Bank of Japan Working Paper Series

Does Information Technology Induce the De-skilling of Contingent Workers?: Experiences in the Japanese Electrical and Electronic Industry

Hiroyuki Chuma*
chuma@iir.hit-u.ac.jp

Daiji Kawaguchi*
kawaguch@econ.hit-u.ac.jp

No.10-E-3
March 2010

Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-0021, Japan

* Hitotsubashi University

Does Information Technology Induce the De-skilling of Contingent Workers?: Experiences in the Japanese Electrical and Electronic Industry[1]

Hiroyuki Chuma and Daiji Kawaguchi[2]
Hitotsubashi University

Abstract

This paper examines the effect of introduction of information technology driven manufacturing information systems (IT-MIS) to workshops on the usage of contingent workers and subsequent productivity growth based on an unique survey of workshop supervisors of the Japanese electrical and electronic industry. The analysis indicates that the introduction of IT-MIS enhances the variety of tasks performed by contingent workers and induces productivity growth at the workshops. Productivity enhancement at workshops with IT-MIS critically depended on extensive information sharing between regular and contingent workers, as well as between regular workers and designers and/or fabrication engineers. These results indicate that merely introducing IT-MIS does not automatically lead to productivity enhancement. Enhanced productivity depends on the organizational design of communication structures among the affected employees, including contingent workers.

[1] This paper is a revised version of the paper presented at the conference at the Bank of Japan on November 26 and 27, 2009, jointly organized by the Bank of Japan and the University of Tokyo. We gratefully acknowledge comments from Souichi Ohta and participants of the conference. The results in this paper are based on Chuma and Kawaguchi (2007). The views expressed here are solely of authors in their personal capacity.
[2] Email addresses, Chuma: chuma@iir.hit-u.ac.jp, Kawaguchi: kawaguch@econ.hit-u.ac.jp

1. Introduction

Computer-mediated information technology (IT) has started to significantly alter the architectural structure of the social division of labor, as documented by Autor, Katz and Krueger (1998), Autor, Levy and Murnane (2003), Autor, Katz and Kearney (2007), and Goos and Manning (2007). These studies point out that IT is apt to be complementary with skilled workers and that a reduction in computer prices generally boosts the scarcity of the skilled relative to the unskilled. IT-driven work reorganizations also tend to complement high-skilled workers, which further increases their scarcity and the *ex ante* and *ex post* flexibility of workforce (Caroli and van Reenen (2001), Black and Lynch (2001), Bresnahan, Brynjolfsson and Hitt (2002), Bartel, Ichniowski and Shaw (2007)).

A similar bipolarization between the (regular) skilled and the (contingent) unskilled tends to be equally observable in various workshops in Japan. As illustrated in Figures 1 and 2, for example, reflecting the increasing scarcity of the skilled, the fraction of contingent workers among production workers has rapidly increased since the mid-1990s *pari passsu* with the accelerated adoption of IT-driven manufacturing information systems (IT-MIS).[3] The corresponding stratification of employment into contingent and regular groups also has been posing acute social problems, such as economic inequality, falling quality of products and services, and corporate identity crises.[4]

To be sure, as in the Toyota Production System (TPS), highly skilled supervisors (called *Kumicho* in Japanese) are still playing a vital role, in a quite autonomic way, as spatiotemporal coordinators among unskilled workers, skilled workers, and engineers (e.g., Koike, Chuma, and Ohta (2001)). Kumicho's integrated knowledge for coordination, however, could be no longer being fully embodied within a specific person in a stand-alone mode. Rather, such knowledge must be jointly owned among the concerned regular and contingent workers/engineers and, whenever necessary, be mobilized promptly and autonomously among them. Consequently, to secure the closest coordination among all those concerned, IT-MIS, as exemplified by the manufacturing execution system (MES), are rapidly being installed, together with advanced autonomic hardware systems.[5]

Contrary to the conventional view (e.g., Braverman (1974)), however, employment stratification does not always necessitate the de-skilling of contingent workers. The contingentness

---

3 A similar phenomenon is also observable in the United States (Estevao M. and S. Lach (1999a), (1999b)).

4 Autor, Katz and Kearney (2007), Goos and Manning (2007), and Genda (2008) report such a tendency in the United States.

5 Such a tendency is particularly prominent at semiconductor workshops, where the complexity of products and fabrication technologies has been rapidly increasing, together with sharply tightening speed-to-market constraint s(Chuma (2007)).

of employment *per se* does not induce de-skilling. Indeed, although it depends on the embedded communication structures in organizations (Kogut (2008)), the just-in-time processing capability of IT-MIS could make the knowledge database be a public good (Zuboff (1988)). This database could bring about the unrestrictedness in the zoom-in or -out of various micro and macroscopic viewpoints like “Google Earth,” which swiftly refine the granularity of common knowledge for accurate and efficient communication among the concerned employees. Such a refinement could make both regular and contingent workers understand at a glance the relationship between the whole and parts in manufacturing systems. It could also expand, more quickly and cheaply than otherwise, the depth and breadth of their tasks to cope well with the broader range of requests for customization. As a result, even the complementarity among contingent and regular workers and engineers could be endogenously strengthened all the more in such communication-rich organizations (e.g., Zuboff (1988), Chuma (2007)).

The main contribution of this paper is to empirically substantiate the above benefits of prompt, precise, and panoramic visualization due to IT-MIS by considering its impact on various productivity indices in manufacturing workshops. To provide corroboration for this conjecture, we pay a special attention to the effect of IT-MIS on the de-skilling or up-skilling tendency among contingent workers based on the Survey on Human Resource Development of Manufacturing Supervisors (Japanese Electrical, Electronic and Information Unions (JEEIU (2007)).[6] The survey was conducted for supervisors ("*Kumichos*") and their candidates at the workshops of major manufacturers in the electrical and electronic industry in Japan.

More specifically, we will examine: 1) what effects an introduction of IT-MIS has on the ratio of contingent workers and the depth and breadth of their assigned tasks; 2) how an introduction of IT-MIS contributes to such productivity indicators as the degree of quality improvement, reduction in cost, (production) lead-time, or work in process (WIP); and 3) how embedded communication methods among contingent (unskilled), regular (skilled) workers and fabrication or design engineers influence these productivity indicators.

