

**The technological progress and the transformation
of labor organization:
Modernization of Japanese coal mining
from the 1900s to the 1930s**

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Abstract

This paper focuses on the interaction between the changes in production technology and the transformation of labor organization in the coal mining. Along with the introduction of modern technology, the Japanese coal mining experienced drastic changes both in the labor organization and the labor market. Coal mining firms moved from indirect employment to direct employment and built up the internal labor market in which investment in human capital was conducted by each firm, as new skills were required for handling machines newly introduced. At the same time, when traditional skills being less useful, intermediary bodies that had supplied workers with firms disappeared and firms directly came in the labor market to hire freshmen.

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Introduction

Transition of labor organization from the one that had kept autonomy within the firm to the one that was directly controlled by the firm has attracted attentions of many scholars in history and economics. Many interesting and drastic changes in incentive mechanisms occurred along with technological changes. Mining industry, coal mining industry in particular, is a good case to inquire this issue, since it had a long history as a traditional industry and developed rapidly as a modern industry during industrialization. In the same firm of the same industry, phenomenal transformation of organization has been observed. This paper studies an organizational changes in coal mining industry in the Chikuho district, Kyusyu, a southern island of Japan from the 1900s to the 1930s, when rapid modernization progressed there. Section 1 summarizes a theoretical viewpoint on which this paper stands on, section 2 focuses on organizational changes within mining firms and institutional changes in the labor market, and section 3 deals with formation of the internal labor market in Japanese coal mining industry.

1. The transformation of labor organization in the Japanese coal mining

1.1 Two types of problem from the asymmetric information

Coal mining firm could not observe miners' skill and behavior, especially when its operation depended on manual skill (traditional skill). There existed two types of problem from asymmetric information between the firm and miners.

1.1.1 Moral hazard

The firm could not observe what miners did inside of coal mine. Even if a miner lied about his/her effort to the firm, it could not judge whether it was true or not. Hence it could not know how to provide incentives. This, moral hazard was provoked by asymmetric information between the firm and miners about miners' action after entering the employment contract.

1.1.2 Adverse selection

Especially when operation of coal mining depended on manual skill, the firm could not evaluate the skill. It could not decide what kind of person suited the job. This, adverse selection was provoked by asymmetric information between the firm and miners about miners' skill or type before entering the employment contract.

1.2 Indirect control of labor organization under asymmetric information problems

This section focuses on the level of asymmetric information and its effect on the labor organization. There were four stages in the transition of labor organization.

1.2.1 Naya system

When both moral hazard and adverse selection was serious, both recruitment and monitoring were fully delegated to inside contract system (naya system) by the firm. Naya originally meant barns or small houses for miners and inside contract system in coal mining was called the naya system. A naya organization consisted of a head and some units of miners. The head of naya was delegated by the firm to recruit miners, to motivate them to work, and also to care about miners' daily living conditions. He received payment by taking responsibility of such things on behalf of the firm. He received wages of all miners in his naya in a lump. He handed exact amount of wage to each miner determined by him. There was a difference between the amount he received from the firm and the amount he paid out to miners as wage. This difference belonged to him. That was the primary portion of his information rent acquired by dealing with asymmetric information and calming adverse selection and moral hazard problems. This is an economic interpretation of "pocketing" miners' wage.

1.2.2 Sewagata system

When only adverse selection existed, the firm took sewagata system. As mining machines were introduced by the firm, it could observe how many workers were necessary in order to mine a certain amount of coal. The introduction of a coal cutter affected miners' daily operation, and this was important part that determined their wage. The firm now understood how to give incentives to miners through wage setting. That is, moral hazard was eased. The labor organization was transformed to the next stage, indirect monitoring with direct employment, called sewagata system. A sewagata conducted the half portion of the head of naya's work. We could regard this was just a change of the name. However sewagata kept out of handling miners' wage at all. Other works, typically recruiting, were still delegated to sewagata by the firm.

1.2.3 Directly managed naya

This case was observed in the early 1900s. We closely look at this in chapter 2. Neither adverse selection nor moral hazard had really been solved, but the firm tried to work on the adverse selection problem.

As already mentioned, a naya generally took dual structure: naya as a whole and small units belonging to the naya, each of which unit was composed of a leader and several miners. The firm tried to directly control the leaders of small units, not through the head of naya. This simplified the inside contract system with directly controlling small units. Daily operations were carried on by miners belonged to units. The firm had used to pay information rent to the heads of naya. Then he paid information rent to the leaders of units. Both information rents were incurred by the firm as a

whole. The firm tried to save double information rent by skipping the head of naya and directly hiring leaders of small units.

This organizational change was not directly related to technological change at mining process, while it seemed that mechanization at bord transportation improved information observed by the firm. The firm still did not observe inside of its coal mine. After this organizational change, it skipped the head of naya but still delegated the leaders of units to give incentives to miners. This stage was achieved probably because the firm tried to put the traditional skill under internal control and it realized naya's dual structure was not necessary. It began to directly hire the leaders of small units of a naya.

1.2.4 Direct labor organization

When both problems were considerably eased, the firm chose perfectly direct labor organization. After introduction of mining machines, the firm could know the needed skill and it could recruit appropriate workers. Thus it did not need to delegate anything to inside contract system any more. It only had to train miners to be able to use machines. It did not have to care about workers' ex-job. It abolished inside contract system (naya system) and the services that had been carried on by the heads of naya now turned to be handled by members of the firm's administrative staff.

