

Railroad expansion and entrepreneurship: evidence from Meiji Japan

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July 2013

Abstract

Railroads in Meiji Japan are credited with facilitating factor mobility as well as access to human and financial capital, but the impact on firms is unclear. Using a newly developed firm-level dataset and a difference-in-differences model that exploits the temporal and spatial variation of railroad expansion, I assess the relationship between railways and firm activity across Japan. Results indicate that railroad expansion corresponded with increased firm activity, particularly in manufacturing, although this effect is mitigated in less populous regions. These findings are consistent with industrial agglomeration in areas with larger markets and earlier development among both new and existing establishments.

Keywords: agglomeration, entrepreneurship, firm genealogy, late development

JEL classification: L26, N75, O53

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I. Introduction

One of the foreign inventions Commodore Matthew Perry brought with him on his visit to Japan in 1854 was a miniature steam locomotive that ran on a mile-circumference track.¹ Curious onlookers were impressed not only by the novelty of the design, but especially with its rapidity: one impromptu rider sitting atop the train “clung with a desperate hold to the edge of the roof... and described the experience `as though it were flying.”² Eighteen years and a revolution later, the Meiji emperor opened the country’s first railway between Tokyo and Yokohama, which cut the day-long journey by foot to less than an hour by train.³

Among the many technological and institutional changes sweeping Japan in the late nineteenth century, the railroad has been credited with a leading role in promoting industrialization and economic growth⁴. This premise is consistent with the benefits of improved transportation infrastructure, which include lower transit costs, market integration and expansion, and intersectoral linkages.⁵ Casual observation of Japan's economic performance seems to corroborate this view: between 1872, when the country's first railway was completed, and 1907, when the government nationalized the industry, national income tripled in real terms.⁶ During this same period, the domestic rail network expanded from 29 to 7,152 kilometers; the number of locomotives from 10 to 1,924; and annual passengers carried from 495,000 to 101 million.⁷

Correlation, however, is not causation, and studies ascribing a causal link between railroads and economic development have typically relied on counterfactual comparisons of social savings or indirect measures of economic activity like population growth.⁸ Less clear are how the arrival of the railway directly affects entrepreneurs and industries or how these would have behaved differently in the absence of locomotive technology, especially for countries that

¹ This was not the first train seen in Japan; the previous year a Russian envoy demonstrated locomotive technology aboard his ship, but the model was smaller in scale and viewed by many fewer (Free, 2008, p. 22).

² Ericson (1996), p. 4. This is echoed in contemporary newspaper accounts, which stated that “[t]he railway train will be as fast as the wind or a cloud. Without such a miraculous device it would be impossible for a human being to do a thing like this unless he possessed the wings of a bird”; in Nagao (1929), p. 5, quoting from the 6 September 1872 issue of *Nichi Nichi Shimbun*.

³ Free (2008), pp. 11 and 85.

⁴ Lockwood (1954) writes that unlike western countries, railroads allowed Japan to “[gain] the economies of a national system almost at the outset” and that they “facilitated a geographic extension of the internal and external market by lowering the cost of moving goods and people” (p. 106). See also Crawcour (1997), pp. 58-61, and Ericson (1996), pp. 31-32 and 52.

⁵ Rostow (1960), chapter 4.

⁶ Data from Maddison (2003). Official Japanese data provide nominal income series starting in 1875, which indicate a six-fold increase by 1907; see Japan Statistical Association (1987), series 13-3, Yamada estimates.

⁷ *Ibid.*, series 8-4, 8-6, and 8-14. Historical data begin in 1886 for freight traffic, which grew from 426,000 tons to 18,605,000 in 1907 (series 8-15).

⁸ Classic studies include Fogel (1964) and Fishlow (1965), while Atack et al (2009) and Herranz-Loncan (2011) are more recent examples.

may have well-developed shipping transport links like Japan. This uncertainty is in part due to a lack of historic firm-level data as well as difficulty in finding appropriate analogues with which to compare economic outcomes.

Another factor to consider is that railroad access may have differential consequences on the connected locations themselves. While railroads may increase economic activity for the macroeconomy, economic geography suggests that agglomeration forces can draw business activity away from newly accessible areas (aka, periphery) toward already established manufacturing centers, and thus mitigate potential economic gains in the former.⁹ This theoretical prediction would seem to apply to Meiji Japan, where there were already large disparities in population and commerce between major cities like Tokyo and Osaka and the more remote prefectures. Taking account of differences between regions may clarify the distributional effects of the railroad and other spatially oriented technologies at a country's early stage in development.¹⁰

The aims of this paper are twofold: to examine the railroad-growth relationship through the lens of firm activity; and to highlight the variable effects of railway access across industries and regions. The research design uses a newly developed firm-level dataset drawn from corporate genealogies and a difference-in-differences methodology that exploits the variation in the timing of railroad network expansion across Japanese prefectures. The genealogies comprise one of the oldest sources of Japanese establishment data across the industrial spectrum, thus providing a more representative view of microeconomic activity than that based on government records and case studies of major firms.¹¹ The empirical analysis compares firm activity in regions before and after they gained railroad access while controlling for regions that did not experience a change to their transport technology. Furthermore, by including prefectural population as a measure of market size, one can separate the general effects of railroad expansion on firm activity from those due to agglomeration and provide a simple test of the theoretical predictions from economic geography.

Results indicate that railway access had a small, but positive impact on entrepreneurship across prefectures in general. Furthermore, firm activity differed between industries following the arrival of the railroad, with manufacturing enterprises (in particular, textiles) increasing more rapidly as well as shifting toward more populated locations. This finding is consistent

⁹ Krugman (1991a). Using Spanish industrialization as an example, Krugman (1991b) writes that depending on how much transport costs decrease, "over some range closer integration actually leads production to move perversely from the point of view of comparative cost" and he concludes that "railroads and steamships led to deindustrialization of the periphery" (pp. 97-98). This point has been refined more recently with the distinction of original (climate) and acquired (resource investment) features specific to locations; see Crafts and Wolf (2012).

¹⁰ Present-day examples may include the expansion of high-speed rail and rollout of broadband internet access; see Crafts (2004).

¹¹ See Tang (2011) for an empirical analysis of technological leadership using firm genealogical data.

with the rationalization of capital-intensive production away from smaller markets given greater labor availability and lower transport costs. The documented role of low-value manufacturing to early Japanese industrialization suggests that this discrete change in firm activity represents a substantive contribution of railroads to economic growth despite an uneven distribution of activity. Discussion of these findings and a number of caveats to interpreting them follows in the final section of the paper.

II. Background and motivation

Railroad construction in Japan began with the 29 kilometer stretch between Tokyo and its nearest deepsea port Yokohama. Two years later, in 1874, a similar length of track was laid between Osaka and the port city Kobe, approximately 500 kilometers to the west. While the government, which provided funding for these projects, anticipated that the two major cities of Tokyo and Osaka would be connected by rail in the near future, it was not until 1889 that the Tokaido route between them was finally completed.¹²

The delay owed chiefly to financing. Given the costs of the its modernization program, deteriorating balance of payments, pacifying restless samurai, and controlling inflation, the central government found it difficult to continue investing in railroad infrastructure.¹³ It was not until the 1880s that network expansion began apace, during which the government allowed the private sector to enter the industry and lay its own tracks in local areas and other parts of the country not served by the public network, as shown in Table 1. Both public and private railroads expanded methodically, radiating away from Tokyo and Osaka toward the extremities of the main island of Honshu and connecting major cities in other prefectures, as shown in Figure 1. Short tracks were also laid on the islands of Hokkaido, Shikoku, and Kyushu, which tended to be privately-owned and resource extraction oriented.¹⁴

[Table 1 and Figure 1]

The motivations to build a national railway system were legion: for the government, better transport infrastructure meant centralization of political authority, national defense, and

¹² The Tokaido route was one of five major routes pre-dating the Meiji Period that were extensively used for long distance travel between the administrative (Tokyo) and commercial (Osaka) centers and outlying regions.

