outline of the above measures in January 1972. The measures for the spinning industry consisted of (1) purchases of “excessive” production facilities, (2) financial assistance, including long-term loans for working capital and credit guarantees, and (3) funds for a structural improvement program. Then, disposal was implemented from December 1972 till November 1973.

The rules in the scheme were documented by MITI and the industry, which are summarized as follows (JSA, 1979, p.147-8; JSA monthly report, Apr. 1972, p.51-70, Feb. 1973, p.60-2).

(1) The coverage of spinning machines purchased

TIRA purchases the following types of spinning machines, based on applications from companies. This range includes all types of spinning machines that members of five trade associations (including JSA) deem as operable and list on the ledger of fixed assets as of the fiscal-year end latest to the end of 1971, with some exceptions (machines owned by large firms and illegal machines are excluded.).

(2) The purchasing price

For the standard type of spinning machine, the purchasing price per spindle is 8,800 yen plus the resale value as scraps for the incumbent firms, and 10,000 yen plus the resale value as scraps.for the exiting firms. The purchasing price is adjusted based upon machine type and size, ranging from 75% to 130% of the above standard price.

(3) The goal and expenses

The planned goal of purchasing is about 500,000 spindles and the initial fund is 4.58 billion yen. All expenses for purchasing spinning machines are paid from the initial and additional government budgets.

(4) Penalties on violators

To put the brake on increases in capacity, applicants are required for 10 years that exiting firms cannot be engaged in spinning business and that incumbent firms cannot increase capacities. Applicants are also required to set aside 20% of the purchasing price as a deposit, which is to be forfeited them if the above requirements are violated. Moreover, trade associations are required to pass resolutions not to increase capacities, industry-wide, for 10 years.

The actual achievements were 1,113,585 spindles (289 firms) in total, of which 396,112 (96 firms) were by exits and 717,473 (193 firms) were by incumbents. The achievements by JSA firms were 525,389 spindles in total, where 135,241 were by 13 exits and 390,148 by 46 incumbents. The coverage by material use was broader than the specified spinning machine designated under the 1967 law and it included machine used for wool, hemp or other textiles, while non-operable machine were excluded from the target.

The features in the above scheme can be summarized in the following five points. First, the policy gave firms monetary incentive to scrap spinning machines. At least theoretically, a more profitable firm scraps less under this scheme (Appendix 2). The policy also offered more incentive to small and medium firms and exiting firms, which could have the similar effect.

Second, the coordination for enforceability occurred throughout the process. The favorable treatment of priority order for small and medium firms and exiting firms in disposal was the result of negotiation between MITI and the industry (JSA, 1979, p.144-8). The coordination also occurred over penalties on violators[10]. Third, the voluntary disposal gave firms a similar opportunity as the 1968-69 scrapping to consider their long-term return on investment at the same timing.

Fourth, however, there are negative factors against that the scrapping was welfare-enhancing. Since the direct purpose was compensation for the industry' loss, the process of making the planned goal for disposal did not start at the predicted balance between demand and supply, but at their requests. In addition, all disposals were implemented at government expenses with the higher purchasing price, which is hard to be justified solely by the presence of sunk cost. The scale of incentive seems to be larger than the 1968-69 case, the details of which will be examined in section 3. Lastly, the Structural Improvement Program was also strengthened, which could have the opposite effects against the disposal, as stated before.

Scrapping policy in 1978 -79

In this period, disposal of production facility was proceeded separately between major firms and small and medium firms. While major firms tried to take advantage of the scheme under the *Tokutei fukyo sangyo anteika rinji sochi ho* (Law on Temporary Measures for the Stabilization of Specified Depressed Industries; hereafter, the 1978

[10] The problem was on the requirement for trade associations to pass resolutions in rule (4). In contrast to other trade associations, JSA expressed opposition to the requirement and started renegotiation with MITI on the grounds that the resolution by trade association lacked coherence with policy principles after the abolition of the registration system in 1970. Instead of making resolutions. JSA ended up recording in the minutes that each applicant promised to fulfill the requirement, and that each non-applicant voluntarily gave consideration not to increase capacities in the industry unless the situation changed drastically (JSA, 1979, p.149-50).

law) enacted in 1978, small and medium firms used the *Kyodo haiki jigyo* (Joint-scrapping program) funded by the Small Business Promotion Corporation (in short, SMPC).

The purpose of the above 1978 law was disposal of production facilities in the *Kozo fukyo gyoshu* (Structurally Depressed Industries) and The *Men to boseki gyo* (Cotton Spinning Industry; including staple rayon, hemp and synthetic fiber spinning) and The *Somo to boseki gyo* (Worsted Spinning Industry) were designated respectively. The law prescribed the preparation of the Stabilization Basic Plan including the goal and timing of disposal of production facility, establishment of the *Tokutei Fukyo Sangyo Shinyo KIkin* (Credit Foundation for Structurally Depressed Industries; CFSDI), and the procedure to direct concerted actions to facilitate disposal. CFSDI provided credit guarantee for financing the expenses to release security interest due to disposal and to pay the retirement fee. While the concerted actions was exemption of the Antimonopoly Act, the regulations for prohibiting deviators were not introduced.

The scheme of the cotton spinning industry was (1) The planned goal of disposal was about 6% of total production capacity in the Basic Plan, and (2) The concerted actions were not directed by the Minister of International Trade and Industry. Consequently, firms in the cotton spinning industry voluntarily disposed of spinning machines by each firm's own decision, and the actual achievements were about 484 thousands spindles (78% of the planned goal) in 1979.

Meanwhile, in cotton, rayon and synthetic fiber spinning industry, small and medium firms in JSA and other two trade associations launched together the new association to apply to the joint-scrapping program. This program was exemption of the Antimonopoly Act. More than 90% of expenses for disposal were financed by SMPC and all participants in the association were obligated to repay. Consequently, 1.04 million spindles of spinning machine were disposed by 107 firms in 1978-79 (Nihon Sen'i Shinbun, 1983; Korenaga, 2002).

Although detailed data on the purchasing price in the joint-scrapping problem are not available, at least the following three points can be listed as features in the above couple of schemes. First, compared to the past scrapping policies, as a whole, highly anticompetitive measures were not taken. Although the joint-scrapping program was a kind of concerted actions, major firms did not join an explicit collective action. Moreover, competition policy was strengthened and strictly enforced during the periods by the revision of the Antimonopoly Act in 1977 and tightening of approvals on recession cartel[11].

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[11] After the recession cartel in Apr.1977 - Jun. 1977, the cotton spinning industry including JSA tried voluntary reduction in production (*Jishu gensan*) thereafter until the

Second, as for effectiveness of disposal, previous studies suggest that the joint-scrapping problem could work better than the 1978 law. Peck, Levin and Goto (1987) examined the degree of policy achievement in the target industries in the 1978 law and pointed out the possibility that inefficiency due to disposal of production facility was small in two spinning industries where many small firms exited, and that those exits might be caused by the joint-scrapping program[12].

Finally, in contrast with past scrapping policies, other policies could facilitate an economic resource shift. While the [New] Structural Improvement Program under the revised 1967 law was less effective since its utilization rate in 1975-81 was quite low (Yamazawa, 1988), temporary laws relating the 1978 law offered public policy measures for employment adjustment and depressed regions[13]

3. Measuring productivity and profitability

3.1 Estimation of production function

In this section, I estimate production function using firm-panel data and calculate each firm's productivity and profitability (marginal product) of capital, which will be used later as a key variable of investment function analyzed in the next section.

Model and estimation procedure

Assume that a firm i's production technology at time t can be represented as the following Cobb-Douglas production function.

$$Y_{it} = {L_{it}}^{\beta_L} {E_{it}}^{\beta_E} {M_{it}}^{\beta_M} {K_{it}}^{\beta_K} \cdot \exp(\beta_0 + \omega_{it} + \eta_{it}) \quad \text{for } t = 1,\ldots,T \qquad (1),$$

where Y_{it} is output, L_{it}, E_{it}, M_{it} and K_{it} are inputs of labor, energy, material and capital stock. $\exp(\beta_0 + \omega_{it} + \eta_{it})$ represents the Hicks-neutral technical change. (β_L, β_E, β_M, β_K, β_0) are structural parameters. ω_{it} is productivity shock realized during time t and observable for firm i during time t, but unobservable for econometricians. On the other hand, η_{it} is idiosyncratic shock unobservable for both firm i during time t and

next cartel in May 1981- Jun. 1981.

[12] Korenaga (2002) examined the coordination process for designation of two spinning industries using the trade associations' documents, and pointed out that, in case of cotton spinning, their primary purpose was not implementing disposal under concerted actions, but using the Basic Plan as a means for discussing measures for import restraints.

[13] See Sekiguchi and Horiuchi (1988). they pointed out that the scale of assistance from public funds for laid-off workers and depressed areas was far larger than those for capacity reduction

econometricians. Calculating the natural logarithm of both sides in Eq. (1), we can get

$$y_t = \beta_0 + \beta_L l_t + \beta_E e_t + \beta_M m_t + \beta_K k_t + \omega_t + \eta_t \quad (2),$$

where $(y_t,\ l_t,\ e_t,\ m_t,\ k_t)$ are the natural logarithm of $(Y_{it},\ L_{it},\ E_{it},\ M_{it},\ K_{it})$ and the subscript i is suppressed for simplicity.

The existence of the term ω_t makes it difficult to estimate consistently the structural parameter in Eq. (2). Since a firm can observe ω_t during time t, if it adjusts the level of some inputs in response to the realized value of ω_t, then the problem of endogeneity occurs. In general, endogeneity can lead to inconsistency of the standard OLS estimate of parameters. Moreover, Levinsohn and Petrin (2003. hereafter LP (2003)) pointed out that, under such positive correlation between inputs and ω_t, panel OLS estimation of production function tend to underestimate the coefficient of capital stock. Olley and Pakes (1996, hereafter OP (1996)) and LP (2003) developed the 2-step estimation procedure to solve this problem by specifying the stochastic process of ω_t and assuming the investment function or demand function to intermediate goods to absorbing the shock from ω_t. Since OP (1996) procedure requires that the actual investment is always positive, which hardly hold in my data, I employed the LP (2003) procedure. Assume that ω_t follows the first order Markov process:

$$\mathrm{P}(\omega_t | I_{t-1}) = \mathrm{P}(\omega_t | \omega_{t-1}) \quad \text{for t = 1,...,T} \quad (3),$$

where I_{t-1} is the information set a firm hold at time t and includes a sequence of the past ω_t's realized values $(\omega_1, \ldots, \omega_{t-1})$. $\mathrm{P}(\omega_t | I_{t-1})$ is the density of ω_t conditional on I_{t-1}. Eq. (3) represents the statistical properties and it means that the expectation of the future ω_t that a firm makes at time t-1 solely depends on ω_{t-1}, the observable value already realized at that time. Second, assume that labor (l_t), energy (e_t) and material (m_t) are variable inputs but that capital (k_t) is a state variable. Specifically, a firm chooses $(l_t,\ e_t,\ m_t)$ simultaneously right after it observes the realized value of ω_t at time t, while k_t is predetermined at time t-1 when ω_t has not been realized yet. Third, assume that factor demand for materials is the following function:

$$m_t = f(\omega_t, k_t) \quad (4),$$

which means that material inputs is determined based on a couple of state variables (ω_t, k_t) observable for a firm at time t. If this function is monotonically increasing in ω_t, the inverse function can be derived:

$$\omega_t = f^{-1}(m_t, k_t) \qquad (5),$$

This equation enables us to represent ω_t as the nonlinear function of (m_t, k_t) observable for econometricians. In other words, the latter two variables can be used as proxies for ω_t. Substituting Eq. (5) into Eq. (2), we can derive the estimated equation.

$$\begin{aligned} y_t &= \beta_0 + \beta_L l_t + \beta_E e_t + \beta_M m_t + \beta_K k_t + f^{-1}(m_t, k_t) + \eta_t \\ &= \beta_E l_t + \beta_E e_t + \phi(m_t, k_t) + \eta_t \end{aligned} \qquad (2a),$$

where $\phi(m_t, k_t) \equiv \beta_0 + \beta_M m_t + \beta_K k_t + f^{-1}(m_t, k_t)$. LP (2003) proposes to approximate $\phi(m_t, k_t)$ with either a nonparametric or semiparametric function. I employ the third-order polynomial of (m_t, k_t), $\phi(m_t, k_t; \lambda)$, with parameters λ.

Moment conditions for identification can be derived in the following way. Since the last term in the RHS of Eq. (2a), η_t, is unobservable for a firm at time t, a firm's decisions on (l_t, e_t, m_t) does not depend upon η_t. k_t is predetermined at time t-1 before η_t is realized, so k_t does not also depend upon η_t. Moreover, the any-order lag of (l_t, e_t, m_t, k_t) chosen before time t-1 does not depend upon the unrealized η_t. The sufficient conditions for these properties are the following assumption on sequential exogeneity.

$$\mathrm{E}(\eta_t | l_t, e_t, m_t, k_t, l_{t-1}, e_{t-1}, m_{t-1}, k_{t-1}, \ldots, l_1, e_1, m_1, k_1) = 0 \quad \text{for t = 1,...,T} \qquad (6).$$

Under these conditions, η_t is orthogonal to all covariates in Eq. (2a), which guarantees consistent estimation of $(\beta_L, \beta_E, \lambda)$ by OLS. This is the 1st stage of the estimation routine from LP (2003). For identification, at least the zero conditional mean assumptions on (l_t, e_t), which can be derived from Eq. (6), are needed.

The rest of the structural parameters, (β_M, β_K), are estimated in the 2nd stage. From Eq. (3), the conditional mean of ω_t is $\mathrm{E}(\omega_t | I_{t-1}) = \mathrm{E}(\omega_t | \omega_{t-1})$. Defining $\xi_t \equiv \omega_t - \mathrm{E}(\omega_t | \omega_{t-1})$, we can show $\mathrm{E}(\xi_t | I_{t-1}) = 0$. Since I_{t-1} contains the any order lag of factor inputs chosen at or before time t-1, we can get the following condition:

$$\mathrm{E}(\xi_t | k_t, l_{t-1}, e_{t-1}, m_{t-1}, k_{t-1}, l_{t-2}, \ldots) = 0 \quad \text{for t = 1,...,T} \qquad (7).$$

In the 2nd stage, LP (2003) proposes the following estimation routines to get a consistent estimator of (β_M, β_K). First, given any candidate values $\beta^* = (\beta_M^*, \beta_K^*)$, calculate the estimate of ω_t as $\widehat{\omega}_t = \hat{\phi}_t - \beta_M^* m_t - \beta_K^* k_t$, where $\hat{\phi}_t = \phi(m_t, k_t;\ \hat{\lambda})$ and $\hat{\lambda}$ is the OLS estimate of λ from the 1st-stage. Secondly specify $\mathrm{E}(\omega_t|\omega_{t-1})$ as parametric function of ω_{t-1} and regress $\widehat{\omega}_t$ on the lag of itself to get the estimate of $\mathrm{E}(\omega_t|\omega_{t-1})$. Next calculate the estimate of $\eta_t + \xi_t$ as $\widehat{\eta_t + \xi_t} = \widehat{\omega}_t - y_t - \hat{\beta}_L l_t - \hat{\beta}_E e_t - \beta_M^* m_t - \beta_K^* k_t - \mathrm{E}(\widehat{\omega_t|\omega_{t-1}})$. Under conditions (6) and (7), the following moment conditions hold:

$$\mathrm{E}[(\eta_t + \xi_t)Z_t] = 0 \quad \text{for t = 1,...,T} \qquad (8),$$

where $Z_t = (k_t, l_{t-1}, e_{t-1}, m_{t-1}, k_{t-1}, l_{t-2}, \dots)$. Finally we obtain estimates $(\hat{\beta}_M, \hat{\beta}_K)$ by minimizing the GMM criterion function with respect to $\beta^* = (\beta_M^*, \beta_K^*)$:

$$\min_{\beta^*} \sum_h \left\{ \sum_t (\widehat{\eta_t + \xi_t}(\beta^*)) Z_{ht} \right\}^2 \qquad (9),$$

where h is indexing the elements of Z_t. For identification, it is enough to use at least two orthogonal conditions of $(k_t,\ m_{t-1})$ among Z_t from Eq. (8)[14].