To the best of our knowledge, this type of empirical research has not yet been sufficiently conducted in preceding economic studies. To be sure, for example, Autor, Levy and Murnane (2002), (2003) clearly show that IT complements workers in carrying out problem-solving and complex communication activities. Bartel, Ichniowski and Shaw (2007) also convincingly demonstrate that IT investments improve all stages of the fabrication processes by reducing setup times, inspection times and production lead times, which further change even business strategies for product innovation and customization. In contrast to these studies, we consider the impact of

6 Details are available from http://www.jeiu.or.jp/research/0705/index.html

IT-MIS on communication structures among regular and contingent workers and engineers and its significance on various productivity indices. In this sense, we believe that our research could provide an additional meaningful viewpoint of what computers do and what people do with computers.

An analysis of survey responses reveals that the introduction of IT-MIS has not yet significantly increased the portion of contingent workers at workshops, while it enhances the depth and breadth of their tasks. In particular, they are inclined to become involved in equipment inspection or maintenance, as well as simple trouble shooting, such as machine restarting after correcting minor errors. Workshops equipped with IT-MIS are also superior in all productivity indicators of quality, cost, lead-time, and WIP to the ones without it.[7] This relationship holds even after partially controlling the effect of the reverse causality that highly productive workshops *per se* tend to introduce IT-MIS.

Furthermore, the statistical analysis clearly reveals the importance of communication among contingent, regular workers and engineers to fully substantiate the positive effect of IT-MIS on productivity. Indeed, the more frequent the study meetings at workshops between contingent and regular workers or the formal and informal design-review opportunities between regular workers and engineers took place, the larger the positive effects on time-scheduling (TA) and quality-control (QC) management.

This paper is organized as follows. Section 2 introduces the survey data. Section 3 lays out the empirical methodology. Section 4 reports the results of our analysis. The last section provides a summary and discusses policy implications.

2. Outline and Main Characteristics of the Survey Data

2.1 Outline of the Survey

This study utilizes the Survey on the Human Resource Development of Supervisors at Manufacturing Workshops (SHRDS).[8] The SHDS was conducted in November 2006 for manufacturing establishments that belong to local unions under the Japanese Electrical, Electronic and Information Unions (JEEIU: http://www.jeiu.or.jp/). The actual sampling was conducted in three steps: first local unions, then establishments within them, followed by their supervisors or their candidates. The first selection of local unions was based on the wage survey that the JEEIU had previously conducted. In the survey, the relevant 167 local unions were picked up. There were maximally 300 supervisors at a large local union, and only 2 supervisors at small ones. The

[7] 52% of supervisors at workshops with IT-MIS reported an improvement in TS management and 34% of them reported improvement in QC management.

[8] One of the authors was involved in this survey from its design stage.

corresponding numbers for supervisor candidates was 70 or 2, respectively.

Questionnaires were distributed to 4,000 supervisors at 167 local unions, and to 1,000 supervisor candidates at 122 of those unions. Each local union collected and distributed the questionnaires using securely sealed envelopes. The response rate was 69.8% (2,790) for supervisors and 76.5% (765) for their candidates. At unions with over 100 supervisors the response rate exceeded 90%, on average.

2.2 Main Characteristics of the Survey Data

Table 1 reports the descriptive statistics of various variables to be utilized in our statistical analysis. After cleaning missing data, the actual sample size of supervisors and candidates is reduced to 3,040. Among these, 1,147 (38%) are working at workshops with IT-MIS and 1,893 (62%) are working at workshops without it.

Since supervisors or their candidates responded to the survey, it is useful to describe the background of respondents first. About 45% of the respondents are between 40 and 49 years of age. Adding those over 50 years of age, the ratio amounts to 60%. Reflecting such an age structure, the respondents' average job tenure is 22 years.[9] There is little difference in age and tenure between those in workshops with and without IT-MIS. The ratio of bachelor's or higher degree holders is a little higher for the workshops without IT-MIS. This seemingly contradicts the well-known findings that IT and skills are complementary (Caroli and van Reenen (2001) and Bartel, Ichiniowski and Shaw (2007)). As far as supervisors and their candidates are concerned, however, educational background might not be a good proxy for level of skills in Japan's electrical and electronic industry.

The survey measures the supervisor's (or candidate's) degree of playing-manager by asking the proportion of time they spend on production lines each day. On average, 66% of their time is spent in production lines, regardless of whether the production lines adopt IT-MIS or not. Workshops with IT-MIS have a slightly higher prospect for long-term demand for products than those without it.

As far as the types of workshops are concerned, 24% and 38% of supervisors work for assembly or machining shops, respectively. Supervisors have 26 subordinate regular and 22 contingent workers, on average. About 32% of supervisors belong to the electronic parts industry. Types of workshops have no relation with their adoption of IT-MIS, while the difference in industry matters a little, with the electronic parts industry being more likely to adopt IT-MIS.

[9] In fact, the cross table between age and tenure shows that they are mostly so-called "permanent employees" who have been working for the same companies since just after graduating from high school. It is also surprising that 35% of them never experienced internal transfers beyond the sections in question and 35% of them did so once or twice at most.

The survey asks about the usage of contingent workers at the workshop that each respondent supervises. The definition of contingent workers in this survey includes all non-regular workers (*Hi-seishain*) such as contracted workers (*Ukeoikou*), dispatched workers (*Haken-rodosha*), and part-time workers. Whether IT-MIS is introduced or not makes little difference in the portion of contingent workers (see "Portion of contingent workers at workshops" in Table 1). In contrast, workshops with IT-MIS tend to delegate difficult as well as repetitive tasks to contingent workers (see "Degree of task-allocation to contingent workers"). Contingent workers' degree of commitment in difficult tasks is significantly higher for such items as "equipment inspection," "handling simple equipment troubles," and "substituting themselves for absentees" (see "Degree of task-commitment by contingent workers"). In this sense, an introduction of IT-MIS is apt to expand the depth and breadth of tasks assignable to contingent workers.

Supervisors and their candidates whose workshops have introduced IT-MIS fully recognize that all productivity indicators (with respect to quality, cost, lead-time, and WIP) have improved or significantly improved since around 2000 (see "<Change in productivity indicators>" related to quality, cost, lead-time, and WIP in Table 1). Although 52% of them also acknowledge the improvement in schedule (or progress) management with IT-MIS, only 34% of them do so for Quality Control / Quality Assurance (see "Effect of IT-MIS introduction"). These results indicate that the effect of IT-MIS on productivity indicators might depend on other important factors, such as the means or extent of information sharing among stakeholders.

