Referral Hiring of Miners

Case from the Coal Industry in Early Twentieth-Century Japan*

ISS Discussion Paper Series
F–164

Mayo Morimoto†
Institute of Social Science, The University of Tokyo

February 2018

Abstract

Many firms do hire workers by referral hiring and, thus, recognize its worth as one of the hiring method used personal networks. This study investigates under what circumstances and for what type of workers a firm can more efficiently use referral hiring than otherwise in the Japanese coal mining industry in the 1900s, which was the fast-growing industry in the emerging economy. We first predict, based on our model, that referral hiring is more efficient when job applicants' skills are too complicated or sophisticated for employers to decide on a right candidate. Then, building an original data set from employment contract documents from a colliery operated in the 1900s, we show that traditional manual skilled workers were likely to be hired through referrals, while modernized skilled workers and unskilled workers were not likely to be hired through referrals.

Keywords: referral hiring, adverse selection, informal job networks.
JEL: O14, O15, J46, L22.

*The author thanks Masaki Nakabayashi, Peter Orazem, Esther Redmount, Susumu Cato, Daiji Kawaguchi, Yuji Genda, Naofumi Nakamura, Hideshi Itoh, Hideo Owan, Ryo Nakajima, Seung-Gyu Sim, Takashi Shimizu, Akifumi Ishihara, Tomoya Nakamura, and the participants of the Osaka Workshop on Economics of Institutions and Organizations in December 2013, Contract Theory Workshop East in May 2014, 18th Annual Conference of The International Society for New Institutional Economics in June 2014, the 2015 ASSA/AEA Annual Meeting in January 2015, the 2015 Midwest Economics Association Annual Meeting in March 2015, The Workshop on History of Economic Institutions in April 2016, Society of Labor Economists 21st Annual Meeting in May 2016, 2016 Asia Meeting of the Econometric Society in August 2016, and Asian and Australasian Society of Labour Economics Inaugural Conference 2017 for their useful comments and suggestions. This research is financially supported by Grant-in-Aid for Research Activity Start-up (16H06705) and was by Grant-in-Aid for JSPS Research Fellows (26-7670).

†Corresponding address: Institute of Social Science, The University of Tokyo, Hongo 7-3-1, Bunkyo, Tokyo 113-0033, Japan. E-mail: morimoto@iss.u-tokyo.ac.jp

1 Introduction

In emerging economies, where labor markets integration is ongoing, personal networks naturally take an essential role (Munshi (2003), Dolfin and Genicot (2010)).[1] Personal networks are the more critical the more severe asymmetric information is, when employers hire workers. Employers do not know where they find adequate workers as they require with lack of information. The issue does not vanish even in advanced economies.

To address the challenge of hiring, recruiting workers and finding a job through personal networks are a common measure (Kajisa (2007), Larsen et al. (2011), Mano et al. (2011), and Fafchamps and Moradi (2015)).[2] For instance, referral hiring, which is one of the solutions of adverse selection problems, is widely observed not only in emerging economies but also in advanced economies.[3] It can reduce employers' ex ante uncertainty about worker productivity, and it functions as a screening mechanism to reduce information asymmetry (Montgomery (1991), Simon and Warner (1992), Ekinci (2016)). Rees (1966) argues that using referral hiring benefits for both employers and job seekers.[4] Granovetter (1995) studies the role of social contacts when finding a job.[5]

In this study, we investigate a case of the Japanese coal mining industry a century ago. Japan was a buoyant emerging economy, not anemic matured one, at that time. Our analysis would help understand modern emerging economies better. At the same time, difficulties in recruitment are not specific to emerging economies. It would be more serious and prevalent in industries in which sophisticated skills are required either in emerging or advanced economies. Employers and human resources (HR) division managers might not be familiar with those skills. In that sense, our analysis would provide a general

[1] Some studies argue that personal networks can lead to a vicious circle in developing countries. Nakajima et al. (2018) and Munshi and Rosenzweig (2006) focus on the Indian caste system and they show that low caste workers are likely to rely on personal networks and lower caste men persist using caste ties and the networks keep to channel them traditional occupations, which are mostly low-paid. Nakajima et al. (2018) focus on occupational choices of disadvantaged farm households and note that there are not only farm or non-farm jobs and classify eight categories. Munshi and Rosenzweig (2006) focus on their school choices and the consequences.

[2] Larsen et al. (2011) find that there is a significant positive wage premium associated with obtaining a job through informal hiring methods in comparison with through formal contacts, using matched employer–employee dataset from Vietnam. Fafchamps and Moradi (2015) use recruitment data from the British colonial army in Ghana in the early twentieth century, and they find that referred recruits were likely to have taller hight and larger chest circumference.

[3] Tassier and Menczer (2008) defined referral hiring as hiring through the use of social or familial contact. Many studies recognize families, relatives, friends, previous co-workers, and incumbent employees as a referrer.

[4] Rees (1966) finds that referrals can reduce adverse selection problems and job seekers can obtain more information about the jobs in which they are interested than when not using referral hiring.

[5] Fafchamps and Moradi (2015) cast doubt on the usefulness of referral hiring, while most research argue that it brings many benefits. Fafchamps and Moradi (2015) show that referred recruits were likely to desert and to be discharged. Referral hiring is a representative example of informal job search channels. There are several studies of comparison between formal and informal channels. Stupnytska and Zaharieva (2015) distinguish between three job search channels: one formal channel, and two informal channels: family and professional networks. They warn against lumping family and professional contacts into one informal job search channel. Social ties are also a major example of informal channels. Granovetter (1995) argues that weak ties in social networks better transmit information about job opportunities than do strong ties, such as links between relatives or between close friends. Wang and Seifert (2017) empirically show that employees hired as a result of an employee referral with strong ties are less likely to resign than in the case of weak ties, and that strong ties are related to having a managerial role.

viewpoint to study labor markets of professionals.

Many firms actually hire workers through referrals. Galenianos (2014) reports that at least half of workers find their jobs through referrals, based on the results of surveys from preceding literature.[6] Burks et al. (2015) analyze personnel data from nine large firms in three industries (call centers, trucking, and high-tech), and reports that 36%, 20%, and 33% of workers were referred, respectively.[7] Ekinci (2016) focuses on referral recruitment from current employees. He notes that firms have developed formalized methods of attracting referrals from current employees. In addition, 69% of employers in the United States have a formal employee referral program, with about 27% of new hires being generated from employee referrals, according to a survey conducted in 2010 by CareerBuilder.

Employers use referral hiring in order to mitigate adverse selection problems because they can obtain more information about job applicants (Pinkston (2012)). Workers often have more information about their own skills and abilities than firms do. In addition, job applicants have an incentive to exaggerate their skills. Thus, firms are at an information disadvantage relative to workers. Using referral hiring may reduce uncertainty about the match quality of job applicants. Furthermore, firms often assume that employees associate with people similar to themselves. Referrers may be acquainted with people with similar abilities and be more adept than employers at assessing applicants' skills.[8]

Many previous studies have argued that hiring through referrals is more productive for employers, and job applicants are more likely to be hired through referrals. Furthermore, referred workers are less likely to quit than nonreferred workers are (Nakajima et al. (2010)). These studies compare referred and nonreferred workers empirically and predict differences between them theoretically. However, few studies examine the circumstances or types of workers that lend themselves to the efficient use of referral hiring. This might be because most studies do not assume that workers have heterogeneous skills. Burks et al. (2015) analyze data from nine large firms in three industries and compare workers' productivity between three skill types in terms of whether workers are referred or nonreferred. They show that referred workers and nonreferred workers have economically similar performance in call centers, but that referred

[6]Galenianos (2014) lists results as follows on pp.306–307. More than 85% of workers use informal contacts when searching for a job (National Longitudinal Survey of Youth (Holzer (1988)), more than 50% of all workers found their job through their social network (the Panel Study of Income Dynamics (Corcoran et al. (1980)) , in most European countries 25-45% of workers find their jobs through referrals (the European Community Household Panel (Pellizzari (2010)), 37–53% of employers use the social networks of their current employees to advertise job vacancies (the National Organizations Survey (Mardsen (2001)), the Employment Opportunity Pilot Project (Holzer (1987)), 36% of firms filled their last opening through a referral (EOOP (Holzer (1987)).