Data and definition of variables

Our main resource of data is (*Menshi) boseki jijo sankosh*o (Statistics on the Japanese cotton-spinning industry, Japan Spinners' Association (JSA), 1965-79), unless other sources are referred. This data contains 134 firms at the beginning of 1965 and 85 firms 1979 and it covers at least 64.7% and 61.9% of workers in the cotton and chemical fiber spinning industry at 1965 and 1979[15]. JSA data contains detailed input-output infomation for several segments (spinning, weaving, and so on), from which I use only data on the spinning segment.

The panel dataset is arranged based on data availability and events. For new entrants after 1965, observations a year after their entries are used. For firms vanishing due to exit or those dropping from this survey due to withdrawal from JSA, observations a year before these events are used. For firms merging into a single firm or a firm separated into multiple firms, I treat them as hypothetical firms by consolidating data before mergers

[14] I used the Stata program offered by Petrin, Poi and Levinsohn (2004) for the estimation routine of Levinsohn and Petrin, where optimization is based on Newton's method. The bootstrap is also used for inference, sampling with replacement from firm-level observation.
[15] The number of workers in JSA data is 107,727 in 1965 and 52,006 in 1979, but the figures are underestimated because it excludes non-production workers at the headquarters office. On the other hand, total number of regular workers in cotton spinning industry and chemical fiber spinning industry are 166,451 and 84,027 from MITI statistics (1965, 1979).

or after separations. For firms temporarily stopping operation due to a fire, not reported and so on, observations from stopping year to restarting year are excluded. For firms missing data, the corresponding year is excluded. Consequently, the number of firms is at most 124 and the number of observations is 1441 in 1965-79.

As for definitions of variables, I followed Kiyota and Okazaki (2010), but made some modifications due to data availability. Output is defined as the weighted average of 9 output commodities[16], where the weight is the sales share of each commodity. Sales data is not available in JSA data, so I used unit price data from Wholesale Price Statistics (Bank of Japan) to calculate sales.

All inputs are those used in the spinning stage of production. For labor, I used the sum of the number of production workers and white-collar workers, and multiplied it by the total hours of operation in a year to convert to flows[17]. Capital stock is the operating number of spindles of spinning machines. Material input is defined as the weighted average of 7 materials, where the weight is each share of material costs[18]. Energy input is electricity usage[19]. The above outputs and inputs are transformed to logarithmic value. Finally, to capture the overall deterministic time trend, year dummies are added to Eq. (2a).

Estimation Results

The results are in Table 2. As for 1965-79, the OLS results (PF-11) shows that the estimate of coefficient of k, $\hat{\beta}_K$, is negative and statistically significant, which contradicts the usual assumption on monotonicity. The null that there exists constant returns to scale

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[16] 9 commodities are pure cotton spun yarn, mixed cotton spun yarn, pure rayon spun yarn, mixed rayon spun yarn, other natural fiber spun yarn, pure synthetic spun yarn, mixed synthetic spun yarn, cotton waste, other waste. Subcategories of synthetic spun yarn are vinylon, polyester, acrylic and others. See details in the Appendix 1.

[17] The original data of capital and labor are biannual, where each half period value is a 6-month average of the number of operable spindle of spinning machines and workers, so I calculated a 12-month average to average the former-half and the latter-half values. 6-month averages of the number of workers are not available in 1973-5, so I use the average of the end-of-year values at current and previous years instead.

Similarly, total hours of operation at each half period is a firm's 6-month average of operated days multiplied by its 6-month average of operated hours per day, but with a few data missing. I substituted the other half value or the industry's average of the year for missing values and calculated the average of both half values multiplied by 12.

[18] 7 Commodities are cotton, rayon staple, other natural fibers (including cotton waste), vinylon, polyester, acrylic, and other synthetic fibers.

[19] The data on coal and heavy oil usage are available only in 1965-69. I calculated each share at the industry level by the calorie conversion factor from General Energy Statistics (1965, Agency for Natural Resources and Energy). The resulting shares are electricity 94.8%, coal 0.3%, and heavy oil 4.9% in 1969 and stable over 1965-69. Therefore, I believe that electricity can be used as a plausible proxy for energy usage.

is rejected. On the other hand, the LP result using (l_t, e_t, k_t, m_{t-1}) as IVs is (PF-12), where $\hat{\beta}_K$ turns to be positive, as suggested by LP (2003). Here, the existence of constant returns to scale is not rejected.

Since structural break could occur around 1973-74, I also estimated in the sub-periods. The results in the 1965-73 estimation are shown in the third and fourth column. Again, LP procedure gives larger $\hat{\beta}_K$ than OLS and constant returns to scale is not rejected. On the other hand, in the case of the latter half of the 1970's, since estimation under just identification restriction suffered difficulties in convergence, I added more IVs and estimated under over-identification restriction, shortening the estimation period. The results in 1976-79 are shown in the fifth and sixth column. Contrary to 1966-73, the coefficient of labor also turns out to be insignificant along with that of capital, which suggests that these inputs were used more excessively than the previous periods. LP procedure again raises the coefficients of capital and constant returns to scale is not rejected.

The industry's productivity growth

Estimation of production function enables us to make several measures on firm performances. Since we added year dummies for overall technical change, a firm i's productivity level in year t, $prdct_{it}$, is defined as

$$prdct_{it} = \exp(\omega_{it} + \sum_{s=66}^{t} \beta_s \cdot dum[s]_{it}) \tag{10}$$

where $dum[s]_{it}$ is the year s's dummy, which is equal to 1 if t = s or 0 otherwise, and β_s is its coefficient. Then the aggregated productivity level in year t, $prdct_t$, is defined as the weighted average of Eq. (10).

$$prdct_t = \sum_i \{s(Y)_{it} \cdot prdct_{it}\} \tag{11}$$

where $s(Y)_{it}$ is the share of a firm i's output in year t. The estimates of $prdct_t$ are obtained by inserting the estimates $(\widehat{\omega}_{it}, \hat{\beta}_t)$ into Eq. (10) and evaluating Eq. (11) with the actual data of Y_{it}. The results are shown in Figure 1.

According to the 1965-79 estimate, the industry's productivity level shows an upward trend from 1967, but falls after 1973 in two consecutive years, and then increases again with weak fluctuations after 1976. The estimates in sub-periods (1965-73, 76-79) also support this evidence, although the 1976-79 estimate levels are quite low due to the different starting year. To check the contribution of omega and the overall technical change, the productivity level due to only ω_{it} are also calculated and shown in the figure. We can see that while the evolution of $\widehat{\omega}_{it}$ mostly explains the baseline of productivity level during the whole periods, the contribution of the overall technical change slightly appears in 1967-73, but disappears in 1974 and thereafter. This means that the unobserved source heterogeneous among firms is quite important.

3.2 Capital profitability and the scale of incentives for scrapping

Estimation of production function also gives as marginal product of capital containing the unobserved productivity, a stream of which is one of the key components in the long-term return on investment, along with the resale value in the future. Here, I compare the available purchasing prices for scrapping with them to roughly grasp the scale of incentives generated by policies.

Marginal product of capital is derived from Eq. (1), noting that β_0 is incorporated into the level of ω_{it} and not directly estimated.

$$pmpk_{it} = P_{Y,it} \cdot \partial Y_{it}/\partial K_{it} = P_{Y,it} \cdot \beta_K {L_{it}}^{\beta_L} {E_{it}}^{\beta_E} {M_{it}}^{\beta_M} {K_{it}}^{\beta_K - 1} \cdot prdct_{it} \qquad (12)$$

Since the sale share are different among firms, I put the subscript i to the price variable to show the price difference each firm faces. Then, the aggregated marginal product of capital in year t is defined as the weighted average of Eq. (12).

$$pmpk_t = \textstyle\sum_i \{s(K)_{it} \cdot pmpk_{it}\} \qquad (13)$$

where $s(K)_{it}$ is the share of a firm i's capital in year t. The estimates of $pmpk_t$ are obtained by inserting the estimates of $prdct_{it}$ and structural parameters into Eq. (12). and evaluating at firms' data on outputs, inputs and price. $P_{Y,it}$ is the weighted average of 9 output commodities' prices, and the weight is the sale share of each commodity, which were already defined before.

Figure 2 shows the resulting nominal and real estimates of $pmpk_t$, where the latter is deflated by GDP deflator (1965 base year)[20], along with the unit price of the spinning machine in 1965-72 available from BOJ statistics. The estimated nominal marginal product of capital shows quite similar movements to productivity. It starts to increase in 1967, keeps an upward trend until 1973, falls in 1974-75, but increases again from 1976

[20] There is a possibility that $pmpk_t$ is overestimated because it can also reflect the marginal product of other types of equipment which are strongly complementary to spinning machines.

and continues at a higher level than periods before 1973. On the other hand, the estimates of real marginal product of capital shows relatively modest upward trends before 1973 than nominal ones, and after 1974, falls at the lower level than before 1973. Such evidence is taken to mean that the investment environment firms faced got drastically worse around 1974.

Compare the nominal $pmpk_t$ with the purchasing price in 1968-69 and 1972-73 scrapping, ignoring the resale value in the future and time discount factor. Then, we can see that the scale of incentives generated by voluntary disposal is large enough for a firm in average to consider the long-term decision on investment in both periods. As for the 1968-69 case, the "gross" purchasing price (excluding the resale value) of an operable machine in compulsory disposal (3,000 yen) was about one third of the price of a new machine in 1968 (10,163 yen), and higher than the 1969 value of $pmpk_t$ (1981.5 yen), but lower than the sum of 1969-70 values (1,981.5 + 2,343.5 = 4,325.0 yen). This means that for a firm planning to use the last unit of machine for more than 2 years, compulsory disposal of it could result in loss. Similarly, the "gross" purchasing price for voluntary disposal offered by JSA (5,000 yen) was about half the price of a new machine, and lay between the sum of 1969-70 values and that of 1969-71 values (1,981.5 + 2,343.5 + 2,465.7 = 6,790.7 yen). This means that for at least an incumbent firm planning to disinvest within 2 years, voluntary disposal would be attractive[21].

As for 1972-73 case, the purchasing price for (voluntary) disposal for incumbents (8,800 yen) was about 80% of the price of a new machine, and lay between the sum of 1974-75 values (3,728.2 + 2,759.3 = 6,487.5 yen) and that of 1974-76 values (3,728.2 + 2,759.3 + 3,628.2 = 10,115.7 yen) of $pmpk_t$. Similar results were obtained in the price for disposal by exits. This means that at least for a firm planning to disinvest or exit within 2 years, scrapping would be attractive[22].

Figure 2 also depicts the evolution of the industry level of physical capital (spinning

[21] I also compared the purchasing price with the residual values of existing machines in the accounting base, by amortizing the unit price of new machines in each year with the depreciation rate in tax law in those days. The ordinary depreciation rate is 15.2% (14 years) in 1965-69, 18.9% (11 years) in 1970 and 20.6% (10 years) in 1971-79, calculated from the useful life of spinning machines in the parentheses by the declining balance method (the final residual value is 10%).

The calculated residual values in 1968-69 are 4,674 and 3,964 yen if it was purchased in 1966, so voluntarily disposing machines purchased two years before could avoid the asset loss, although compulsory disposal could hurt the balance sheets. Similarly, the calculated residual value in 1972-73 are 8,512 and 6,762 yen if purchased in 1971, so even disposing machines purchased just a year before could avoid the asset loss.

[22] The scale of incentive in 1972-73 scrapping could be larger because the estimates of $pmpk_t$ based on the1976-79 estimation are lower than those based on the1976-79 estimation.

machine) measured in several states, which are available from JSA data[23]. The policy impacts to these production facilities will be examined in the following sections.

4. Econometric analysis on effects of scrapping policies

4.1 Direct effects on investment under policy implementation

The incentives offered by scrapping policy apparently affected a firm's investment behavior but, as already clarified in section 3, the policy schemes are quite different between the periods, and common policy variables are not available in the whole period. One of the standard approaches to model such policy effects is to identify the "structural change" in a firm's investment decision. More specifically, I split the whole period into several sub-periods and estimate investment function in the form of saturated model with the policy-implementation-year dummy.

Model and estimation procedure

Assume the following investment function.

$$\ln(K_{t+1}) = \alpha_0 \cdot \ln(K_t) + \beta \cdot \ln(pmpk_t) + x_t\gamma + u_t \quad \text{for t = 1,...,T} \qquad (14).$$

The subscript i is suppressed for simplicity. $\ln(K_t)$ and $\ln(pmpk_t)$ are the natural logarithms of capital stock and real marginal product of capital at time t, both of which were defined in the previous section. The model reflects the timing of a firm's decision that it observes during period t the realized value of $pmpk_t$ given K_t chosen in the previous period, and chooses K_{t+1} at the end of period t. This is consistent with assumptions on variable inputs and capital stock for production function estimation. x_t is a vector of other controlling variables including unity and chosen before or, at the latest, at the beginning of time t. u_t is the idiosyncratic error defined later. The lag of dependent variable, $\ln(K_t)$, appears in the RHS of Eq. (14), which represent the partial adjustment of investment behavior. Subtracting $\ln(K_t)$ from the both sides of Eq. (14) and

[23] The number in registered units is on machines registered under the New Textile Law until 1970, which includes not only operable machines (machines ready for operation), but also machines legally banned for use under either the above law or the recession cartel approved by the Japan Fair Trade Commission. The number in operable and non-operable units are on machines surveyed for *Seisan dotai tokei chosa* (Current Survey of Production, MITI). The latter unit consists of machines legally banned for use, or stopped for reparations, modification or transfer. We can also use installed units after 1970. According to descriptions in JSA data, the coverage of the above all types of units are almost similar in that the main material inputs are raw cotton, rayon staple and synthetic staple.

approximating the LHS with $\ln(K_{t+1}) - \ln(K_t) \fallingdotseq (K_{t+1} - K_t)/K_t \equiv I_{t+1}/K_t$, we can get

$$I_{t+1} \,/\, K_t = \alpha \cdot \ln(K_t) + \beta \cdot \ln(pmpk_t) + x_t\gamma + u_t \tag{15},$$

where $I_{t+1} \,/\, K_t$ is called the investment capital ratio, and $\alpha = \alpha_0 - 1$. When a firm exits from market, $K_{t+1} = 0$, so $I_{t+1}/K_t = -K_t/K_t = -1$. This means that the dependent variable is censored at -1 if a firm exits, so I employed the following Pooled Tobit model as an estimated equation.

$$I_{it+1} \,/\, K_{it} = \max[\,-1,\ \alpha \cdot \ln(K_{it}) + \beta \cdot \ln(pmpk_{it}) + x_{it}\gamma + u_{it}] \tag{16},$$

$$u_{it} | \ln(K_{it}), \ln(pmpk_{it}), x_{it} \sim \text{Normal}(0, \sigma_u^2) \tag{17},$$

where the lag of dependent variable could be allowed in RHS. As for the unobserved cross-sectional heterogeneity, the unobserved heterogeneity in productivity level, ω_{it}, is available from estimated production function and included in $pmpk_{t-1}$, and the lag of dependent variable is added to Eq. (14). Therefore, I believe that the unobserved cross-sectional heterogeneity in investment behavior would be well captured by these variables. Under these assumptions, the parameters in Eq. (16) are consistently estimated by the partial likelihood method. The parameter restrictions on Eq. (16) with or without the policy are derived from the model in Appendix 2.