2 The beginning of transformation: A case of Aso Coal mining Co. in the 1900s.

Aso Coal Mining Co. was one of the largest local companies in the Chikuho district. Aso Co. purchased the Second Fujidana Coal Mine from a local merchant in 1902 and it to Mitsui Coal Mining Co. in 1907.

2.1 Recruitment by the Second Fujidana Coal Mine

The Second Fujidana Coal Mine still mainly depended on naya system, but partly adopted kind of intermediate labor organization in which employment was direct but monitoring was indirect. Aso Co. seemed to be in transition from inside contract system to fully direct labor organization. In the early 1900s, it had not introduced longwall mining method and neither mining machines yet. Hence the role of the heads of naya was still critical in the process of mining. At the same time Aso Co. introduced a new intermediate organization that was still a part of inside contract system. So a question comes into our mind, that is, how Aso Co. tried to ease the asymmetric information between workers and the firm without introduction of new mining method and mining machines.

There are some historical documents that help us approach the question. The most useful on is applications of miners for this coal mine. The applications contained applicant's name, his/her date of birth, previous job, date of application, and name of his/her guarantor. The guarantor was the head

of naya, the leader of smaller miners' group, or a member of administrative staff of human resources.

2.2 Structure of the labor market seen on the applications

Applications of 776 miners have been preserved for the period from 1902 to 1907. Male applicants were 590 and female applicants were 186. Among male applicants, 193 people applied with their family members; his wife, son, daughter, brother, or mother. The regional distribution of their origins is seen on the Table 1.

Table 1		Home addresses of miners	
		Fukuoka	272
		Saga	37
		Oita	83
Kyushu		Kumamoto	57
		Nagasaki	16
		Miyazaki	7
		Kagoshima	6
		Hiroshima	90
		Shimane	32
Chugoku		Yamaguchi	31
		Okayama	13
		Tottori	6
		Ehime	72
Shikoku		Kagawa	22
		Tokushima	8
		Kochi	6
		Hyogo	7
Kinki		Osaka	4
		Wakayama	3
		Nara	2
Total			774

(From 1902 to 1907)

The number of guarantor was 87. This coal mine began to partly adopt the direct employment, while labor organization after employment was completely indirect. The feature of guarantees and the number of guarantees for a month depended on each guarantor.

On some applications, there were applicants' thumbprints under their name. On some other applications, applicants put their seal on it. This difference indicates that some skilled miners had moved among coal mines. They wanted to have their own seals as their identification.

There are five overlapping applicants' names on a few applications. Generally the duration between the first application and the second one was short. The guarantors of three of the five were different on the first time and the second time. It is doubtful whether these persons had applied really

two times. The guarantor might make a false report about that application in order to acquire the reward of recruiting (information rent about miners' skill) on each appearance. Even if those were not false reports, it indicates that the firm had only roughly checked them.

2.3 Reduced complexity of the inside contract system

On these applications, there were some cases of special applicants. Two applicants seemed to form a small miners' group and they were leader of them. One is Torataro Hirata. He applied in February 7th, 1907 with five relatives and four other people. He was 28 years old then. He guaranteed nine applicants including his five relatives and himself. Guaranteeing himself seems interesting and we could infer that. Guaranteeing himself meant he applied without being guaranteed by anybody. Hence it seems that he was directly employed by Aso Co. Furthermore after the application he became the guarantor of three applicants who operated a winch, and they were from the same village as his.

The other was Fukataro Iwamoto. He applied in July 3rd, 1905 with six applicants, and all of them were from the same village, which had a big coal mine. Except his own application, the name Iwamoto was written on each application of other applicants. It shows that he was the leader and as well as he himself was a skilled miner.

Some applicants guaranteed other applicants after they were hired. This indicates they were promoted and probably within direct labor organization.

In the dual structure of naya system, these two miners were leader of the units. Aso Co. tried to simplify the naya organization by directly hiring them, not through the head of naya. Now Aso Co. directly enter employment contract with these leaders of units and these leaders brought and led miners in their units.

3 The intellectual skill and the internal labor market

3.1 Change of mining method and its impact on productivity

In the coal mining, progresses for the most important modernization were mechanization at bord transportation and at mining process and the change of mining method. Mechanization at bord transportation was finished by 1900 at almost all coal mines in Chikuho district. About the change of mining method, room and pillar mining method was gradually replaced with longwall mining method in the 1900s. Efforts of mechanization of mining process began after Russo-Japanese War, and more coal mining firms started to try mechanization of mining process after WWI. And the mining machines prevailed in the late of 1920s. The firm aimed to achieve greater efficiency of

mining by this development.¹ The development proceeded only gradually, depending on the specific feature of veins of each mine.

In room and pillar mining method, operations were decentralized. In other words, a coal mine was run under inside contract between the firm and the naya. Then the head of naya delegated real operation to several units, each of which consisted of a few miners. Each skilled miner was engaged in mining at the face that was allotted to him and almost independent. While in longwall mining method small faces were consolidated to long ones at which several miners worked on mining together, mining, loading, attaching pillars and filling sand and rock after mining were systematically divided. The introduction of longwall mining method also created a condition favoring mechanization of mining process because extended face meant reduced marginal cost of mechanized mining, given that fixed cost of mining machine was generally high².

Furthermore we look at both mining method from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)* (Osaka employment agency (1926)).