[7]See Burks et al. (2015), p. 816.

[8]Burks et al. (2015) identify the reason why firms use referral hiring and benefit from referral hiring (1) as learning theory which means that referral hiring may reduce uncertainty for potential workers, (2) as homophily theory which means that referrers may have similar abilities with referrals and (3) as peer benefit theory which means that a referrer and his/her referral may produce benefits by working in the same organization together. Ekinci (2016) also mentions the idea of homophily. Specifically, he argues that a referral's output is a signal of the referring employee's ability and employee referrals serve a screening function because referring employees have incentives from career concerns to refer high-ability applicants.

workers in trucking have fewer accidents, and referred workers in high-tech are more likely to invent patents than are nonreferred workers.[9] The latter finding is supported by the results of Nakajima et al. (2010). Nakajima et al. (2010) show that "networked" inventors tend to be more productive and have longer tenure than non-networked inventors do. They define networked inventors as people who work with collaborator(s) with whom they have worked in past research activities. Furthermore, they argue that such informal job networks act as a screening mechanism to select inventors' research ability. These results imply that referral hiring is useful and suitable when applicant skills are too complicated or specialized for employers or for employees in a human resources division to decide on a suitable candidate. We investigate and present a similar argument here.

We investigate employment contract documents,"Miner Job Applications," from a coal mining firm operated in the 1900s in Japan (See Section 3). In the 1900s, coal mining firms were in a transitional period from both of managerial, including hiring, and technical aspects. In terms of a technical aspect, drainage pumps were introduced in the 1890s. These were the first machinery used in coal mines. Conveyance elevators were introduced around the same time.[10] Before that, mined coal was towed by a horse or a cow. Still, the mining process, which was the key production process, depended on manual skills using picks. Workers required high traditional manual skills and the work site conditions were dark, narrow, and dangerous.[11] If mined incorrectly, a large amount of water suddenly could pour out and the roof of a mineshaft could collapse. Deadly accidents could have happened.

On the other hand, conveyance elevator operators required a different type of skills, which we call modernized skills. Their jobs were not simple. A government document that reported on coal mines in Chikuho district said that such workers required high-level skills, glegness, and presence of mind because they jumped into and out of coal boxes attached to a conveyance elevator with a rope. Conveyance elevators operated at about 50 km/h.[12]

In addition to traditional manual skilled workers and modernized skilled workers, coal mining firms used many workers from farming villages. Workers from farming villages often worked for a coal mine during the agricultural off-season and some of them just left their villages. Firms employed such unskilled workers. It means there were at least three different skill types in the coal mining industry.

Job applicants in the Japanese coal mining industry generally applied through a referrer. We find

[9] See Burks et al. (2015), pp. 806–807.

[10] See Sumiya (1968), pp.299–313. He put together overall conditions of major coal mines in Kyushu area from Konoe (1898). Sumiya (1968) noted that after the introduction of conveyance elevators firms faced needs to manage people who worked at the conveyance process directly without delegating it to the "dormitory system," that we will explain later (p.314).

[11] Ogino (1993) mentioned that it was difficult to manage and monitor workers in a coal mine by the firm because workers moved several times from one coal bed to another during their shifts, in addition to the dangerous work-site (p.61).

[12] See Osaka Chihou Shokugyo Shokai Jimukyoku (Osaka Administrative Office of Employment Agency) (1926), p. 32.

that with less than 10% applicants were nonreferred (See Section 3), which we call "direct recruitment." Using data included individuals with the different skill types, this study examines when firms should use referral hiring, as well as, which skill types are most suitable for referral hiring.

The skills described in Nakajima et al. (2010) and Burks et al. (2015) have much in common in the coal mining industry. The skills required for miners a century ago may seem different to those required by inventors in a high-tech industry in the 21st century, as described in Nakajima et al. (2010) and Burks et al. (2015). However, they have important characteristics in common, namely that workers' types are private information and both sets of skills are too complicated for employers and human resource employees to understand. Miners required high levels of traditional manual skills, while workers in high-tech require high levels of advanced skills. Thus, the presence of serious asymmetric information between employers and job applicants meant that using referral hiring was an effective method of hiring productive workers.

In this study, we first develop a simple model to help understand our question of when firms should use referral hiring, focusing on the intensity of using referral hiring, firms' selection skills, and technological conditions. We obtain two predictions about the optimal level of using referral hiring: (1) the optimal referral hiring level is increasing in the productivity differences among workers; and (2) the optimal referral hiring level is increasing in the technology levels if there is a complementary effect between using referral hiring and the firm's selection skills, while the optimal referral hiring level is decreasing in the technology levels if there is a substitution effect between using referral hiring and the firm's selection skills. We provide examples corresponding to three different skill types of workers in the Japanese coal mining industry: traditional manual skilled workers, modernized skilled workers, and unskilled workers, in order to understand our predictions.

Then, we build an original data set from employment contract documents, "Miner Job Applications," from a colliery operated from 1902 to 1907 to test the predictions. We obtain the consistent result with Predictions (1) and (2). Our results show that (i) traditional manual skilled workers were more likely to be hired by referral hiring; (ii) modernized skilled workers were less likely to be hired by referral hiring; and (iii) unskilled workers were also less likely to be hired by referral hiring.

Here, we briefly review a unique intermediary organization of labor used in the Japanese coal mining industry from the late 19th century to the early 20th century, called the "dormitory system." Firms built dormitories around their coal mines as residences for miners. Each dormitory had a leader, called a dormitory head, to whom firms delegated the tasks of managing miners, including monitoring, paying, and recruiting miners. Dormitory heads were used to be just a miner. They had a long career and

accumulated experience in coal mines.[13] They became a head once they were accepted as a leader of workers by the firm and workers.[14]

In the early days of the coal mining industry, firms subcontracted the recruitment of workers entirely to dormitory heads and were not involved in drawing up employment contracts with individual miners. However, The Mining Act of 1892 compelled all coal mining firms in Japan to make a list of their workers. Technically, this meant that firms had employment contracts with individual miners. However, in practice, the firms still did not recruit all miners. Instead, they delegated the recruitment function to referrers, to whom they paid a fixed fee for the service.[15] In this case, dormitory heads and skilled miners played roles as a referrer. Here, we define referrers as people who search for job applicants, screen their skills, and refer and introduce them to a company.