Certainly, we need the following *caveat* when emphasizing the effect of IT-MIS on productivity indicators. Without a doubt, there exists dependence between product variety at each workshop and IT-MIS introduction. To partial out the effect of product characteristic change on the usage of contingent workers and productivity, the term "Changes in characteristics of products" in Table 1 is utilized. The findings show that, at workshops with IT-MIS, the following have been increasing: specification and variation in products, sophistication and complication in functions, number of embedded parts for assembling, and difficulty in product-testing. If these complications in products can be assumed to be exogenous, then we can identify the effect of IT-MIS on the use of contingent workers or productivity by controlling for these changes. There is a tendency for product life cycles tend to be shortened at workshops with IT-MIS, although the causality is not very clear, as reported in Table 1.[10]

3. Methodology of analysis

The descriptive statistics indicate that the introduction of IT-MIS tends to expand the range of

[10] These findings are consistent with what Bartel, Ichiniowski and Shaw (2007) found for the US valve manufacturing industry.

tasks that contingent workers perform. We now attempt to statistically examine the impact of IT-MIS introduction on their good use. In clearing up such causality, it is critical to discern the factors that promote the use of contingent workers, as well as the introduction of IT-MIS. This is because such factors as the growing complexity of products or their shortening life cycles could encourage both IT-MIS introduction and use of contingent workers. To cope with this endogeneity problem, while controlling such product-related changes, we also control the characteristics of supervisors and their candidates and the difference in their divisions and industries. Meanwhile, if the adoption of IT-MIS increases the complexity of products and shortens their life cycles, as reported by Bartel, Ichiniowski and Shaw (2007), the estimates suffer from post-treatment control bias (Rosenbaum (1984)), which underestimates the true causal impact.

To execute the above multiple regression, we apply the ordered probit method. Suppose that the "ratio of contingent workers at the workplace" is the explained variable. In this case, based on the unobservable value function (Y*), the corresponding workshop is assumed to choose the largest value among the following four alternatives. The value function is thought to depend on such factors as supervisors' (or candidates') educational level, the adopted manufacturing system (including information systems and technological characters), the affiliated industries, market characteristics of its products, and other unobservables (u). More concretely, Y* is assumed to follow the linear function:

$$Y^* = X\beta + u,$$

where X is a vector of explanatory variables, β is the corresponding parameters, and u is an error term. We assume that the error term follows a conditional normal distribution: $u|x \sim N(0,1)$, which implies the independence of u from explanatory variables X.

If the value of the function falls into area 1 ($Y^* \le \mu_1$), the workshop is considered to select the alternative of "no contingent worker (in the workplace)." Similarly, if Y* goes into area 2 ($\mu_1 \le Y^* \le \mu_2$), "a few contingent workers"; if the area 3 ($\mu_2 \le Y^* \le \mu_3$), "half contingent workers"; if the area 4 ($\mu_3 \le Y^* \le \mu_4$), "mostly contingent workers"; and if the area 5 ($Y^* \ge \mu_4$), "only contingent workers." The values of threshold μ_j (j = 1, 2, 3, 4) are assumed to be the same for all supervisors (candidates) and are estimated as parameters.

Parameter vectors of β are estimated by maximizing the log likelihood function derived from these model specifications. Taking into account the fact that more than one supervisor is sampled from an identical workplace, the standard error is calculated with a method robust to clustering on the workplace level.

4. Results of Analysis

4.1 Effect of IT-MIS and Use of Contingent Workers

The ordered probit estimates using the ratio of contingent workers (at workshops) as the dependent variable are reported in the first through fourth columns of Table 2. The results indicate that, irrespective of the presence or absence of control variables, such as the change in kinds of products or the characteristics of supervisors (candidates), the introduction of IT-MIS does not lead to a higher contingent worker ratio. The fifth through eighth columns of Table 2 report the impact of IT-MIS, along with other explanatory variables, on contingent workers' degree of task-commitment. The fifth column shows that workshops with IT-MIS have a stronger tendency to delegate complicated jobs to contingent workers. This result does not change even after controlling the change in kinds of products, the characteristics of supervisors (or candidates), and workplace individualities. According to estimate results in Table 2, although the introduction of IT-MIS does not quantitatively increase contingent workers' employment, it does expand the range of tasks assigned to them.

Table 3 further examines the kinds of specific tasks in which contingent workers become more involved because of IT-MIS. Here, the introduction of IT-MIS, along with other explanatory variables, is regressed on the participation dummy that takes the unit value if contingent workers become involved in such tasks as "finding quality defects," "investigating root causes of quality defects," etc. The result indicates the positive impact of IT-MIS on "investigating root causes of quality defects," "inspecting equipment," "handling simple equipment troubles," "substituting for absentees," and "revising standard-task manuals." The impact is particularly strong for "inspecting equipment" and "handling simple equipment troubles."

At workshops with IT-MIS, various kinds of sensing and barcode-reading information are collected via the network server through monitoring devices installed in various places at workshops, while the resulting description of the whole and parts of fabrication processes could be fed back moment by moment to the corresponding workshops. Consequently, whether workers are regular or contingent, the more open the collected and processed database is, the more precisely they can understand at a glance the process conditions in their charge within plants. Such a precise and panoramic visualization enables the detailed clarification of inspection items, the swift awareness of problems, and the quick finding of their root causes, etc., which makes contingent workers responsible for equipment inspection and troubleshooting of its minor failure, such as temporary stopping.

In the above sense, the introduction of IT-MIS may expand the depth and breadth of tasks assigned to contingent workers through its capability of providing prompt, precise, and panoramic visualizations of fabrication processes. Evidently, however, such benefits of visualization are not always valuable. Indeed, the attainable benefits are quite dependent on the extent and granularity of the collected and processed information shared among the involved workers. Moreover, the effects of information sharing significantly depend on the resolution of information and to whom the collected and processed information is accessible.

In addition, even when such information is accessible to both regular and contingent workers, the relevant granularity of shared information depends on the adopted labor-division system among contingent and regular workers and engineers. Such a system *per se* is determined by the adopted method of organizational management.[11] Furthermore, granularity stipulates the speed and preciseness of communication among these individuals. Therefore, in what follows, we will examine what kinds of influences the differences in organizational management exert on manufacturing performance, such as quality improvement or reduction in costs, production lead-time, and WIP.

