Effects of Electrification on the Production and Distribution in the Coal Industry:
Evidence from 1900s Japan*

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Abstract

This paper studies how electrification affected the economic performance and industrial relations of the Japanese coal mining industry in the 1900s. We find that electrification considerably improved productivity and increased the number of workers, but had statistically zero effects on miners' wages and significantly declined the labor income share, using difference-in-differences estimation. We explain this phenomenon by using the "superstar firm" hypothesis, which provides a consistent explanation of the recent declines in labor income share in the US economy.

JEL classifications: D24, L94, O13, O14, Q40.
Keywords: Electrification, labor income share, productivity, industrial revolution, technological change, coal mining.

1 Introduction

Electrification, since its introduction, has been one of the biggest technological and environmental changes for developing economies. It affects not only human living conditions but also production. However, its effects are not entirely obvious, especially on production conditions because, in the early stages of economic development, the organizational structures in firms are not well-established and can be fragile and thus electrification in industrial economies can affect the inter/intra-organizational structures of industries. As a result, electrification can have a negative impact, especially on employment or distribution in such economies.

In this study, we examine how electrification impacted production and distribution using the case of the Japanese coal mining industry in the 1900s.[1] Particularly, we focus on the coal industry in Chikuho district, Kyushu area, southern Japan (see Figure 1). The Chikuho district was one of the biggest coal production areas, with around 50% of the coal output in Japan being produced here in the 1900s.[2] Japan consumed coal domestically and also exported it, mainly to China as marine fuel.[3] Specifically, coal was the third most exported product in 1898, after raw silk and cotton yarn.[4] The Japanese coal mining industry was a determinant of the Japanese industrial revolution,[5] which began at the end of 19th century. At that time, electric power usage had started being implemented in Japan, as well as in Chikuho for the coal mining industry. Therefore, the coal mining industry in the Chikuho district is a good case of how economic development can be affected by electrification.

This study estimates the effects of electrification on productivity, the number of workers, wages, and labor income share using data on 27 coal mining firms in 1908 and 1909 using a difference-in-differences approach. Our findings are as follows. First, electrification considerably improved productivity (by 53%) and significantly increased the number of miners (by

[1] The coal mining industry played a leading role for economic development. Numerous scholars studied how the industry changed and affected the entire economy, among others, see Boal and Pencavel (1994), Boal (1995), Boal (2009), Morantz (2013), Kerkvliet (1991), Greasley (1990), and Burhop and Lübbers (2009).

[2] See Ogino (1993), pp. 16, 140.

[3] See Sumiya (1968), pp. 184–189, pp. 247–248, and pp. 262–266.

[4] See Oku (2011), pp. 41–42.

[5] This was true at least until the 1930s.

15%).[6] Second, it had statistically zero effects on coal miners' wages. Finally, electrification declined the labor income share by 43%. These results imply that the economic performances of coal mining firms were drastically improved by electrifications, which the labor income share declined, which means electrification most benefited employers. Indeed, wages did not significantly increase and, thus, electrification did not improve coal miners' pecuniary situation.

Further, our results indicate that the production and distribution of the coal mining industry were affected by electrification as follows. First, productivity and labor demand increases are expectable and natural. Since the introduction of electric power was considered technological progress, productivity must have increased. Given the increase in productivity, it was optimal for coal mines to increase the number of workers.

Second, the fact that the wages did not significantly change is associated with labor supply conditions. Historians reported that the labor supply was extremely elastic in the Japanese coal mining industry until the late 1920s (Sumiya, 1968; Ogino, 1993; Ichihara, 1997). They argue that the labor market was tight and miners moved frequently from one coal mine to another, looking for a good coal bed or a well-paid job. This means Lewis's hypothesis was likely to be true for the labor market at that time (Lewis, 1954). Therefore, capitalists could take labor from the market without increasing wages.