Data and definition of variables

The source of data is almost same as in the previous section. K_{it} is the number of spinning machines at the end-of-year t-1, and I_{it+1} is defined as the change in K_{it} from the end-of-year t-1 till the end-of-year t. The expected coefficient sign of $\ln(K_{it})$ is ambiguous because it depends upon both the speed of partial adjustment ($\alpha = \alpha_0 - 1$ can be negative) of capital stock and scale economies due to other reasons than through production (Recall that constant returns to scale is not rejected in the previous section). To examine the difference in policy effects, I used several states of capital stock (operable, registered or installed), already explained at the end of section 3.2. $pmpk_t$ has already been defined and calculated in the previous section and deflated by a GDP deflator. I used several estimates obtained in section 3 to check the robustness. The expected sign of its coefficient is positive.

x_{it} contains the following variables. The first group captures effects of the downstream production stages in a firm. $weatwi_{it}$ is a dummy of a firm i's holding production facilities for weaving or twisting at the beginning of year t. Similarly, $txpr_{it}$ and $prcs_{it}$ are dummies of firm i's holding production facilities for secondary textile products or processing at the beginning of year t, respectively. All data are available from JSA data. The expected sign of these coefficients are ambiguous due to competing powers: While these activities can be the source of technological spillover, diversification of commodities, or scale economies due to shared use of managerial resources and common facilities and offices (which have positive effects), they can also change the opportunity cost of resources in the spinning stage and cause resources to shift toward the downstream stages (which have negative effects).

The second group in x_{it} are on a firm's experiences in past events. mrg_{it} is a dummy for a firm i's having been experienced mergers prior to year t. Similarly, dcm_{it} is a dummy for a firm i's having been experienced separations prior to year t. Both events are available in JSA data. Since these events rearrange firm organization and management practices, it is not easy to predict the expected sign of both coefficients.

The third group in x_{it} measure the differences in firm characteristics in wider scope, but are used only in the sub-period estimation (1966-73 and 1974-79) due to data limitation. $dvrty_{it}$ is a dummy of a firm i's operating non-textile business activities inside the firm at the beginning of the estimated periods. $afflte_{it}$ is a dummy of a firm i's having affiliate firms at the beginning of the estimated periods. Both data are compiled from *Zenkoku sen'i kigyo yoran* (the Yearbook of Textile/Apparel Companies; the Credit Exchange Agency). Due to data limitation, both are measured as of the fiscal year-end of 1966 in the 1966-73 estimation, or the fiscal year-end of 1973 in the 1974-79 estimation, respectively[24]. fdi_{it} is a dummy of a firm i's holding overseas affiliated companies during the estimated periods. Data are compiled from *Kaigai shinshutsu kigyo soran* (Overseas Japanese companies database; Toyo Keizai Inc.) and measured in 1966-74 or 1974-79, respectively. The expected sign of these three coefficients are also ambiguous, affected by competing powers. The reasons are similar to the downstream stage activities mentioned before: These variables capture not only the differences in the opportunity cost of resources in the spinning stage measured over the border of the segment, the firm or the nation, but also effects of technological spillover, a kind of scale economies, or the channels to overseas market. Year dummies are also added to the estimated equation to control effects of the unobserved time-varying factors including the

[24] Information on business relations and human or capital ties were picked up from credit records in the Yearbook. Consequently, the following firms are defined as "holding affiliate firms": (1) firms holding subsidiaries, affiliates or a parent firm, (2) firms under capital participation or supervision of other firms, (3) firms being engaged in consignment production from material suppliers, and (4) firms management representatives of which is also a board member of other firms. Identifying the effect of each category was difficult due to a small sample size.

interest rate.

Moreover, in estimation of 1966-69, a couple of minor modifications were made for controlling the effect of other policies. First, the adjusted amount of operable machines ($K_{o,it}^{a}$) was also used as K_{it} to correct the effect of the short-term suspension under the recession cartel: $K_{o,it}^{a} = K_{o,it} + s_{it}K_{o1,it}/9$ for t = 1965 and 1966 and $K_{o,it}^{a} = K_{o,it}$ for otherwise. Here, $K_{o,it}$ is the (unadjusted) amount of operable machine, $K_{o1,it}$ is the first segment' amount of $K_{o,it}$, and s_{it} is the share of cotton-spun yarn and rayon-spun yarn for a total output of spun yarn[25]. Second, to control the effect of S & B constraint on investment, I modeled the effect of binding constraints by parameterizing the Lagrange multiplier as a function of $K_{s,it}/K_{o,it}$ in Appendix 2. $K_{s,it} = K_{r,it} - K_{o,it}$ is the amount of suspended machines, where $K_{r,it}$ is the amount of registered machines. The expected sign of its coefficients is positive without scrapping policy, but ambiguous with that policy (see Appendix 2).

Panel dataset are arranged based on data availability and attritions in the same manner as estimation of production function in the previous section. Consequently, the number of firms is at most 117, and the number of observations is 1339 (including 27 exits) in the 1966-79 estimation. Similarly, there were 115 and 815 (including 14 exits) in the 1966-73 estimation, 93 and 524 (including 13 exits) in the 1974-79 estimation. In the case of using $dvrty_{it}$, $afflte_{it}$ and fdi_{it}, the sample decreased to 101 and 744 (including 9 exits) in the 1966-73 estimation, 84 and 490 (including 12 exits) in the 1974-79 estimation. The saturated model was estimated in the sub-periods, considering the change in the business conditions (around 1973-74), as well as the change of the overall policy scheme (around 1970 and 1974-75), explained in section 2.

Estimation Results

Table 3 summarizes the results of 1966-79, 1966-73 and 1974-79 estimations without the interaction terms[26]. For comparison, I used the number of operable machines available during the whole period. Focusing on the results on key variables, at least the

[25] The recession cartels were implemented from October 1965 until March 1967, and almost all JSA firms joined. The agreement for concerted actions prescribed that each firm suspended 10% of the operable spinning machines that belonged in the first segment (used for production of cotton-, rayon- or synthetic-spun yarns) and that had been used for production of cotton- or rayon-spun yarn since January 1965 (JSA, 1969, p.208-18; JSA monthly report, Oct. 1965, p.2-20, Jun. 1966, p.30-40.). Then, the amount of machines still operable in the first segment after 10% suspension can be approximated by $s_{it}K_{o1,it}$, and $s_{it}K_{o1,it}/9$ is equal to the amount of the short-term suspended machines under the cartels.

[26] The OLS results were almost the same as the Tobit ones in all cases, so only the Tobit results are listed. Similar results were obtained between several estimates of $pmpk_t$, so only the results using the 1965-79 estimates are listed.

following two findings can be made. First, $\ln(pmpk_{it})$ has positive effect on capital investment in 1966-79 and 1966-73, but does not in 1974-79. When using only $\ln(K_{it})$ and $\ln(pmpk_{it})$ without year dummies, the estimated coefficients are all statistically significant. Those of $\ln(pmpk_{it})$ are small, but all positive as expected in all the estimation periods (Eq. (1-1), (2-1) and (3-1)). However, once adding year dummies and past event variables, while similar results are obtained in 1966-79 and 1966-73 (Eq. (1-2) and (2-2)), the statistical significance in the estimated coefficients of $\ln(pmpk_{it})$ vanished in 1974-79 (Eq. (3-1)). This contrast persists even if other factors are controlled (Eq. (1-3), (2-3) and (3-3)). These results suggest that while firms with the lower return on investment invested less or disinvested as a whole before 1973, these firm s ceased to do so during the depression period after 1974. Second, the coefficients of $dvrty_{it}$, $afflte_{it}$ and fdi_{it} are all insignificant in both sub-periods (Eq. (2-4) and (3-4)).

Next, splitting 1966-73 at the year 1970 when the registration system for production facilities was abolished, I estimated the model with the interaction terms in 1966-69 and 1971-73. The most amounts of disposal occurred in 1969 under the 1968-69 policy and in 1973 under the 1972-73 policy. So defining the policy-implementation year dummy as 1969 year dummy in the former case and 1973 year dummy in the latter case, I inserted the interaction terms of this dummy and all covariates into the model[27].

The 1966-69 estimation is listed in Table 4. The main results are in Eq. (4-5oa) and (4-5o), and the results are quite similar with or without adjusting the effect of the recession cartel. First, while the estimated coefficient of $\ln(pmpk_{it})$ is positive and significant, that of the interaction terms, $\ln(pmpk_{it}) * ydum69$, is negative at the same order of magnitude and significance. In short, the positive relationship between investment and its returns vanished under scrapping policy. This suggests that, treating several kinds of schemes (compulsory, voluntary, or by exits) together, a firm on average scrapped machines regardless of their profitability, which could generate distortion in resource allocation. Second, the estimated coefficient of $K_{s,it}/K_{o,it}$ is significantly positive as expected, while that of the interaction terms, $K_{s,it}/K_{o,it} * ydum69$, is insignificant. This means that a firm with more suspended machines invested more on operable machines, which further implies that scrap & build constraint also distorted a firm's investment decision during the period with or without scrapping policy. Third, to some extent, the above results depend upon firm exits from the market. The statistical significance in the

[27] $dvrty_{it}$, $afflte_{it}$ and fdi_{it}, are dropped out of the equation since the coefficients were insignificant in most cases and marginally significant in a very few cases. The results from the late 1970s are suppressed because I estimated the saturated models as well, but most of the estimated coefficients are insignificant and any economically interpretable results on the key variables could not be obtained stably.

coefficients of main variables decrease if we drop censored data due to firm exits (Eq. (4-3oa)), which implies that firm exits had a considerable role in cutting down unprofitable production facilities.

The results on registered machines are in the latter part of Table 4. Note that the results can be considered a combination of the following different kinds of firm decisions. Under the S & B constraint, a unit of increase in operable machines needs two units of decrease in suspended ones. So the changes in registered machines ($K_{r,it} = K_{o,it} + K_{s,it}$) contain at least a unit of decrease due to this constraint if a firm increases operable ones, which reverses the expected sign of regression coefficients (see Appendix 2). At the same time, $K_{r,it}$ also decreases due to a firm exit, and in this case, we can expect the same sign of coefficients as those of operable machine[28].

First, we can also find the role of firm exits to cut down the unprofitable machines. The estimated coefficient of $\ln(pmpk_{it})$ is significantly positive in Eq. (4-3ra), but turn to be insignificant in Eq. (4-2ra) if samples censored by firm exits are excluded. Second, in Eq. (4-5ra), the coefficient of the interaction terms, $\ln(pmpk_{it}) * ydum69$, is significantly negative at the same order of magnitude as that of $\ln(pmpk_{it})$, which is similar to the results in Eq. (4-5oa) and (4-5o). In short, under scrapping policy, the positive relationship between investment and its returns vanished again in this case. Third, the estimated coefficient of $K_{s,it}/K_{o,it}$ is significantly negative, while that of the interaction terms, $K_{s,it}/K_{o,it} * ydum69$, is still insignificant (Eq. (4-5ra)). This means that a firm with more suspended machines decreased more in registered machines during the period with or without scrapping policy. We see again that scrap & build constraint distorted a firm's investment decision, but did so in the opposite direction of the operable machine's case.

The 1971-73 estimation is listed in Table 5. First, similar to the 1966-69 estimation, we can find again that firm exits worked to enhance the use of profitable machine in both cases of operable and installed one. While the coefficients of $\ln(pmpk_{it})$ has low statistical significance if firm exits are excluded (Eq. (5-2o) and (5-2i)), their significance increases once these samples are included (Eq. (5-3o) and (5-3i)). Second, as for the effect of scrapping policy, the results are different between the different states of machines (Eq. (5-4o) and (5-4i)). While the estimated coefficient of $\ln(pmpk_{it})$ is significantly positive in both equations, that of the interaction terms, $\ln(pmpk_{it}) * ydum73$, is not significant in the case of operable ones, but significantly negative at the same order of magnitude in the case of installed ones. In short, under scrapping policy,

[28] A firm may also decrease the suspended machine simply due to its low return in the future when it is allowed to operate, but it is difficult to estimate such kind of returns separately. In this sense, there is the possibility of model misspecification in the results on registered machines.

the positive relationship between investment and its return still remained in terms of operable machines but vanished in terms of installed ones. The difference between the two cases suggests that some firms still held the installed but non-operable machines, regardless of their profitability, even after scrapping was implemented, possibly because the target of scrapping was the operable machine only, as explained in section 2.

4.2 Effects on post-policy investment through revelation of the long-term return

Here, I focus on voluntary disposal in 1968-69, which was offered by JSA, and examine its indirect effect on post-treatment investment during 1970-72, which is the liberalization periods after the abolition of the registration system for production facilities and just before the next scrapping policy was implemented.

A distinctive feature of this policy schemes is that it not only could force a firm to commit to irreversible disinvestment, but also could help a firm calculate its long-term return on investment given other firms' decisions. As previously mentioned, the purchasing price, even if excluding the resale value as scrap, was more than the sum of the short-term capital profitability for the following two years (see subsection 3.2), and imposed the penalty which was at least 20% (= 1,000/5,000) or 60% (= 3,000/5,000) of the purchasing prices (see section 2). Since the presence or absence in voluntary disposal is the indicator of the long-term return on investment, a firm's participation in voluntary disposal can be viewed as its revelation of its long-term return on investment observable for other firms. The hypothesis tested here is that firms having participated in voluntary disposal in 1968-69 still remained invest less or disinvest during 1970-72, controlling other factors including the short-term return on investment.