4.2 IT-MIS and its impact on manufacturing performance

We now statistically examine how much IT-MIS affects the manufacturing performance represented by quality improvement, reduction in costs, production lead-time, and WIP. The SHRDS asked the supervisors (or candidates) to evaluate the extent to which the above items (quality, cost, lead-time, and WIP) had improved, compared with the situation around year 2000. Respondents could choose from four possible answers to each question: "1 = Worse," "2 = No change," "3 = Improved," and "4 = Significantly improved." Using this evaluated value as a dependent variable, the Ordered Probit method is utilized to examine the effect of IT-MIS adoption on productivity, holding various workshop characteristics constant.

The first through eighth columns of Table 4 report estimates on quality improvement, cost reduction, production lead-time, and WIP. In this table, for each performance item, two estimation results are shown with and without control variables. The number of observations consists of supervisors and their candidates. The results show that the introduction of IT-MIS has a statistically significant, positive impact on quality improvement.

Certainly, the difficulty in quality improvement must depend on characteristics of the products themselves, which could, in turn, influence the decision for IT-MIS introduction. To mitigate such an effect of reverse causality, we also estimated the model with additional explanatory (proxy) variables that capture differences in product characteristics. The result is displayed in the second column, which shows that the impact of IT-MIS is a little bit smaller than the one in the first column. Although this suggests the existence of the above reverse causality, the magnitude of

[11] For example, the depth and breadth of participants' participation in design reviews, the frequencies of those meetings, and their implementation methods.

coefficient change is rather negligible between these two cases. Among these proxy variables, the impact of "increasing complexity in fabrication processes" and "shortening product life cycles" are significantly positive. In other words, workshops with such characteristics tend to be equipped with IT-MIS.

The third and fourth columns of Table 4 report the estimation results about cost reduction. In this case, IT-MIS also provides a (significantly) positive impact on cost reduction. Adding the same explanatory (proxy) variables as the above makes the effect of IT-MIS slightly lower, but it is still significant.

Estimation results about the reduction in production lead-time are shown in the fifth and sixth columns of Table 4. "Production lead-time" means the total time allocated to completing the products in question. The results suggest that IT-MIS significantly contributes to the shortening of production lead-time. The impacts also do not change, irrespective of the presence of control (proxy) variables. To reduce the production lead-time, in addition to various persistent efforts at workshops, effective supply chain management (SCM) must be established to procure materials and parts from outside venders in a just-in-time manner. The result thus suggests that IT-MIS could be effective in coping with such a difficult process.

Last, estimation results for the reduction in WIP are indicated in the seventh and eighth columns of Table 4. The reduction in WIP can be achieved more easily than that in production lead-time. This is because persistent efforts at workshops could markedly contribute to WIP reduction. In this sense, IT-MIS is expected to significantly reduce WIP. The reported estimate supports this. We also note that the impact of IT-MIS does not change even by adding explanatory (proxy) variables.

4.3 Introduction of IT-MIS and communication efficiency in workshops

The previous section confirmed that IT-MIS has a significant, positive impact on quality improvement, reduction in costs, production lead-time, and WIP. The analysis in section 4.1 also clarifies the fact that IT-MIS expands the depth and breadth of tasks assigned to contingent workers. Based on these results, however, it would be too hasty to conclude that an expansion could make manufacturing performances of the corresponding workshops further improved than they are.

Indeed, IT-MIS tends to increasingly subdivide the existing system of labor division, which in turn fosters a tendency toward an extra-rigid separation between unskilled contingent and skilled regular workers. If this happens, especially in typical workshops in Japan characterized by a "*kumicho line*," IT-MIS might have significant negative impacts on manufacturing performance. This is because, in such a system, the efficiency of communication among the concerned people could sharply decline, such that the benefits of prompt, precise, and panoramic visualization resulting from IT-MIS could be valuable only in a restricted way.

Hence, in this section, only workshops equipped with IT-MIS are taken up to scrutinize what kinds of influences the enhancement of communication efficiency resulting from IT-MIS exerts on TS and QC management. The utilized indices of communication efficiency are the frequency of study meetings at workshops between contingent and regular workers and the incidence of design-review meetings (formal or informal) between regular workers and designers and/or fabrication engineers.

Descriptive statistics in Table 1 indicate that the ratio of supervisors (or their candidates) who replied that “IT-MIS has made TS management easier than before” is 52% among the workshops with IT-MIS. The corresponding ratio of people who replied that “IT-MIS has made QC management easier than before” is only 34%. These numbers suggest that the mere introduction of IT-MIS does not automatically lead to productivity enhancement. In contrast, Table 1 indicates that workshops with IT-MIS more frequently hold study meetings between contingent and regular workers or share information between regular workers and designers and/or fabrication engineers than those without IT-MIS. These facts suggest the existence of a complementary relationship between the communication efficiency and IT-MIS, which naturally leads to productivity enhancement.

Table 5 reports results of probit analyses about how the enhancement of communication efficiency resulting from IT-MIS improves TS and QC management. The dependent dummy variable is whether TS or QA management is improved or not. We pay special attention to the dummy explanatory variables that indicate the presence of study meetings at workshops between contingent and regular workers and design-review meetings between regular workers and designers and/or fabrication engineers.

The first and second columns of Table 5 report the impact on TS management. According to the first column, although both study meetings and design-review meetings positively contribute to TS management, only the latter is significant. The results do not change even after controlling other explanatory variables, such as change in kinds of products, characteristics of supervisors (or their candidates), and the workplace individualities (see the second column).

The third and fourth columns of Table 5 report the impact on QC management. The results demonstrate that both study meetings and design-review meetings positively and significantly contribute to QC management. The significance level of the latter is much larger than the former. The results do not change even after controlling the aforementioned explanatory variables (see the fourth column).

What we can see from these analyses is the critical importance of extensive information sharing, even at workshops with IT-MIS, between regular and contingent workers as well as between regular workers and designers and/or fabrication engineers. Certainly, IT-MIS could greatly strengthen capabilities of prompt, precise, and panoramic visualization about fabrication processes. Whether or not such benefits might lead to productivity enhancement, however, depends on the organizational design of communication structures among the concerned individuals, including contingent workers.

5. Summary and Implications

The expansion of IT usage could enhance the *ex ante* and *ex post* flexibility of manufacturing systems, which makes it possible to easily mass-customize more complex and better products with a shorter lead-time and lower costs (Bartel, Ichniowski and Shaw (2007)). In addition, suppliers' high capability for "speed to market" could permit infinite diversity of users' preferences to entail their erratic changes. Conversely, erratic preferences could influence speed to market. Such hyperactive reflexivity between users and suppliers unavoidably calls for frequent use of skilled and unskilled contingent workers as a real-option strategy (Dixit and Pindyck (1994)). As a natural result, what kind of phase change comes into being in the labor markets? Does IT-MIS induce further de-skilling or up-skilling of contingent workers, while markedly increasing demand for them?