Finally, we consider the effects on the labor share, which cannot be explained by the standard neoclassical approach because, under a class of standard production functions, the labor income share is constant for any technological progress.[7] Our principal explanation of this phenomenon is related to a recent study by Autor et al. (2017), which explain the decline of the labor income share in the US economy. They formulate a production function with fixed costs of overhead labor. In their model of imperfect competition, the technological progress in "superstar" firms can lower the labor income share in these firms. The higher the outputs and labor demands are, the lower the labor income share is. In our context, the electrified mines were superstar firms: they registered technological progress and needed more coal miners. Further, their labor income share decreased because of electrification. Consequently, our results

[6] Here, miners denote the workers who worked inside a coal mine, that is, not only coal miners.
[7] Here, we simply assume standard production functions, such as the Cobb-Douglas.

are explained by this superstar hypothesis.[8]

Several preceding studies investigate this relationship between electrification and development as follows. In Indian manufacturing, Allcott et al. (2016) present that electricity shortages negatively affect plant revenues and Hulten et al. (2006) show that electric generation capacity accounts for substantial productivity growth. Khandker et al. (2013), Chakravorty et al. (2014), and Bridge et al. (2016) show that electrification increases household income. Dasso and Fernandez (2015) show that electrification in rural Peru increases earnings and hourly wages by about 35% among women, while there is no such a benefit among men. On the other hand, Dinkelman (2011) shows that electrification in South Africa reduces female wages and increases male earnings.

Our main contribution to the literature is twofold. First, we estimate the effects of electrification on the internal distribution of firms, as well as production. The above-mentioned studies identify the effects on the absolute changes of wages or output, while this study also considers the labor income share, which is affected by industrial relations and organizational structures. We then relate our estimation results to the recent study of Autor et al. (2017), along with Lewis's (1954) hypothesis. Second, to the best of our knowledge, this study is the first attempt to investigate the effects of electrification in the Japanese coal mining industry before WWI. Recently, several authors examine the labor income share of Japanese industries (Yoshikawa, 1994; Hashimoto, 2017; Fukao and Perugini, 2018). However, most studies focus on the period after WWII or more recent periods. We consider only the coal mining industry in this paper, given that the coal mining industry was one of the most important sectors in Japan. However, our analysis is suggestive in understanding how technological change can affect the organizational structure or distribution in general.

The remainder of this paper is organized as follows. Section 2 explains how electrification was implemented in the Japanese coal mining industry. Section 3 describes the data. Section 4

[8]There is another possibility: suppose that wages were determined by some bargaining process between employers and employees. In this case, electrification can affect bargaining power. If the bargaining power of the employers increases, the labor income share decreases. Aoki (1990) argues that the bargaining between employers and workers was crucial for the development of the Japanese economy by focusing on economies after WWII, while we consider economic development in the 1900s.

presents the estimation equation and results. Section 5 concludes the paper.

2 Background: Electrification in the Japanese coal mining industry

We identify the electrified coal mines as coal mines equipped private power generation facilities. This assumption can be unusual from the current perspective but the situation of electrification in Japan in the 1900s was different from the current electrification programs conducted in developing economies, such as connecting households to electrical grids. Here, we illustrate the relevance of our assumption by analyzing how electrification was conducted in the Japanese coal mining industry.

The usage of electricity was introduced in the 1880s in Japan for electric lighting. Since the electricity distribution system was small-scale and only applied over short distances at that time, large factories had to equip their own power generation facilities and used electric lighting by generating their own electric power. This resulted in the widespread use of electric lighting among factories and development of the Japanese spinning industry. Large factories generated electric power by their own generating facilities even after they started using electric power not only for lighting but also for the operation of electric machines.[9]

Hydro-electric generation increasingly was dominant nationally over coal-fired power generation because of the increasing coal prices. However, the business operators in Kyushu that used coal-fired power generation accounted for 70% since the area was a coalfield.[10]

The electricity-generating capacity by private power generation constituted 75% of the total capacity in Kyushu and 30% in all Japan in the late 1900s.[11] This situation was because there were large-scale shipyards, steel plants, and coal mines in Kyushu, and all owned large-scale private power generation facilities. Therefore, we regard electrification as the process of

[9] See Hidemura (1979), pp. 35–37, Inoue (1979), pp. 115, 118–119, and Matsushima (1979), p. 134.