¹³ Crawcour (1997), p. 59, and Aoki et al (2000), p. 11. See also Free (2008), chapter 6, and Ericson (1996), chapter 2, for greater discussion of the political and economic context of Meiji railway financing.

¹⁴ Hokkaido and Kyushu were major coal producing regions, which attracted private investment in railway construction linked to the mining industry; Free (2008), pp. 28 and 398-399. Shikoku was relatively resource poor and had minimal railway development except around the two ports of Takamatsu and Tokushima (ibid, p. 28).

spreading economic growth to rural areas.¹⁵ For the private sector, following fiscal retrenchment in the 1880s and supported by interest rate guarantees, railways were also viewed as a profitable venture.¹⁶ As railroad investments required larger sums than could be provided by any single private investor, these ventures also made active use of the newly established equity exchanges. To coordinate public objectives with private financing, the government issued a number of laws in the 1880s and 1890s that standardized railway construction as well as identified which government-planned lines could be bid on by private investors. Localities could also petition for amendments or extensions after 1892, when the Railway Construction Law was passed. Public-private collaboration continued until the nationalization of major trunk lines between 1906 and 1907, which left only urban tramlines and ancillary extensions in the hands of private investors.

That certain localities and sectors benefitted from railway access is readily documented, such as the silk producing area in central Nagano prefecture. Following the completion of the Shin'etsu railroad between northern Nagano and Tokyo-Yokohama in 1893, highly perishable raw silk could be carried to the closest train station 40 kilometers away instead of five times that distance to the capital. When the line was extended to the Suwa district itself, "production...increased dramatically and the cocoon collection area expanded" to cover most of sericultural area in central Japan.¹⁷ Consumption of coal also grew with the national economy (and was used by the railroad industry itself), which largely relied on railroad or mixed rail-sea transport for distribution.¹⁸ Countering these examples, however, is the iron and steel sector, which despite obvious industrial linkages to rail construction and transport arguably did not benefit from them over most of the Meiji Period given the location of deposits and the initial reliance on imported materials. Only following government intervention did railroads contribute to the industry's growth, notably with the 1907 railway nationalization that guaranteed demand for domestically produced iron and steel.¹⁹

These industrial and prefectural differences relationship suggest a closer examination of the relationship between Japan's expanding rail system and economic activity. As shown in Figure 2, if one looks at period-wide trend rates of rail network length, national income, exports,

¹⁵ Aoki et al (2000), p. 15; Crawcour (1997), pp. 58-61.

¹⁶ Ibid. These considerations notwithstanding, given the existence of coastal and riverine shipping, mountainous terrain, and a system of roads connecting the central cities to outer regions, it is possible that the spread of railroads did not represent a fundamental improvement in transportation access. Since the Tokugawa Period (1603-1868), rice and fish-meal fertilizer were shipped from the northern regions and Hokkaido to central Honshu; Aoki et al (2000), p. 5. Furthermore, hundreds of feudal nobility *daimyo* paid biennial visits to Tokyo as part of their *sankin kotai* obligations to the ruling shogunate, which promoted inter-regional transit and commerce.

¹⁷ Aoki et al (2000), pp. 21-22, and Ericson (1996), p. 42-48.

¹⁸ Ibid.

¹⁹ Ibid., pp. 32 and 38.

and the number enterprises, it is difficult to discern similar patterns between rail expansion and the other indicators, especially given the former's discontinuous growth.²⁰

[Figure 2]

Historical studies of Japanese railroads have typically eschewed statistical analysis, however, and few explicitly estimate the railway's impact on the economy.²¹ This may owe to a lack of data from this period; appropriate methods to test hypotheses; or interest in visiting a topic considered already settled. Fortunately, there is an extensive literature available on this subject for other countries, and empirical studies suggest that the railroad usually had a positive effect on economic welfare (although whether the impact is sufficient to drive growth is still debated), as measured through cost savings, consumer surplus, urbanization, or agglomeration.²² Many of these studies, especially those using the social savings approach, rely on counterfactuals to support the claim of welfare gains, which can pose an epistemological problem in identifying causality.²³

Alternative methods have been used to demonstrate a link between railroads and growth. Donaldson (2010) uses a general equilibrium trade model and highly detailed region price data to estimate the direct impact of an expanding railway system on the colonial Indian economy. His approach allows him to calculate reductions in trade costs and regional price differences as well as gains in income, which he finds amounting to a 16 percent increase due to rail access, much higher than Fogel's estimate of 4.7 percent for the United States in 1890. Atack et al (2009), on the other hand, focus on population growth and urbanization as possible consequences of railroad development, and find evidence that railroads "caused" urbanization in the American Midwest. They do so using a novel GIS-augmented dataset and a difference-in-differences empirical model to compare pre- and post-access census years in affected counties against those that remained unaffected in the mid 1800s. In terms of research design, this paper is more similar to the approach taken by Atack et al, with the data and methodology described below.

²⁰ That said, the consequences of railroad construction may not behave in a monotonic or linear fashion. Nonetheless, the trend for manufacturing output is highly similar to that for GDP, and is omitted from the figure for clarity.

²¹ That said, these works provide a wealth of detail and historical context and are cited throughout this paper.

²² A survey of older literature on social savings can be found in O'Brien (1977), while a more recent discussion is Leunig (2010).

²³ Besides a number of assumptions about the elasticity of substitution, actual and opportunity costs, and pricing behavior, the use of a model-based counterfactual as a control group renders long term estimates more difficult to calculate reliably. Externalities and general equilibrium effects are separate and even less tractable issues.

III. Research design

This paper uses a new firm-level dataset collected from corporate genealogies and a difference-in-differences model to identify causality.²⁴ The genealogies, assembled by business historians in the *Shuyo Kigyo no Keifuzu* [Genealogical Charts of Major Japanese Firms] collection, are based on company histories of 1,089 firms listed on the Tokyo Stock Exchange in 1984 and contain establishment entries dating back to the nineteenth century or earlier. Besides dates of establishment and exit or reorganization, each entry may also provide the type of ownership, an industry identifier, and the location of establishment. To compare across prefectures and between major industries during the Meiji Period, non Meiji-era startups and those without both industry and location are excluded; this decreases the number of establishments to 1,644. The remaining data cover all 47 prefectures and are disaggregated into four major industry categories: primary production and construction; manufacturing; finance; and other services. The three latter groups can be further classified into thirteen narrower categories, which are shown in Table 2 along with other summary statistics. The sector that had the largest relative change in startup activity following rail access was non-financial services, followed by manufacturing, while the greatest absolute increase occurred in finance. However, because railroad expansion took place over a few decades, a simple difference between the two periods may be misleading.