To answer to these questions, based on a questionnaire survey (SHDS) conducted by JEEIU (2007), this study analyzed the pervasive effect of the introduction of IT-MIS on the employment of contingent workers. According to the analysis, the bipolarization of employment into contingent and regular workers has been prominent since the mid-1990s; however, IT-MIS itself did not yet noticeably lead to an increase in the contingent worker ratio among workshops represented in JEEIU research. Instead, it significantly expanded the depth and breadth of tasks assigned to those workers. In addition, IT-MIS contributed significantly to such productivity indicators as quality improvement, reduction in costs, production lead-time, and WIP.

On top of that, productivity enhancement at workshops with IT-MIS critically depended on extensive information sharing between regular and contingent workers, as well as between regular workers and designers and/or fabrication engineers. In fact, the enhanced communication efficiency with IT-MIS, mainly resulting from prompt, precise, and panoramic visualization of fabrication processes, significantly improved efficiency in TS and QC management. These results indicate that merely introducing IT-MIS does not automatically lead to productivity enhancement. Enhanced productivity depends on the organizational design of communication structures among the affected employees, including contingent workers.[12]

[12] The importance of such an organizational management is exemplified by field research conducted at the semiconductor production workshop of Hiroshima Elpida. For the details, see Chuma (2007).

These findings entail several policy implications. First, Japan's current public employment policy is generally inclined to prohibit (dispatched) contingent workers in manufacturing workshops, although the policy has been liberalized since 2004. Such a policy, however, cannot effectively solve such social problems as "economic inequality" that the Japanese widely perceive to result from a bipolarization between regular and contingent workers. Indeed, it is crystal clear that such a harsh policy would bring about a similar situation to that which occurred before 2004, when contingent workers had been, barely within law, contracted out to various workshops through employment contractors with whom the recipient firms had direct contract agreements. Under this arrangement, contingent workers were at least formally prohibited from communicating with firms' regular workers, under the specious reasoning that permitting unrestricted communication amounted to hiring them directly.

Second, to avoid reverting to such a precarious situation, the employment authority should adopt a public policy that expands the depth and breadth of tasks assigned to contingent workers and enhances the communication efficiency between contingent and regular workers and/or engineers, while permitting (dispatched) contingent workers in manufacturing workshops. As the first step towards such a policy, for example, the employment authority should insist that contracts involving contingent workers have greater transparency and granularity and clarify contractors' and firms' responsibilities toward contingent workers. In fact, such attempts could increase job satisfaction and set proper remuneration for contingent workers, so that their incentives to acquire skills and to communicate inside and outside the concerned groups might be strengthened.

Third, as the popularity of real-option strategies must be further boosted to mitigate the risk of long-term employment, contingent workers' enhanced skills must be employed effectively beyond pre-established corporate boundaries. The present analysis suggests that elaborate customization and complexity in products and their fabrication technologies ought to favor the up-skilling over the de-skilling of workforce, including contingent workers, even under the IT-MIS. If so, public subsidies for expanding the depth and breadth of tasks assigned to such workers must be socially desirable to internalize such external effects.

Lastly, we need to emphasize the limitation of our analyses. Although they vividly describe the situation at the widespread workshops of major manufacturers in the electrical and electronic industry in Japan, most of data analyzed in this paper are constructed from the productivity-related indices subjectively evaluated by group leaders ("Kumicho") and their candidates. Hence, we have to draw the generalizations based on our results with due caution. To mitigate such a limitation, the utilization of objective data reported in like balance sheets or profit-loss tables must be desirable.[13] Finally, we would like to emphasize an indirect but a little supportive fact for our analyses that, at the workshops with increased contingent workers, many of Kumichos and their candidates in this survey (SHRDS) feel very troubled about inefficiency caused by them. In this sense, they do not have incentives to promote to employ contingent ones.

References

・Abe, Masahiro (2001) "How Does Information Technology Influence Employment? (in Japanese, Joho-tsushin-gijutsu ha koyo ni dou eikyo shiteiruka?" *Nihon Rodo Kenkyu Zasshi*, No. 498

・Autor, David H., Lawrence F. Katz and Alan Krueger (1998), "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics*, Vol. 113, No. 4, pp. 1169-1213

・Autor, David H., Frank Levy and Richard J. Murnane (2002), "Upstairs, Downstairs: Computers and Skills on Two Floors of a Large Bank," *Industrial and Labor Relations Review*, Vol. 55, No. 3, pp. 432-447

・Autor, David H., Lawrence F. Katz and Melissa S. Kearney (2008), "Trends in U.S. Wage Inequality: Revising the Revisionists," *Review of Economics and Statistics*, Vol. 90, No. 2, pp. 300-323

・Bartel, Ann, Casey Ichniowski and Kathryn Shaw (2007), "How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Workers Skills," *Quarterly Journal of Economics*, Vol. 122, No. 4, pp. 1721-1758

・Braverman, Harry (1974), *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century*, Monthly Review Pres, New York

・Bresnahan, Timothy F. (1999), "Computerization and Wage Dispersion: An Analytic Reinterpretation," *Economic Journal*, Vol. 109, No. 456, pp. 390-415

・Bresnahan, Timothy F., Erik Brynjolfsson, and Lorin M. Hitt (2002), "Information Technology, Workplace Organization, the Demand for Skilled Labor: Firm-Level Evidence," *Quarterly Journal of Economics*, Vol. 117, No. 1, pp. 339-376

・Brynjolfsson, Eric and Haim Mendelson (1993), "Information Systems and the Organization of

[13] We initially pursued for this line of approach. But most of the establishments sampled in SHRDS belong to giant multi-divisional firms like Hitachi, NEC, Mitsubishi Electric, etc. so that the objective information relevant for our analyses is quite difficult to collect.