[10] See Kyushu Electric Power Co., INC (2007), pp. 69–70. Kyushu Electric Power Co., INC (2007) is the company history of Kyushu Electric Power Co., INC and describes how electrification was implemented in Kyushu.

[11] The remaining electric power was generated by electric power suppliers. There were eight electric power suppliers in Kyushu in 1900 (see Kyushu Electric Power Co., INC (2007), pp. 50, 73).

equipping private power generation facilities and identify the effects of electrification based on whether coal mines owned the facilities or not. In 1904, there were 24 business operators that owned private power generation facilities in Kyushu. Fourteen were coal mining firms and 10 of them were located in Chikuho district.[12]

3 Data sources

The data used in this study come from two sources. First, the wage data come from the *Chikuho Coal Mining Association Monthly Newsletter*, published from September to December 1909.[13] These newsletters rarely included information on wages consecutively. Instead, it usually reported the monthly coal outputs and number of miners for coal mines that produced over 1000t of coal and employed more than 100 miners. We use the special articles, titled "Operation of Major Coal Mines in the Stagnation," over four consecutive months, including data on 27 mines from January 1908 to October 1908 and from January 1909 to October 1909.[14] The articles reported coal miners' monthly average wages per person per day, monthly coal output, and number of workers at the end of each month.

Second, the data on electric power usage come from the *Directory of Electric Power Industry* in 1908 and 1909.[15] This *Directory* included information on business operators with private power generation facilities.[16] Of the 27 coal mines mentioned above, 13 in 1908 and 15 in 1909 had private power generation facilities.

[12]See Kyushu Electric Power Co., INC (2007), pp. 50–51. In Chikuho district, steam-power drainage pumps and conveyance elevators came into use in 1880 and 1881, respectively. (See Sumiya (1968), pp. 214-215, 310, 464465 and Ogino (1993), pp. 1718, 41.) The Mitsubishi Namazuda coal mine was the first business operator in Chikuho that used electricity for electric lighting in 1895 and then for conveyance elevators in 1898 (see Kyushu Electric Power Co., INC (2007), pp. 50–51.).

[13]The newsletter was issued monthly from 1904 to 1941.

[14]The main purpose of the articles was to solve the stagnation in 1909 by comparing the data in 1908 with those in 1909 and learning from other coal mines' situations. The data coverage of individual coal mines ranges between seven and 10 months each year.

[15]The first *Directory* reported the situation in 1907. The *Directory* for 1907—1910 was issued in 1911. We do not obtain such information before 1907. The *Directory* for 1907 reported that there were six coal mines which owned private power generation facilities in 1907 and all of them continued to own the facilities in 1908 and 1909.

[16]The *Directory* provided detailed information such as the number of boilers, power engines, and power generators, as well as the total horsepower of power engines and kilowatts provided by power generators that each "electrified" business operator owned.

The coal mines with private power generation facilities used electricity, but we do not know whether the other mines did so or not. We do not have information on which coal mines were connected to the electricity grid and bought electricity. However, the coal mines without private power generators were not able to use a large amount of electricity. In addition, there was only a poor electricity distribution system. We thus identify the effects of electrification based on whether the coal mines had private power generators or not, as mentioned in Section 2.

The summary statistics are presented in Table 1. From 1908 to 1909, the average real wage and labor income share decreased by 6.7% and 11.7%, while the average output, number of workers, and productivity increased by 8.5%, 7.0%, and 4.3%, respectively. Table 2 presents the averages of variables with and without private power generators (PPG) for each year. The amount of output and number of workers with PPG is significantly larger than without PPG for both years. Other variables do not show large differences with and without PPG over both years.[17]

4 Results

We use the difference-in-differences approach to examine the effects of electrification, showing the differences in employment and production outcome between the coal mines without a PPG in 1908 and those with one in 1909. We estimate the following equation:

$$E_{it} = \beta_0 + \beta_1 PPG_{it} + \alpha_t + M_i + \varepsilon_{it}, \tag{1}$$

where E_{it} is the outcome variable (monthly productivity, number of miners,[18] real wage,[19] and labor income share[20]); PPG_{it} is an electrification dummy that equals 1 if mine i owned private

[17]Takanoe (1908) and Takanoe (1911) report that 63.0 % and 66.7% of these coal mines used electric lighting in 1908 and in 1909, respectively.