In room and pillar mining, at a coal seam whose roof was hard, miners horizontally mined coal along the seam leaving some pillars of coal in order to prevent the roof from falling down. When the coal seam existed not so deep, the cost of maintenance of bords was small and it was relatively easy to adjust the amount of output as to changes of market price. On the other hand, when the coal seam existed deep, it was difficult to maintain the bord. The pillars were always pressured by the roof and it could result in coal pillar being heated up and igniting by being squeezed down. If coal pillars were mined (that were left deliberately for safety.), it was likely for fall of ground to occur. So it was necessary to deliberately adjust the number of coal pillars for ensuring security.³

Next, we look at longwall mining method. Miners placed a lot of faces (the point where people mine coal) at a coal seam. And after coal was mined, the faces were filled up with sands and rocks. Using this method, large amount of coal could be mined at one time. Unlike room and pillar mining method, it was well-ventilated inside of coal mine. They usually did not leave coal so that it less happened for coal to fire spontaneously, for gas to be produced, and for dust explosion to be occurred. Above all things, it was suitable for using mining machines. In this method, however, there were a few faults. Only skilled workers could achieve high performance. Filling up faces with sand and rock required plenty of sand and rock and a lot of time and effort. Once they started to mine, it was not easy to intermit mining as to changes of price. When gas was spouted at a face, it got spread around the face.⁴

¹ Ogino (1993), pp. 19, 262.

² Sumiya (1968), p. 386.

³ Morimoto (2008), p. 10. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, pp. 16-17.

⁴ Morimoto (2008), p. 11. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, pp. 15-16.

Document 1⁵

At that time⁶ room and pillar mining method was dominant in the Chikuho district. Each coal mine had fine and also thick coal seam like coal mine as in Hokkaido these days. Hence a firm could not make a quick decision which seam was going to be mined first, and the coal seam that was finest and whose roof was the robustest was mined. Workers mined coal with leaving pillars of coal, so they did not need to put wooden poles and pay so much attention about collapsing. But it had to be careful that the coal pillars were not mined. Thus they painted pillars calcimine, which was white, to prevent coal pillars from being mined. If a miner had coal attached with that white, in even the slightest, the head of naya would take all of his/her payment and he/she would be hit by the head and driven out of the coal mine. But even in those days, at older coal mines, they started to get coal from the pillars. When it was performed, the roof was collapsed. The number of injured person was getting larger and attaching wooden pole found a lot of trouble. And some people insisted that it would be better off mining widely without leaving coal pillars, that is, taking longwall mining method which was adopted in foreign countries.

This referred to risk management and incentive control in room and pillar mining method.

Document 2⁷

Although male and female workers enter the mine with their clothes on, they almost stripped down once they started their work. Men were naked except of their loincloths, and women were also naked except of their waistcloths... It is not hard to imagine what happened between men and women in a dark and wide bord when they dressed such as that. These inappropriate relationships between male and female workers were also raised by the mining method. In pillar and bord mining method that ware then prevailed, female swamper met male workers and sometimes had relationships with them when they carried mined coal for a little long distance... In long wall mining method recently introduced, the moral order has been improved by the facility under which more workers work at the same face and coal wagons are parked near the face.

This referred to the effect on monitoring by adopting longwall mining method. By adopting that

⁵ Morimoto (2008), p. 12. Originally from Shintaro Ishiwata, *Chikuho Sekitan Kougyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no.292, 1928, pp. 7-9.

⁶ It meant 1903.

⁷ Morimoto (2008), p.13. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, p. 76.

method, the number of workers at one face became larger than before, so that adultery which had been committed in the period of room and pillar mining method never happened any more. It indicated that monitoring by the firm had been improved. And it also implied that “underground” culture of miners got disappeared.

3.2 Enhanced productivity with modernization

3.2.1 Result of technological change

Table 2 Technology and productivity of coal mines in the Chkuho district, comparison between 1903 and 1927.

year	1903	1927	notes
Output of coal (tons)	5,500,000	14,550,000	
Mining method	Bord and pillar method	Longwall method	Some coal mines already adopted longwall method in 1903. In 1927, more coal mines were on the way to introduce mining machines.
Blasting operation	Gelignite (blasting gelatin) against hard rocks. Black powder against faces.	Various blasts either imported or made in Japan against rocks. Dynamite against faces.	Jackhammers were used in many coal mines in 1927.
Output per miner at face	20.0 tons per month	22.5 tons per month	For some coal mines, the number of miners, the denominator, includes miners who attached poles and operators of jackhammers.
Output per miner (all miners)	10.0 tons per month	12.0 tons per month	The denominator is the total number of all miners including miners who attached poles, operators of jackhammers, and were engaged in other tasks.
Average wage of miner at face	50-55 sens per day	200 sens per day	
Average wage of all miners	35-40 sens per day	150 sens per day	
Price of 1.8 liter of rice at coal mine	15 sens	34 sens	
Incentive wage per 1 ton of coal output	60 sens	150 sens	

Source: Shintaro Ishiwatari, "Chikuho sekitan kogyo no shorai ni tsuite (On the future of the coal mining industry in the Chikuho district)," *Chikuho sekitan kogyo kumiai geppo (Monthly report of the Chikuho Coal Mining Association)*, no. 292, 1928, pp. 11-13.

3.2.2 Quantitative analysis of labor input

Using *Chikuho Sekitan Kougyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association.)*, we analyze the relation between the quantity of labor input by department and coal output and department.⁸

⁸Morimoto (2008), p. 15. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, pp. 29-33, 45.

Define relevant variable as follows. Y : total amount of output in the month, X_1 : the number of miners consisted of two kind of workers who mined coal and who attached poles, X_2 : the number of workers who operated elevator moved by winch, X_3 : the number of lightmen and carpenters, X_4 : the number of coal cleaners, X_5 : the number of machine operators and electric mechanics, X_6 : the number of factotums.

$$Y = aX_1^{\beta_1}X_2^{\beta_2}X_3^{\beta_3}X_4^{\beta_4}X_5^{\beta_5}X_6^{\beta_6} \quad (0 \leq \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 \leq 1) \quad (1)$$

Some coal mines reported only the total number of two types of miners so that we cannot differentiate these two kinds. Lightmen and carpenters were not directly related with mining but they worked inside of coal mine, so we define the X_3 is the sum of them. Both machine operators and mechanics were involved in operations and maintenance, so we define the X_5 is the sum of them.