Modern Enterprise," *Journal of Organizational Computing*, Vol. 3, pp. 245-255

・Black, Sandra E. and Lisa M. Lynch (2001), "How to Compete: The Impact of Workplace Practices and Information Technology on Productivity," *Review of Economics and Statistics*, Vol. 83, No. 3, pp. 434-445

・Caroli, Eve and John van Reenen (2001), "Skill-Biased Organizational Change? Evidence from a Panel of British and French Establishments," *Quarterly Journal of Economics*, Vol. 116, No. 4, pp. 1449-1492

・Chuma, Hiroyuki (2003), "Bipolarization in Labor Markets: Based on Contingent Contarcted Workers (in Japanese, Rodo Shijo Niokeru Nikyokuka Keikou: Ukeoikou Kyuzou no Jireikara)," *Financial Review*, No. 67, pp.57-74, (http://www.mof.go.jp/f-review/r67/r_67_057_074.pdf)

・Chuma, Hiroyuki (2007), "Exploring Factors behind the Weakening Competitiveness of Japan's Semiconductor Production System: In View of Paper's Principle (in Japanese, Nihon no Handoutai Seisan System no Kyousouryoku Jakka Youin wo Saguru: Papert's Principle no Shiten kara)," *Cognitive Studies* (Journal of Japanese Cognitive Science Society), Vol. 14, No. 1, pp. 39-59

・Chuma, Hiroyuki and Daiji Kawaguchi (2007), "Does Manufacuring Information System Increase Contingent Workers? (in Japanese,Seisan Joho Sisutemu ha Koyou no Hitenkeika wo Unagasuka)," *Hitotsubashi Business Review*, Winter, pp. 66-83

・Dixit, Avinash, K. and Robert S. Pindyck, 1994, *Investment under Uncertainty*, Princeton University Press, Princeton, New Jersey.

・Estevao, Marcello and Saul Lach (1999a), "Measuring Temporary Labor Outsourcing in U. S. Manufacturing," *NBER Working Paper Series* 7421.

・Estevao, Marcello and Saul Lach (1999b),"The Evolution of the Demand for Temporary Help Supply Employment in the United States," *NBER Working Paper Series* 7427.

・Genda, Yuhji (2008), "Irregular employment as the lower tier of internal labor market (in Japanese, Naibu-Rodoshijyo Kaiso toshiteno Hiseiki)," *Keizai Kenkyu*, Vol. 59, No. 4, pp.340-356

・Golding, Claudia and Lawrence Katz (1998) "The Origins of Technology-Skill Complementarily," *Quarterly Journal of Economics*, Vol. 113, No. 3, pp. 693-732

・Goos, Maarten and Alan Manning (2007) Lousy and Lovely Jobs: the Rising Polarization of Work in Britain, *Review of Economics and Statistics*, Vol. 89, No. 1, pp.118-133

・Japanese Electrical, Electronic and Information Unions (2007), *The Envioronmental Changes around Supervisers at Manufacturing Workshops and Their (Productivity) Performance (in Japanese, Seizogenba Kantokusha wo Torimaku Kankyohenka to Genba Performance ni Kansuru Kenkyu)*, Research Report Series 11 (http://www.jeiu.or.jp/research/0705/index.html)

・Kogut, Bruce (2008), *Knowledge, Options, and Institutions*, Oxford University Press, New York

・Koike, Kazuo, Hiroyuki Chuma, Sohichi Ohta (2001), *Manufacturing Skills in Workshops of Auto*

Industry (in Japanese, Monozukuri no Gino: Jidosha Sangyo no Shokuba de), Toyo Keizai Shimposha

・Edward Lazear (1995) *Personnel Economics*, MIT Press, Cambridge, Massachusetts

・Murnane, Richard and Frank Levy (2004) *The New Division of Labor: How Computers Are Creating the Next Job Market*, Princeton University Press, Princeton, New Jersey

・Rosenbaum, Paul, R. (1984) "The consequences of adjustment for a concomitant variable that has been affected by the treatment," *Journal of the Royal Statistical Society*, Ser. A (General), Vol. 147, no.5, pp. 656–666

・Zuboff, Shoshana (1988) *In The Age of the Smart Machine: The Future of Work and Power*, Basic Books, New York

Table 1: Descriptive statistics

	Introducing IT-MIS		
	No	**Yes**	**Total**
Portion of contingent workers at workshop			
No contingent worker	11.07	8.87	9.70
A few contingent workers	41.94	42.95	42.57
Half of the workers are contingent workers	27.81	29.64	28.95
Majority of the workers are contingent workers	18.83	18.12	18.39
All the workers are contingent workers	0.35	0.42	0.39
Degree of task-allocation to contingent workers			
Most of tasks done by regular workers	17.79	14.58	15.79
Contingent workers do repetitive tasks, while regular workers do difficult ones	32.00	30.06	30.79
Contingent workers do repetitive tasks and a part of difficult tasks, while Regular workers do most of difficult tasks and a part of repetitive tasks	43.94	47.02	45.86
Most of tasks done by contingent workers	6.28	8.35	7.57
Degree of task-commitment by contingent workers			
Finding poor product quality	0.59	0.59	0.59
Trouble-shooting poor product quality	0.11	0.13	0.12
Equipment inspection	0.39	0.46	0.43
Handling simple equipment troubles	0.40	0.45	0.43
Handling complex equipment troubles	0.07	0.08	0.07
Substituting themselves for absentees	0.60	0.64	0.63
Educating and training new employees	0.28	0.30	0.29
Setup change in introducing new products	0.47	0.49	0.48
Revising job or task standard manuals	0.04	0.06	0.05
<Change in productivity indicators>			
Degree of quality improvement since around 2000			
Got worse	8.37	6.44	7.17
Changed little	29.03	20.07	23.45
Improved	51.35	57.11	54.93
Significantly improved	11.25	16.38	14.44
Degree of Cost improvement since around 2000			
Got worse	5.23	4.01	4.47
Changed little	27.90	19.44	22.63
Improved	53.62	54.73	54.31
Significantly improved	13.25	21.82	18.59
Degree of Improvement in lead time since around 2000			
Got worse	5.38	3.97	4.50
Changed little	27.92	19.57	22.74
Improved	53.37	54.70	54.20
Significantly improved	13.32	21.76	18.56
Degree of Improvement in WIP since around 2000			
Got worse	6.10	6.60	6.41
Changed little	34.26	23.09	27.30
Improved	46.82	51.24	49.57
Significantly improved	12.82	19.07	16.71
Effect of IT-MIS introduction			
Schedule (progress) management becoming easier	-	0.52	-
QC (quality control)/QA(quality assurance) becoming easier	-	0.34	-