[Table 2]

Before proceeding with statistical analysis of the data, it may be useful to assess their validity for use. From the table, it is readily apparent in this dataset that banking by far had the highest number of startups over the whole of the Meiji Period, followed by transport and communication, and then by textiles. The possible undercount of firms in the primary and non-finance tertiary sectors, which usually predominate in non-industrial economies, may be due to the composition of the corporate genealogies that they are drawn from (ie, large listed firms), and that both manufacturing and financial firms were better documented historically than those in other sectors, especially in other services.²⁵ Many individual genealogies for a given industry do, however, include antecedent firms in different sectors, which reduces the bias from the industrial distribution of firms that were listed in 1984.

Even with possible representational bias between sectors in the firm sample, for this paper's analysis, a more relevant issue is whether the within industry distribution is consistent

²⁴ Yagura and Ikushima (1986).

²⁵ Over half (627) of the genealogical collection are manufacturing firms, while financial companies number 131. As of March 2012, there are 1,684 firms listed in the first tier (ie, large capitalization) of the Tokyo Stock Exchange, of which 823 are classified as manufacturing; see Tokyo Stock Exchange (2012).

over time and location. Unfortunately, there is little documentation of firms at the prefectural level prior to the 1900s for Japan as a whole, much less for non-financial sectors at a subnational level. Official comprehensive statistics exist for banking at the prefectural level, but only starting in 1893, when considerable railroad expansion had already taken place.²⁶ That said, it may be instructive to compare national aggregates of firm establishment, and where possible, more detailed series at the sector or prefectural level. Table 3 provides correlation results of series based on official statistics with that using the genealogical data.

[Table 3]

In the top panel, I compare the *Shuyo* genealogical establishment series to multiple official sources at the national level. The first column includes annual number of firms in three sectors, manufacturing, commerce, and transport, and were collected by the Japanese Statistical Association for its *Historical Statistics of Japan* reference database.²⁷ The second column, also collected by the JSA, provides the number of factories across various manufacturing industries, while the third column contains banking data collected by the Ministry of Finance in its *Ginko Soran* [Comprehensive List of Banks] annual report. The bottom panel of Table 3 is at the prefectural level, and compares the genealogical data against by the Ministry of Finance's data as well as the Japanese Bankers Association (JBA) database, the latter including data for the whole of the Meiji Period.²⁸

The correlation results suggest a strong correspondence between the genealogical data and official sources both at the national and prefectural level. In the national series comparisons, all three sectoral series have pairwise correlation coefficients exceeding 0.70 in firm counts between the years 1884 and 1912, and for manufacturing factories, the positive correlation improves to 0.95 in the period 1886 to 1908. This is similar also to the banking series, which exceeds 0.99 for the years 1893 to 1912. For the latter sector, the correlation between the *Shuyo* series and both the Ministry of Finance and Japanese Bankers Association series weakens slightly when disaggregated by prefectures, but still exceeds 0.80 across all overlapping years. Moreover, for the entire Meiji Period, correlation coefficients for the *Shuyo* and JBA series exceed 0.90 in 41 of the 47 prefectures at 1 percent statistical significance. Assuming that genealogical firm data across all sectors were collected in similar fashion, this indicates reasonable confidence that the dataset is representative of the Japanese economy during the Meiji Period and can be used for disaggregated analysis.

²⁶ Japan Ministry of Finance (various).

²⁷ Japanese Statistical Association (1987), series 15-5 and supplementary series 6-1.

²⁸ Japanese Bankers Association (2012).

Applied to the question of railway impact, the genealogical data are aggregated by year, prefecture, and major industry to create a balanced panel dataset that covers the entire Meiji Period, between 1868 and 1912. They are also combined with railway data from the *Ekimei Jiten* [Rail Stations in Japan] handbook, published by Chuo Shoin. The handbook provides a comprehensive list of all rail stations established in the country, their founding dates, locations by city and prefecture, and other identifying information. The earliest year of station establishment in each prefecture is used to determine access, and is verified with secondary sources.²⁹ Prefecture level data on population and geography come from the *Historical Statistics of Japan*, published by the Japan Statistical Association.³⁰

For the empirical analysis, the paper employs a difference-in-differences methodology, comparing the number of firms established during the Meiji Period in each prefecture before and after it gains access to railroads.³¹ In line with predictions from the economic geography and transaction cost literatures, the rationale is that railroad access is a discrete change that increases factor mobility through lower transportation costs and wider market access, so firm activity would correspondingly increase to take advantage of these improvements. At the same time, it is anticipated that activity would vary based on extant conditions like pre-access market size, leading to agglomeration in larger markets and dispersion in smaller ones. As a point of reference, prefectures that gain access are compared to others that did not experience a contemporaneous change to their railroad infrastructure. The reduced form OLS model follows, with separate regressions for each industry group:

$$y_{it} = \beta_0 + \beta_1 x_{1it} + \beta_2 x_{2i} + \beta_3 x_{3t} + \beta_4 x_{4it} + \varepsilon_{it}, \text{ where}$$

y_{it} = total number of firms for prefecture i in year t

x_{1it} = rail access dummy variable for prefecture i in year t

x_{2i} = prefecture fixed effect

x_{3t} = year fixed effect

x_{4it} = interaction of control variables for prefecture i in year t

ε_{it} = error term

To measure the effect on firm activity, the dependent variable y_{it} is the total annual number of enterprises in each of the prefectures, indexed by i . This number is a net firm count that includes both new Meiji-era startup establishments in the prefecture and those that continue their operations; those that changed location or discontinued activity are excluded.

²⁹ These include Aoki et al (2000), Ericson (1996) and Free (2008).

³⁰ Prefectural population figures for 1884 were collected for the month of January while following years were for December; for consistency, the 1884 data are dated as 1883.

³¹ Card and Krueger (1994) is a well known study using this methodology, and Atack et al (2009) apply it to their study on nineteenth century American railroads. Firms established prior to the Meiji Period are not included in the dataset.

The main control variable of interest is the term x_{it} , which takes the value of zero for all years prior to rail access in prefecture i and the value of one in post-access years. Additional control variables include the prefectural population in 1883, prefectural coastline length, and fixed effects for prefecture and year. Prefectural population can be interpreted as a proxy for local market demand and agglomeration potential and the ordinal ranking among prefectures in 1883 is consistent over the whole period of analysis. One drawback of including this variable is that it reduces the number of years available for analysis as prefectural population data are unavailable prior to 1883, whereas eleven prefectures gained access prior to 1884.³² Furthermore, three prefectures gained access after the Meiji Period, and are also excluded from analysis as the genealogical data are collected only up to 1912. This reduces the number of prefectures available for analysis to 33. Similarly, coastline length is used to proxy for access to coastal transport, which may act as a substitute for rail transport.

For a causal interpretation of estimates based on the difference-in-differences methodology, two conditions should be met. The first is in the choice of control group (ie, prefectures that did not gain railroad access), which must be sufficiently similar to the treatment group in aspects aside from the treatment itself. Since most prefectures gained rail access during the Meiji Period, this suggests that there were no characteristics that predisposed them against rail development.³³ Moreover, outliers in access timing, such as prefectures that gained access earliest (eg, Tokyo, Osaka) and latest (eg, Okinawa), are also excluded from the analysis for the abovementioned reasons. This allows for division of the prefectures into control and treatment groups based on year of access and other time-invariant features. Table 4 provides the list of prefectures, their dates of railroad access, and other characteristics.