Taking logarithm natural number of the equation (1),

$$\ln Y = \ln a + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 \quad (2)$$

When we focus only on workers of inside of coal mines, (3)

$$\ln Y = \ln a + B \quad (3)$$

As primary analysis we exercise OLS on the equations (2) and (3) by data of *Chikuho Sekitan Kougyou Kumiai Geppou (Monthly Report of Chikuho Coal Mining Industry Association)*.

First separating labor input inside coal mines from others we have estimation result for 1910 to 1912 and for 1914 to 1915 in Table 3.

Table 3 Output and labor inputs: Worker inside coal mines, 1910-1912, 1914-1915.

Dependent variable: Coal production.				
Number of observations	669			
Degree of freedom	665			
R^2	0.907			
adjusted R^2	0.906			
Independent variable	coefficient	standard error	t value	p value
constant	3.471	0.120	28.811**	0.000
X_1 : Miners	0.713	0.034	21.209**	0.000
X_2 : Elevator	0.141	0.032	4.399**	0.000
X_3 : Lightmen	0.176	0.035	4.983**	0.000

Note: **: Significant at 1 percent.

Next we have the same estimation for 1925 to 1929 in Table 4.

Table 4 Output and labor inputs: Workers inside coal mines, 1925-1929.

Dependent variable: Coal production.				
Number of observations	855			
Degree of freedom	851			
R^2	0.935			
adjusted R^2	0.935			
Independent variable	coefficient	standard error	t value	p value
constant	3.822	0.108	35.547**	0.000
X_1 : Miners	0.589	0.030	19.501**	0.000
X_2 : Elevator	0.292	0.025	11.462**	0.000
X_3 : Lightme	0.134	0.025	5.278**	0.000

Note : ** : Significant at 1 percent.

Then using all series of labor input for 1910 to 1912 and 1914 to 1915, we have estimation result in Table 5.

Table 5 Output and labor inputs: All workers, 1910-1912, 1914-1915.

Dependent variable: Coal production.				
Number of observations	689			
Degree of freedom	680			
R^2	0.920			
adjusted R^2	0.920			
Independent variable	coefficient	standard error	t value	p value
constant	3.586	0.114	31.495**	0.000
X_1 : Miners	0.608	0.034	17.946**	0.000
X_2 : Elevator	0.081	0.031	2.647**	0.008
X_3 : Lightme	-0.020	0.039	-0.511	0.609
X_4 : Coal cle	0.102	0.023	4.357**	0.000
X_5 : Machine	0.190	0.022	8.686**	0.000
X_6 : Factotum	0.057	0.021	2.799**	0.005

Note : ** : Significant at 1 percent.

Then we have the same estimation for 1925 to 1929 in Table 6.

Table 6 Output and labor inputs: All workers, 1925-1929.

Dependent variable: Coal production.				
Number of observations	0.961			
Degree of freedom	0.961			
R^2	855			
adjusted R^2	848			
Independent variable	coefficient	standard error	t value	p value
constant	4.665	0.119	39.115**	0.000
X_1 : Miners	0.205	0.033	6.152**	0.000
X_2 : Elevator	0.179	0.020	8.822**	0.000
X_3 : Lightmen	0.062	0.020	3.133**	0.002
X_4 : Coal cle	0.209	0.015	13.532**	0.000
X_5 : Machine	0.166	0.025	6.611**	0.000
X_6 : Factotum	0.167	0.015	11.298**	0.000

Note: **: Significant at 1 percent.

On Table 3, all coefficients are statistically significant. The coefficient of X_1 (miners) is the largest, which shows that input of miners had a large impact on output. On Table 4, also all coefficients are statistically significant. The coefficient of X_1 is again the largest, which shows that input of miners had a large impact. Then comparing coefficients of Tables 3 and 4, it is seen that the coefficient of X_1 on Table 4 is a little bit smaller than on Table 3 and that the coefficient of X_3 (elevator operators) is twice larger than on Table 3. These differences in coefficients of X_1 and X_3 seem to show that mining process was a kind of bottleneck in the 1910s.⁹ That is, in the 1910s, while winches were already adopted, mining machines were not yet. So the high productivity of transportation in coal mine was not fully performed because of mining process that still depended on manual labor. However in the late 1920s, mining machines were adopted major coal mines that enabled already mechanized transportation system to fully perform.

3.3 Modernization and incentives for intellectual skill formation

3.3.1 Internalization of skill formation

In the period of when workers manually mined coal, the productivity strongly depended on their

⁹ Sumiya(1968), pp. 311-312.

traditional skill. That has been often referred to by the literature. As the skill was commonly useful, turnover of miners was very rapid with little thought of specific feature of each coal mine. After introduction of mining machine such as a coal cutter, how were characteristics of skill transformed?

Document 3¹⁰ “Survey of coal mines: The Third Mine of Mitsui Tagawa Coal Mine, comments by Nakane, the engineering manager.”