Changes in characteristics of products			
Increasing specifications and variation in products	72.0	77.76	75.59
Increasing sophistication and complication in functions	65.74	77.71	73.19
Increasing number of embedded parts for assembling	33.13	42.05	38.68
Increasing difficulty in testing	60.24	68.15	65.16
Shortening product life cycles	35.05	45.80	41.74
Degree of information sharing at workshops			
Involving contingent workers at study meetings	39.61	78.13	74.80
Sharing information with design and fabrication engineers	9.68	12.63	11.51
Characteristics of supervisors and workshops			
Age of supervisor			
-24 years of age	0.35	0.42	0.39
25-29	2.09	2.32	2.24
30-34	14.30	13.42	13.75
35-39	22.84	24.78	24.05
40-49	44.55	44.80	44.70
50-	15.87	14.26	14.87
Average Tenure of supervisors (unit: years)	21.95	21.72	21.81
(Standard Deviation)	(7.52)	(7.39)	(7.43)
Ratio of bachelor or higher degree holders	6.71	3.54	4.74
Degree of playing-manager	65.74	66.40	66.15
Prospect for positive long-term demand	38.27	40.10	39.41
Types of workshops			
Machining (or processing)	24.06	24.35	24.43
Assembling	38.10	35.87	36.71
Testing or QC/QA	10.37	12.10	11.51
Equipment operation	6.36	8.40	7.63
Others	21.10	19.18	19.90
Belonging Industry			
Heavy electric machinery	8.98	4.97	6.48
Home appliances	13.08	15.06	14.31
Telecommunication equipment	11.77	11.62	11.68
Electronic parts	32.00	39.09	36.41
Controllers	4.18	4.23	4.21
Batteries	1.74	2.32	2.11
Auto-parts	6.02	5.86	5.92
Other electrical equipment	22.23	16.85	18.88
Number of observations	1147	1893	3040
	37.73%	62.27%	

Table 2 Determinant factor for the use of contingent workers, Estimates based on ordered Probit analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Contingent worker ratio 5: All the workers are contingent workers 4:Majority of the workers are contingent workers 3: Half of the workers are contingent workers 2: A few contingent workers at workshop 1: No contingent worker at workshop				Degree of task-commitment of contingent workers 4: Most tasks are done by contingent workers 3:Contingent workers do a part of difficult as well as repetitive tasks, while regular workers do difficult as well as a part of repetitive tasks 2: Contingent workers mostly do repetitive tasks, while regular workers do difficult tasks 1: Regular workers do most of tasks			
Introducing IT-MIS	0.04	0.01	0.01	0.01	0.13	0.11	0.12	0.12
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Increasing products variety	-	0.23	0.16	0.17	-	0.19	0.16	0.16
		(0.05)	(0.05)	(0.05)		(0.05)	(0.05)	(0.05)
Increasing complexity in fabrication processes	-	0.10	0.08	0.07	-	0.10	0.09	0.08
		(0.05)	(0.05)	(0.05)		(0.05)	(0.05)	(0.05)
Shortening product cycles	-	0.11	0.10	0.08	-	0.03	0.02	0.01
		(0.04)	(0.04)	(0.04)		(0.04)	(0.04)	(0.04)
Increasing numbers of embedded parts for assembling	-	-0.07	-0.06	-0.03	-	-0.04	-0.04	-0.01
		(0.05)	(0.05)	(0.05)		(0.05)	(0.05)	(0.05)
Advancing product-testing methods	-	-0.03	-0.02	0.01	-	-0.02	-0.02	0.00
		(0.04)	(0.04)	(0.04)		(0.04)	(0.04)	(0.04)
Tenure	-	-	-0.01	-0.01	-	-	-0.01	-0.01
			(0.00)	(0.00)			(0.00)	(0.00)
Ration of bachelor or higher degree holders	-	-	-0.03	0.06	-	-	0.05	0.11
			(0.09)	(0.09)			(0.09)	(0.10)
Degree of playing-manager	-	-	0.28	0.23	-	-	0.22	0.16
			(0.04)	(0.04)			(0.04)	(0.04)
Prospect for positive long-term demand	-	-	0.30	0.34	-	-	0.12	0.14
			(0.04)	(0.04)			(0.04)	(0.04)
Including workshop-type dummy?	No	No	No	Yes	No	No	No	Yes
Including Industry dummy ?	No	No	No	Yes	No	No	No	Yes
Number of observations	3040	3040	3040	3040	3040	3040	3040	3040
Log likelihood	-3896.88	-3870.68	-3812.09	-3731.74	-3663.73	-3649.34	-3628.86	-3579.68

Note: Numbers in parentheses are standard deviations.

Table 3 Determinant factors for the use of contingent workers by type of task

Dependent variable is a dummy variable whose value is equal to 1 when contingent workers are involved in each task; Probit estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Finding poor product quality	Trouble-Shooting poor product quality	Equipment inspection	Handling simple equipment troubles	Handling complicated equipment troubles	Substitution for absentees	Educating and training new employees	Setup change in introducing new products	Revising job or task standard manuals
Introducing IT-MIS	-0.00	0.02	0.06	0.04	0.01	0.04	0.00	0.01	0.02
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Increasing products variety	0.08	0.01	0.03	0.08	0.02	0.07	0.01	0.10	0.01
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Increasing complexity in fabrication processes	0.00	0.01	0.03	0.03	0.01	0.02	0.06	0.04	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Increasing numbers of embedded parts for assembling	-0.05	0.02	-0.05	-0.04	0.00	-0.03	-0.00	-0.02	0.02
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Advancing product-testing methods	0.01	-0.01	0.03	0.01	-0.00	-0.03	-0.01	-0.01	-0.02
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Shortening product life cycles	-0.03	0.03	0.02	0.03	0.00	-0.01	0.03	-0.04	0.01
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Tenure	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ratio of bachelor or higher degree holders	0.04	0.07	-0.01	0.02	0.03	0.10	0.06	0.10	0.09
	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)
Degree of playing-manager	0.07	0.00	0.05	0.04	0.01	0.06	0.05	0.10	0.02
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Prospect for positive long-term demand	0.09	0.01	0.08	0.06	0.01	0.07	0.04	0.06	-0.01
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Number of observations	3040	3040	3040	3040	3040	3040	3040	3040	3040
Log likelihood	-1976.41	-1076.88	-2014.51	-2019.78	-780.56	-1949.32	-1778.95	-2039.00	-610.88

Note: The coefficients are marginal effects. Numbers in parentheses are standard deviations. The estimation includes the types of workshops and industry dummies, but the coefficients are not reported.