[Table 4]

This paper uses the year 1893 to separate the prefectures into two groups: a treatment group of 18 prefectures that gained access between 1884 and 1893, and a control group of 15 prefectures that gained access between 1894 and 1912.³⁴ This year was selected as it precedes the First Sino-Japanese War (1894-1895), which contributed to a dramatic expansion of the

³² These prefectures include Tokyo, Kanagawa, Hyogo, Osaka, Kyoto, Hokkaido, Shiga, Fukui, Saitama, Gunma, and Gifu. Note that prefectures gaining access in 1883 also not included as they would appear to have been treated for the entire period starting that year.

³³ This may not have been true for three prefectures that gained railroad access after the Meiji Period: Ehime (1914), Kochi (1924), and Okinawa (2003). These prefectures are also off the main island of Honshu, where most commercial activity took place and government policy was focused.

³⁴ The eighteen prefectures in the treatment group include Aichi, Aomori, Ibaraki, Fukuoka, Fukushima, Hiroshima, Iwate, Kagawa, Kumamoto, Mie, Miyagi, Nagano, Nara, Niigata, , Okayama, Saga, Shizuoka, and Tochigi. The fifteen prefectures in the control group include Akita, Chiba, Ishikawa, Kagoshima, Miyazaki, Nagasaki, Oita, Shimane, Tokushima, Tottori, Toyama, Wakayama, Yamagata, Yamaguchi, and Yamanashi.

public investment in armaments and public works with possible knock-on effects to firm activity; and it divides the set of prefectures into numerically similar groups. Analysis of these two groups is based on changes in firm activity between 1884 and 1893. These groups are shown on the map of Japan in Figure 3 along with those excluded from analysis.

[Figure 3]

The second condition for a causal interpretation is that the decision to extend the railway network itself is not itself determined by the measured outcome of firm establishment. In other words, entrepreneurs intending to establish firms or maintain operations should not influence the decision to expand rail access to a particular location. This appears to be valid since the government's objective to railroad expansion at the start of the Meiji Period was for national security and resource access, not commercial development.³⁵ Extensions of the railway system north and west in Honshu connected population centers usually along the most geographically and cost efficient paths and were meant to (and did) facilitate troop movements and securing the Pacific coastline.³⁶ Moreover, local and commercial lobbying for the placement of railroad track was also not observed prior to the creation of the national parliament in 1890 and the aforementioned passage of the 1892 Railway Construction law, which presented the government's vision of a national railway system and proposed lines identified for private investment.³⁷

To address concerns about control group selection and endogeneity, additional specifications exclude prefectures that have correlation coefficients less than 0.90 in the banking series comparison; those that are landlocked or have long coastlines (over 1,000 kilometers); and those with disproportionately small or large surface areas (outside one standard deviation of the average of prefectures in the control and treatment groups). The first robustness check addresses concerns that the data are not representative of official statistics, while the latter two remove outliers in the availability of coastal transport and ease of railway construction, respectively.

³⁵ The disinterest in (or ignorance of) commercial viability is highlighted by the lack of cost-revenue analysis made by the government in its early railway ventures and the large cost overruns in the first railroad between Tokyo and Yokohama (Free, 2008, p. 55). See also Yamamoto (1993), chapters 1 through 3.

³⁶ This was true even in the late Tokugawa Period, with proposals to build a railroad from Osaka to the then imperial capital Kyoto so as to "speed troops from the Choshu and Satsuma domains in the south [via steamer to Osaka] in the event of an emergency to 'defend' the Emperor from colonizing foreigners" (Free, 2008, p. 29).

³⁷ "[I]n railroad policy, government bureaucrats essentially had the field to themselves and were able to make decisions independently of private business, which had yet to organize politically or to secure formal representation in the national government" (Ericson, 1996, p. 16). See also Free (2008), p. 21.

IV. Results

The main regression results from the difference-in-differences analysis are presented in Tables 5 and 6, the former comparing estimates of firm activity aggregated across all sectors and the latter by major industry group. In Table 5, columns A through C include all prefectures that gained access to railroads between the years 1884 and 1912, and indicate that rail access is associated with an average prefectural net increase of between 2.19 (column B) and 2.60 (column C) firms per year.³⁸ These estimates, however, do not identify rail access as a causal factor and may obtain from a general increase in economic activity and population since all prefectures gained access over the period. When the period of analysis is shortened to create a control group (columns D through F), the net increase in the number of firms following rail access is more modest, from 0.46 (column E) to 0.51 (column F). Nevertheless, given the average number of firms by prefecture without rail access for this period is 3.75, the lower bound for a net increase in activity due to rail access is approximately 12 percent. In terms of the difference in average firm activity before and after rail access, this represents 23 percent of the total increase.

[Tables 5 and 6]

This overall positive effect notwithstanding, when population is interacted with rail access (columns E and F), the individual effect of rail access (row 1) is negative and statistically significant while the estimated coefficient on the interaction is positive (row 3). This indicates a decrease in firm activity in prefectures with less than around 700,000 inhabitants in 1883, which is true for seven of the eighteen prefectures in the treatment group for all years between 1884 and 1893.³⁹ Based on the coefficients in column F and an average of 1.91 firms per year for these least populated areas, the annual net loss of 0.56 firms represents a 29 percent fall in firm activity. Also of interest is that while its coefficient is consistently negative across specifications, the interaction of rail access and coastline length is never statistically significant, which suggests little impact from the former on firm activity even in areas with greater access to coastal transport.

The results in Table 6 disaggregate firm activity by industry, and show that the change in firm activity is largely due to the manufacturing sector (column B), particularly in textiles (column E). All else equal, manufacturing firm activity in treatment prefectures increased by 0.44 firms, which accounts for 33 percent of firm activity following rail access. In textiles, the

³⁸ This is calculated using the average 1883 prefectural population of 824,149 for prefectures that gained rail access over the period 1884 through 1912. For the years 1884 through 1893, the mean population is 854,448.

³⁹ These seven prefectures are Aomori, Kagawa, Iwate, Miyagi, Nara, Saga, and Tochigi, each averaging 610,783 in population over this period.

increase is 0.27 firms per annum, which is nearly 43 percent of post-rail firm counts.

To consider the impact of rail access on the change in firm numbers instead of the stock of firms, I also use the first difference of annual firm counts as the dependent variable. As shown in Table 7, rail access is only significant when interacted with population in textiles (column E) and to a lesser extent services (column D). This suggests that along with an absolute impact on firm activity shown in previous tables, rail access corresponds to a continuous increase in startup activity and firm survival (ie, industry expansion) in these sectors.

[Table 7]

To check the robustness of the above estimates, a number of different specifications are used and shown in Tables 8 through 10. The first check limits analysis to prefectures that had correlation coefficients exceeding 0.90 when comparing the genealogical bank series against the Japanese Bankers Association series. Consistent with the earlier estimates, rail access accounts corresponds to an increase in firm activity across all sectors (column A) of 0.45, which represents 26 percent of the increase between the pre- and post-rail access periods. Again, the effect is concentrated in manufacturing (textiles), which accounts for 56 percent (58 percent) of the increase in total firm activity between periods.