As coal mining companies have made effort for increase of productivity these days, what most of them are really doing is to consolidate faces, to introduce machines as possible, to cut workforce, and thus to mechanize coal mining. The more machines are used, the more serious effect on output of coal a breakdown of a machine could have, and hence whether members of staff and miners are skilled or not has become an important issue. In particular, such as recently when workforce is extremely cut, frequent absence of skilled workers immediately affects output of coal. It is critical to fill vacant positions and improve their skill, and the firm would face a serious decrease of output otherwise. Therefore our mine has three 60-hour courses of training programs for security of mine, electricity, and mechanics, and has a special training program for 90 days to foster operators of coal cutter, in which trainees practice operation of coal cutter and rock drill and study basic electricity and mechanics. Our mine also hire young workers who are expected to be trained as mechanics. It takes considerable time to train miners to be skilled, and it takes even a few years to foster a member of staff at some departments. Because ordinary workers often leave to other companies, it is more difficult to improve their skill than expected. Probably as many other companies find, even at a time such as now when unemployment rate is high, it is hard to hire workers of good quality, which looks like a little paradox.

First of all, the skill of operating machines was very important. Absence of skilled miners had seriously negative effects on performance. If the firm could not improve skill formation which was newly required with modernization and recruit promising miners, it would have difficulty in its management. Third, the firm conducted training sessions each of which was for 60 hours in a lump about operation safety and handling electricity and machines. It took one month and half to teach the method of operating a coal cutter. It implied that even after introduction of machines skilled workers were still needed. Because it was totally new kind of skill for using totally new machines, it was not traditional one which used to be dominant and was intra-industry. And miners had to be taught that skill in the firm. We could name it intellectual skill. Since it was new, the firm had no alternative but

¹⁰ Morimoto (2008), pp. 31-32. Originally from *Chikuho Sekitan Kogyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no.305, 1929, pp. 61-62.

to train miners. The firm fostered mechanics from youth. This indicated that the firm often hired inexperienced applicants who were expected to serve for long years and tried to invest in their human capital. It took many months for miners to be skilled and a few years to be appointed as a member of staff. That is, the firm had to employ miners over a long period of time and offer a bonus, we look at later, for long continued service in order to form skill and to prevent them from moving to other coal mine. Finally, even though there was excess-supply of labor, appropriate miners were hard to be found, that is, not everyone could become a miner but only a skilled worker could.

Document 4¹¹ “Survey of coal mines: The Third Mine of Mitsui Tagawa Coal Mine, comments by Nakane, the engineering manager.”

It is regretted that there often occur accidents in coal mines. From the beginning of this year our mine has started a program for security and has found a small decrease of minor injury, but not of serious injury, so we think we need to improve methods of operation to systematic ones, but we have not yet reached far in fact. We sometime tend to think keeping security contradicts with earning profit before we really improve security..., but actually security contributes to profit if security is pursued in earnest. I think the way to improve security is to have workers pay attentions, to improve facility, and to train workers to avoid accidents occurred by less informed or less skilled workers. Among these three approaches, while having workers pay attentions might seem to decrease productivity, improvement of facility and training of workers inevitably increase productivity. Hence if you carry out thorough these three, keeping security will be accompanied by boosting productivity.

Nakane stated that thorough safety control had to be carried out for increasing productivity. So that the firm needed to call for workers’ attentiveness, introduce new machines, and keep those machines in good condition. Moreover he mentioned the firm should teach operation of machines to miners and make miners accumulate and enhance knowledge and skill. And he emphasized that both introduction of machines and training miners’ skill were directly linked with not only safety control but also increased productivity.

The “skill” mentioned by Nakane totally different from traditional skill needed before mechanization. Before mechanization, miners pickaxed a face, but that traditional skill of manual labor became useless with mechanization. Different skill to operate machines equipped with the coal mine they worked on became necessary. Furthermore after introduction of longwall mining method and mining machines, all processes of coal mining had been streamlined under the initiative.

¹¹ Morimoto (2008), p. 33. Originally from *Chikuho Sekitan Kogyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no.305, 1929, pp. 61-62.

Operation of each machine had to fit the streamlined system. Hence the new skill was systematic knowledge about operating machines, which can be called an “intellectual skill.” The training program for formation of this new skill had to be instructed by engineers, not by old skilled miners, and basically the knowledge and skill were accumulated within the firm.

Because the firm conducted training sessions and offered a bonus for long continued service, it obviously aimed to employ miners for a long duration and to make them form skill. Conducting training sessions exactly meant forming intellectual skill by the firm’s own expenditure. Investment in human capital inside the firm and a bonus for continued service encouraged formation of intellectual skill. But if some miner was poached by another coal mine after investment in his skill, the firm would lose the cost of investment and it would not be able to get any profit from the investment in human capital. Therefore the firm offered houses and a bonus for continued service in order to prevent miners from being poached.

The firm considered that workers could increase the additional amount of output comparable with the cost of training sessions and bonus for continued service, thus it conducted the training sessions. And in order to keep skilled miners working for its coal mine and not to waste investment in their human capital, it offered a bonus for continued service. On the other hand, for miners, the bonus for continued service had the feature of increasing opportunity cost to leave the coal mine. The skill was formed in this way. The skill might not be necessarily firm specific, but it was intellectual skill formed in the firm. Before introduction of mining machines, manual skill was intra-industry common and also was formed in naya that was outside the firm. The intellectual skill was not that kind of skill and again, it was for operating machines and was fostered in the firm.