Table 4 Introduction of MES and change in productivity: Ordered Probit estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Quality improvement 1: Got worse 2: Changed little 3: Improved 4: Significantly improved		Cost improvement 1: Got worse 2: Changed little 3: Improved 4: Significantly improved		Lead time improvement 1: Got worse 2: Changed little 3: Improved 4: Significantly improved		WIP improvement 1: Got worse 2: Changed little 3: Improved 4: Significantly improved	
Introducing IT-MIS	0.25	0.22	0.23	0.19	0.29	0.25	0.22	0.20
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Increasing products variety	-	-0.01	-	0.03	-	0.11	-	-0.02
		(0.05)		(0.05)		(0.05)		(0.05)
Increasing complexity in fabrication processes	-	0.10	-	0.15	-	0.14	-	0.04
		(0.05)		(0.05)		(0.05)		(0.05)
Increasing numbers of embedded parts for assembling	-	0.01	-	-0.03	-	-0.00	-	0.02
		(0.05)		(0.05)		(0.05)		(0.04)
Advancing product-testing methods	-	-0.08	-	-0.14	-	-0.18	-	-0.15
		(0.05)		(0.05)		(0.05)		(0.05)
Shortening product life cycles	-	0.12	-	0.15	-	0.17	-	0.11
		(0.04)		(0.04)		(0.04)		(0.04)
Tenure	-	0.00	-	0.00	-	0.00	-	0.01
		(0.00)		(0.00)		(0.00)		(0.00)
Ratio of bachelor or higher degree holders	-	0.06	-	-0.05	-	-0.00	-	0.00
		(0.10)		(0.10)		(0.10)		(0.09)
Degree of playing-manager	-	0.03	-	0.08	-	0.15	-	0.15
		(0.04)		(0.04)		(0.04)		(0.04)
Prospect for positive long-term demand	-	-0.02	-	0.14	-	-0.06	-	-0.05
		(0.04)		(0.04)		(0.04)		(0.04)
Number of observations	3040	3040	3040	3040	3040	3040	3040	3040
Log likelihood	-3439.15	-3404.48	-3316.31	-3265.07	-3379.11	-3315.21	-3564.05	-3515.82

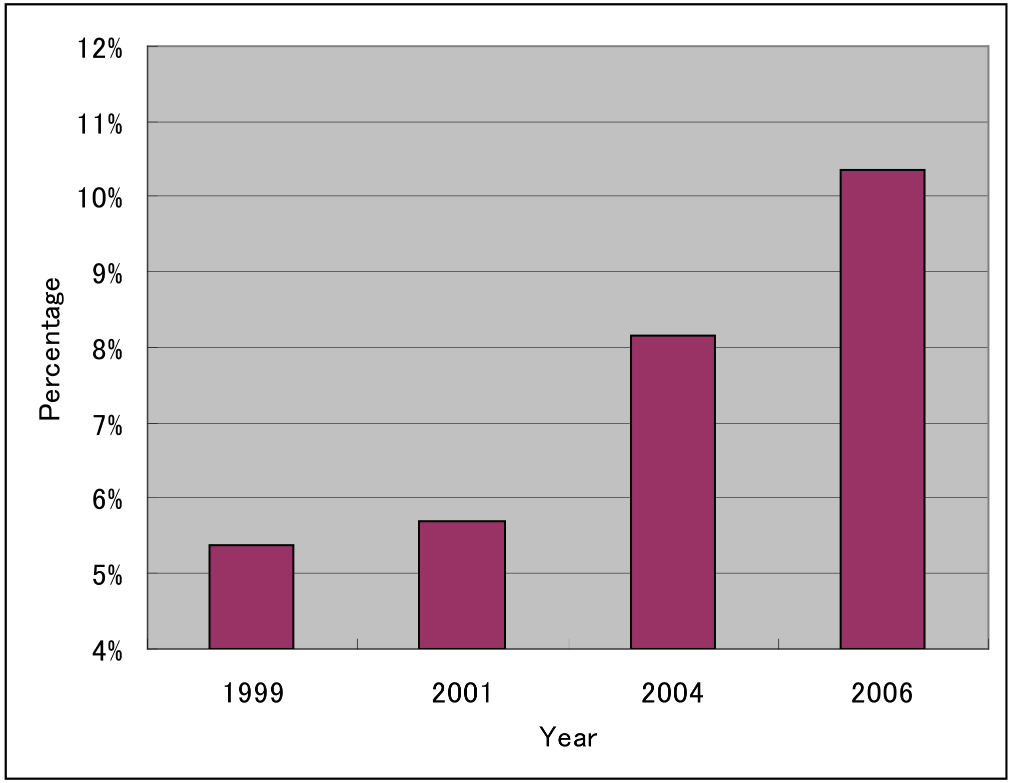
Note: The coefficients are marginal effects. Numbers in parentheses are standard deviations. The estimation includes types of workshops and industry dummies, but the coefficients are not reported.

Table 5 Determinant factors for success after the introduction of IT-MIS: Probit estimates

	(1)	(2)	(3)	(4)
Dependent variable	1: Schedule management improved 0: No change or got worse		1: QC/QA management improved 0: No change or got worse	
Study meetings with contingent workers	0.05	0.05	0.08	0.08
	(0.03)	(0.03)	(0.03)	(0.03)
Information sharing with design and fabrication engineers	0.12	0.12	0.14	0.14
	(0.03)	(0.03)	(0.04)	(0.04)
Increasing kinds of products	-	-0.01	-	0.01
		(0.03)		(0.03)
Increasing complexity in fabrication processes	-	0.11	-	0.06
		(0.03)		(0.03)
Shortening product life cycles	-	-0.02	-	0.03
		(0.03)		(0.02)
Increasing numbers of embedded parts for assembling	-	-0.04	-	-0.06
		(0.03)		(0.03)
Advancing product-testing methods	-	0.02	-	0.06
		(0.02)		(0.02)
Tenure	-	0.00	-	0.00
		(0.00)		(0.00)
Ratio of bachelor or higher degree holders	-	0.01	-	0.04
		(0.06)		(0.06)
Degree of playing-manager	-	0.00	-	-0.05
		(0.03)		(0.02)
Prospect for positive long-term demand	-	0.01	-	-0.03
		(0.02)		(0.02)
Number of observations	1893	1893	1893	1893
Log likelihood	-1302.62	-1268.03	-1147.97	-1147.97

Note: The coefficients are marginal effects. Numbers in parentheses are standard deviations. The estimation includes types of workshops and industry dummies, but the coefficients are not reported.

Figure 1: Percentage of Contingent Workers in Manufacturing



Source: Authors' calculation based on Survey of Establishment and Firm Survey, Private Establishments, Manufacturing Sector (F), Percentage of Dispatched and Contract Workers among All Workers.