Model and estimation procedure

One of the merits in viewing a firm participation as its revelation of the long-term return is that this enables us to derive the estimated equation from the long-term investment decision, without extrapolating policy variables and its interaction terms. Assume the following investment function,

$$\ln(K_{t+1}) - \ln(K_t) = \delta_1 R'^{e}_{L,t+1} + x_t\delta_2 + e_t \qquad (18).$$

The subscript i is suppressed for simplicity. The LHS of Eq. (18), $\ln(K_{t+1}) - \ln(K_t)$, is the growth rate of capital during period t+1. $R'^{e}_{L,t+1}$ is the expected value of the long-term return on investment at time t+1 thereafter that a firm makes during period t, where the subscript L indicates the long-term and e the expected value. x_t is a vector of other controlling variables including unity. x_t was chosen before or, at the latest, at the beginning of period t. The timing of a firm's decision is the same as the model in the previous subsection. e_t is the idiosyncratic error. Deriving Eq. (18) from time t until t + T -1, respectively, and summing the each side of them, we have the following.

$$\begin{aligned}\ln(K_{t+T}) - \ln(K_t) &= \delta_1 \textstyle\sum_{s=1}^{T} R'^{e}_{L,t+s} + (\sum_{s=0}^{T-1} x_{t+s})\delta_2 + \sum_{s=0}^{T-1} e_{t+s} \\ &= \delta_1 \textstyle\sum_{s=1}^{T} R'^{e}_{L,t+s} + x_t(T\delta_2) + \sum_{s=0}^{T-1} e_{t+s} \qquad (19).\end{aligned}$$

To derive the second equality, x_t is assumed to be constant over the period, which is plausible in the dataset. Assume further that $R'^{e}_{L,t+s}$ can be represented as the following linear approximation of the expected value:

$$R'^{e}_{L,t+s} = \mathrm{E}\left(R_{L,t+s} \middle| R_{t+s-1}, R^{e}_{L,t+s-1}\right) = \theta_0 + \theta_1 R_{t+s-1} + \theta_2 R^{e}_{L,t+s-1} \qquad (20),$$

where R_{t+s-1} is the short-term return on investment during period t+s-1. Eq. (20) means that a firm observes the short-term return on investment and revises its expectation on the long-term return on investment during the current period, given the past expectation. Inserting the lag of Eq. (20) into itself repeatedly toward time t, $R'^{e}_{L,t+s}$ is represented as a linear function of $(R_{t+s-1}, R_{t+s-2}, \dots, R_t, R^{e}_{L,t})$, and then substituting it into Eq. (19) and re-parametrizing, we can get

$$\ln(K_{it+T}) - \ln(K_{it}) = \textstyle\sum_{s=0}^{T-1} \beta_s R_{it+s} + \beta_L R'^{e}_{L,it} + x_{it}\gamma + u_i \qquad (21),$$

where $u_i = \sum_{s=0}^{T-1} e_{i,t+s}$ .To deal with data-censoring problems due to firm exits, I approximated the LHS with $I_{it+T}/K_{it} = (K_{it+T_i} - K_{it})/K_{it}$, where T_i is T or the year a firm i exited, whichever is smaller, and replace the first term in the RHS with $\beta_S \cdot \bar{R}_{S,i}$, where $\bar{R}_{S,i} = (T_i^{-1} \sum_{s=0}^{T_i-1} R_{it+s})$ is the average of the short-term return on investment from year t until the year $T_i - 1$. Since $R'^{e}_{L,it}$ is unobservable, I used its indicator, $I[R'^{e}_{L,it}]$, defined later. Finally, adding $\ln(K_{it})$ to the RHS to capture the partial adjustment, I employed the following cross-sectional Tobit model as an estimated equation.

$$I_{iT+1} \,/\, K_{it} = \max[\,-1,\ \alpha \ln(K_{it}) + \beta_S \bar{R}_{S,i} + \beta_L I[R'^{e}_{L,it}] + x_{it}\gamma + u_i] \qquad (22),$$
$$u_i \middle| \ln(K_{it}), \bar{R}_{S,i}, R^{e}_{L,it}, x_{it} \sim \mathrm{Normal}(0, \sigma_u^2) \qquad (23).$$

$I[R'^{e}_{L,it}]$ is derived as follows. Consider the situation where a firm i makes a decision at time t about whether to apply to the voluntary disposal after the compulsory disposal. A firm increases the amounts of disposal by an additional one spindle by comparing P_V, which is the purchasing price for the voluntary disposal, with $R'^{e}_{L,it}$ that a firm expects this additional 1 spindle would make thereafter. Consequently, the amounts of disposal is chosen at the level where P_V is equal to the expected value of the long-term return from the last spindle that a firm took out, which is equal to $R'^{e}_{L,it}$ right after the application periods expires. In this context, the following relationship holds: $P_V = R'^{e}_{L,it}$ if a firm joins the voluntary disposal, but $P_V < R'^{e}_{L,it}$ if a firm does not. Therefore, the absence or presence of voluntary disposal can work as the indicator on the level of $R'^{e}_{L,it}$. In other words, the higher $R'^{e}_{L,it}$ a firm has, the less it is likely to apply to the voluntary disposal. Define the indicator variable:

$I[R'^{e}_{L,it}]$ = 1 if a firm participated in the voluntary disposal, otherwise 0,

which is a nonlinear function of $R'^{e}_{L,it}$ and negatively correlated with it.

Data and definition of variables

The sources of data are the same as the previous subsection. To examine the persistence of policy effect, I used three different lengths of the measurement period of the investment, from the end of 1969 until the end of 1970, 1971 or 1972. K_{it} is the number of spinning machines at the end of 1969, and I_{it+1} is defined as the change in K_{it} from the end of 1969 until the end of the last year in each period, or the year a firm exited, whichever is smaller. I also used two states of capital stock (operable, and operable plus non-operable) to examine the difference in policy effects. The expected sign of coefficient of $\ln(K_{it})$ is ambiguous due to the competing powers explained previously. $\bar{R}_{S,i}$ is defined as the average of the logarithm of real $pmpk_t$ (defined in section 3) from 1969 until the second last year in each period, or the previous year before a firm exited, whichever is smaller. This variable is renamed $\text{avg.}\ln(pmpk)$ for simplicity. x_{it} contains ($weatwi_{it}$, $txpr_{it}$, $prcs_{it}$, mrg_{it}, dcm_{it}), which has been defined in the previous subsection, and here measured as the beginning of 1970[29].

As for $I[R'^{e}_{L,it}]$, since the number of registered machines is available as policy variable, $I[R'^{e}_{L,it}]$ is calculated defined as follows.

$I[R'^{e}_{L,it}]$ is equal to 1 if the number of spindles of the registered spinning machines

[29] I also used $dvrty_{it}$, $afflte_{it}$ and fdi_{it}, but these coefficients were insignificant in most cases and marginally significant in a very few cases.

owned by a firm i decreased by strictly more than 6.25% from the end of June 1968 until the end of June 1969, otherwise 0,

which is renamed $policy_i$ thereafter. Since all firms were forced to decrease 6.25% by the compulsory disposal, 6.25% is the cutting point between participants and non-participants, and the variable shows the presence or absence of voluntary disposal[30]. The expected sign of its coefficient is negative since it negatively correlates with $R'^{e}_{L,it}$.

Attritions due to other events are treated in the same manner as the previous subsection. The number of observation is 100 in the 1969-70 estimation, and 98 in 1969-71 and 1969-72. Finally, I also tried different types of tests with the Average Treatment Effect model proposed by Rosenbaum and Rubin (1983).

Estimation results

The results are in Table 6[31]. As for operable machines, the estimated coefficient of the key variable, $policy_i$, is negative as expected and significant in all cases (Eq. (6-1o), (6-2o) and (6-3o)), which means that a firm having participated in voluntary disposal in 1968-69 invested less during the post-policy period, controlling other factors[32]. The estimated coefficient of another key variable, $\text{avg.}\ln(pmpk)$, is positive as expected in all cases and turns out to be significant in 1969-72, which suggests that the short-term return on investment in subsequent years is also important to make an investment decision through revising the expectation. Similar results were obtained in operable plus non-operable machines, but the estimated coefficient of $policy_i$ is smaller and its

[30] Although the actual disposal was implemented from October 1968 until March 1969, based upon the number of spinning machines as of August 1968, there are several evidences that the indicator captures in some extents the participants in voluntary disposal. First, the total number of spinning machines in operable units and non-operable units are monthly available only in the aggregated level from JSA data, and the percent changes are relatively low during the gaps: -1.25% from June till September in 1968, 0.26% from March till June in 1969. Second, the estimated number of participants from the indicator are 52 firms (*Judaibo* 8, *Shinbo* 12, and *Shinshinbo* 32), while the actual number is 66 (8, 13, and 45, respectively) from JSA (1979).

Some firms decreased less than 6.35%, possibly due to exemption from compulsory disposal mentioned in section 2, but this does not lower reliability of the indicator because such firms were reluctant to scrap.

[31] There is no censoring in 1969-70, so I used only the OLS. I used several estimates of $pmpk_t$ obtained in section 3 but the results were quite similar, so only the results using the 1965-73 estimates are listed. The OLS results in other periods were also almost the same as the Tobit ones, so I suppressed the former ones.

[32] Recall that, in the previous subsection, positive relationship between investment and short-term return on investment vanished in 1969 when voluntary disposal was implemented (Eq. (4-5oa), (4-5o) and (4-5ra)). This means that the indicator captures variation that cannot be explained by the short-term return on investment.

significance is a bit lower (Eq. (6-1on), (6-2on) and (6-3on)).

Finally, I estimated the average treatment effect model, using the same covariates except for perfect regressors (mrg_{it} and dcm_{it}) and ignoring the endogeneity of post-treatment variables. The regression adjustment estimator was employed, assuming that both of the conditional means for the treated group and the control group are linear function of the observables. The results are shown at the bottom of Table 6. The ATE (average treatment effect) is negative and significant in all cases, but the significance is lower in operable plus non-operable machines. The ATT (average treatment effect for the treated) is negatively significant only in operable ones. Therefore, we can conclude at least that, on average, scrapping policy picked up the losers disinvesting operable machines in the post-treatment period from the whole population[33].

5 Conclusion

The main results of this paper are as follows. Although the estimated trend of the industry level productivity changed in the mid-1970s, significant parts of productivity change in the industry was due to ,not the overall factor, but the unobserved factors heterogeneous among firms. The scale of incentive offered by the scrapping policy was larger than the estimated short-term return on investment, which suggests that firms could make a long-term decision on scrapping.

As for direct effect on investment under policy implementation, scrapping in 1968-69 made distortions in a firm's disinvestment, possibly because a part of disposal was implemented under compulsory disposal based on a pro rata basis. Distortions by scrap-and-build constraint on investment was also observed. On the other hand, such distortion could not be observed in 1972-73 scrapping for operable machines. Although I do not deny that the result might be caused by using voluntary disposals only, note that the coordination between policy authority and the industry and between firms also occurred. Once including non-operable machines, however, the distortion was confirmed again. This suggests that some firms still held the installed but non-operable machines regardless of their profitability even after disposal. That was possibly because the target of policy was only operable machines. Firm exits had a considerable role to cut down the unprofitable machines with or without scrapping policy in 1966-69 and 1971-73. I could not obtain any meaningful results from scrapping in 1978-79.

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[33] Surprisingly, policy effect in the case of operable machines remained when the measurement periods extended to the end of 1973, after the next scrapping was completed.

In the case of 1968-69, although the total amount of disposals was not partially correlated with the short-term return on investment, I confirmed that firms having participated in the voluntary disposal still invested less in the post-treatment period, using several types of tests. In other word, firms having been picked up by voluntary scrapping were actually losers in the post-treatment period. This result is consistent with the explanation that a firm's participation in the voluntary disposal was its revelation of the long-term return on investment observable for other firms. Note that this result may depend upon the fact the combination of compulsory and voluntary disposal collectively generated incentives. Especially since the compulsory disposal was implemented just before the voluntary one, and it forced reluctant firms to disinvest, it inevitably affected variation of capital profitability among firms.

I should also note that this paper did not offer quantitative results to examine whether the policy offered incentives enough to facilitate industry-wide resource shifts to other industries. Considering together several evidence offered by other existing studies, we still cannot deny that these skillfully designed policy schemes were, as a whole, far from welfare-enhancing.

Finally, as for policy evaluation in 1978-79, given the fact that much of the workers in the industry were young female and that not a few firms had been located in urban neighborhoods, my conjecture is that regional factors, such as land price and urbanization, influenced the industry, and may become an issue in the future.

Appendix 1: Data

Table A1 Definitions and Sources of unit price

	Item name	Definition	Sources
Outputs:			
P_{Y_1}	Pure cotton-spun yarn [1]	$\begin{cases} P_{Y_{1,20}} & if\ c^i \le 20 \\ \{(30-c^i)P_{Y_{1,20}} + (c^i-20)P_{Y_{1,30}}\}/10 & if\ 20 < c^i \le 30 \\ \{(40-c^i)P_{Y_{1,30}} + (c^i-30)P_{Y_{1,40}}\}/10 & if\ 30 < c^i \le 40 \\ P_{Y_{1,40}} & if\ 40 < c^i \end{cases}$	
$P_{Y_{1,20}}$	20-count pure cotton-spun yarn		BOJ.
$P_{Y_{1,30}}$	30-count pure cotton-spun yarn		BOJ.
$P_{Y_{1,40}}$	40-count pure cotton-spun yarn		BOJ.
c^i	Firm i's average account [2]		JSA.
P_{Y_2}	Mixed cotton-spun yarn	$(P_{Y_1} + P_{Y_3})\ /\ 2$	
P_{Y_3}	Pure rayon-spun yarn		BOJ.
P_{Y_4}	Mixed rayon-spun yarn	$(P_{Y_1} + P_{Y_3})\ /\ 2$	
P_{Y_5}	Other natural fiber-spun yarn	$\{P_{Y_1} + P_{Y_3} + (P_{Y_{W1}} + P_{Y_{W2}})/2\}\ /\ 3$	
$P_{Y_{W1}}$	Woolen yarn		BOJ.
$P_{Y_{W2}}$	Worsted yarn		BOJ.
P_{Y_6}	Pure synthetic-spun yarn	$P_{Y_{6V}}W_{Y_{6V}} + P_{Y_{6P}}W_{Y_{6P}} + P_{Y_{6A}}W_{Y_{6A}} + P_{Y_{6O}}W_{Y_{6O}}$, where W_{Y_j} is the share of sales, defined by unit price times quantity.	
$P_{Y_{6V}}$	Pure vinylon-spun yarn		BOJ
$P_{Y_{6P}}$	Pure polyester-spun yarn [3]	$\{P_{M_5}(\text{in 1965}) \times P_{Y_V}(\text{in 1965})\ /\ P_{M_4}(\text{in 1965})\} \times PI_{Y_P}$	
PI_{Y_P}	Polyester-spun yarn (index, 1965 base year)		BOJ
$P_{Y_{6A}}$	Pure acrylic-spun yarn [3]	$\{P_{M_6}(\text{in 1965}) \times P_{Y_V}(\text{in 1965})\ /\ P_{M_4}(\text{in 1965})\} \times PI_{Y_A}$	
PI_{Y_A}	Acrylic-spun yarn (index, 1965 base year)		BOJ
$P_{Y_{6O}}$	Other pure synthetic-spun yarn	$(P_{Y_V} + P_{Y_P} + P_{Y_A})/3$	
P_{Y_7}	Mixed synthetic-spun yarn	$P_{Y_{7V}}W_{Y_{7V}} + P_{Y_{7P}}W_{Y_{7P}} + P_{Y_{7A}}W_{Y_{7A}} + P_{Y_{7O}}W_{Y_{7O}}$, where W_{Y_j} is the share of sales, defined by unit price times quantity.	
$P_{Y_{7V}}$	Mixed vinylon-spun yarn	$(P_{Y_1} + P_{Y_{6V}})\ /\ 2$	
$P_{Y_{7P}}$	Mixed polyester-spun yarn	$(P_{Y_1} + P_{Y_{6P}})\ /\ 2$	
$P_{Y_{7A}}$	Mixed acrylic-spun yarn	$(P_{Y_1} + P_{Y_{6A}})\ /\ 2$	
$P_{Y_{6O}}$	Other mixed synthetic-spun yarn	$(P_{Y_1} + P_{Y_{6O}})\ /\ 2$	

P_{Y_8}	Cotton waste [4]	$0.54 \times P_{M_1}$	
P_{Y_9}	Other fiber waste [4]	$0.54 \times (P_{M_2}W_{M_2} + P_{M_3}W_{M_3} + P_{M_4}W_{M_4} + P_{M_5}W_{M_5} + P_{M_6}W_{M_6} + P_{M_7}W_{M_7})$, where W_{M_j} is the share of material costs, defined by unit price times quantity.	
Material Inputs:			
P_{M_1}	Raw cotton		BOJ
P_{M_2}	Rayon staple		BOJ
P_{M_3}	Other natural fibers	$(P_{M_1} + P_{M_2} + P_{M_W}) / 3$	
P_{M_W}	Raw wool		BOJ
P_{M_4}	Vinylon staple		BOJ
P_{M_5}	Polyester staple		BOJ
P_{M_6}	Acrylic staple		BOJ
P_{M_7}	Other synthetic fibers	$(P_{M_4} + P_{M_5} + P_{M_6}) / 3$	

Notes:

1. The unit price of pure cotton yarns by count are not available in several years, so I extended their unit price in other years by the price index of pure cotton yarns.
2. The original data of average count are biannual, where each half period value is a 6-month average of count in pure cotton-spun yarn, and there are a few data missing in average count. I substituted the other half value or the industry's average of the year for missing values and calculated the average of both half values.
3. As for pure polyester and acrylic-spun yarn, only price indices are available in this period. I estimated each unit price in 1965 as listed above and extend them with each price index.
4. Unit prices of cotton waste and other fiber waste are not available from BOJ price data. I estimated price ratio of cotton waste to raw cotton, based on quantity and value of domestic consumption of each item from temporary volume of Census of Manufactures (MITI, 1963). The resulting price ratio is 124.6 (yen/1kg) / 229.0 (yen/1kg) = 0.544.