Since the skill needed at that period was completely new kind, investment in human capital necessarily had to be made in the firm. Winches and mining machines were new technology which was introduced from the West at that time. Thus the firm needed miners with the new skill who could operate the new machines. On the other hand, the traditional skill gradually became less required. Exactly because this technology was completely new and thus its prevalence still on going, the production system accompanied by the technology had a kind of specificity at the market in the sense that necessary skill for it was not yet priced at the market. This specialized knowledge and skill did not exist at the market, and the firm could not help but foster the skill. Because the skill could not be priced at the market, workers did not have incentives to incur the cost of acquiring the skill and the firm had to do that.¹² As we saw in the **Document 3**, the new kind of skill did not exist at the labor market and it was difficult to find appropriate worker even when unemployment rate was high.

As for miners’ wage, the firm offered miners a little bit higher wages, either as higher basic

¹² Odaka (1984), p. 278.

wage or additionally paid bonuses, than wage in the market. This aimed to prevent them from leaving the firm. The firm tried to weaken their incentives to move to other coal mine. When there did not exist miners with intellectual skill, if the firm offered the same wage as the market, then miners lost their incentives for continued service. If they left the firm, it meant waste of the cost of training session. Furthermore the firm had to train newly hired miners, which was the additional cost it incurred. The firm also had to stay with newly hired workers of low productivity for awhile. As long as workers earned higher wage than wage in the market which worked as incentives for continued service, they continued to serve the same coal mine.¹³ An incentive for continued service was various bonuses in the Chikuho district.

Generally individual firms tried to introduce a new technology little bit faster than other firms did, and to earn excess profits until others caught up with. Whether the firm could have miners acquire the intellectual skill or not were the condition that determined whether the firm could get excess profits or not. Once other firms started to introduce the new technology, the difference between the leader and others would disappear and the leading firm had to concern about its miners being poached by other firms. Therefore we could guess that the intellectual skill had the firm's own specificity. If the firm expected the possibility of poached, it offered the bonus for continued service for long years.

3.3.2 Incentives for intellectual skill formation in the firm

Intellectual skill needed after introduction of mining machines inevitably fostered inside the firm. In order to earn returns on the investment in their human capital, the firm had to employ miners as long as possible. This understanding was commonly shared in the Chikuho Coal Mining Industry Association.¹⁴ But turnover of miners was traditionally very rapid. Thus it was not easy for the firm to make miners settle down one coal mine. Tables 7 and 8 show the employee turnover at Mitsubishi-Namazuta coal mine and Mitsui-yamano coal mine.

¹³ Odaka (1984), pp. 278-279.

¹⁴ Morimoto (2008), p. 35. Originally from Shintaro Ishiwata, *Chikuho Sekitan Kougyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no.268, 1926, p. 26.

Table 7 Yearly turnover of miners at Mitsubishi-Namazuta coal mine, 1915-1919.

Year	Number of miners at the end of June <i>a</i>	Number of Recruitment of the year <i>b</i>	Turnover of the year <i>c</i>	Rate of recruitment $d=b/a$	Rate of turnover $e=c/a$
1915	2,194	3,628	3,741	165%	171%
1916	2,310	5,937	5,486	257%	237%
1917	3,194	5,561	5,226	174%	164%
1918	2,790	5,103	5,051	183%	181%
1919	3,091	4,843	4,940	157%	160%

Source : Ogino (1993), p. 150.

Table 8 Yearly turnover of miners at Mitsubishi-Yamano coal mine, 1914-1920.

Year	Number of miners at the end of the year <i>a</i>	Number of Recruitment of the year <i>b</i>	Turnover of the year <i>c</i>	Rate of recruitment $d=b/a$	Rate of turnover $e=c/a$
1914	199	360	414	180.9	208.0
1915	155	132	176	85.2	113.5
1916	234	515	436	220.1	186.3
1917	288	549	495	190.6	171.9
1918	361	537	424	148.8	117.5
1919	382	724	605	189.5	158.4
1920	400	671	667	197.8	166.8

Source : Ogino (1993), p. 150.

From Tables 7 and 8, the employee turnover was quite rapid in the late 1910s. In 1916, for instance, the turnover rate soared in both Mitsubishi-Namazuta coal mine and Mitsui-Yamano coal mine. Especially in Namazuta, the turnover rate was around two hundred percent in the year. The situation gradually changed since the late 1920s.

Table 9 Turnover of miners in Fukuoka Prefecture.

Year	Number of miners <i>a</i>	Number of Recruitment of the year <i>b</i>	Turnover of the year <i>c</i>	Rate of recruitment $d=b/a$	Rate of turnover $e=c/a$
1925	146,457	132,457	138,417	90.4	94.5
1931	83,486	39,557	56,772	47.4	68.0
1935	97,125	89,240	79,734	91.9	82.1

Source : Ogino (1993), p. 276.

Table 10 is the turnover of whole Fukuoka prefecture. The turnover was still high but went down below one hundred percent. In comparison with the 1910s, we could say that the employee turnover was declining.

Table 10 Monthly turnover of miners at coal mines in the Chikuho district, January to December, 1925.

Month	Number of coal mines surveyed	Number of miners at the end of month <i>a</i>	Number of Recruitment of the month <i>b</i>	Turnover of the month <i>c</i>	Rate of recruitment $d=b/a$	Rate of turnover $e=c/a$
January	121	206,234	12,696	12,309	6.2%	6.0%
February	122	209,544	14,008	12,480	6.7%	6.0%
March	122	212,803	14,763	15,155	6.9%	7.1%
April	122	211,411	13,214	17,606	6.3%	8.3%
May	122	211,615	15,279	15,075	7.2%	7.1%
June	123	210,644	12,396	13,511	5.9%	6.4%
July	124	210,606	13,762	14,076	6.5%	6.7%
August	124	209,044	11,036	12,597	5.3%	6.0%
September	124	208,373	12,472	13,352	6.0%	6.4%
October	123	207,205	13,318	14,486	6.4%	7.0%
November	122	207,251	12,068	12,022	5.8%	5.8%
December	121	207,453	10,131	9,929	4.9%	4.8%
Average	123	208,349	13,179	13,550	6.3%	6.5%
Total			155,143	162,598	74.5%	78.0%

Source: *Chikuho sekitan kogyo kumiai geppo (Monthly report of the Chikuho Coal Mining Association)*, no. 268, 1926, pp. 25-26.