[18]"Miners" refers to workers who worked inside a mine, thus, not only coal miners.

[19]We use nominal wage data and convert it into the real value using the consumer price index from Okawa et al. (1967) for each year.

[20]We obtain labor income share by following equation:$(\text{nominal wage})(\text{number of miners})/(\text{coal price})(\text{coal output})$. We obtain data on coal price for each year using the amount of coal output and value of output in Fukuoka prefecture, where all of the coal mines were located, from Nou Shou Mu Daijin Kanbo Tokei Ka (Dept. of Agriculture and Commerce Section of Statistics) and Nou Shou Mu Daijin Kanbo Tokei Ka (Dept. of Agriculture

power generating facilities at period t, and 0 otherwise; α_t denotes a period dummy; and M_i is a vector of individual coal mine characteristics (e.g., coal beds, depth of the main shaft, distance from the port) for each coal mine $i(= 1, \ldots, 27)$[21] and period t (from January 1908 to October 1909). Here, ε_{it} is the error term, allowed to correlate with $\varepsilon_{it'}(\forall\, t, t')$. The results for equation (1) are shown in Table 3.

To control for the outcomes at period $t-1$ (E_{it-1}) that may affect E_{it}, we run another regression:

$$E_{it} = \beta_0 + \beta_1 PPG_{it} + \beta_2 E_{it-1} + \alpha_t + M_i + \varepsilon_{it}. \tag{2}$$

The results for equation (2) are shown in Table 4.

Table 3 presents our main estimation results. We focus on the coefficients of PPG in each column, which show the effects of electrification.

Column (1) represents the estimation results for the monthly productivity of firms. It shows that electrification improved productivity by 53%. Most period dummies are also effective: productivity was influenced by period effects. Columns (2) shows the number of miners increased by 15% because of electrification. Additionally, only one coefficient on the period dummy is statistically significant: employment was not often influenced by period effects.

Column (3) presents the estimation results on wages. It shows that electrification had no statistically significant effects on wages. On the other hand, it indicates that the period dummy for 1909 has strongly negative effects: wages declined in 1909 compared to January 1908. Column (4) represents the estimation results on the labor income share. Specifically, it shows that electrification decreased the labor income share by 43%. Here, only a few period dummies are significant and, thus, the labor income share was not influenced by period effects.

Table 4, which corresponds to equation (2), shows similar results to Table 3. In this case, the effects of electrification on monthly productivity and number of miners is not significant. However, the observations for the labor income share are robust.

Now, we explain and interpret our results. Electrification allowed coal mines to use new

and Commerce Section of Statistics).

[21] We obtain data on the number of miners in 25 coal mines among the 27 coal mines.

technologies and machines. For example, the introduction of electric lighting was important for miners because candles could cause fires or coal dust explosions. Steam-power machinery disturbed production process because it raised the temperature inside the mine more than electric-power machinery. As electric machines made miners more productive, it is natural that electrification improved productivity.

As to the effect on wages, an important feature of the economic environment is the existence of a sufficient labor supply. At that time, workers came from not only Kyushu but also areas not contiguous to Kyushu (see Figure 1). According to Morimoto (2018), which investigates employment contract documents from a colliery operated in the 1900s, 38% of job applicants were from outside Kyushu. Quantitatively, the main labor force was formed of ex- or current farmers, which often worked in a mine during the agricultural off-season.[22] As reported by Morimoto (2018), job applicants whose previous job was in farming accounted for 14%. Since there were so many farmers that could potentially work in coal mines, labor supply was almost unlimited. Consequently, firms were able to employ labor without any rise in wages. This explains our result on wages.