Appendix 2: Derivation of investment function under scrapping policy

Here I build an economic model of investment decision under both the scrap-and-build clause and scraping policy during the late 1960's and clarify the determinants and restrictions on their parameters. Investment decisions under a less complicated policy scheme during 1970's is also examined as one of the nested models.

Assume that a firm faces the problem of profit-maximization over a couple of time periods, the current one and the future one, and further that the latter period consists of a finite number of sub-periods. Let t be the index of time period where t = 1 is the current period and sub-periods in the future are from t = 2 until T. At the beginning of t = 1, a firm holds capital stock, $K(1)$, which is the sum of two different states of capital stock, $K_o(1)$ and $K_s(1)$. The former is the number of operable machines while the latter is the number of suspended ones, and both are predetermined prior to t = 1, say t = 0, and treated as given in t = 1. A firm invests in t = 1 to choose the level of capital stock, $K_o(2)$ and $K_s(2)$, in the future period, but it is assumed, for simplicity, that a firm cannot invest in t=2 and thereafter. Let $I_o(1)$ and $I_s(1)$ be the amount of investment to the operable and suspended machine respectively, then $I_o(1) \equiv K_o(2) - K_o(1)$ and $I_s(1) \equiv K_s(2) - K_s(1)$ by definition. Moreover, under the S & B rule, a firm cannot increase the suspended machine under the registration system and is required to scrap 2 physical units of the existing suspended one to install 1 unit of a new operable machine. This constraint implies that $K_s(1)$ put a cap on investment to the operable machines such that $I_o(1) \leqq K_s(1)/2$ and that $I_s(1) = -2 \cdot I_o(1)$ if $I_o(1) \geqq 0$, and if a firm does not decrease $K_s(1)$ for any other reasons.

As for return on investment, assume that a firm can use the operable machines in production during all sub-periods from 2 until T but can only use the suspended machines in the last period, T, when those machines become operable due to the abolition of the registration system. Let $R_t(K_o(t))$ be the gross return on investment to machine actually operated at the sub-period t and assume that its marginal return is positive but monotonically decreasing in $K_o(t)$: $R'_t > 0$ and $R"_t < 0$. The investment cost for an operable machine is defined as the sum of the user cost and the adjustment cost. Let the former be $UC(1) \cdot I_o(1)$ and the latter $\varphi(I_o(1)/K_o(1)) \cdot I_o(1)$. $UC(1)$ is the user cost per unit of operable machine, normally depending on the nominal interest rate, the physical depreciation rate, the tax rate, and the purchasing and resale prices of machine. Assume that $\Psi(\cdot)$ is monotonically increasing and convex. Then $\varphi' > 0$ and $\varphi" > 0$.

Under the above settings, a firm's profit maximization problem is defined as follows.

$$\max_{\{I_o\}} R_{-T}[K_o + I_o] + R_T[K_o + I_o + \mu\{K_s - 2 \cdot I_o\}] - UC \cdot I_o - \varphi(I_o/K_o) \cdot I_o$$

subject to $I_o \leqq K_s/2$ (A1),

where the time scripts are dropped. $R_{-T}[K_o + I_o] \equiv \sum_{t=2}^{T-1} R_t[K_o(1) + I_o(1)]$, which is the sum of the gross return from t = 2 until T-1, and $R_T[K_o + I_o + \mu\{K_s - 2 \cdot I_o\}]$ is the gross return in the last sub-period T. Note that the suspended machines is only operated in T and μ is the obsolesce rate ($0 \leqq \mu \leqq 1$) and that the time discount rate is ignored.

Let the Lagrangian function be $L = R_{-T}[K_o + I_o] + R_T[K_o + I_o + \mu\{K_s - 2I_o\}] - UC \cdot I_o - \varphi(I_o/K_o) \cdot I_o + \lambda_0(K_s/2 - I_o)$, Kuhn=Tucker conditions are as follows.

$$\partial L/\partial I_o = R'^*_{-T} + (1 - 2\mu)R'^*_T - UC - \{\varphi'(i_o^*) \cdot i_o^* + \varphi(i_o^*)\} - \lambda_0^* = 0,$$
$$\lambda_0^* \cdot (K_s/2 - I_0^*) = 0,\ \lambda_0^* \geqq 0,\ K_s/2 - I_0^* \geqq 0.$$

where $i_o \equiv I_o(1)/K_o(1)$, and $R"^*_{-T}$ and $R"^*_T$ are the second derivative evaluated at i_o^*. We can easily confirm if the regularity condition and Slater's condition are satisfied at each local point. So given the concavity of $R_t(\cdot)$ and the convexity of $\varphi(\cdot)$, the above conditions are sufficient for the optimal solution for some values of μ. Then, using the monotonicity of $\widetilde{\varphi}(i_o) \equiv \varphi'(i_o) \cdot i_o + \varphi(i_o)$ in i_o, we can derive the following equation.

$$i_o^* = \widetilde{\varphi}^{-1}[\, R'^*_{-T} + (1 - 2\mu)R'^*_T - UC - \lambda_0^* \,] \quad \text{(A2).}$$

Two kinds of solutions could occur here. The first case is $\lambda_0^* = 0$, where the S & B rule's constraint is not binding. In this case, the optimal level of investment ratio, i_o^*, is solely determined by Eq. (A2), which shows the sign of the impact of the marginal return and the user cost. The second case is $\lambda_0^* > 0$, where the constraint is binding and then $i_o = (1/2) \cdot K_s/K_o$. In this case, inserting this constraint directly into the right hand side of the estimated equation can make other factors irrelevant, so I parameterize λ_0^* as a function of observable proxies instead[34]. Linearizing (A2) and the above constraint around the optimal solution, (i_o^*, λ_o^*) with respect to $(i_o, K_o, K_s, \lambda_0)$ gives[35]

$$\partial\lambda_o/\partial K_o = R"^*_{-T} + (1 - 2\mu)R"^*_T + (\widetilde{\varphi}'(i_o^*)/K_o) \cdot i_o^* > 0$$
$$\text{for sufficiently small } |R"^*_{-T}| \text{ and } |(1 - 2\mu)R"^*_T|,$$

34 This approach for examining the effects of a binding constraint by parametrizing the Lagrange multiplier has been used in several fields of economic research. For example, credit constraint in agricultural investment decision (Hubbard and Kashyap, 1992), and foreign exchange constraint in import demand (Emran and Shilpi, 1996).

35 Given small $|R"_t{}^*|$ for t = 2,..., T, the inequality in the first equation is more likely to hold for sufficiently smaller T or sufficiently larger μ, which means that the abolition of the registration system will come in the nearer future or the suspended machine is less obsolete.

$$\partial\lambda_o/\partial K_s = (1/2)\cdot\{R''^{*}_{-T} + (1-2\mu)R''^{*}_{T} - \widetilde{\varphi}'(i_o^*)/K_o\} < 0.$$

Given the above properties, I propose $\lambda_0 = \lambda_0(K_s/K_o)$ as a theoretically consistent parameterization of λ_0. Then, $\partial\lambda_0/\partial(K_s/K_o) < 0$, and, combining it with the sign of partial derivatives in Eq. (A2), we have the following restrictions on investment function.

$$\partial i_0/\partial(R'_{-T} + (1-2\mu)R'_{T}) > 0,\ \partial i_0/\partial UC < 0,$$
$$\text{and } \partial i_0/\partial(K_s/K_o) = \partial i_0/\partial\lambda_0\cdot\partial\lambda_0/\partial(K_s/K_o) > 0 \qquad \text{(A3).}$$

The set of inequalities (A3) mean that a firm with higher return, lower user cost or more suspended machines invests more. Investment behavior in the absence of the S & B rule can also be examined in a case of λ_0^* = 0, where the parameter restrictions on determinants are $\partial i_0/\partial(R'_{-T} + R'_{T}) > 0$ and $\partial i_0/\partial UC < 0$ only. Finally, since the sum of investments to both operable and suspended machines is $\mathrm{I} = I_o + (-2I_o) = -I_o$, the investment ratio for total machine is $i \equiv \mathrm{I}/K = -(K_o/K)i_o$, where $K \equiv K_o + K_s$. Then the parameter restrictions are opposite in sign to (A3) in absence of decreases in $K_s(1)$ due to other reasons.

Next, suppose that scrapping policy is implemented at the end of the current period. The policy scheme in the late 1960's is somewhat complicated and consists of compulsory disposals and voluntary ones. In the former scheme, a firm is forced to sell and scrap the specified amounts of operable or suspended machines (the total is $\bar{Q}_c$) at the specified price (P_c for operable one and $P_c\cdot\zeta$ for suspended one, where $0 \leqq \zeta < 1$). In the latter case, a firm can voluntarily sell and scrap operable or suspended machines at the specified price (P_v for operable ones and $P_v\cdot\zeta$ for suspended ones, where $P_v > P_c$). Assuming that a firm cannot expect in advance policy implementation at the timing of investment decision in problem (A1), the profit maximization problem a firm faces is

$$\max_{\{Q_o,Q_{oc},Q_{sv}\}} \begin{array}{l} P_v\{(Q_o - Q_{oc}) + \zeta Q_{sv}\} + P_c\{Q_{oc} + \zeta(\bar{Q}_c - Q_{oc})\} + R_{-T}[\widetilde{K}_o - Q_o] \\ +R_T[\widetilde{K}_o - Q_o + \mu\{\widetilde{K}_s - (Q_{sv} + \bar{Q}_c - Q_{oc})\}] - \varphi(Q_o/\widetilde{K}_o)\cdot Q_o \end{array}$$
$$\text{subject to } Q_o - Q_{oc} \geqq 0,\ Q_{oc} \geqq 0,\ Q_{sv} \geqq 0,\ \bar{Q}_c - Q_{oc} \geqq 0,$$
$$\widetilde{K}_o - Q_o \geqq 0,\ \textit{and}\ \widetilde{K}_s - (Q_{sv} + \bar{Q}_c - Q_{oc}) \geqq 0 \qquad \text{(A4),}$$

where Q_o is the sum of compulsory and voluntary disposal for operable machines, Q_{oc} is the amount of compulsory disposal for operable ones, and Q_{sv} is the amount of voluntary disposal for suspended ones. Then $Q_o - Q_{oc} \equiv Q_{ov}$ is the amount of voluntary disposal for operable ones and $\bar{Q}_c - Q_{oc} \equiv Q_{sc}$ is the amount of compulsory disposal for suspended ones. $\widetilde{K}_o \equiv K_o + I_o^*$ and $\widetilde{K}_s \equiv K_s - 2I_o^*$, which are operable and suspended capital stock after investment in problem (A1). The incentives offered by the policies are that voluntary disposals are always preferred to compulsory ones ($P_v > P_c$) although a firm is required to scrap $\bar{Q}_c$ in the latter scheme, and that, under nonlinear pricing to different states of machines in each schemes, a slight change in the difference between the relative purchasing price of the operable to the suspended ($1/\zeta$) and its relative opportunity cost, $\{R'_{-T} + R'_T + \tilde{\varphi}(q_o)\}/\mu R'_T$, can switch the priority order among two states of machines a firm scraps in each scheme, depending on the level of $\tilde{K}_o$ and $\tilde{K}_s$.

The Lagrangian of problem (A4) is $L = P_v\{(Q_o - Q_{oc}) + \zeta Q_{sv}\} + P_c\{Q_{oc} + \zeta(\bar{Q}_c - Q_{oc})\} + R_{-T}[\tilde{K}_o - Q_o] + R_T[\tilde{K}_o - Q_o + \mu\{\tilde{K}_s - (Q_{sv} + \bar{Q}_c - Q_{oc})\}] - \varphi(Q_o/\tilde{K}_o) \cdot Q_o + \lambda_1(Q_o - Q_{oc}) + \lambda_2 Q_{oc} + \lambda_3 Q_{sv} + \lambda_4(\bar{Q}_c - Q_{oc}) + \lambda_5(\tilde{K}_o - Q_o) + \lambda_6\{\tilde{K}_s - (Q_{sv} + \bar{Q}_c - Q_{oc})\}$. The usual procedure based upon Kuhn=Tucker conditions and comparative statistics clarifies the properties of the optimal solution[36]. First, as long as the total amount of disposals for operable ones (Q_o) is smaller than $\tilde{K}_o$ ($\lambda_5 = 0$), Q_o is determined by $\partial L/\partial Q_o = P_v - R'^*_{-T} - R'^*_T - \{\varphi'(q_o^*) \cdot q_o^* + \varphi(q_o^*)\} + \lambda_1^* = 0$, where $q_o^* \equiv Q_o^*/\tilde{K}_o$. Inverting it with respect to q_o^*,

$$q_o^* = \tilde{\varphi}^{-1}[\, P_v - (R'^*_{-T} + R'^*_T) + \lambda_1^* \,] \qquad \text{(A5)},$$

which means that if the amount of voluntary disposals for operable machines (Q_{ov}) is positive, it implies $\lambda_1 = 0$, then a firm with lower return under higher purchasing price disposes of more operable ones. Second, if $\lambda_1 > 0$, which implies $Q_{ov} = 0$, there are several patterns of optimal scrapping under subsets of binding constraints. Table A2 summarizes the patterns satisfying the rank condition under $\lambda_1 > 0$, $\lambda_5 = 0$, $\tilde{K}_o > 0$ and $\tilde{K}_s > 0$.

Third, in Table A2, the partial derivatives of λ_1^* with respect to the first two variables means that a firm less likely to do voluntary disposal for operable ones under the lower P_v or the higher requirement of compulsory disposal ($\bar{q}_c \equiv \bar{Q}_c/\tilde{K}$, where $\tilde{K} \equiv \tilde{K}_o + \tilde{K}_s$). Fourth, the signs of partial derivatives of λ_1^* with respect to $\tilde{K}_o$ and $\tilde{K}_s$ differ between patterns, which means that, contrary to problem (A1), there is no common and theoretically consistent parameterization of λ_1^* capturing the effect of the binding constraints in all patterns. Finally, scrapping only under voluntary disposal for operable machine in the early 1970's can also be examined as a nested case in problem (A4) and the parameter restrictions are given by (A5) with $\lambda_1^* = 0$.

[36] The objective function in problem (A4) is concave since its Hessian, $\mathrm{H}(Q_o, Q_{oc}, Q_{sv})$, is negative semidefinite. The leading principal minors of order 1, 2 and 3 are $R''^*_{-T} + R''^*_T - \tilde{\varphi}'^*/\tilde{K}_o < 0$, $(R''^*_{-T} - \tilde{\varphi}'^*/\tilde{K}_o) \cdot R''^*_T > 0$, and 0, respectively.