In the early 20th century, white-collar management rarely went into their colliery to supervise workers. Mining coal and maintaining mineshafts required a high level of manual skills. Workers acquired these skills by accumulating field experience in coal beds. This made it difficult for management to screen appropriate candidates when hiring new workers. Thus, they delegated recruiting workers to the dormitory heads and skilled miners, who acted as referrers, and then employed workers based on their recommendations.

Several coal mining firms tried to manage workers directly in the 1900s.[16] There were two recruitment methods by firms without relying on referral hiring. One was the "direct recruitment," which was nonreferral based. Firms recruited and hired workers directly. The other was "directly controlled dormitory." Firms had a greater control over these dormitories than they did over ordinary dormitories. Note that we refer to the traditional dormitory as an ordinary dormitory to avoid confusion with the directly controlled dormitory. Directly controlled dormitory heads also recruited workers and acted like a referrer. However, their recruitment was the other one of firms' recruitment methods.

It was the Japanese industrial revolution era in the early 20th century requiring workers with new skills although there was still a need for traditional manual skilled workers, such as coal miners and pillar workers,[17] and new entrants, such as farmers. In this study, we consider how firms use referrals in the labor market comprising workers with heterogeneous skill types.

[13] Workers in the Japanese coal mining industry did not always stay in the same coal mine for a long time in the 1900s. They often moved from one coal mine to another because they looked for a good coal bed so that they got paid well.

[14] There is no documented criterion to become a dormitory head.

[15] We consider that referrers did not have an incentive to refer low-ability applicants even though referral fee was a fixed payment. Referrers cared about own reputation as argued by Ekinci (2016). Moreover, their job was life-threatening, even a slightest mistake would result in a disaster, and miners' job information networks were built in relative small area and reputations may spread fast. Thus, they seriously had career concerns when referring applicants.

[16] In the 1900s, it was in the organization's transitional phase.

[17] Pillar workers propped up a mine roof with wooden or coal pillars to prevent the roof from collapsing and removed those pillars once done. This was very dangerous work and required artisanal skills.

The remainder of this paper is organized as follows. Section 2 provides theoretical predictions on the effects of referral hiring by introducing a simple model. Section 3 describes "Miner Job Applications." In Section 4, we use the documentation to show the empirical results. The final section concludes the paper.

2 Benefits of referral hiring: Theoretical predictions

2.1 Model

Here, we develop a simple model in order to understand the mechanism behind referral hiring in the coal mining industry in early twentieth-century Japan.[18] There is a coal mining firm that hires workers in a job market. The HR recruits workers directly and also the firm uses referral hiring as an indirect way of recruiting.

We assume that there are two types of workers: high-productivity and low-productivity workers. Each high-type worker produces coal output q_H and each low-type worker produces q_L, where $q_H > q_L > 0$. Wages in the coal mining industry consist of an hourly wage as a base salary and a performance-based wage[19]: $w_i = \alpha + \beta q_i$ ($i = H, L$), where $\alpha > 0$ and $\beta > 0$.

All coal output is assumed to be sold at the same price $p > 0$. The sales amount of the high type is $Q_H = pq_H$ and that of the low type is $Q_L = pq_L$. The firm cannot observe the types of workers before hiring. The probability ϕ of hiring the high type is potentially dependent on various factors, such as the existence of job networks, job advertisements, and a good reputation. In this paper, we simply assume that it depends on the firm's selection skill parameter c (≥ 0) that comes from technological environments, an intensity r (≥ 0) of referral hiring and the HR recruitment activities:[20] the probability of hiring the high type is given by $\phi(r, c)$.[21] Here, r and c are measured in terms of money.

We assume that the probability $\phi(r, c)$ of hiring the high type is increasing both in r and c, and $\phi(0, 0) > 0$. An important factor of this paper is $\partial\phi/\partial r$, which represents the marginal effect of referral hiring. We assume diminishing returns to r, i.e., $\partial^2\phi/\partial r^2 < 0$. We allow $\partial^2\phi/\partial r\partial c$ to be positive or negative. If it is positive (resp. negative), there is complementary (resp. substitution) effects between the technological conditions c and referral hiring activities r. Indeed, r and c are expected to be com-

[18] Our model is minimal for this purpose. As we will see, firm do not choose the number of workers or capital equipment in this model. We here focus on the case where a firm needs one more worker and has options on referral hiring activities, given the current number of workers, capital equipment, or other factors.

[19] Miners Investigation (Kofu chosa gaiyo) published in 1913 explains miners wage scheme(Ogino (1993), p. 62.).

[20] We consider that referral hiring is delegating referrers to recruit workers. Both dormitory heads and skilled miners acted as referrers and were paid referral fees by the firm.

[21] Our probability structure $\phi(r, c)$ can be regarded as a reduced one that is derived from a more complicated model.

plementary when both the referrers and the firm have enough knowledge to recruit workers; r and c are expected to be substitutes when there is information that only one of the referrers and the firm can have, for example, depending on a job assignment.

The expected profit of the firm is expressed as follows:

$$\pi = \phi(r, c)(Q_H - w_H) + [1 - \phi(r, c)](Q_L - w_L) - (r + c).$$

In the long-run, the firm can choose both the intensity r of referral hiring and the level c of its selection skills. In the short-run, the firm only can choose r, and c is fixed. We focus on the short-run case.[22] The firm chooses the intensity of referral hiring to maximize its profit: the maximization problem is $\max_{r \geq 0} \pi$. The maximized profit is assumed to be positive. This implies that the price of output is larger than the performance-based wage rate β.

2.2 Analysis

By differentiating π with respect to r, we obtain the first-order condition of the problem as follows:

$$\frac{\partial \phi(r, c)}{\partial r} \times (p - \beta) \times (q_H - q_L) - 1 = 0. \tag{1}$$

We assume that there is an interior solution and the optimal referral hiring level is denoted by r^*, which satisfies (1).[23]

The first-term of the left-hand side of (1) corresponds to the marginal productivity of referral hiring, while the second term corresponds to the marginal cost. The marginal productivity consists of three factors: the marginal effect of referral hiring, mark up, and the productivity difference between types.

Let the productivity difference $q_H - q_L$ between high and low types be denoted by A. By the implicit function theorem, we obtain the following:

$$\frac{\partial r^*}{\partial A} = -\frac{\partial \phi / \partial r}{A \partial^2 \phi / \partial r^2} > 0, \tag{2}$$

$$\frac{\partial r^*}{\partial c} = -\frac{\partial^2 \phi / \partial r \partial c}{\partial^2 \phi / \partial r^2} \lessgtr 0 \Leftrightarrow \frac{\partial^2 \phi}{\partial r \partial c} \lessgtr 0. \tag{3}$$

We can also show that r^* is increasing in the mark up $(p - \beta)$. In the short-run, the coal price p and

[22] We will examine the employment contract documents for five years in the following sections. Within five years, technology was not able to improve. It is natural to assume that c is fixed.

[23] The interior solution is guaranteed if $\partial \phi / \partial r$ is sufficiently large around zero and it approaches zero as r goes infinity (note that we also assume that $\partial \phi / \partial r$ is decreasing in r).

the performance wage β will not change. We do not consider any changes of the mark up because our data that we use in our empirical analysis is for five years (1902–1907) and p and β were stable within the five years.

According to (2), the firm's expected profit can increase by using referral hiring when there is a large difference in workers' productivity. According to (3), $\partial r^*/\partial c$ is positive (resp. negative) if r and c are complementary (resp. substitutes). This indicates that r^* increases as the firm's selection skills improve when both the referrers and firms' selection skills contribute to hiring the high-type workers (when r and c are complementary); that r^* decreases as the firm's selection skills improve when there is information about required skills of a job assignment that only the firm can know (when r and c are substitutes).