[Table 8]

To improve the correspondence between prefectures in both control and treatment groups, those that were landlocked or had coastlines exceeding 1,000 kilometers are excluded from the estimates reported in Table 9.⁴⁰ As before, the general effect of rail access is negative and the interaction with population is positive, with the average annual firm count increasing by 0.52, or 20 percent of the increase between pre- and post-rail periods. Manufacturing and services all experience a net gain in firms following rail access, and for the latter, the interaction with coastline length is positive and slightly statistically significant. More dramatically, for textiles the increase accounts for nearly 73 percent of level change between periods.

[Table 9]

Lastly, given the importance of surface area to railroad construction and timing, I use the subset of prefectures that have surface areas within one standard deviation of the average

⁴⁰ The excluded prefectures are Hiroshima, Kagoshima, Kumamoto, Mie, Nagano, Nagasaki, Nara, Tochigi, Yamaguchi, and Yamanashi.

across control and treatment groups to limit the impact of outliers within the control and treatment groups. The results are qualitatively consistent with earlier results, showing that firm activity rose across all sectors by 1.06 firms per annum, or 44 percent of the level increase between periods. In manufacturing, the increase is 0.68 firms (68 percent), while in textiles it is 0.36 firms (80 percent).

[Table 10]

V. Conclusion and discussion

The findings from the difference-in-differences analysis suggest that rail access has a positive impact on firm activity for the economy in general, although there are notable differences between prefectures and industries. Manufacturing, compared to other sectors, experienced substantial increases in firm activity following access after adjusting for initial prefectural population. Furthermore, the opposing signs on rail access and its interaction with population suggests that industrial agglomeration, measured in the number of firms, took place as a response to the railroad and came at the expense of less populated areas.

There are a number of caveats to taking these results at face value, however. The first relates to the dataset, which despite having a larger number of historically undocumented firms than existing sources, may be small to give precise estimates. Since the 1,644 startup firms in the dataset only include firms that started up during the Meiji Period, the analysis ignores the contribution of firms existing prior to 1868. Furthermore, more than 900 additional firms were excluded from the analysis as they either had no industry or location identifiers. Considering that the prefectures with the most economic activity, Tokyo and Osaka, were also excluded given their early acquisition of railroads, also diminishes the generalizability of the results to the economy in absolute measure.

The issue of data selection aside, the findings of increased firm activity, particularly in manufacturing, and of agglomeration are perhaps not obvious given features of the Meiji Japanese economy and existing infrastructure.⁴¹ While entrepreneurs may have started and continued operations as a result of improved transport links and wider markets, it can be argued that extensive measures of firm activity are not representative of higher capital intensity and within-firm scale expansion. Using firm counts that account for firm entry and exit may not adequately address this concern.

Furthermore, dispersive forces seem as likely to operate since entrepreneurs may not be able to fully capitalize on improved transportation infrastructure for industrial production.

⁴¹ That said, research on early twentieth century Japanese factory location suggests that agglomeration took place due to inter-industry linkages and demand for consumption goods; see Imaizumi (2008). These data, however, postdate most of the railway expansion era, so do not directly implicate railroad access itself as a determining factor, although changes in rail freight may have been influential.

Contributing factors include private monopolies of regional track and the precedence of passenger over freight traffic, which led to excess demand for freight services.⁴² A consequence of this meant that railways were not obliged to provide discounts for bulk shipping, and thus reduced the incentive to produce more than what was locally demanded, which is one of the qualifications of the Krugman model.⁴³ The availability of coastal freight, which was extensively used prior and throughout Japan's industrialization, may weaken the relevance of newer forms of freight transport, although the above analysis attempts to account for this factor.⁴⁴ Possible complementarity across types of transport can be seen in the revenues earned by private railways, where earnings from passengers exceeded those of freight for every year since 1890 until their nationalization in 1906-07.⁴⁵ Thus, a general equilibrium model that accounts for some of these features may provide clearer predictions for this setting.

In terms of economic significance, the difference-in-differences methodology using startup establishment has the advantages of clear explication and direct measurement of industrial activity. This approach also allows analysis that does not require price and output data, which are difficult to find at the subnational level. Taking the next step of measuring welfare impact, however, is less tractable without more detailed data. While some scholarship directly links entrepreneurship and economic growth, the findings in this paper are only suggestive.⁴⁶ In contrast, studies using the social savings approach incorporate price information can estimate welfare gains for the economy as a whole. If disaggregated price data can be found prior to and following rail access, it may be possible to apply the same difference-on-differences approach but also measure welfare improvement.

With these caveats in mind, the empirical results from the current analysis are still suggestive in adding to our understanding about the impact of railways on Meiji Japanese firm activity, and in turn, the country's industrialization. While the aims of the government and industrialists may not have been necessarily aligned in motivating the expansion of the railroad network, the utility of such infrastructure for both strategic and economic objectives became

⁴² Nagao (1929), pp. 18-19.

⁴³ Free (2008) writes: "[s]uch was the excess demand for railway shipment of goods that when one particular shipper asked for a discount from the [privately-owned] Nippon Tetsudo, the general manager would not allow for any discount at all if the shipper shipped 10,000 tons of freight or 100,000 tons. Freight hauling concerns took second priority to passenger traffic for almost the entire Meiji era" (p. 187). Krugman (1991a) states that a combination of lower transport costs, scale economies, and greater demand for manufacturing would lead to agglomeration. However, even with falling transport costs, it may be that local characteristics still prevail in determining industrial location; see Crafts and Mulatu (2006).

⁴⁴ Nagao (1929) writes that the inversion of the passenger-freight revenue ratio compared to other countries "is partly due to the circumstance that Japan, being surrounded by seas, can avail herself more readily of the facilities of maritime transportation" (p. 9). At the same time, rail freight could have positive feedback on sea freight, and thus act as complements instead of substitutes.

⁴⁵ Japan Statistical Association (1987), series 8-20.

⁴⁶ See for example Gries and Naudé (2008) and Dejardin (2000).

increasingly obvious, ultimately leading to the nationalization of the network toward the end of the Meiji Period.