Table A2 The patterns of scrapping under $\lambda_1 > 0$ and $\lambda_5 = 0$

Pattern	1	2	3	4	5	6
$\lambda_2, \lambda_3, \lambda_4,$ and λ_6	$\lambda_2 > 0,\ \lambda_3 > 0,$ $\lambda_4 = 0,\ \lambda_6 = 0$	$\lambda_2 > 0,\ \lambda_3 = 0,$ $\lambda_4 = 0,\ \lambda_6 = 0$	$\lambda_2 > 0,\ \lambda_3 = 0,$ $\lambda_4 = 0,\ \lambda_6 > 0$	$\lambda_2 = 0,\ \lambda_3 > 0,$ $\lambda_4 = 0,\ \lambda_6 = 0$	$\lambda_2 = 0,\ \lambda_3 > 0,$ $\lambda_4 = 0,\ \lambda_6 > 0$	$\lambda_2 = 0,\ \lambda_3 > 0,$ $\lambda_4 > 0,\ \lambda_6 = 0$
The amounts of disposal	$Q_{ov}^* = 0$	$Q_{ov}^* = 0$	$Q_{ov}^* = 0$	$Q_{ov}^* = 0$	$Q_{ov}^* = 0$	$Q_{ov}^* = 0$
	$Q_{oc}^* = 0$	$Q_{oc}^* = 0$	$Q_{oc}^* = 0$	$0 \leqq Q_{oc}^* \leqq \bar{Q}_c$	$Q_{oc}^* = \bar{Q}_c - \widetilde{K}_s$	$Q_{oc}^* = \bar{Q}_c$
	$Q_{sv}^* = 0$	$0 \leqq Q_{sv}^* \leqq \widetilde{K}_s - \bar{Q}_c$	$Q_{sv}^* = \widetilde{K}_s - \bar{Q}_c$	$Q_{sv}^* = 0$	$Q_{sv}^* = 0$	$Q_{sv}^* = 0$
	$Q_{sc}^* = \bar{Q}_c$	$Q_{sc}^* = \bar{Q}_c$	$Q_{sc}^* = \bar{Q}_c$	$0 \leqq Q_{sc}^* \leqq \widetilde{K}_s$	$Q_{sc}^* = \widetilde{K}_s$	$Q_{sc}^* = 0$
Partial derivatives of λ_1^*						
P_v	-1	$-(1-\zeta/\mu) < 0$ if $\mu > \zeta$	-1	-1	-1	-1
$\bar{q}_c$	$-\mu R''^*_T \widetilde{K} > 0$	0	0	$-\mu\left\{\frac{\mu\Delta_1-\Delta_2}{\Delta_1-\Delta_2}\right\} R''^*_T \cdot \widetilde{K} > 0$	$-[R''^*_{-T} + R''^*_T - \tilde{\varphi}'^*/\widetilde{K}_o] \cdot \widetilde{K} > 0$	$-[R''^*_{-T} + R''^*_T - \tilde{\varphi}'^*/\widetilde{K}_o] \cdot \widetilde{K} > 0$
$\widetilde{K}_o$	$R''^*_{-T} + R''^*_T(1 - \bar{q}_c) < 0$	$R''^*_{-T} < 0$	$R''^*_{-T} + R''^*_T < 0$	$\mu[\mu(1-\bar{q}_c)R''^*_{-T}R''^*_T - \{1-(1-\mu)\, q_o^* - \mu\bar{q}_c\} \cdot R''^*_T(\tilde{\varphi}'^*/\widetilde{K}_o)]\,/(\Delta_1 - \Delta_2) < 0$	$[R''^*_{-T} + R''^*_T + (\tilde{\varphi}'^*/\widetilde{K}_o) \cdot (\widetilde{K}_s/\widetilde{K}_o)](1-\bar{q}_c) > 0$ if $\lvert R''^*_{-T}\rvert$ and $\lvert R''^*_T\rvert$ are sufficiently small.	$[R''^*_{-T} + R''^*_T - (\tilde{\varphi}'^*/\widetilde{K}_o) \cdot (\widetilde{K}_s/\widetilde{K}_o)\{\bar{q}_c/(1-\bar{q}_c)\}] \cdot (1-\bar{q}_c) < 0$
$\widetilde{K}_s$	$\mu R''^*_T(1-\bar{q}_c) < 0$	0	0	$\mu\left\{\frac{\mu\Delta_1-\Delta_2}{\Delta_1-\Delta_2}\right\} R''^*_T(1-\bar{q}_c) < 0$	$[R''^*_{-T} + R''^*_T - \tilde{\varphi}'^*/\widetilde{K}_o] \cdot (1-\bar{q}_c) < 0$	$-[R''^*_{-T}\bar{q}_c + R''^*_T(\bar{q}_c - \mu) - (\tilde{\varphi}'^*/\widetilde{K}_o)\bar{q}_c] > 0$ if $\bar{q}_c > \mu$

Note: (1) $\widetilde{K} \equiv \widetilde{K}_o + \widetilde{K}_s,\ \bar{q}_c \equiv \bar{Q}_c/\widetilde{K},\ \Delta_1 \equiv R''^*_{-T} + (1-\mu)R''^*_T - \tilde{\varphi}'^*/\widetilde{K}_o < 0$, and $\Delta_2 \equiv \mu(1-\mu)R''^*_T < 0$. $1-(1-\mu)\, q_o^* - \mu\bar{q}_c > 0$ in pattern 4.

(2) $R''^*_{-T},\ R''^*_T$ and $\tilde{\varphi}'^*$ are evaluated at each optimal solution.

References

Beason, R., and Weinstein, D. E. (1996) “Growth, economies of scale, and targeting in Japan (1955-1990),” Review of Economics and Statistics 78 (2), p.286-95.

Emran, M. S. and Shilpi, F. (1996) “Foreign Exchange Rationing and the Aggregate Import Demand Function,” Economics Letters 51 (3), p.315-22.

Horiuchi, T. (1985) “Cooperative capacity disposal in Japanese synthetic fiber industry,” The Journal of Japan Economic Research 14, p.22-46. (in Japanese)

Hubbard R. G. and Kashyap, A. K. (1992) “Internal Net Worth and the Investment Process: An Application to U.S. Agriculture,” Journal of Political Economy 100 (3), p.506-34.

Japan Spinners’ Association (1962) Sengo Bosekishi [Postwar Spinning History], Osaka. (in Japanese)

Japan Spinners’ Association (1969) Boshokugyo ni okeru Kozo kaizen Taisaku no Tenkai [The development of structural improvement measure in the spinning and weaving industries], Osaka. (in Japanese)

Japan Spinners’ Association (1979) Zoku Sengo Bosekishi [The sequel to Postwar Spinning History]. Osaka. (in Japanese)

Japan Spinners’ Association, Nihon Boseki Geppo [Monthly report of Japan Spinners’ Association], Tokyo. (in Japanese)

Kiyota, K., and Okazaki, T. (2010) “Industrial policy cuts two ways: Evidence from cotton-spinning firms in Japan, 1956-1964,” Journal of Law and Economics 53 (3), p.587-609.

Komiya, R., Okuno, M., and Suzumura, K. (1988) Industrial policy of Japan, Academic Press Japan.

Korenaga T. (2000) “The Foreign Exchange Allocation Policy and the Cotton Spinning Industry in Postwar Japan: A Case of Cotton Imports,” The Journal of Economics 66, 16-36. University of Tokyo. (in Japanese)

Korenaga, T. (2002) “Industrial Adjustment Policy and the Role of Trade Association: a case of Spinning Industry (Bosekigyo no Sangyo Chosei to Gyokai Dantai no Kodo),” Seinan Gakuin Daigaku Keizaigaku Ronshu, Vol.37, No.1, 99-116. (in Japanese)

Levinsohn, J., and Petrin, A. (2003) “Estimating Production Functions Using Inputs to Control for Unobservables”Review of Economic Studies, 70 (2), p.317-41.

Ministry of International Trade and Industry, and the Textile Industry Restructuring Agency (1977) Atarashii Sen’i Sangyo no Arikata [The future of New Textile Industry]. Tsusho Sangyo Chosa Kai, Tokyo. (in Japanese)

Ministry of International Trade and Industry (1984) Senshinkoku-gata Sangyo wo Mezashite: Atarashii Jidai no Sen’i Sangyo Bijon [Toward the advanced nation’s industry: Vision of Textile Industry in a New Era]. Toyo Hoki Press, Tokyo. (in Japanese)

Ministry of International Trade and Industry (1993) Tsusho Sangyo Seisakushi [History of International Trade and Industry Policy of Japan] 14. Tsusho Sangyo Chosa Kai, Tokyo. (in Japanese)

Ministry of International Trade and Industry (2012) Tsusho Sangyo Seisakushi [History of Japan's Trade Industry Policy] 3, Keizai Sangyo Chosakai, Tokyo. (in Japanese)

Noland, M., Pack, H. (2003) Industrial Policy in an era of Globalization: Lessons from Asia, Washington, D.C.: Peterson Institute.

Odagiri, H., Goto, A. (1996) Technology and Industrial Development in Japan. Oxford University Press.

Okazaki, T. and Korenaga, T. (2001) “Foreign exchange allocation and productivity growth in post-war Japan: A case of the wool industry,” Japan and the World Economy 11 (2), p.267-85.

Olley, G. S. and Pakes, A. (1996) “The Dynamics of Productivity in the Telecommunications Equipment Industry” Econometrica 64 (6), p.1263-97.

Peck, M. J., Levin, R. C.,and Goto, A. (1987) “Picking losers: Public policy toward declining industries in Japan,” Journal of Japanese Studies 13 (1), p.79-123.

Petrin, A., Poi, B. P., and Levinsohn, J. (2004) “Production function estimation in Stata using inputs to control for unobservables,” Stata Journal, 4 (2), p.113-23.

Rosenbaum, P. R., and Rubin D. B. (1983), “The Central Role of The Propensity Score in Observational Studies for Causal Effects,” Biometrika 70 (1), p.41-55.

Sekiguchi, S. and Horiuch, T. (1988) “Trade and adjustment assistance,” In: Suzumura, K., Okuno, M. (Eds), Industrial Policies of Japan. Academic Press Japan, p.369-93.

Tan, H. W. and Shimada H. (1994) Troubled industries in the United States and Japan, RAND study series, St. Martin's Press, New York.

The Textile Machinery Society of Japan (1987) *Yarns*, Textile Engineering Series III, The Textile Machinery Society of Japan, Osaka. (in Japanese)

Watanabe, J. (2010) Sangyo Hatten Suitai no Keizaishi [Economic history of industry development and decline], Yuhikaku. (in Japanese)

Yamazawa, I. (1981) “Adjustment assistance and import policy in Japanese textile industry,” The Hitotsubashi Review 85, p.21-40. (in Japanese)

Yamazawa, I. (1988) The textile industry. In: Suzumura, K., Okuno, M. (Eds), Industrial Policies of Japan. Academic Press Japan, p.395-23.

Yonezawa, Y. (1978) “Adjustment policies and its appraisal: The case of Japanese textile and leather industry,” The Journal of Japan Economic Research 7, p.534-70. (in Japanese)

Yonezawa, Y. (1981) Sen’i sangyo no sangyo chosei [Industrial adjustment of textile industry]. In: Sekiguchi S. (Eds), Nihon no Sangyo Chosei [Industrial Adjustment of Japan]. Nihon Keizai Shinbun, p.148-76. (in Japanese)

Table 1 Activities of JSA Spinning Firms

Periods	Output of spinning yarn					Capacity		Employee		Number of firms
	Total	Cotton	Rayon staple	Synthetic.	Others	Total	Operable	Total	Female Share	
1960-64	492 (3.6)	470	3	19	0	8,901	7,746 (0.064)	83 (5.92)	86.0	137
65-69	775 (6.8)	478	128	167	3	10,188	9,201 (0.084)	100 (7.78)	81.6	114
70-74	839 (8.7)	466	108	262	2	9,804	9,674 (0.087)	92 (9.14)	74.9	97
75-79	686 (7.8)	393	66	226	2	-	9,080 (0.076)	61 (11.21)	70.6	88
80-84	691 (9.0)	379	63	247	3	-	8,422 (0.082)	44 (15.55)	67.9	77
85-89	612 (9.8)	361	56	191	4	-	7,206 (0.085)	34 (18.09)	65.6	63

Unit: thousand tons (output), thousand spindles of spinning machine (capacity), thousand (employee).

Source: tatistics on the Japanese cotton-spinning industry, JSA, various years.

Notes: (1) The coverage is only on cotton spinning activity in 1960-64, but, after 1965, extended to other activities including rayon sataple and synthetic fibers spinning activity and used cotton spinning. The nonregistered capactiy also included after 1965.

(2) Output of spinning yarn is a five-year average of annual output. Each item is the sum of pure and mixed spunyarn, Cotton yarn includes that made of waste cotton.

(3) Capacity is a five-year average of the year-end spindles of spinning machine. "Operablel" is spindles that can be operational once other inputs in hand. "Total" is "Operable." plus uninstalled, out of operation, or broken-down machine. Total in 70-74 is three-year average of 1970-72.

(4) Total number of employee is a five-year average of the month-end number enrolled. The share of female is the percentage of female employees in total. 60-64 figure is the share in factory workers and 85-89 figure is a three-year average of 85-87.

(5) Number of firm is a five-year average of the end of year value.

(6) Parenthesis in output shows output per firm, and those in other columns show inputs per thousand tons of output.

(7) - is not available.