Finally, we reach predictions as follows:

- Prediction 1: the optimal referral hiring level is increasing in the productivity difference among workers.
- Prediction 2: the optimal referral hiring level is increasing in the technology levels if there is a complementary effect between r and c, while the optimal referral hiring level is decreasing in the technology levels if there is a substitution effect between r and c.

2.3 Examples related to our predictions in the coal mining industry

We provide concrete examples in the coal mining industry to help understand the relevance of Predictions 1 and 2.

When is the productivity difference between the high type and the low type significant? Arguably, this occurred when recruiting workers who had the required traditional manual skills in the coal mining industry. For example, coal miners worked while considering all necessary factors, such as the characteristics of a coal bed and a mineshaft in a dark and narrow workplace. As another example, pillar workers propped up a mine roof with pillars (wooden or coal pillars) to prevent the roof from collapsing at a face and then removed these pillars once done. This was life-threatening work and required artisanal skills. Years of experience were required, although this was not the only criterion. The high type of traditional manual skilled workers required both experience and competence. Therefore, when recruiting traditional manual skilled workers, the difference in productivity was large. Then, Prediction 1 tells us that the firm might be more likely to use referral hiring.

Conversely, the productivity difference among new entrants was small. Prediction 1 tells us that the firm might be less likely to have an incentive to use referral hiring when recruiting such workers.

Next, we turn to examples related to Prediction 2. Screening the skills of workers became easier in the presence of newly introduced machine because newly introduced machines worked with an explicit form of knowledge, while traditional works without the machine needed implicit knowledge, which the firm could not screen easily. Newly introduced machines increased the firm's selection skills c.

If there were workers who had worked on the new machines and accumulated the modernized skills, they could refer job applicants. In this case, the firm's selection skills and an incentive to use referral hiring are complementary. Then, Prediction 2 tells us that the firm might be more likely to recruit workers directly and also use referral hiring. On the other hand, if there were not the workers who had accumulated the modernized skills, only the firm's selection skills might be high and the intensity of using referral hiring might be low. This corresponds to the case of substitution. Then, Prediction 2 tells us that the firm might be more likely to recruit workers directly and might not be more likely to use referral hiring.[24]

To sum up, the optimal intensity of using referral hiring depends on the productivity difference, technological conditions, and whether its selection skills and referral hiring are complementary or substitute. In the coal mining industry in the 1900s, the productivity difference and the firm's selection skills depended on workers' types: workers with traditional manual skills, new entrants, and workers with modernized skills.

3 Data: Employment contract document

3.1 Firsthand historical documents: "Miner Job Applications"

Here, we examine historical miner application documents, "Miner Job Applications," [25] left by the Aso family for the Aso Fujidana Second Coal Mine. The Aso Fujidana coal mine was located in Fukuoka prefecture, southern Japan and was operated from 1902 to 1907 by the Aso Company. Fukuoka prefecture had many major coal mines at that time. The coal mine was a relatively large-scale coal mine in Japan.[26] "Miner Job Applications" are job application documents, as well as employment contract documents. The Aso Company required job applicants submit the document.[27]

[24] When the firm recruited traditional manual skilled workers, the firm's selection skills might be low. There might be substitution effects between the firm's selection skills and using referral hiring level. Prediction 2 tells us that the firm might be more likely to recruit workers with traditional manual skills by referral hiring.

[25] All firsthand documents are from "Aso ke Monjo (Documents of Aso)" held by Kyushu Daigaku Fuzoku Toshokan Fusetsu Kiroku Siryokan (Kyushu University Manuscript Library, Historical Record Section).

[26] See Nagahiro (2002), pp.230–246. He makes the ranking of coal mining firms in Japan using governmental documents.

[27] Indeed, job applicants did not actually fill the job applications by hand. We found just several handwriting styles which were written by employees in the Aso HR division. Since no applications appear to have been rejected, we assume all applicants were more likely to be hired.

The Aso Fujidana Second Coal Mine used the dormitory system but began transitioning to a direct employment system. There were two types of direct employment systems. The first was "direct recruitment," which meant not hiring through a referral. When a job applicant was directly recruited, an employee's name of the Aso's HR division is shown on his/her job application. The other type of direct employment system was the "directly controlled dormitory." The firm had greater control over these dormitories than it did over ordinary dormitories. Note that we refer to the traditional dormitory as an ordinary dormitory to avoid confusion with the directly controlled dormitory. Directly controlled dormitory heads also recruited workers as ordinary dormitory heads did. A directly controlled dormitory head's name is shown on the column for the referrer's name of a job application but their recruitment was the other one of the firm's recruitment methods. The coal mine was in the organization's transitional phase.[28]

The job application form had the terms and conditions printed on the right-hand side, and columns to fill in three applicants' details on the left.[29] An employee in the HR division (rather than an applicant) recorded an applicant's registered address, social status, previous job, full name with his/her seal or thumbprint, birth date, his/her referrer's name (with his/her seal), and the date of application. We found several handwriting styles in the job applications. The job applications were not always fully completed but did always include address and name information.

The Mining Act, promulgated in 1890 and enforced in 1892, compelled all mines in Japan to list their miners' names, ages, addresses, previous jobs, and their hiring and firing dates. The Aso Coal Mining Company created the "Miner Job Applications" and also "Miner Address Lists." Around the 1900s, almost all coal mines still used the dormitory system. When firms tried to acquire miners' information, dormitory heads stood to lose their exclusive information rent. If one coal mine had made such a list, the dormitory head would likely move to a different coal mine with his miners to avoid the loss of information rent. However, when all coal mines were required by the Act to make such lists, dormitory heads had no incentive to move elsewhere. The recognition of individual miners was the first step of the transformation to a directly managed organization of labor. Thus, the 1890 Mining Act sparked the initial phase of the transformation to a direct employment system in the coal mining industry.

[28] See Ichihara (1997), pp.78–83 and Ogino (1993), pp.53–57 and pp.135–136. They argued that many coal mines in Japan were in the transitional phase in the 1900s.

[29] There were not always three applicants' information in one application. One application has applicants' information which applied at the same time.

3.2 Description of "Miner Job Applications"

We examine all surviving job applications for the Aso Fujidana Second Coal Mine from 1902 and 1904 to 1907, although mainly from 1905 to 1907. In all, there were 774 job applicants, of which 589 were male (76.1%). Of the latter group, 192 applied with a family member (32.6%). There were 14 females who applied by themselves (7.6%).

Table 1 describes the prefectures from which applicants originated (i.e., their hometowns). Only three people were from the village where the coal mine was located. However, most applicants gave their registered address as the Fukuoka prefecture, where the coal mine was located, and were spread over western Japan (See Figure 1). Many coal mines in the Kyushu area showed a similar trend, with applicants originating from western Japan.[30] This indicates that the labor market in the coal mining industry was being integrated.

We found 79 referrers, broken into three groups: a dormitory head, a directly controlled dormitory head, and the others that we call a skilled miner referrer.[31] Some skilled miner referrers worked for the Aso Fujidana second coal mine. Others did not and were freelance referrers. All received a referral fee after referring a job applicant[32] We have 22 ordinary dormitory heads, 54 skilled miner referrers, and three directly controlled dormitory heads. Of all applicants, 6% were directly recruited ("direct recruitment"), and the name of an employee in the HR division is written on the column for the referrer's name.