Given no change in wage and an improvement in productivity, electrified firms were able to make more profit by increasing the number of coal miners they employed. This explains the fact that electrification has a positive impact on the number of miners.

The last point is the decline of labor income share. As previously explained, this decline, along with other effects, is explained by the superstar firm model formulated by Autor et al. (2017). Since a standard model with neoclassical production functions cannot explain the decline in the labor income share, the authors propose a production function with a fixed amount of overhead labor. Assuming an imperfection in the production market, the labor income share (LIS) of firm i is determined by the following equation:

$$\text{LIS of firm}_i = \frac{(\text{constant})}{(\text{mark up of firm}_i)} + \frac{(\text{fixed cost of overhead labor})}{(\text{revenue of firm}_i)}.$$

Therefore, if productivity improves, labor demand and output increase. This implies the second

[22] Some left their farm villages to work at coal mines and never returned.

term decreases. Additionally, it is possible that productivity leads to an increase in markup. This implies that the first term decreases. The total effect of an improvement in productivity is a decline in the labor income share. According to Autor et al. (2017), the superstar firms with high productivity emerged because of technological changes, yielding low labor income shares in the current markets.[23] This explanation on superstar firms is consistent with our results. That is, electrified coal mines had higher productivity than the other mines. Then, given the low wage level because of an unlimited labor supply, electrified mines hired more labor and achieved higher output levels. This implies that electrified coal mines had higher revenues.

To sum up, the superstar firm effect and unlimited labor supply can naturally explain our results on the production and distribution of the coal mining industry.

However, there are other explanations for our results. Consider that wages are determined by a bargaining process. Electrification was able to affect the organizational structure of firms because PPGs were owned by firms and could change the allocation of authority. Indeed, coal mining firms adopted a new system for organizational structures in the 1900s: before 1900s most firms delegated recruiting workers to several agents, but started recruiting workers themselves around the 1900s.[24] Such organizational changes also modified the bargaining power between employers and workers. It is thus natural to consider that employers had more power because of this change, leading to the decline of the labor income share.

Additionally, coal mining firms had other large costs in addition to wages. Indeed, they used their revenues for paying back debt incurred by the introduction of PPGs. Moreover, PPGs needed other investments on the capitals of these firms. Further, using electric facilities required a certain level of human capital, which was added to their costs. Liquidity shortages can be another reason for the decline in labor income share and lack of change in wages.

[23]The main concern of Autor et al. (2017) is the aggregate value of labor income shares. They discuss that superstar firms yield higher concentrations on the market and, as a result, the aggregate labor income share decreases.

[24]For more detailed arguments on the organizational changes in the coal mining industry, see Sumiya (1968), Ogino (1993), and Morimoto (2018).

5 Concluding remarks

Many large factories, including coal mines, electrified their facilities around the 1900s as a result of the industrial revolution. In fact, Japan had 184 business operators that introduced private power generation facilities in 1909, with 21 coal mining firms in Kyushu having PPGs.[25] This means the coal mining industry was a core of economic development.

In this paper, we examined the effects of electrification in the coal mining industry in the Chikuho district, Kyushu area using rare operational data. We showed that electrification had statistically zero effects on miners' wages, while it substantially improved productivity. The results also showed productivity strongly depended on period effects. Our findings imply that technological improvement does not always translate into a higher labor income share.

Because of data limitations, we used data only for 1908 and 1909. Afterwards, the coal mining industry experienced significant economic changes because of WWI. Therefore, it is important to investigate the impacts of electrification by the end of the next decades. Some coal mining firms grew rapidly, while others did not. As such, there could be differences between the coal mines that were electrified first and those that fell behind in terms of introducing electrification. That is, there can be hysteresis or path dependence in the process of coal mining industry development. For example, these differences can be associated with bargaining power. Workers in coal mines increasingly formed labor unions in the late 1930s. However, the timings or rates of unionization were different among coal mines. It is possible that the electrification at the beginning of the 20th century affected the unionization in the 1930s. However, such a research project remains for future work.