Table 2 Estimation of production function

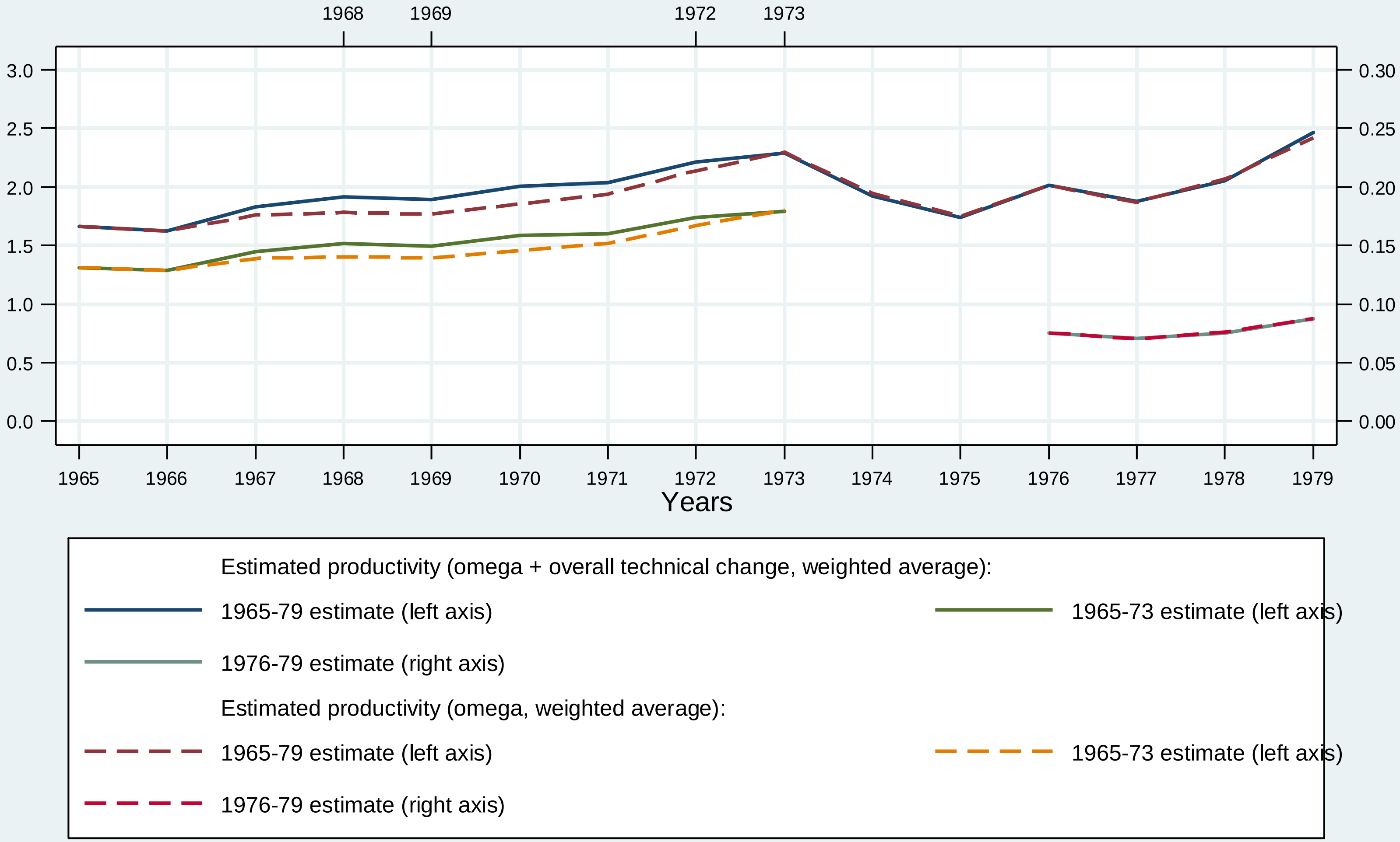
periods	1965–79		1965–73		1976–79	
Eq. no.	(PF–11)	(PF–12)	(PF–21)	(PF–22)	(PF–31)	(PF–32)
Estimation Method	OLS	LP	OLS	LP	OLS	LP
Variable						
l	0.0876 *	0.1021 **	0.1541 **	0.1200 **	0.0113	0.0622
	(0.0507)	(0.0505)	(0.0628)	(0.0592)	(0.0722)	(0.0616)
e	0.1675 ***	0.1398 ***	0.1447 **	0.1655 ***	0.1837 **	0.1547 **
	(0.0521)	(0.0517)	(0.0662)	(0.0498)	(0.0727)	(0.0656)
m	0.7174 ***	0.6788 ***	0.6932 ***	0.6915 ***	0.7706 ***	0.8857 ***
	(0.0440)	(0.1677)	(0.0485)	(0.1724)	(0.0603)	(0.0669)
k	−0.0803 **	0.1082	−0.0943 **	0.0668	−0.0732	0.1490
	(0.0377)	(0.1008)	(0.0455)	(0.0751)	(0.0483)	(0.1266)
ydum66	0.0029	0.0004	0.0046	−0.0007		
	(0.0140)	(0.0144)	(0.0146)	(0.0149)		
ydum67	0.0422 **	0.0380 **	0.0499 **	0.0409 **		
	(0.0212)	(0.0212)	(0.0223)	(0.0190)		
ydum68	0.0728 ***	0.0712 ***	0.0813 ***	0.0758 ***		
	(0.0255)	(0.0213)	(0.0266)	(0.0245)		
ydum69	0.0691 ***	0.0688 ***	0.0781 ***	0.0704 ***		
	(0.0224)	(0.0200)	(0.0243)	(0.0173)		
ydum70	0.0793 ***	0.0800 ***	0.0915 ***	0.0821 ***		
	(0.0245)	(0.0208)	(0.0271)	(0.0194)		
ydum71	0.0490	0.0500 *	0.0632 **	0.0562 **		
	(0.0301)	(0.0253)	(0.0317)	(0.0251)		
ydum72	0.0425	0.0323	0.0613 *	0.0386		
	(0.0324)	(0.0249)	(0.0339)	(0.0256)		
ydum73	0.0195	−0.0018	0.0407	−0.0025		
	(0.0401)	(0.0333)	(0.0434)	(0.0307)		
ydum74	−0.0015	−0.0148				
	(0.0410)	(0.0341)				
ydum75	0.0029	−0.0073				
	(0.0422)	(0.0346)				
ydum76	0.0285	0.0023				
	(0.0503)	(0.0382)				
ydum77	0.0210	0.0057			−0.0094	0.0040
	(0.0501)	(0.0421)			(0.0205)	(0.0205)
ydum78	0.0026	−0.0061			−0.0384	−0.0159
	(0.0552)	(0.0464)			(0.0289)	(0.0251)
ydum79	0.0255	0.0169			−0.0173	0.0015
	(0.0575)	(0.0471)			(0.0248)	(0.0188)
constant	2.1215 ***		1.8484 ***		2.2310 ***	
	(0.3955)		(0.4363)		(0.5639)	
No. of obs.	1441	1441	924	924	336	336
No. of firms.	124	124	120	120	94	94
R2	0.9439	–	0.9475	–	0.9357	–
Test for returns to scale (D. F. =	55.54 ***	0.03	41.92 ***	0.08	25.19 ***	1.69
Identification restriction	_	Just indentified	_	Just indentified	_	Over identified

Notes:

1. In parentheses is an cluster–heteroskedasticity–robust asymptotic standard error in OLS case, whereas there is bootstrapped standard error in LP case. In both cases, each firm is treated as a cluster. ***, ** and * respectively indicate significance at 1, 5 and 10 percent level by two–tailed test.
2. The null of test for returns to scale is that the sum of coefficients on l, e, m, and k is equal to one. The Wald test statistic is chi squared distributed with 1 degree of freedom. ***, ** and * respectively indicate significance at 1, 5 and 10 percent level.
3. Identification restrictions in LP estimation are as follows:
   IVs in eq. (PF–12) and (PF–22) : the current year's l, e and k; the 1 year lag of m.
   IVs in eq. (PF–32) : the current year's l, e and k; 1–year lag of m and k; 2–year lag of m.

Figure 1 The industry's productivity growth

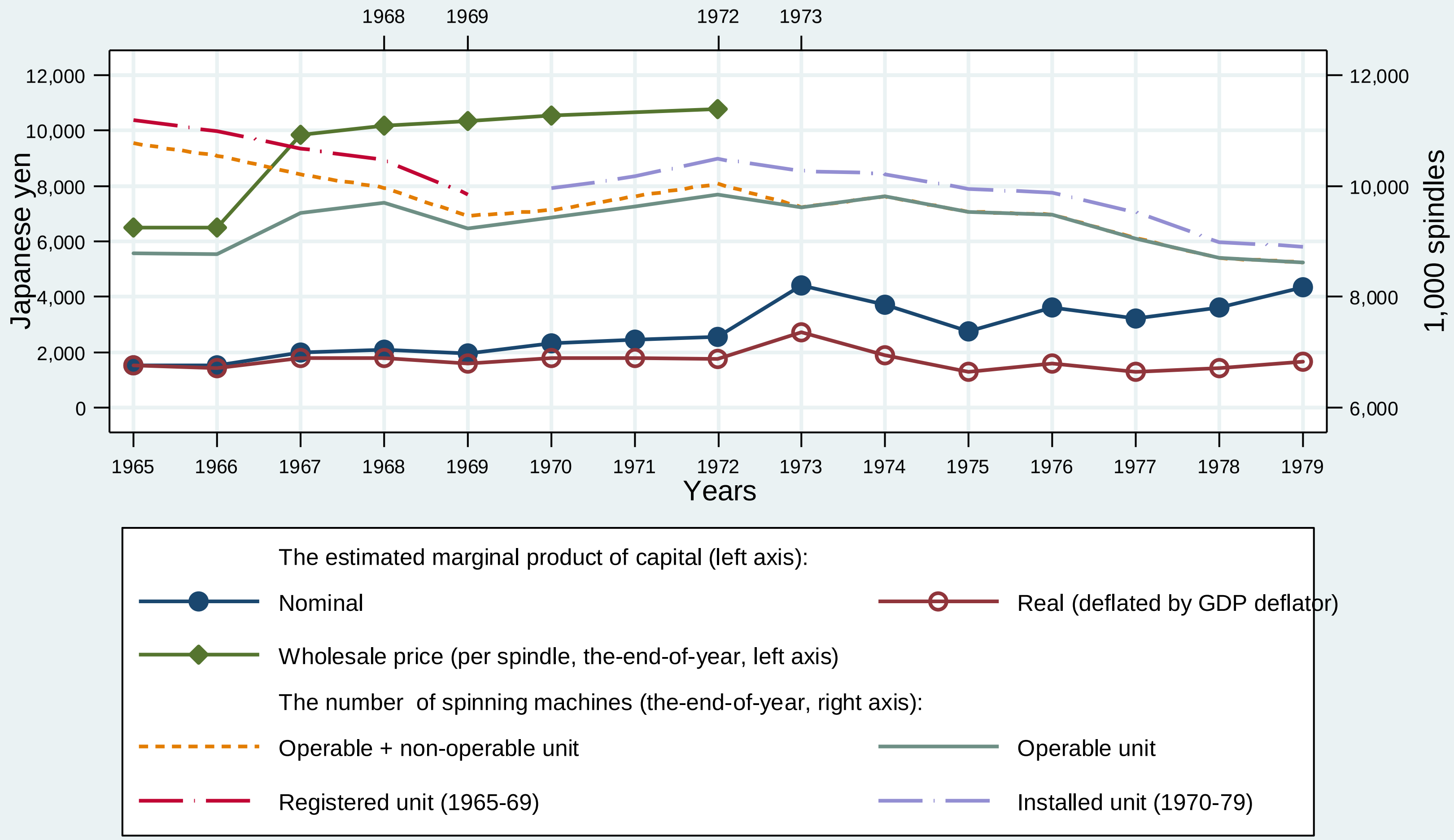
JSA firms in 1965-79



Sources: Productivity are calculated basing upon (PF-12), (PF-22) & (PF-32) in Table 2. See the details in the main text.

Figure 2 Marginal product of capital, and the price and the number of machines

JSA firms in 1965-79



Sources: Statistics on the Japanese cotton-spinning industry (JSA), Wholesale Price Statistics (BOJ).
Nominal and real marginal products of capital are calculated based upon (PF-12) in Table 2.
See the detail in the main text

Table 3 Estimation of invesment function: 1966–79, 1966–73, and 1974–79

State of machine	Operable										
Time periods	1966–79			1966–73				1974–79			
Eq. no.	(1–1)	(1–2)	(1–3)	(2–1)	(2–2)	(2–3)	(2–4)	(3–1)	(3–2)	(3–3)	(3–4)
Estimation	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit	Tobit
Variable											
ln(pmpk)	0.0432 ***	0.0366 ***	0.0408 ***	0.0445 ***	0.0460 ***	0.0539 ***	0.0445 ***	0.0382 **	0.0271	0.0276	0.0080
	(0.0124)	(0.0132)	(0.0131)	(0.0168)	(0.0161)	(0.0171)	(0.0167)	(0.0193)	(0.0216)	(0.0216)	(0.0207)
ln(k)	0.0206 ***	0.0218 ***	0.0216 ***	0.0209 ***	0.0247 ***	0.0234 ***	0.0130	0.0205 ***	0.0170 **	0.0171 *	0.0082
	(0.0051)	(0.0055)	(0.0061)	(0.0066)	(0.0069)	(0.0075)	(0.0081)	(0.0079)	(0.0086)	(0.0103)	(0.0117)
weatwi			0.0426 ***			0.0482 **	0.0398 **			0.0352 *	0.0369
			(0.0149)			(0.0198)	(0.0201)			(0.0201)	(0.0207)
txpr			−0.0145			0.0028	−0.0006			−0.0324	−0.0299
			(0.0136)			(0.0148)	(0.0130)			(0.0231)	(0.0240)
prcs			−0.0206			−0.0429 **	−0.0162			0.0138	0.0250
			(0.0154)			(0.0203)	(0.0139)			(0.0191)	(0.0189)
mrg		−0.0114	−0.0091		−0.0365 **	−0.0321 *	−0.0245		0.0057	0.0048	0.0003
		(0.0185)	(0.0167)		(0.0171)	(0.0172)	(0.0151)		(0.0246)	(0.0218)	(0.0245)
dcm		−0.0406	−0.0450		−0.0140 *	0.0051	0.0133		−0.0588	−0.0747	−0.0586
		(0.0393)	(0.0381)		(0.0077)	(0.0178)	(0.0329)		(0.0567)	(0.0505)	(0.0603)
dvrsty							−0.0058				0.0016
							(0.0281)				(0.0305)
afflte							−0.0122				0.0350
							(0.0148)				(0.0239)
fdi							0.0155				−0.0004
							(0.0255)				(0.0207)
No. of obs.	1339	1339	1339	815	815	815	744	524	524	524	490
No. of the uncensored	1312	1312	1312	801	801	801	735	511	511	511	478
No. of the censored	27	27	27	14	14	14	9	13	13	13	12
No. of firms.	117	117	117	115	115	115	101	93	93	93	86
R-squared											
Log-likelihood	135.9	183.4	189.3	73.1	93.7	98.7	134.5	70.2	92.3	94.7	91.3
σ	0.2093 ***	0.2018 ***	0.2010 ***	0.2132 ***	0.2078 ***	0.2065 ***	0.1965 ***	0.2002 ***	0.1918 ***	0.1909 ***	0.1900 ***
	(0.0133)	(0.0127)	(0.0125)	(0.0178)	(0.0175)	(0.0171)	(0.0182)	(0.0185)	(0.0170)	(0.0169)	(0.0176)
Estimated period and method of ln(pmpk)	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP	1965–79, LP
Year dummies	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes

Notes:

1. In parentheses are cluster-heteroskedasticity-robust asymptotic standard error in all cases by treating each firm as a cluster. ***, ** and * respectively indicate significance at 1, 5 and 10 percent level by two-tailed test.
2. The estimated coefficient of constant term and year dummies are supressed.