3.3 Database construction

We gathered all information from the "Miner Job Applications" into a database, including applicants' previous jobs, whether they applied with their families, their age, the type of referrer, and whether they put their own seal on their job applications. We use this database to test the predictions described in Section 2. See Table 1 for more detail.

[30] See Tanaka (1984), pp.272–274 and Ogino (1993), p.105.

[31] We determine the category of referrers by investigating all surviving "Miner Attendance Records" of the Aso Fujidana Second coal mine. These records contain miners' daily work attendance at the coal mine and provide us with information on the name of dormitory heads and the types of dormitories.

[32] By investigating "Referral Fee Ledger" from the Aso Fujidana Second coal mine, we find that the referral fee was 75 cents per applicant and the referrer got paid another 75 cents a month later when the referred applicant did not move from the coal mine all through the one month. 1.5 kg raw rice was about 14 cents in 1906.

4 Empirical analysis of "Miner Job Applications"

4.1 The applicants

First, we analyze the characteristics of the applicants by means of a logit regression analysis. Table 2 describes which type of applicants tended to put their own seal on their job applications. When applicants put their own seal on the applications, this appeared to indicate they were literate. However, in the 1900s, literacy rates were low in Japan, particularly among miners. Thus, it is worth establishing what kinds of applicants were literate.

Table 2 shows that applicants whose previous jobs were "other miners" tended to carry their own seals. This result indicates that other miners were likely to be literate. In their childhood, elementary schooling was becoming common and, thus, their birth year would affect their literacy level. In addition, males might have had more opportunities to study reading and writing than females did at that time. Therefore, we conduct another regression analysis to control for these factors (see specification 2a). Here, neither of the coefficients of the independent variables, Age and Male, are statistically significant. However, since the coefficient of other miners is significant and positive in both specifications 2a and 2b, we infer that the tendency to carry one's own seal depended on the job type.

We regard people who carried their own seals as being literate. Literacy skills were new skills at that time. We regard those who had literacy skills as applicants with modernized skills, such as conveyance elevator operators. Then, we categorize job applicants into three groups by their previous jobs: (1) new entrants are farmers and workers from neither the mining industry nor agriculture; (2) applicants with traditional skills are coal miners and pillar workers; and (3) applicants with modernized skills are conveyance elevator operators and other miners (see Appendix table 1).

Next, Table 3 describes the tendency to apply to the coal mine with family members. It shows that female workers were likely to apply with their husbands and fathers because the coefficients of Male are negative. Also, it strongly indicates that applicants who previously worked as pillar workers and farmers tended not to apply with their family members.

Specification 3b contains age as an independent variable, but specification 3a does not. Even so, the magnitudes of the odds ratio of pillar worker and farmer in both specifications are not that different. Thus, it is not true that people who used to be pillar workers and farmers were not married because they were young.[33]

[33] We can consider applicants whose previous jobs were farmer tended to be young since the first male child in a famer family traditionally inherited his family farm and male children except the first one had to leave their house. But we do not see such a tendency.

Recall that pillar workers propped up a mine roof with pillars to prevent the roof from collapsing at a face, and removed these pillars once done. This was dangerous work and required artisanal skills. Thus, it is no surprise that the results of Table 3 show that the workers in charge of these dangerous tasks tended to apply by themselves, those with families may prefer to be coal miners.

Moreover, farmers did not yet have industry-specific skills for coal mining and were not yet earning enough to build a family. For this reason, they tended to apply without family members.

4.2 Referral hiring or direct recruitment: logit estimates

In this and the next section, we analyze which skill types of applicants were likely to be referred or to be directly hired. We test the predictions given in Section 2. Table 4 represents logit estimates of the recruitment tendency. The dependent variable is a dummy variable, which indicates whether applicants were hired by direct recruitment or by referral hiring. The independent dummy variables are the types of applicants. We separate the applicant's types into three groups: new entrants, applicants with traditional manual skills, and applicants with modernized skills, as described in the previous subsection. In specification 4a, the control group contains applicants who left the column of previous jobs blank and new entrants. We consider that they were new entrants, in a broad sense. We see that the tendency of direct recruitment of applicants with modernized skills is positive and significant at a 5 % level. In specification 4b, the control group is only those who left the previous job column blank. We find that the tendency of direct recruitment of new entrants are positive and significant at a 1% level and the tendency of applicants with modernized skills are positively significant at a 5% level. Table 4 shows that both new entrants and applicants with modernized skills were likely to be hired directly, rather than using referral hiring.

These are consistent with Predictions 1 and 2. As we considered in Section 2, there were few high-productivity workers among new entrants. Almost all of them were low-productivity workers. The difference between the profits generated by new entrants was negligible. Thus, the optimal intensity of using referral hiring for new entrants is predicted to be low by Prediction 1, which is supported by the results. For applicants with modernized skills, the firm had the information necessary to screen them; that is, c was high. Thus, the optimal intensity of using referral hiring is predicted to be low by Prediction 2, which is the case, as shown in Table 4.

Since the coefficients of applicants with traditional manual skills are not significant in either specification in Table 4, we cannot determine their hiring tendency.

4.3 Referral hiring or direct recruitment: multinomial logit estimates

We explore the hiring tendency of applicants with traditional manual skills in more detail in this section. As noted before, there were three types of referrers: dormitory heads, skilled miner referrers, and directly controlled dormitory heads. The last one was one of the firm's recruitment methods. Thus, we assume that applicants had four options, that is, two types of referral hiring: a referral from ordinary dormitory heads or skilled miner referrers, and two firm's recruitment methods: a referral from directly controlled dormitory heads or being directly recruited by the firm ("direct recruitment"). We analyze the predictions using a multinomial logit regression. The results are shown in Table 5.

In specification 5a, the control group is applicants who were previously farmers, were in an industry other than the mining industry and agriculture, and were left the previous job column blank in their job applications. The result shows that applicants with traditional manual skills were more likely to be hired by a referral from skilled miner referrers, and less likely to be hired by a referral from directly controlled dormitory heads than from ordinary dormitory heads.

The result is consistent with Predictions. As we described in Section 2, the difference between the productivity differences between the high type and the low type was considerable among traditional skilled miners. Then, the optimal intensity of using referral hiring should be high (Prediction 1). The result shows that referral hiring was likely to be used for applicants with traditional manual skills. Skilled miner referrers tended to refer these workers but directly controlled dormitory heads did not. The coefficient of applicants with traditional manual skills is negative but not significant when the dependent variable is direct recruitment. The referral from directly controlled dormitory heads and direct recruitment were the firm's recruitment methods. These results indicate that the firm's recruitment had not been able to hire traditional skilled workers because of the lack of knowledge about their skills. There should be substitution effect between referral hiring and the firm's recruitment. Then, the optimal intensity of using referral hiring should be high (Prediction 2).

The results in both specification 5a and 5b show that applicants with modernized skills were most likely to be hired by direct recruitment since RRR (risk relative ratio) takes the largest value. However, the results also show that they were likely to be hired by a referral from skilled miner referrers at the same time. When the firm hired workers who had the new skills, the firm's selection skills could be high, because they had newly introduced modern machinery, such as conveyance elevators. The firm had the requisite knowledge and skills for screening the candidates. If referrers and the firm were substitutes in hiring applicants with modernized skills, direct recruitment was the best choice for them (Prediction 2). In fact, such applicants were likely to be referred by skilled miner referrers. It turns out that referral

hiring and the firm's selection skills were complementary in hiring them.