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Table 1. Summary statistics

	Total				
	Obs	Mean	Std. Dev.	Min	Max
real wage	432	0.0129	0.0017	0.0093	0.0198
output	432	16283.05	10246.52	1732	52297
workers	396	1525.38	933.91	254	3878
productivity	396	13.01	9.82	3.61	66.25
Labor income share	396	0.54	0.23	0.07	1.58

	1908					1909				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
real wage	216	0.0133	0.0016	0.0094	0.0198	216	0.0124	0.0016	0.0093	0.0195
output	216	15617.23	10439.03	1732	48574	216	16948.86	10030.28	4230	52297
workers	198	1473.71	890.53	282	3878	198	1577.06	974.88	254	3753
productivity	198	12.74	9.32	3.61	61.40	198	13.28	10.33	5.42	66.25
Labor income share	198	0.57	0.26	0.09	1.58	198	0.50	0.18	0.07	1.28

Table 2. Mean of variables by PPG

	1908		1909	
	with PPG	without PPG	with PPG	without PPG
real wage	0.01318	0.01339	0.01243	0.01239
output	21008.10	11223.00	20478.21	13076.86
workers	1771.22	1187.98	1891.86	1158.56
productivity	12.12	13.33	11.30	15.92
Labor income share	0.612	0.527	0.466	0.532

Table 3. Effects of electrification by DID estimation

	E_{it}			
	(1)	(2)	(3)	(4)
VARIABLES	*ln (monthly productivity)*	*ln (number of miners)*	*ln (real wage)*	*labor income share*
PPG	0.531*	0.152**	-0.00260	-0.431**
	(0.258)	(0.0671)	(0.0282)	(0.197)
Period dummy				
Feb. 1908	-0.366***	0.00769	-0.0372**	0.187***
	(0.0382)	(0.0280)	(0.0165)	(0.0255)
March 1908	-0.0784**	0.0249	-0.0103	0.0261
	(0.0306)	(0.0290)	(0.0185)	(0.0238)
April 1908	-0.118***	7.53e-05	-0.0152	0.0354*
	(0.0327)	(0.0421)	(0.0176)	(0.0192)
May 1908	-0.0543	0.0208	-0.0221	-0.000174
	(0.0394)	(0.0460)	(0.0214)	(0.0236)
June 1908	-0.121**	0.0372	-0.0255	0.0534
	(0.0483)	(0.0484)	(0.0220)	(0.0329)
July 1908	-0.112***	0.0671	-0.0348	0.0261
	(0.0310)	(0.0560)	(0.0219)	(0.0182)
Aug. 1908	-0.304***	0.0191	-0.0633***	0.128***
	(0.0330)	(0.0653)	(0.0219)	(0.0206)
Sept. 1908	-0.0856	0.0304	-0.00875	0.0261
	(0.0767)	(0.0548)	(0.0398)	(0.0485)
Oct. 1908	-0.164***	0.121**	0.0385	0.0938
	(0.0418)	(0.0562)	(0.0649)	(0.0600)
Jan. 1909	-0.166***	0.0842	0.00303	0.111***
	(0.0443)	(0.0710)	(0.0233)	(0.0219)
Feb. 1909	-0.180***	0.0867	-0.0409*	0.0942***
	(0.0368)	(0.0737)	(0.0218)	(0.0252)
March 1909	-0.0195	0.111	-0.0602***	0.00395
	(0.0478)	(0.0679)	(0.0176)	(0.0298)
April 1909	-0.0835*	0.0791	-0.105***	0.00917
	(0.0435)	(0.0676)	(0.0173)	(0.0238)
May 1909	-0.0636	0.0650	-0.168***	-0.0247
	(0.0427)	(0.0664)	(0.0249)	(0.0233)
June 1909	-0.111**	0.0284	-0.213***	-0.0271
	(0.0453)	(0.0708)	(0.0274)	(0.0277)
July 1909	-0.179***	0.0107	-0.237***	-0.00255
	(0.0492)	(0.0796)	(0.0230)	(0.0286)
Aug. 1909	-0.184***	-0.0240	-0.236***	0.00742
	(0.0501)	(0.0859)	(0.0251)	(0.0284)
Sept. 1909	-0.225***	0.0159	-0.252***	0.0186
	(0.0515)	(0.0840)	(0.0326)	(0.0335)
Oct. 1909	-0.0962	0.105	-0.223***	-0.0457
	(0.0616)	(0.181)	(0.0643)	(0.0676)
Constant	2.272***	7.012***	6.687***	0.728***
	(0.138)	(0.0476)	(0.0203)	(0.105)
Observations	396	396	432	396
Number of mine	25	25	27	25
R-squared	0.456	0.108	0.672	0.489