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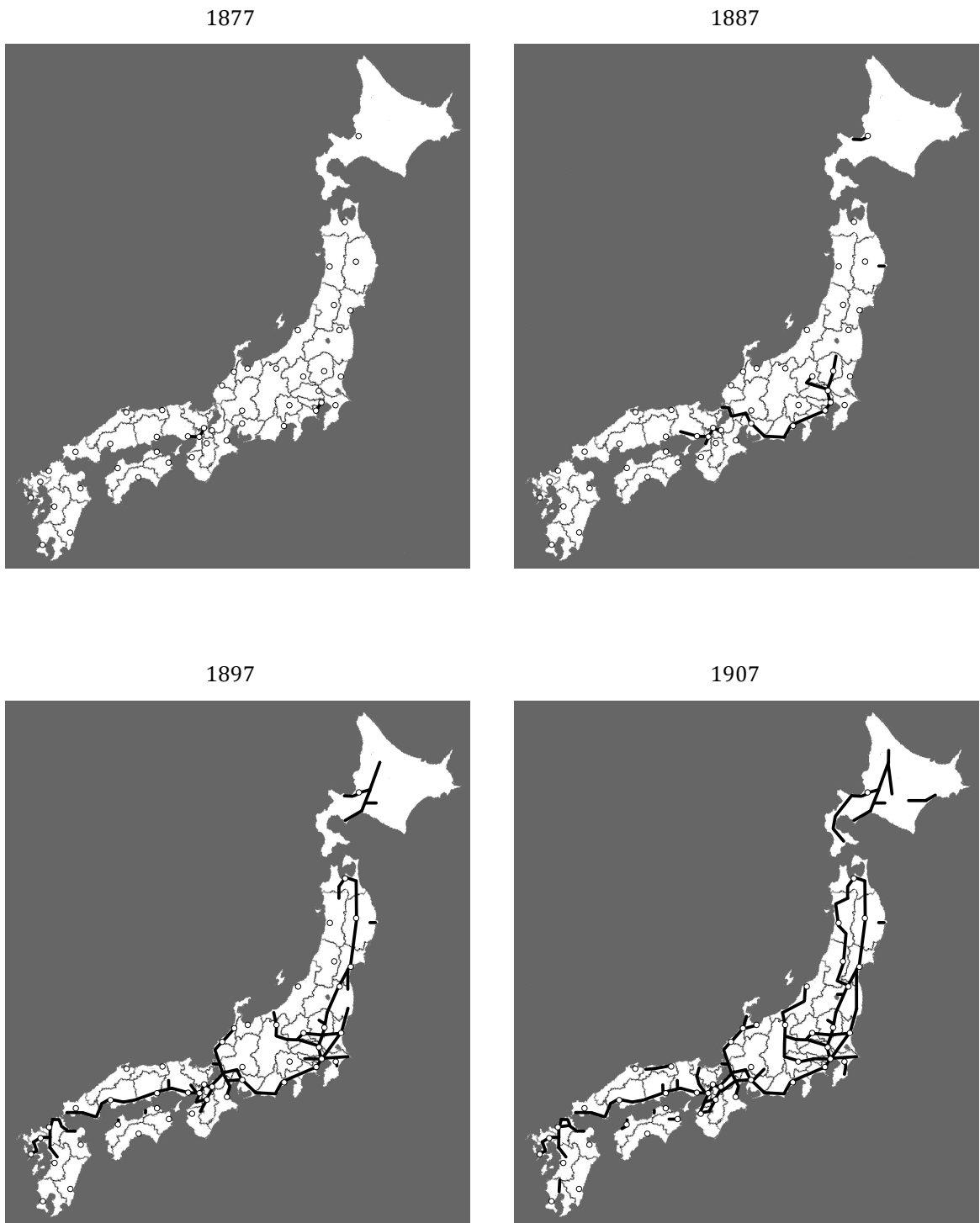
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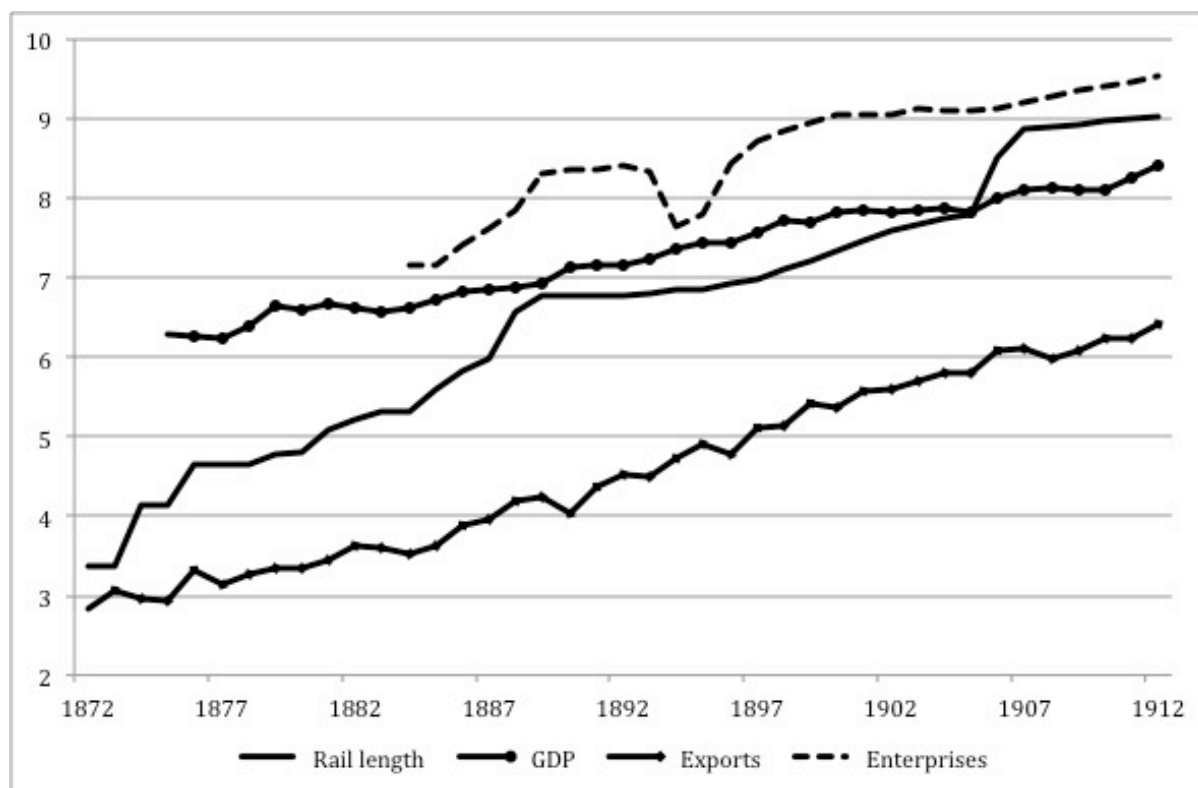
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Figure 1: Japanese rail network expansion



Source: see text.