Table 9 shows the monthly employee turnover rate at the Chikuho coal mining in 1925. The employee turnover rate declined compared with the 1910s (Tables 7 and 8). The monthly total number of employed miners was the same as around two hundred ten thousand throughout the year. Recruitment rate and quit rate stayed flat. It indicates that Chikuho coal mining firms had achieved

stable management. In addition, recruitment rate and quit rate did not change either in busy farming season or in slack farming season, by which we can infer the employee turnover was not seasonally affected by the agriculture sector any more. The firm did not depend on slack labor force in the agriculture sector any longer.

Mitsui coal mining Co. particularly succeeded in stabilizing of the workforce in this direction in the Chikuho coal mining industry. Table 11 shows that the number of workers who had served for long years remarkably increased.

Table 11 Length of service of employees at Mitsui coal mines percentage points

	Year	shorter than 1 year	1 to 3 years	3 to 5 years	5 to 11 years	11 to 16 years	longer than 16 years
Miike coal mine	1921	20.6	32.4	18.0	17.5	6.7	4.8
	1926	12.4	27.6	14.7	30.0	8.7	9.1
	1930	17.0	16.0	10.8	28.5	14.8	12.2
	1935	24.9	28.0	4.3	19.9	11.1	11.8
Tagawa coal mine	1921	36.9	29.9	14.1	15.1	2.7	1.3
	1926	20.3	26.9	18.0	23.9	7.4	3.5
	1930	5.5	24.2	17.9	27.6	14.9	9.9
	1935	25.0	24.7	2.4	25.0	10.8	12.7

Ichihara (1997), p. 141.

Table 12 Turnover rate of miners at Mitsui-Tagawa coal mine, 1921-1939.

Year	Number of miners	Rate of recruitment %	Rate of turnover %
1921	10,337	91.9	135.8
1926	7,671	30.8	53.3
1930	4,878	17.6	57.7
1935	5,066	31.9	17.0
1939	10,893	49.4	31.9

Source: Ogino (1993), p. 310.

Table 12 shows the employee turnover rate of Mitsui-Tagawa coal mine. While the number of miners was over one hundred percent in 1921, it decreased in 1926 and since then it continuously decreased. Mitsui-Tagawa coal mine succeeded in decreasing the employee turnover rate (Table 12) and in increasing workers in continuous service (Table 11).

Furthermore Mitsui Coal Mining Co. also led over other companies in formation of intellectual skill. While Tables 9 and 11 shows the employee turnover rate declined in whole Chikuho coal mining industry, not necessarily all coal mines could not move to the same direction with the same

pace. Table 13 shows the distribution of length of service at Mitsui-Tagawa coal mine and Mitsubishi-Shinnyu coal mine in 1925.¹⁵

Table 13 Length of service of miners, surveyed at the end of November, 1925.

	Shorter than 1 year	1 to 3 years	3 to 5 years	5 to 10 years	longer than 10 years	total
Mitsubishi- Shinyu coal mine	2,675 53.9%	1,299 26.2%	383 7.7%	409 8.2%	201 4.0%	4,967 100%
Mitsui- Tagawa coal mine	2,501 27.3%	2,729 29.8%	1,104 12.1%	1,799 19.7%	1,021 11.2%	9,154 100%

Source : Osaka Chiho Shokugyo Shokai Jimukyoku (Osaka Administrative Office of Employment Agency), Chikuho tanzan rodo jijo (The working situation of coal mines in the Chikuho district), 1926, pp. 86-87.

In Mitsui-Tagawa coal mine, miners who had been working for over five years were more than tripled by comparison with Mitsubishi-Shinnyu coal mine. Mitsubishi-Shinnyu coal mine had many miners who had been working less than a year. The proportion of miners who had been working for over five years was very small. Where did the difference come from?

Document 5¹⁶

Among coal mines I visited this time, while Mitsui Tagawa, Akaike, Dainoura take direct control of labor organization, Mitsubishi Shinnyu takes *sewagata* (indirect hiring and direct monitoring), which means it has not yet abandoned the convention of *naya* and still sticks to an intermediate organization.

This shows that Mitsubishi still remained at *sewagata* system that strongly kept indirect labor organization. The feature of this intermediate form was yet to be broken. On the other hand, Mitsui was ahead in transformation to the direct labor organization.

Different duration of continued service between Mitsui and Mitsubishi could be attributed to the difference of labor organization. Direct employment of workers had a complementary effect on

¹⁵ Morimoto (2008), p. 39. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, p. 86.

¹⁶ Morimoto (2008), p. 39. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, p. 21.

formation of intellectual skill. By contrast, the labor organization of Mitsubishi-Shinnyu coal mine still had a feature of *naya* convention and could not achieve long-term employment.

Document 6¹⁷

In general workers serve for longer years at the Tagawa Coal Mine of Mitsui and the Akaike Coal Mine of Meiji because these company offer pension or rewards for continued service. In particular, workers are said to be generally in continuous service at coal mines of Meiji Mining Company.

This document shows Mitsui-Tagawa coal mine offered a bonus for long continued service. In this way firms gave miners incentives for continued service. We could see this tendency also in two following documents.