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Effects of electrification with lags by DID estimation

			E_{it}	
	(1)	(2)	(3)	(4)
VARIABLES	*ln (monthly productivity)*	*ln (number of miners)*	*ln (real wage)*	*labor income share*
PPG	0.332	0.0382	-0.00431	-0.299*
	(0.211)	(0.0306)	(0.0225)	(0.171)
E_{it-1}	0.300**	0.650***	0.447***	0.263*
	(0.110)	(0.0571)	(0.0767)	(0.148)
Period dummy				
March 1908	0.397***	0.0122	0.0436**	-0.211***
	(0.0718)	(0.0238)	(0.0181)	(0.0430)
April 1908	0.271***	-0.0238	0.0266*	-0.159***
	(0.0365)	(0.0213)	(0.0146)	(0.0279)
May 1908	0.347***	0.0130	0.0219	-0.197***
	(0.0572)	(0.0239)	(0.0135)	(0.0365)
June 1908	0.261***	0.0160	0.0216	-0.134***
	(0.0540)	(0.0269)	(0.0152)	(0.0440)
July 1908	0.290***	0.0352	0.0138	-0.175***
	(0.0408)	(0.0301)	(0.0136)	(0.0279)
Aug. 1908	0.0954**	-0.0342*	-0.00333	-0.0649**
	(0.0399)	(0.0169)	(0.0161)	(0.0278)
Sept. 1908	0.383***	0.0904**	0.0730**	-0.192***
	(0.0922)	(0.0370)	(0.0342)	(0.0618)
Oct. 1908	0.247***	0.0947***	0.0907**	-0.109**
	(0.0425)	(0.0218)	(0.0368)	(0.0435)
Feb. 1909	0.239***	0.0255	-0.00484	-0.124***
	(0.0493)	(0.0312)	(0.0190)	(0.0259)
March 1909	0.403***	0.0479	-0.00450	-0.210***
	(0.0512)	(0.0417)	(0.0151)	(0.0363)
April 1909	0.291***	0.000666	-0.0411***	-0.181***
	(0.0471)	(0.0268)	(0.0141)	(0.0333)
May 1909	0.330***	0.00711	-0.0833***	-0.216***
	(0.0494)	(0.0284)	(0.0157)	(0.0309)
June 1909	0.277***	-0.0204	-0.101***	-0.209***
	(0.0454)	(0.0281)	(0.0194)	(0.0307)
July 1909	0.223***	-0.0142	-0.105***	-0.184***
	(0.0595)	(0.0228)	(0.0189)	(0.0336)
Aug. 1909	0.249***	-0.0274	-0.0865***	-0.185***
	(0.0648)	(0.0202)	(0.0249)	(0.0348)
Sept. 1909	0.212***	0.0332	-0.0879***	-0.172***
	(0.0523)	(0.0358)	(0.0261)	(0.0292)
Oct. 1909	0.344***	0.165	-0.0456	-0.225***
	(0.0686)	(0.148)	(0.0473)	(0.0602)
Constant	1.246***	2.469***	3.661***	0.713***
	(0.265)	(0.396)	(0.511)	(0.128)
Observations	346	346	378	346
Number of mine	25	25	27	25
R-squared	0.502	0.558	0.763	0.518

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Map of Japan with names of prefectures and areas