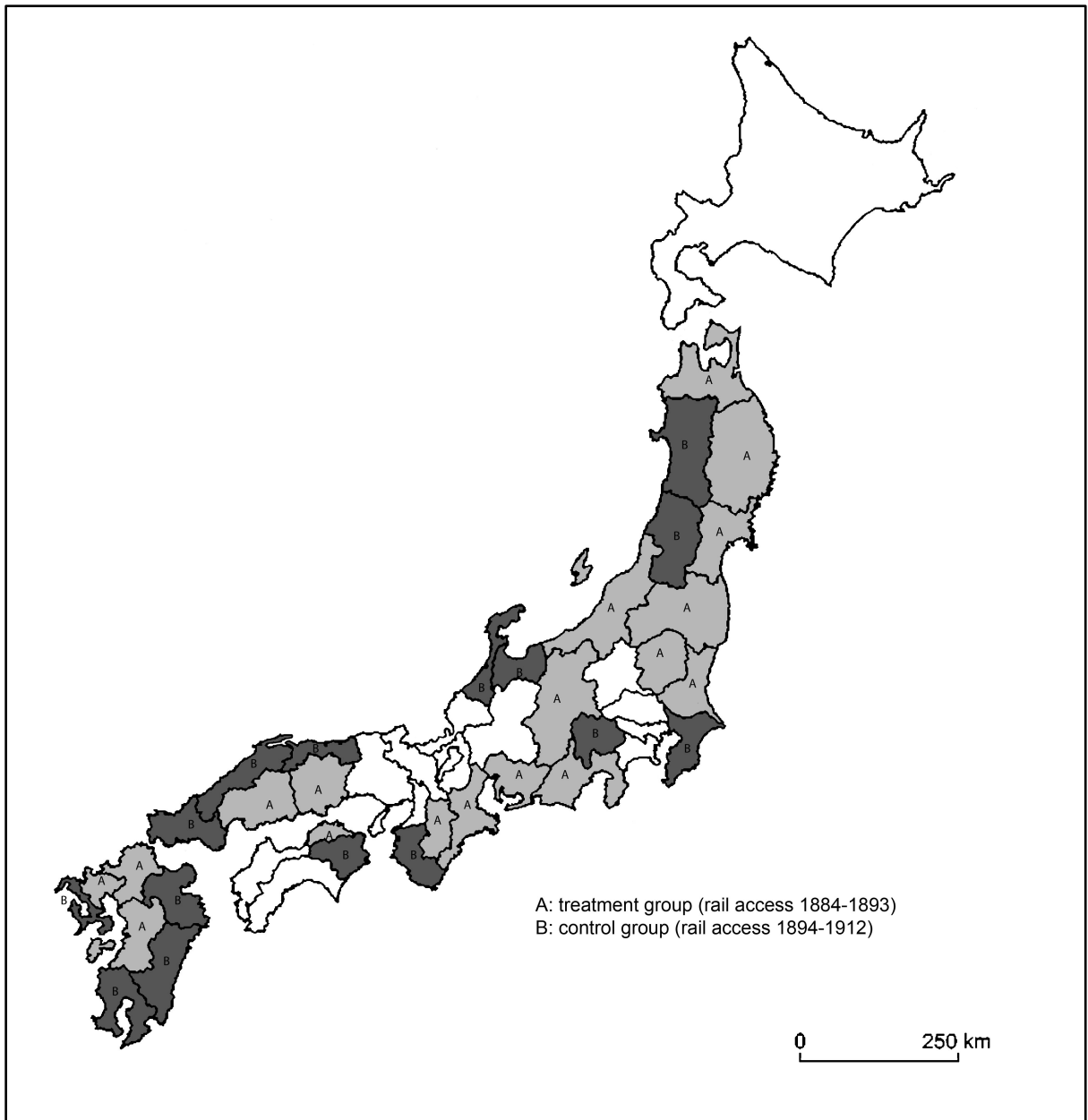
Figure 2: Meiji-era trends of economic indicators



Source: Japan Statistical Association (1987), series 8-4, 10-1, 13-3, and 15-5.

Note: values reported in logs with the following units: rail length (kilometers), GDP and exports (millions of yen, current value), and enterprises (total).

Figure 3: Difference-in-differences groups



Source: see text.

Table 1: Length of Japanese rail network, kilometers

Year	Public	Private ^a	Total
1872	29	0	29
1877	105	0	105
1882	185	0	185
1887	393	472	865
1892	886	2,125	3,011
1897	1,065	3,681	4,746
1902	1,974	5,398	7,372
1907	7,152	1,568	8,720
1912	8,396	2,988	11,384

Source: Japan Statistical Association (1987), series 8-4 and 8-14.

^a includes long-distance and local rail/tram networks

Table 2: Descriptive statistics

	Total	Pre-rail access	Post-rail access
Number of startups	1,644	339	1,305
Primary production	65	14	51
Manufacturing	462	60	402
Ceramic, glass	32	5	27
Chemicals	80	1	79
Food processing	53	11	42
Machinery	70	8	62
Metal processing	41	3	38
Textiles	142	25	117
Wood processing	42	7	35
Other manufacturing	2	0	2
Finance	870	250	620
Banking	757	213	544
Other finance	113	37	76
Services	247	15	232
Retail	64	7	57
Transport and utilities	171	6	165
Other services	12	2	10

Source: author's calculations; see text.

Table 3: Correlations

Shuyo establishments, national	HSJ firms 1884-1912	HSJ factories 1886-1908	GS banks 1893-1912
Manufacturing	0.751 (29)	0.948 (23)	
Retail and commerce	0.716 (29)		
Transport and utilities	0.920 (29)		
Banking			0.994 (20)
Shuyo establishments, prefectural	GS banks 1893-1912	JBA banks 1893-1912	JBA banks 1868-1912
Banking	0.828 (940)	0.831 (940)	0.875 (2,115)

Source: Japanese Statistical Association (1987), Ministry of Finance (various), Japanese Bankers Association (2012), Tang (2013); see text.

Note: all correlation coefficients are statistically significant at the 1 percent level ; number of observations in parentheses.

Table 4: Prefecture statistics

	Rail access year	Population (1883)	Coastline (km)	Surface area (km ²)
Japan		37,451,800	33,889	381,808
Aichi	1886	1,364,400	548	5,055
Akita	1899	639,500	304	11,724
Aomori	1891	490,600	744	9,631
Chiba	1894	1,107,500	535	5,079
Ehime	1914	868,320	1,533	5,699
Fukui	1882	580,600	397	4,018
Fukuoka	1889	1,133,800	589	4,940
Fukushima	1887	854,700	191	13,782
Gifu	1883	869,100	0	10,462
Gunma	1883	629,600	0	6,315
Hiroshima	1891	1,256,600	1,113	8,437
Hokkaido	1880	227,900	4,377	88,454
Hyogo	1874	1,442,600	783	8,427
Ibaraki	1885	925,400	186	6,100
Ishikawa	1897	732,600	581	4,198
Iwate	1890	613,300	661	15,235
Kagawa	1889	639,980	694	1,845
Kagoshima	1900	933,800	2,722	9,081
Kanagawa	1872	650,405	400	2,352
Kochi	1924	545,200	691	7,088
Kumamoto	1891	1,000,000	1,068	7,438
Kyoto	1876	845,500	310	4,559
Mie	1890	874,900	1,105	5,702
Miyagi	1887	643,400	846	7,287
Miyazaki	1911	381,500	445	7,738
Nagano	1888	1,040,100	0	13,557
Nagasaki	1897	704,500	4,137	4,116
Nara	1890	469,539	0	3,730
Niigata	1886	1,583,400	585	12,579
Oita	1897	750,100	725	6,225
Okayama	1890	1,035,000	539	7,019
Okinawa	2003	364,400	1,652	2,387
Osaka	1874	1,163,261	223	1,814
Saga	1889	518,600	357	2,444
Saitama	1883	980,100	0	3,804
Shiga	1880	634,600	0	4,051
Shimane	1908	677,500	814	6,618
Shizuoka	1888	975,900	514	7,770
Tochigi	1885	623,100	0	6,448
Tokushima	1899	649,300	363	4,135
Tokyo	1872	1,325,295	760	2,142
Tottori	1902	380,200	144	3,489
Toyama	1897	700,700	117	4,257
Wakayama	1898	610,800	628	4,733
Yamagata	1901	704,500	0	4,455
Yamaguchi	1899	894,900	110	9,306
Yamanashi	1897	414,800	1,398	6,082

Source: Japanese Statistical Association (1987).