There might be productivity differences from applicants with modernized skills. When the firm recruited workers with the new skills, the firm's selection skills were high, but the productivity differences were still positive. It had been about 10 years since conveyance elevators were introduced. Some workers should become relatively good at operating the machines, but others might not. Thus, there might be some productivity differences. Therefore, referral hiring tended to be used to recruit modernized skilled workers.

We assumed that referrers were homogeneous in our model in Section 2. In fact, there were three types of referrers: ordinary dormitory heads, skilled miner referrers, and directly controlled dormitory heads (one of the firm's recruitment methods). Table 5 tells us that skilled miner referrers were more likely to refer applicants with modernized skills than ordinary dormitory heads. This indicates that dormitory heads could not be involved in recruiting such workers. Dormitory heads started working for the coal mining industry earlier and had a much longer career than skilled miner referrers did. They accumulated more experience in coal mining than skilled miner referrers did, however, their skills were dedicated to manual ones. Dormitory heads did not have a chance to operate newly introduced conveyance elevators, which meant they were at a disadvantage when recruiting workers with modernized skills. Skilled miner referrers had operated conveyance elevators, accumulated the operating skills, and then become referrers. This was why skilled miner referrers tended to refer applicants with modernized skills, while dormitory heads did not.

In specification 5b, the control group is those who left the previous job column blank. Here, we examine the behavior of narrowly defined new entrants (farmers and applicants from neither mining nor agriculture industries). The results show that new entrants were likely to be hired by the firm's recruitment methods: direct recruitment and a referral from directly controlled dormitory heads. The result also shows that new entrants were not likely to be hired by a referral from skilled miner referrers. This is consistent with Prediction 1. As discussed in Section 2, the optimal intensity of using referral hiring for new entrants into the coal mining industry should be low.

5 Conclusion

Referral hiring is attracting the interest of personnel managers and economic researchers. In addition, it was actively used in the Japanese coal mining industry in the 1900s. In this study, we first developed a theoretical model and predicted an optimal intensity of using referral hiring, depending on workers' skill

types and the firm's selection skill levels.

We arrived the following theoretical predictions. When the difference between workers productivity is large, the optimal intensity of using referral hiring is high. When the firm has information about applicants and the firm and referrers are complementary in terms of recruiting, the optimal intensity of using referral hiring is high. When the firm has information about applicants and the firm and referrers are substitutes in terms of recruiting, the optimal intensity of using referral hiring is low.

We tested the predictions using employment contract documents from a coal mining company operated in the 1900s and obtained empirical results that are consistent with the predictions. Applicants with traditional manual skills were more likely to be hired by referrals. Applicants with no skills were less likely to be hired by referrals. Applicants with new skills, which the firm knew well, were less likely to be hired by referrals.

Our results can share with solving current hiring problems. Our results imply that it might be efficient for firms to use referral hiring when workers' skill types are too complicated for HR managers to determine the right candidates. However, it might be efficient for a firm not to use referral hiring when it knows the skill types well, and workers have no skills, like new graduates.

References

Burks, Stephen V., Bo Cowgill, Mitchell Hoffman, and Michael Housman, "The Value of Hiring Through Employee Referrals," *The Quarterly Journal of Economics*, Feb. 2015, *130* (2), 805–839.

Corcoran, Mary, Linda Datcher, and Greg Duncan, "Information and Influence Networks in Labor Markets," in Greg J. Duncan and James N. Morgan, eds., *Five Thousand American Families–Patterns of Economic Progress*, Vol. 8, Michigan: Institute of Social Research, The University of Michigan, Ann Arbor, 1980, chapter 1.

Dolfin, Sarah and Garance Genicot, "What Do Networks Do? The Role of Networks on Migration and "Coyote" Use," *Review of Development Economics*, May 2010, *14* (2), 343–359.

Ekinci, Emre, "Employee referrals as a screening device," *RAND Journal of Economics*, 2016, *47* (3), 688–708.

Fafchamps, Marcel and Alexander Moradi, "Referral and Job Performance: Evidence from the Ghana Colonial Army," *Economic Development and Cultural Change*, July 2015, *63* (4), 715–751.

Galenianos, Manolis, "Hiring through referrals," *Journal of Economic Theory*, July 2014, *152*, 304–323.

Granovetter, Mark, *Getting a Job: A Study of Contacts and Careers 2nd Edition*, Cambridge, MA: Harvard University Press, 1995.

Holzer, Harry J., "Hiring Procedures in the Firm: Their Economic Determinants and Outcomes," *NBER Working Paper*, March 1987, (2185).

_ , "Search Method Use by Unemployed Youth," *Journal of Labor Economics*, Jan. 1988, *6* (1), 1–20.

Ichihara, Hiroshi, *Tanko no Rodo Shakaishi: Nihon no Dento-teki Rodo, Shakai Chitsujo to Kanri (A Social History of Coal Mining Labor: Traditional Labor, Social Order, and Management in Japan)*, Tokyo: Taga Shuppan, 1997. (In Japanese).

Kajisa, Kei, "Personal Networks and Nonagricultural Employment: The Case of a Farming Village in the Philippines," *Economic Development and Cultural Change*, July 2007, *55* (4), 669–707.

Konoe, Mototaro, *Chikuho Tanko-Shi (Survey of Coal Mining Industry in Chikuho District)*, Nakamura Kinko-Do, 1898. (In Japanese).

Larsen, Anna Folke, John Rand, and Nina Torm, "Do Recruitment Ties Affect Wages? An Analysis using Matched Employer-Employee Data from Vietnam," *Review of Development Economics*, July 2011, *15* (3), 541–555.

Mano, Yukichi, Takashi Yamano, Aya Suzuki, and Tomoya Matsumoto, "Local and Personal Networks in Employment and the Development of Labor Markets: Evidence from the Cut Flower Industry in Ethiopia," *World Development*, Oct. 2011, *39* (10), 1760–1770.

Mardsen, Peter V., "Interpersonal ties, social capital, and employer staffing practices," in Nan Lin, Karen Cook, and Ronald S. Burt, eds., *Social Capital: Theory and Research*, New Brunswick, NJ: Transaction Publishers, 2001, chapter 5.

Montgomery, James D., "Social Networks and Labor-Market Outcomes: Toward an Economic Analysis," *American Economic Review*, Dec. 1991, *81* (5), 1408–1418.

Munshi, Kaivan, "Networks in the Modern Economy: Mexican Migrants in the U. S. Labor Market," *The Quarterly Journal of Economics*, May 2003, *118* (2), 549–599.

_ **and Mark Rosenzweig**, "Traditional Institutions Meet the Modern World: Caste, Gender, and Schooling Choice in a Globalizing Economy," *American Economic Review*, Sept. 2006, *96* (4), 1225–1252.

Nagahiro, Toshitaka, "Senkanki Nihon ni Okeru Tanko Kigyo no Tokeiteki Kansatsu (Statistics Analysis of Coal mining Firms in Japanese Inter-War Period)," *Enerugi-Shi Kenkyu: Sekitan wo Chushin toshite (History of Energy: Focus on Coal Mining)*, March 2002, *17*, 211–246. (In Japanese).