Table 4 Estimation of invesment function with the interaction terms: 1966-69

State of machine	Operable						
Eq. no.	(4-1oa)	(4-2oa)	(4-3oa)	(4-4oa)	(4-5oa)	(4-4o)	(4-5o)
Estimation method	Tobit	Tobit	OLS	Tobit	Tobit	Tobit	Tobit
Adjusting the short-term suspension	Yes	Yes	Yes	Yes	Yes	No	No
Variable							
ln(pmpk)	0.0405 **	0.0551 **	0.0296 *	0.0496 **	0.0668 **	0.0495 **	0.0666 **
	(0.0198)	(0.0260)	(0.0158)	(0.0201)	(0.0260)	(0.0207)	(0.0266)
ln(pmpk) * ydum69		−0.0559 **			−0.0652 **		−0.0650 **
		(0.0283)			(0.0296)		(0.0300)
ln(k)	0.0148 **	0.0177 **	−0.0013	0.0115	0.0132	0.0118	0.0136
	(0.0074)	(0.0090)	(0.0044)	(0.0071)	(0.0086)	(0.0073)	(0.0089)
ln(k) * ydum69		−0.0126			−0.0089		−0.0093
		(0.0135)			(0.0131)		(0.0133)
ks/ko	0.0512 *	0.0551 *	0.0327	0.0437 *	0.0466 **	0.0399 *	0.0422 *
	(0.0270)	(0.0283)	(0.0231)	(0.0232)	(0.0230)	(0.0238)	(0.0237)
ks/ko * ydum69		−0.0421			−0.0361		−0.0317
		(0.0454)			(0.0407)		(0.0417)
weatwi			0.0302 *	0.0554 ***	0.0697 ***	0.0563 ***	0.0708 ***
			(0.0162)	(0.0195)	(0.0240)	(0.0204)	(0.0251)
weatwi * ydum69					−0.0557 *		−0.0567 *
					(0.0332)		(0.0339)
txpr			−0.0173	−0.0162	−0.0208	−0.0162	−0.0205
			(0.0159)	(0.0174)	(0.0208)	(0.0182)	(0.0219)
txpr * ydum69					0.0116		0.0113
					(0.0233)		(0.0245)
prcs			0.0073	−0.0202	−0.0266	−0.0233	−0.0303
			(0.0124)	(0.0251)	(0.0301)	(0.0273)	(0.0329)
prcs * ydum69					0.0326		0.0363
					(0.0326)		(0.0353)
mrg	−0.0400 **	−0.0197	−0.0121	−0.0301	0.0070	−0.0381	−0.0088
	(0.0197)	(0.0250)	(0.0220)	(0.0251)	(0.0264)	(0.0232)	(0.0268)
mrg * ydum69		−0.0476			−0.0765 **		−0.0607 *
		(0.0308)			(0.0335)		(0.0342)
dcm	−0.0378 ***	0.0037	−0.0400 ***	−0.0373	0.0067	−0.0357	0.0088
	(0.0140)	(0.0178)	(0.0137)	(0.0234)	(0.0283)	(0.0249)	(0.0302)
dcm * ydum69		−0.1294 ***			−0.1430 ***		−0.1451 ***
		(0.0227)			(0.0342)		(0.0357)
ydum67	0.0088	0.0086	0.0018	0.0102	0.0103	0.0926 ***	0.0928 ***
	(0.0260)	(0.0259)	(0.0216)	(0.0262)	(0.0262)	(0.0275)	(0.0275)
ydum68	0.0395	0.0372	0.0333 *	0.0383	0.0356	0.0377	0.0351
	(0.0250)	(0.0249)	(0.0196)	(0.0250)	(0.0249)	(0.0248)	(0.0246)
ydum69	−0.0256	0.1348	−0.0312 **	−0.0249	0.1244	−0.0255	0.1267
	(0.0213)	(0.1619)	(0.0145)	(0.0214)	(0.1635)	(0.0210)	(0.1647)
constant	−0.1927 **	−0.2283 **	−0.0168	−0.1861 **	−0.2165 **	−0.1879 **	−0.2191 **
	(0.0916)	(0.1084)	(0.0496)	(0.0888)	(0.1049)	(0.0907)	(0.1072)
No. of obs.	429	429	424	429	429	429	429
No. of the	424	424	424	424	424	424	424
No. of the censored	5	5	0	5	5	5	5
No. of firms.	115	115	113	115	115	115	115
R-squared			0.0511				
Log-likelihood	128.9	130.1		133.0	135.1	120.9	123.0
σ	0.1740 ***	0.1735 ***		0.1724 ***	0.1715 ***	0.1774 ***	0.1765 ***
	(0.0247)	(0.0247)		(0.0243)	(0.0243)	(0.0254)	(0.0253)
Estimated period and method of ln(pmpk)	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP

Notes:
1. In parentheses are cluster-heteroskedasticity-robust asymptotic standard error in all cases by treating each firm as a cluster. ***, ** and * respectively indicate significance at 1, 5 and 10 percent level by two-tailed test.
2. LP means Levinsohn and Petrin's procedure.

Table 4 (Continued)

State of machine	Registered				
Eq. no.	(4-1ra)	(4-2ra)	(4-3ra)	(4-4ra)	(4-5ra)
Estimation method	Tobit	Tobit	OLS	Tobit	Tobit
Adjusting the short-term suspension	Yes	Yes	Yes	Yes	Yes
Variable					
ln(pmpk)	0.0381 *	0.0562 **	0.0252	0.0453 **	0.0644 **
	(0.0210)	(0.0273)	(0.0161)	(0.0210)	(0.0267)
ln(pmpk) * ydum69		-0.0670 **			-0.0712 **
		(0.0297)			(0.0309)
ln(k)	0.0135 *	0.0160 *	-0.0013	0.0116	0.0133
	(0.0075)	(0.0088)	(0.0038)	(0.0071)	(0.0084)
ln(k) * ydum69		-0.0114			-0.0095
		(0.0133)			(0.0128)
ks/ko	-0.1028 **	-0.1117 **	-0.1140 ***	-0.1101 ***	-0.1190 ***
	(0.0448)	(0.0458)	(0.0434)	(0.0401)	(0.0405)
ks/ko * ydum69		0.1028 **			0.1052 **
		(0.0489)			(0.0463)
weatwi			0.0257 *	0.0511 ***	0.0589 ***
			(0.0137)	(0.0180)	(0.0213)
weatwi * ydum69					-0.0336
					(0.0319)
txpr			-0.0184	-0.0175	-0.0179
			(0.0161)	(0.0177)	(0.0214)
txpr * ydum69					-0.0034
					(0.0280)
prcs			-0.0030	-0.0304	-0.0377
			(0.0118)	(0.0275)	(0.0332)
prcs * ydum69					0.0462
					(0.0369)
mrg	-0.0259	-0.0357	0.0075	-0.0113	-0.0031
	(0.0186)	(0.0253)	(0.0109)	(0.0170)	(0.0251)
mrg * ydum69		0.0101			-0.0263
		(0.0314)			(0.0314)
dcm	-0.0588 ***	-0.0296 *	-0.0539 ***	-0.0516 **	-0.0172
	(0.0139)	(0.0173)	(0.0121)	(0.0241)	(0.0294)
dcm * ydum69		-0.0832 ***			-0.1154 ***
		(0.0229)			(0.0357)
ydum67	-0.0226	-0.0217	-0.0305 *	-0.0215	-0.0206
	(0.0235)	(0.0234)	(0.0182)	(0.0236)	(0.0236)
ydum68	0.0048	0.0023	-0.0021	0.0036	0.0007
	(0.0238)	(0.0236)	(0.0178)	(0.0237)	(0.0236)
ydum69	-0.0594 ***	0.0795	-0.0662 ***	-0.0591 ***	0.0739
	(0.0192)	(0.1574)	(0.0105)	(0.0193)	(0.1591)
constant	-0.1507 *	-0.1817 *	0.0189	-0.1529 *	-0.1799 *
	(0.0895)	(0.1050)	(0.0382)	(0.0873)	(0.1027)
No. of obs.	429	429	424	429	429
No. of the	424	424	424	424	424
No. of the censored	5	5	0	5	5
No. of firms.	115	115	113	115	115
R-squared			0.1246		
Log-likelihood	141.4	143.5		145.3	147.8
σ	0.1689 ***	0.1680 ***		0.1674 ***	0.1664 ***
	(0.0263)	(0.0262)		(0.0259)	(0.0259)
Estimated period and method of ln(pmpk)	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP

Table 5 Estimation of invesment function with the interaction terms: 1971-73

State of machine	Operable				Installed			
Eq. no.	(5-1o)	(5-2o)	(5-3o)	(5-4o)	(5-1i)	(5-2i)	(5-3i)	(5-4i)
Estimation method	Tobit	OLS	Tobit	Tobit	Tobit	OLS	Tobit	Tobit
Variable								
ln(pmpk)	0.0930 ***	0.0476 **	0.1030 ***	0.1327 ***	0.0668 *	0.0169	0.0702 *	0.1347 ***
	(0.0342)	(0.0199)	(0.0372)	(0.0476)	(0.0375)	(0.0240)	(0.0381)	(0.0451)
ln(pmpk) * ydum73				-0.0997				-0.1917 **
				(0.0736)				(0.0847)
ln(k)	0.0518 ***	0.0092	0.0542 ***	0.0740 ***	0.0550 ***	0.0141	0.0582 ***	0.0788 ***
	(0.0162)	(0.0132)	(0.0183)	(0.0246)	(0.0161)	(0.0120)	(0.0177)	(0.0226)
ln(k) * ydum73				-0.0654 **				-0.0663 *
				(0.0327)				(0.0386)
weatwi		0.0371	0.0439	0.0522		0.0039	0.0107	0.0223
		(0.0361)	(0.0453)	(0.0558)		(0.0232)	(0.0360)	(0.0428)
weatwi * ydum73				-0.0310				-0.0357
				(0.0907)				(0.0841)
txpr		-0.0050	0.0276	0.0231		0.0167	0.0471	0.0435
		(0.0236)	(0.0338)	(0.0398)		(0.0224)	(0.0335)	(0.0395)
txpr * ydum73				-0.0036				-0.0181
				(0.0671)				(0.0708)
prcs		-0.0113	-0.0822 *	-0.1195 **		-0.0213	-0.0888 **	-0.1239 **
		(0.0211)	(0.0453)	(0.0559)		(0.0185)	(0.0448)	(0.0518)
prcs * ydum73				0.1372 **				0.1445 **
				(0.0696)				(0.0681)
mrg	-0.0607 *	-0.0255	-0.0576 **	-0.1079 ***	-0.0753 **	-0.0386 **	-0.0710 ***	-0.1017 ***
	(0.0347)	(0.0207)	(0.0232)	(0.0340)	(0.0347)	(0.0178)	(0.0242)	(0.0362)
mrg * ydum73				0.1560 ***				0.0992 *
				(0.0457)				(0.0571)
dcm	0.0324	0.0134	0.0848 **	0.1081 **	0.0346	0.0367 *	0.1076 **	0.1209 **
	(0.0252)	(0.0261)	(0.0428)	(0.0471)	(0.0243)	(0.0221)	(0.0437)	(0.0487)
dcm * ydum73				-0.0945				-0.0808
				(0.0774)				(0.0734)
ydum72	-0.0780 **	-0.0456	-0.0777 **	-0.0765 *	-0.0652 *	-0.0349	-0.0669 *	-0.0627 *
	(0.0393)	(0.0289)	(0.0395)	(0.0393)	(0.0372)	(0.0278)	(0.0376)	(0.0374)
ydum73	-0.1042 ***	-0.1033 ***	-0.1034 ***	0.6163 *	-0.1230 ***	-0.1259 ***	-0.1262 ***	0.6444
	(0.0351)	(0.0277)	(0.0358)	(0.3604)	(0.0342)	(0.0284)	(0.0356)	(0.4177)
constant	-0.5402 ***	-0.0650	-0.5854 ***	-0.8035 ***	-0.5717 ***	-0.0974	-0.6087 ***	-0.8552 ***
	(0.1857)	(0.1302)	(0.2015)	(0.2628)	(0.1862)	(0.1283)	(0.1996)	(0.2477)
No. of obs.	286	277	286	286	286	277	286	286
No. of the uncensored	277	277	277	277	277	277	277	277
No. of the censored	9	0	9	9	9	0	9	9
No. of firms.	100	98	100	100	100	98	100	100
R-squared		0.0681				0.0846		
Log-likelihood	-39.0		-37.4	-35.0	-28.2		-26.8	-21.7
σ	0.2629 ***		0.2614 ***	0.2593 ***	0.2526 ***		0.2514 ***	0.2469 ***
	(0.0310)		(0.0302)	(0.0298)	(0.0243)		(0.0241)	(0.0232)
Estimated period and method of	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP	1965-73, LP

Notes:

1. In parentheses are cluster-heteroskedasticity-robust asymptotic standard error in all cases by treating each firm as a cluster.
   ***, ** and * respectively indicate significance at 1, 5 and 10 percent level by two-tailed test.
2. LP means Levinsohn and Petrin's procedure.

Table 6 Estimation of investment function with prolicy variable: 1969–72

State of machine	Operable			Operable + Non-operable		
measurement period of g (k)	1969–70	1969–71	1969–72	1969–70	1969–71	1969–72
Eq. no.	(6–1o)	(6–2o)	(6–3o)	(6–1on)	(6–2on)	(6–3on)
Estimation	OLS	Tobit	Tobit	OLS	Tobit	Tobit
Variable						
avg. ln(pmpk)	−0.0297	0.0995	0.2041 *	−0.0266	0.1540 *	0.2101 *
	(0.0260)	(0.0761)	(0.1106)	(0.0250)	(0.0884)	(0.1139)
ln(k)	0.0052	0.0230	0.1585 ***	0.0005	0.0138	0.1508 ***
	(0.0113)	(0.0209)	(0.0578)	(0.0108)	(0.0206)	(0.0569)
policy	−0.0519 **	−0.1337 **	−0.2151 **	−0.0414 *	−0.1200 **	−0.1674 *
	(0.0261)	(0.0561)	(0.0938)	(0.0248)	(0.0598)	(0.0978)
weatwi	0.0168	0.0881	0.1229	0.0136	0.1046	0.1387
	(0.0259)	(0.0715)	(0.1148)	(0.0244)	(0.0703)	(0.1205)
txpr	0.0325	0.1023	0.1721	0.0373	0.1130	0.1519
	(0.0271)	(0.0689)	(0.1083)	(0.0279)	(0.0720)	(0.1077)
prcs	−0.0494 *	−0.0861	−0.3404 **	−0.0349	−0.0447	−0.3170 **
	(0.0291)	(0.0519)	(0.1515)	(0.0296)	(0.0523)	(0.1481)
mrg	−0.0895	−0.1411 **	−0.3461 ***	−0.0772	−0.1462 **	−0.3760 ***
	(0.0704)	(0.0678)	(0.1265)	(0.0679)	(0.0730)	(0.1427)
dcm	0.0467	0.1009	0.1658	0.0405	0.0944	0.1190
	(0.0287)	(0.0627)	(0.1403)	(0.0288)	(0.0700)	(0.1383)
constant	0.0085	−0.1892	−1.6444 **	0.0370	−0.1434	−1.6037 **
	(0.1150)	(0.2357)	(0.6270)	(0.1108)	(0.2372)	(0.6214)
No. of obs.	100	98	98	100	98	98
No. of the uncensored	–	96	91	–	96	91
No. of the censored	–	2	7	–	2	7
R–squared	0.0860			0.0643		
Log–likelihood	–	−13.6	−61.2	–	−17.5	−63.9
σ	–	0.2682 ***	0.4287 ***	–	0.2794 ***	0.4421 ***
		(0.0509)	(0.0480)		(0.0506)	(0.0566)
Estimated period of ln(pmpk)	1965–73	1965–73	1965–73	1965–73	1965–73	1965–73
The estimates by Average Treatment Effect model						
No. of the treated	47	47	47	47	47	47
No. of the control	53	51	51	53	51	51
ATE	−0.0476 **	−0.1145 **	−0.1838 **	−0.0380 *	−0.0974 *	−0.1409 *
	(0.0222)	(0.0485)	(0.0792)	(0.0212)	(0.0514)	(0.0832)
ATT	−0.0449 *	−0.1120 **	−0.1665 **	−0.0356	−0.0882	−0.1238
	(0.0246)	(0.0543)	(0.0745)	(0.0241)	(0.0591)	(0.0771)

1. In parentheses are heteroskedasticity–robust asymptotic standard error in all cases. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively by two–tailed test.
2. In each period, measurement periods of g (k), the growth rate of equipment, and the calculation formula of the annual average of ln(pmpk) are as follows.
   1969–70: g (k) is calculated from the end of 1969 till the end of 1970. The annual average of ln(pmpk) is 1969 value.
   1969–71: g(k) is calculated from the end of 1969 till the end of 1971. The annual average of ln(pmpk) is from 1969 till 1970 or the previous year before a firm exits, whichever is earlier.
   1969–72: g(k) is calculated from the end of 1969 till the end of 1972. The annual average of ln(pmpk) is from 1969 till 1971 or the previous year before a firm exits, whichever is earlier.