Table 5: Difference-in-differences results, all industries

DV: Number of firms	[A]	[B]	[C]	[D]	[E]	[F]
Rail access	1.087 (1.022)	-8.762** (3.725)	-8.548** (3.481)	0.429 (0.488)	-2.862*** (1.014)	-2.705*** (0.979)
Rail x 1883 Population (10 ³)		1.329*** (0.475)	1.500*** (0.461)		0.389** (0.148)	0.405** (0.150)
Rail x Coastline (10 ³ km)			-1.847 (1.119)			-0.526 (0.789)
Constant	3.909*** (0.825)	3.909*** (0.677)	3.909*** (0.664)	3.909*** (0.192)	3.909*** (0.189)	3.909*** (0.192)
Control/treatment prefectures	n/a	n/a	n/a	15/18	15/18	15/18
Year coverage	1884-1912	1884-1912	1884-1912	1884-1893	1884-1893	1884-1893
Observations	957	957	957	330	330	330
R ²	0.577	0.621	0.633	0.187	0.281	0.284

Source: see text.

Significance levels: *10%, **5%, ***1%

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture.

Table 6: Difference-in-differences results, major industry groups

DV: Number of firms	[A]	[B]	[C]	[D]	[E]
	All sectors	Manufacturing	Finance	Services	Textiles (Mfg)
Rail access	-2.705*** (0.979)	-1.433*** (0.363)	-0.906* (0.496)	-0.253* (0.141)	-0.824*** (0.278)
Rail x 1883 Population (10 ³)	0.405** (0.150)	0.225*** (0.047)	0.101 (0.077)	0.032* (0.017)	0.149*** (0.042)
Rail x Coastline (10 ³ km)	-0.526 (0.789)	-0.114 (0.274)	-0.120 (0.359)	-0.084 (0.078)	-0.380 (0.231)
Constant	3.909*** (0.192)	0.576*** (0.083)	3.030*** (0.095)	0.091*** (0.027)	0.242*** (0.060)
Control/treatment prefectures	15/18	15/18	15/18	15/18	15/18
Year coverage	1884-1893	1884-1893	1884-1893	1884-1893	1884-1893
Observations	330	330	330	330	330
R ²	0.284	0.308	0.118	0.072	0.274

Source: see text.

Significance levels: *10%, **5%, ***1%

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture.

Table 7: Difference-in-differences results, net firm growth

DV: Change to number of firms	[A]	[B]	[C]	[D]	[E]
	All sectors	Manufacturing	Finance	Services	Textiles (Mfg)
Rail access	-0.567 (0.484)	-0.308 (0.298)	-0.149 (0.233)	-0.089** (0.041)	-0.279 (0.175)
Rail x 1883 Population (10 ³)	0.064 (0.062)	0.046 (0.046)	-0.002 (0.039)	0.011* (0.006)	0.043** (0.019)
Rail x Coastline (10 ³ km)	-0.066 (0.282)	-0.054 (0.154)	0.015 (0.146)	-0.014 (0.028)	0.038 (0.110)
Constant	0.271 (0.309)	0.062 (0.100)	0.262 (0.181)	0.031 (0.034)	0.034 (0.068)
Control/treatment prefectures	15/18	15/18	15/18	15/18	15/18
Year coverage	1884-1893	1884-1893	1884-1893	1884-1893	1884-1893
Observations	330	330	330	330	330
R ²	0.046	0.034	0.048	0.030	0.086

Source: see text.

Significance levels: *10%, **5%, ***1%

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture.

Table 8: Difference-in-differences robustness check, JBA correlation

DV: Number of firms	[A]	[B]	[C]	[D]	[E]
	All sectors	Manufacturing	Finance	Services	Textiles (Mfg)
Rail access	-2.941** (1.080)	-1.536*** (0.386)	-0.976* (0.526)	-0.278* (0.157)	-0.852*** (0.300)
Rail x 1883 Population (10 ³)	0.413** (0.153)	0.230*** (0.047)	0.102 (0.078)	0.033* (0.017)	0.150*** (0.043)
Rail x Coastline (10 ³ km)	-0.321 (0.848)	0.021 (0.281)	-0.116 (0.378)	-0.055 (0.082)	-0.370 (0.260)
Constant	4.276*** (0.217)	0.655*** (0.095)	3.276*** (0.108)	0.103*** (0.031)	0.276*** (0.068)
Control/treatment prefectures	12/17	12/17	12/17	12/17	12/17
Year coverage	1884-1893	1884-1893	1884-1893	1884-1893	1884-1893
Observations	290	290	290	290	290
R ²	0.301	0.320	0.129	0.081	0.278

Source: see text.

Significance levels: *10%, **5%, ***1%

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Prefectures from the control and treatment groups are limited to those with correlation coefficients exceeding 0.90 based on the Japanese Bankers Association series.

Table 9: Difference-in-differences robustness check, coastline restriction

DV: Number of firms	[A]	[B]	[C]	[D]	[E]
	All sectors	Manufacturing	Finance	Services	Textiles (Mfg)
Rail access	-6.369** (2.705)	-2.619*** (0.844)	-2.222* (1.204)	-0.556*** (0.198)	-1.764** (0.677)
Rail x 1883 Population (10 ³)	0.626** (0.251)	0.285*** (0.074)	0.178 (0.129)	0.053*** (0.018)	0.191*** (0.068)
Rail x Coastline (10 ³ km)	2.804 (2.163)	1.042 (0.704)	1.081 (1.025)	0.172* (0.098)	0.730 (0.480)
Constant	3.913*** (0.244)	0.391*** (0.100)	3.174*** (0.126)	0.043 (0.024)	0.130* (0.067)
Control/treatment prefectures	11/12	11/12	11/12	11/12	11/12
Year coverage	1884-1893	1884-1893	1884-1893	1884-1893	1884-1893
Observations	230	230	230	230	230
R ²	0.394	0.388	0.164	0.174	0.374

Source: see text.

Significance levels: *10%, **5%, ***1%

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Prefectures from the control and treatment groups are limited to those with coastlines between 1 and 1,000 kilometers in length.

Table 10: Difference-in-differences robustness check, surface area restriction

DV: Number of firms	[A]	[B]	[C]	[D]	[E]
	All sectors	Manufacturing	Finance	Services	Textiles (Mfg)
Rail access	-2.352*** (0.825)	-1.234*** (0.290)	-0.910* (0.530)	-0.269* (0.148)	-0.769*** (0.254)
Rail x 1883 Population (10 ³)	0.511*** (0.181)	0.249*** (0.054)	0.148 (0.104)	0.042** (0.019)	0.166*** (0.054)
Rail x Coastline (10 ³ km)	-2.106** (0.903)	-0.527 (0.331)	-0.749 (0.590)	-0.198* (0.106)	-0.640* (0.347)
Constant	3.654*** (0.246)	0.654*** (0.105)	2.731*** (0.120)	0.077** (0.034)	0.231*** (0.079)
Control/treatment prefectures	10/16	10/16	10/16	10/16	10/16
Year coverage	1884-1893	1884-1893	1884-1893	1884-1893	1884-1893
Observations	260	260	260	260	260
R ²	0.352	0.351	0.167	0.092	0.285

Source: see text.

Significance levels: *10%, **5%, ***1%

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Prefectures from the control and treatment groups are limited to those with surface areas within one standard deviation of the prefectural average.