Nakajima, Maki, Keijiro Otsuka, and Takashi Yamano, "Jobs Off the Farm: Wealth, Human Capital, and Social Group in Rural Eastern India," *The Journal of Development Studies*, 2018, *54* (1), 111–132.

Nakajima, Ryo, Ryuichi Tamura, and Nobuyuki Hanaki, "The effect of collaboration network on inventors' job match, productivity and tenure," *Labour Economics*, August 2010, *17* (4), 723–734.

Ogino, Yoshihiro, *Chikuho Tanko Roushi Kankeishi (History of Industrial Relations of the Coal Mining in the Chikuho District)*, Fukuoka: Kyushu Daigaku Shuppan Kai, 1993. (In Japanese).

Pellizzari, Michele, "Do Friends and Relatives Really Help in Getting a Good Job?," *Journal of Labor Economics*, April 2010, *63* (3), 494–510.

Pinkston, Joshua C., "How Much Do Employers Learn from Referrals?," *Industrial Relations*, April 2012, *51* (2), 317–341.

Rees, Albert, "Information Networks in Labor Markets," *The American Economic Review*, March 1966, *56* (1/2), 559–566.

Simon, J. Curtis and John T. Warner, "Matchmaker, matchmaker: the effect of old boy networks on job match quality, earnings, and tenure," *Journal of Labor Economics*, July 1992, *10* (3), 306–330.

Stupnytska, Yuliia and Anna Zaharieva, "Explaining U-shape of the Referral Hiring Pattern in a Search Model with Heterogeneous Workers," *Journal of Economic Behavior & Organization*, Nov. 2015, *119*, 211–233.

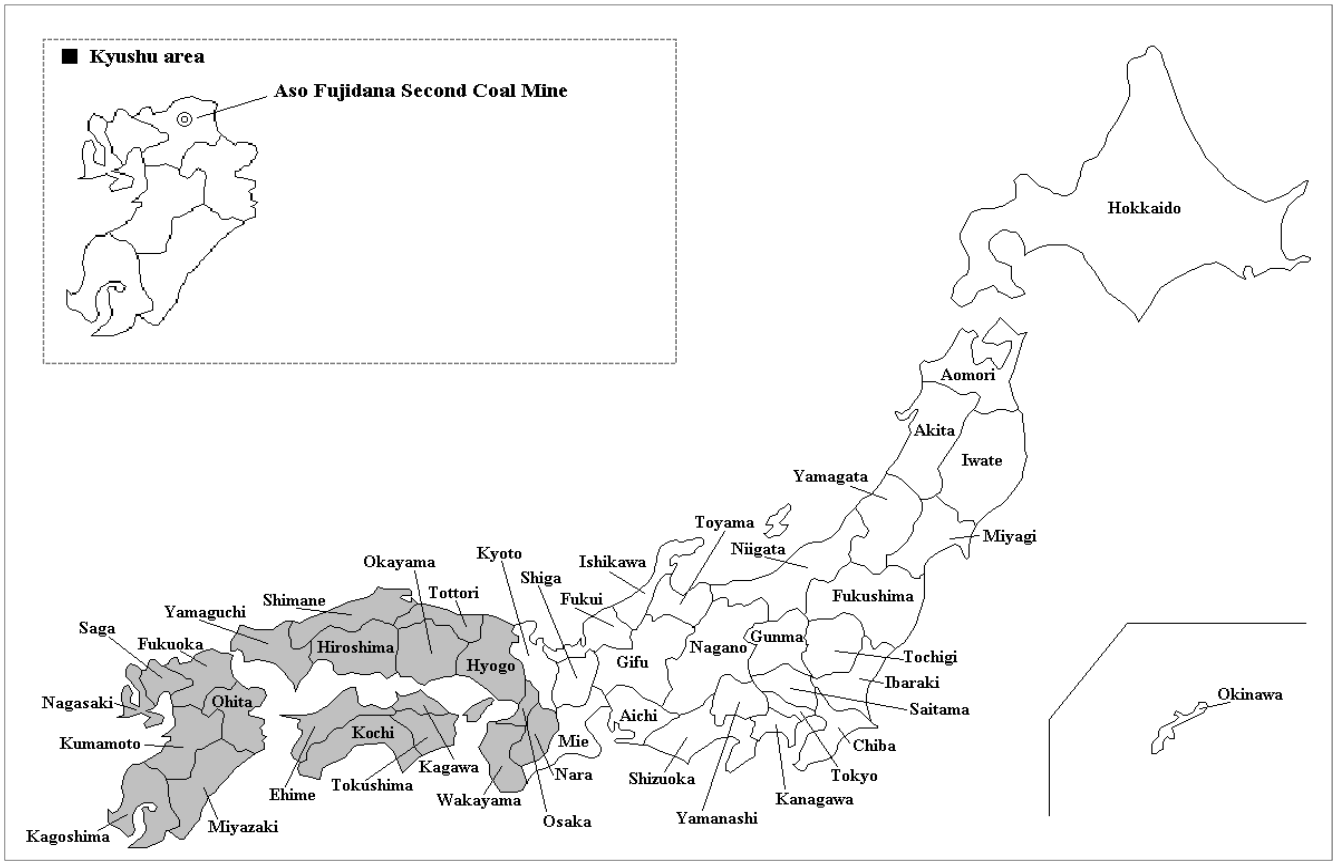
Sumiya, Mikio, *Nihon Sekitan Sangyo Bunseki (Analysis on the Japanese Coal Mining Industry)*, Tokyo: Iwanami Shoten, 1968. (In Japanese).

Tanaka, Naoki, *Kindai Nihon Tankou Rodo-shi Kenkyu (Research on Labor History at coal mines in modern Japan)*, Chiba: Sofukan, 1984. (In Japanese).

Tassier, Troy and Filippo Menczer, "Social network structure, segregation, and equality in a labor market with referral hiring," *Journal of Economic Behavior & Organization*, June 2008, *66* (3-4), 514–528.

Wang, Wen and Roger Seifert, "Employee referrals: A study of 'close ties' and career benefits in China," *European Management Journal*, Aug. 2017, *35* (4), 514–522.

Figure 1. Prefectures from which applicants originated



Source : "Miner Job Applications."
Notes: The applicants were from shaded prefectures.

Table 1. Previous job type, registered address and average age

District / Prefecture	Sum	(%)	Previous job						
			Coal miner	Pillar worker	Conveyance elevator operator	Other miner	Farmer	Miscellaneous	Unknown
Sum	774	100.0	61	51	7	24	107	8	516
Kyushu	478	61.8	42	22	6	19	57	7	325
Fukuoka	272	35.1	28	13	5	10	43	3	170
Saga	37	4.8	4	0	0	1	1	2	29
Oita	83	10.7	1	4	0	2	9	0	67
Kumamoto	57	7.4	5	1	1	6	4	0	40
Nagasaki	16	2.1	3	2	0	0	0	2	9
Miyazaki	7	0.9	0	2	0	0	0	0	5
Kagoshima	6	0.8	1	0	0	0	0	0	5
Chugoku	172	22.2	5	11	1	3	29	0	123
Hiroshima	90	11.6	5	7	1	3	17	0	57
Shimane	32	4.1	0	2	0	0	5	0	25
Yamaguchi	31	4.0	0	1	0	0	3	0	27
Okayama	13	1.7	0	1	0	0	4	0	8
Tottori	6	0.8	0	0	0	0	0	0	6
Shikoku	108	14.0	11	13	0	2	21	1	60
Ehime	72	9.3	8	11	0	2	11	1	39
Kagawa	22	2.8	2	0	0	0	7	0	13
Tokushima	8	1.0	0	1	0	0	3	0	4
Kochi	6	0.8	1	1	0	0	0	0	4
Kinki	16	2.1	3	5	0	0	0	0	8
Hyogo	7	0.9	1	1	0	0	0	0	5
Osaka	4	0.5	0	1	0	0	0	0	3
Wakayama	3	0.4	0	3	0	0	0	0	0
Nara	2	0.3	2	0	0	0	0	0	0
Average age			29.4	29.5	26.7	29.0	26.8	31.3	27.6

Source : “Miner Job Applications.”