Document 7¹⁸

The 15th clause: Awards and rewards of workers

Allowance for retirement will be added to the one stipulated by the law, and the perquisite for continued service will be paid to employees who have worked for 25 consecutive years, the perquisite for semi continued service will be paid to employees who have worked for 20 consecutive years, and a silver watch will be given to employees who have worked for 15 consecutive years, and a wooden drinking cup will be given to employees who have worked for 10 consecutive years.

This shows that Mitsui-Tagawa also provided award in accordance with length of service.

Document 8¹⁹ “Survey on coal mines: Akaike Coal Mine of Meiji Mining Co.”

Welfare provisions, (3) Benefit programs.

- a. Healthcare: Employees and their family are privileged to receive medical examination without charge.
- b. Employees are paid bonus, attendant bonus, special bonus and bonus for continued service

¹⁷ Morimoto (2008), p. 40. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, p. 85.

¹⁸ Morimoto (2008), p. 40. Originally from *Chikuho Sekitan Kougyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no. 305, 1929, p. 59.

¹⁹ Morimoto (2008), p. 40. Originally from *Chikuho Sekitan Kougyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no. 304, 1926, p. 66.

twice a year.

c. House and dormitory: 153 houses for administrative staff and 1,360 rooms for employees are provided without charge.

d. Provision of articles for daily use: Shops run by the company sell them at discount prices. Some other shops also designated.

This shows Akaike coal mine offered the bonus for continued service in 1929 and also shows the bonus resulted in continued service as we see on **Document 6**. The *a* stipulated Akaike offered medical examination without charge. This means Akaike coal mine reduced risk with work in the coal mine. Benefit programs referred on *a*, *c* and *d* aimed to encourage miners to have family. Job of miners was hard in the dark. Living with family generally means higher cost of movement that could result in longer service. Dormitories without charge enhanced this effect.

Document 9²⁰ “Survey and interview with the chief: Meiji Mining Company.”

Interview with Mr. Iwanaga, the chief.

Interviewer: How about the turnover?

Iwanaga: It's low recently in particular. The company is proud of the low turnover of miners who generally often move.

Interviewer: What about married miners?

Iwanaga: They amount to one-third of the whole.

Interviewer: How about their attendance compared with unmarried miners?

Iwanaga: Sometime unmarried miners are better, but their attendance is not stable and sometime really bad. In contrast, attendance of married miners is stable on average, and they seem better at last.

Mr. Iwanaga was the chief of Meiji Mining Co. that own Akaike coal mine on **Document 8**. The turnover rate of miners at Meiji Mining Co. was small in 1927. This was a result of offering the bonus for continued service and benefits programs. What is remarkable with **Document 9** is that married miners' attendance was stable. Meiji Mining Co. knew that benefits programs on **Document 8** could make miners serve longer, and it created a favorite environment for having their family. And that led to continued service.

These **Documents 6, 7 and 8** shows that the firm gave miners incentives for continued service.

²⁰ Morimoto (2008), p. 41. Originally from *Chikuho Sekitan Kougyo Kumiai Geppo (Monthly Report of Chikuho Coal Mining Industry Association)*, no. 281, 1927, p. 81.

Document 10²¹

Bonuses include ones for diligence, perfect attendance, attendance, and output. And bonuses to encourage them to serve longer are regularly paid bonus (summer and winter) and bonus for continuous service. Bonuses nominally for diligence or continuous service were originally introduced for recruitment and for increase of productivity, and thus many benefits and bonuses were taken during a boom, but we cannot see any special one except for one to withhold skilled miners from leaving, but it rather means that current bonuses and benefits are well-designed.

This clearly states that a bonus for continued service was “to withhold skilled miners from leaving.” The firm had to keep skilled miners even if it meant paying excess money.

Document 11²²

It is beneficial in any sense to keep miners loyal to the company and to make himself and his son consecutively serve the company. This is the reason why each coal mine company has provided incentives for continuous service, has improve welfare and benefits and has introduced pension system mentioned above that has miners serve the company without anxiety about the future.

It could be said to be a thorough policy for promotion of continuous service that the firm encouraged even miners’ children to work at the coal mine, not only the firm induced miners to have loyalty to the coal mine. When the firm expected fathers and their sons work together, fathers likely continued to serve for the firm until their sons grew up to work. If fathers and sons really began to work together, the family was expected to settle at the coal mine and to serve for long years.

Document 12²³

(According to) the family survey of the Dainoura Coal Mine of Kaijima and the Tagawa Coal Mine of Mitsui, the most of nonemployees are babies and children, and male and female adults

²¹ Morimoto (2008), p. 42. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, pp. 47-48.

²² Morimoto (2008), p. 42. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, p. 85.

²³ Morimoto (2008), p. 42. Originally from *Chikuho Tanzan Rodo Jijo (The working situation of coal mine in the Chikuho district)*, 1926, p. 57.

and aged people are not many... Pupils of the primary school amounts to 3,255 out of 9,362 nonemployees at the Dainoura Coal Mine of Kaijima, and it is a little surprising that we meet so many children while walking around the coal mine. It is because the company prefer hiring young married couples and thus fertility rate is high.

Preference for young married couples shows the firm's policy that had young miners settle at the coal mine, given that families that spanned two generations more unlikely move to other coal mines.

Coal mining firms in the 1920s generally tried to motivate miners to serve longer. The goal of such a policy was the intellectual skill formed in the firm. Firms first invested in miners' human capital to enhance productivity, then offered benefit programs such as bonuses for continued service to earn return from the formed skill. Hiring miners with family was also a part of the policy.

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