Note : Average age is caluculated by applicants' birth date and their application date.

Table 2. Applicants' previous jobs and their seals

Logistic regression Dependent V.: Put own Seal on job application	2a			2b		
	Coef.	Z stat	Odds ratio	Coef.	Z stat	Odds ratio
Coal miner	-0.31	-0.640	0.733	-0.225	-0.460	0.799
	(0.488)			(0.493)		
Pillar worker	-1.806*	-1.770	0.1643	-1.647	-1.610	0.193
	(1.020)			(1.024)		
Conveyance operator	0.314	0.290	1.369	0.454	0.410	1.575
	(1.089)			(1.095)		
Other miner	1.219***	-1.040	3.3824	1.397***	2.890	4.045
	(0.471)			(0.484)		
Miscellaneous	1.007	2.590	2.738	1.147	1.370	3.148
	(0.829)			(0.838)		
Farmer	-0.410	1.220	0.6638	-0.256	-0.630	0.774
	(0.394)			(0.404)		
Age				0.000168	0.010	1.000
				(0.0144)		
Male				-0.239	-0.810	0.788
				(0.295)		
Constant	-2.106***	-14.880		-2.012***	-4.420	
	(0.142)			(0.455)		
Observations	774			710		
LR Chi2	15.11			15.380		
Log Likelihood	249.7227			223.121		

Source : "Miner Job Applications."

Notes : Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3. Applicants' previous jobs and applying with families

Logistic regression Dependent V.: Applied with family member	3a			3b		
	Coef.	Z stat	Odds ratio	Coef.	Z stat	Odds ratio
Coal miner	0.122	0.450	1.1296	0.177	0.560	1.1939
	(0.272)			(0.315)		
Pillar worker	-1.520***	-4.180	0.2188	-1.550***	-3.470	0.2122
	(0.364)			(0.446)		
Conveyance operator	-1.025	-1.220	0.3588	-0.393	-0.470	0.6752
	(0.841)			(0.845)		
Other miner	-0.619	-1.440	0.5382	-0.149	-0.320	0.8619
	(0.431)			(0.466)		
Miscellaneous	-1.207	-1.470	0.299	-0.609	-0.740	0.5441
	(0.821)			(0.825)		
Farmer	-0.916***	-4.030	0.4	-0.607**	-2.350	0.5447
	(0.227)			(0.258)		
Age				0.00730	0.740	1.0073
				(0.00987)		
Male				-3.007***	-10.080	0.0494
				(0.298)		
Constant	0.109	1.230		2.288***	5.950	
	(0.0882)			(0.384)		
Observations	774			710		
LR Chi2	40.370			215.380		
Log Likelihood	-514.695			-382.820		

Source : "Miner Job Applications."

Notes : Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4. Referral hiring or direct recruitment, logit estimates.

Logistic regression Dependent V.: Referral hiring = 0, Direct recruitment = 1.	4a			4b		
	Coef.	Z stats	Odds ratio	Coef.	Z stats	Odds ratio
New entrant				1.080***	3.14	2.9460
				(0.345)		
Applicant with traditional manual skills	-0.370	-0.76	0.6904	-0.0858	-0.17	0.9178
	(0.486)			(0.501)		
Applicant with modernized skills	1.044**	2.03	2.8413	1.329**	2.51	3.7769
	(0.515)			(0.530)		
Constant	-2.693***	-16.48		-2.978***	-14.52	
	(0.163)			(0.205)		
Observations	774			774		
	LR Chi2(2)	4.31		LR Chi2(3)		13.21
Log Likelihood	-181.22			-178.72		

Source : "Miner Job Applications."

Notes : Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5. Referral hiring with three type of referrers or direct recruitment, multinomial logit estimates.

Multinomial logit regression Dependent V.: Direct recruitment = 0, Skilled miner referral agent = 1, Direct controlled dormitory head = 2 , Dormitory head = 3.	5a			5b		
	Coef.	RRR	Z stats	Coef.	RRR	Z stats
Direct recruitment						
New entrant				1.241***	3.46	3.49
				(0.355)		
Applicant with traditional manual skills	-0.322	0.73	-0.65	-0.0115	0.99	-0.02
	(0.492)			(0.507)		
Applicant with modernized skills	1.624***	5.08	2.84	1.934***	6.92	3.3
	(0.572)			(0.586)		
Constant	-2.317***		-13.98	-2.628***		-12.69
	(0.166)			(0.207)		
Directly controlled dormitory head						
New entrant				2.222***	9.23	7
				(0.318)		
Applicant with traditional manual skills	-1.500**	0.22	-2.05	-0.705	0.49	-0.94
	(0.732)			(0.753)		
Applicant with modernized skills	-0.247	0.78	-0.23	0.548	1.73	0.51
	(1.059)			(1.074)		
Constant	-2.055***		-13.95	-2.851***		-12.4
	(0.147)			(0.230)		
Skilled miner referrers						
New entrant				-0.997**	0.37	-2.55
				(0.391)		
Applicant with traditional manual skills	0.423*	1.53	1.84	0.325	1.38	1.4
	(0.230)			(0.232)		
Applicant with modernized skills	1.521***	4.58	3.62	1.424***	4.15	3.38
	(0.420)			(0.421)		
Constant	-1.116***		-11.17	-1.018***		-9.76
	(0.0999)			(0.104)		
Dormitory head	(base outcome)			(base outcome)		
Observations	774			774		
	LR Chi2(6)	28.56		LR Chi2(9)	104.94	
Log Likelihood	-758.20			-720.01		

Source : "Miner Job Applications."

Notes : Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix table 1. Three Categories of job applicants by their previous jobs

Category	Previous job found in Miner job applications	Average age	
New entrant	Farmer Miscellaneous	27.1	
Applicant with traditional manual skills	Coal miner Pillar worker	29.4	27.8
Applicant with modernized skills	Conveyance elevator operator Other miner	28.5	

Source : "Miner Job Applications."

Note : Average age is caluculated by applicants' birth date and their application date.

Appendix table 2. Proportion of applicants and previous job by application year

Applicant type	All applicants		New entrant	Applicant with traditional manual skills	Applicant with modernized skills	unknown
Year		%	%	%	%	%
unknown	13	1.7	15.4	23.1	7.7	53.8
1902	3	0.4	0	0	0	100
1904	1	0.1	0	0	0	100
1905	283	36.6	0.7	18.4	2.1	78.8
1906	160	20.7	42.5	2.5	4.4	50.6
1907	314	40.6	13.7	16.9	5.4	64
SUM	774	100	14.9	14.5	4	66.7

Source : "Miner Job Applications."