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Railroad Expansion and Entrepreneurship: Evidence from Meiji Japan

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Keywords: agglomeration, deindustrialization, 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 growth[4]. This view 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 sector, 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

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[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.

have behaved differently in the absence of locomotive technology, especially for countries that may have existing transport links like coastal shipping in 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 may apply to Meiji Japan, where there were already large disparities in population and commerce between major cities like Tokyo and Osaka and prefectures in outlying areas. 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 comprehensive prefecture-level dataset of firms and a difference-in-differences methodology that exploits the variation in the timing of railroad network expansion across Japanese prefectures. These data are disaggregated also at the major industry level and provide figures for firm capitalization, thus providing a more representative view of regional activity than that based on national accounting data, 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 prefecture-level controls like population and geography to proxy for market size and market accessibility, 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 while railway access had consistently negative impact on new firm establishment across prefectures, the effect is attenuated by initial population size.

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[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.

Furthermore, total capitalization and average firm capital increase after controlling for initial population levels and the geographic features of coastline length and surface area. Together, these findings are consistent with the rationalization of capital-intensive production away from smaller markets given greater availability of labor and finance and increasing firm scale to serve dispersed markets. Although the substantial increase in firm numbers and capital in already established markets during the period of railway expansion suggests that the contribution of railways to economic growth is unclear, the distributional consequences within industries and across regions were substantial. 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]

[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).

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

[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.

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, 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 tended to have a positive effect on economic welfare as measured through cost savings, consumer surplus, urbanization, agglomeration, productivity, or market access.[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 (forthcoming) 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. Donaldson and Hornbeck (2013) examine county-level land values and transport accessibility to assess the impact of rail access, and estimate a decrease of nearly two-thirds in value absent

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[19] Ibid., pp. 32 and 38.

[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 counterfactural 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.

rail. 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.

III. Research design

To analyze the impact of Japanese railways on industries and across regions, this paper uses prefectural data compiled by the Japanese Cabinet Office, Bureau of Statistics. Starting in 1886, the Japanese Cabinet produced annual volumes of prefecture-level statistics, with coverage of land, population, industry, and health across the country (later including its colonies). These data were produced separately from those by the Japan Statistical Association, which is affiliated with the Statistics Bureau of Japan and the publisher of the *Historical Statistics of Japan* and current official statistics.[24] Unlike the latter historical data collection, which has few series before the twentieth century at both the industry and prefecture level, the Cabinet Office data disaggregate these back to the year 1883. Industry series include also total capitalization by prefecture, which can then be divided by prefecture firm counts to obtain average firm capitalization. Table 2 summarizes these industry statistics for the last thirty years of the Meiji Period, while Table 3 presents some population and geographic data for Japan in the year 1882.

[Tables 2 and 3]

Applied to the question of railway impact, the Cabinet Office data are aggregated by year, prefecture, and major industry to create a balanced panel dataset that covers the entire Meiji Period, between 1883 and 1912.[25] They are 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

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[24] A new edition of the *Historical Statistics of Japan* was published in 2006, which updated (and omitted) some data series.
[25] Since industry series were reported at high disaggregation before 1887, some were combined to match the following years.

sources.[26] Prefecture level data on population and geography (ie, coastline length, surface area) come from the Cabinet Office and *Historical Statistics of Japan*, respectively.[27]

For the empirical analysis, the paper employs a difference-in-differences methodology, comparing the annual number of firms in each prefecture before and after it gains access to railroads to prefectures that do not experience a change to rail access over the same period.[28] 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 and goods mobility through lower transportation costs and wider market access, so 1) firm activity in areas with rail would corresponding increase to take advantage of these improvements. At the same time, it is anticipated that 2) activity would vary based on extant conditions like pre-access market size, leading to agglomeration of firm activity in larger markets and dispersion from smaller ones.[29] As a point of reference, prefectures that gain access are compared to others that did not experience a contemporaneous change to their railroad infrastructure (ie, either already had rail access or did not receive it during the period of analysis). The reduced form OLS model follows, with separate regressions for each industry group:

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

y_{it} = firm activity 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 one of three measures: the total annual number of firms in each of the prefectures, indexed by i; the total capitalization of firms by prefecture; and the average capital per firm in each prefecture. The main control variable of interest is the term x_{1it}, 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 1882, prefectural coastline length and surface area, and fixed effects for prefecture and year. Prefectural population in 1882, which predates the Cabinet

[26] These include Aoki et al (2000), Ericson (1996) and Free (2008).

[27] Prefectural population figures for 1883 were collected for the month of January, which is coded as 1882. Also, some prefecture boundaries changed during the 1880s, so constituent areas were combined for a prefecture total or based on obsolete provincial names, which were still in use during the early 1880s.

[28] 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.

[29] Krugman (1991b).

Office firm data, can be interpreted as a proxy for local market demand and agglomeration potential. Similarly, coastline length is used to proxy for access to coastal transport, which may act as a substitute for (or complement to) rail transport, and surface area may reflect the ease and rapidity with which rail network can reach local markets.

This paper uses the years between 1883 and 1893 to identify a treatment period, and thus separates the country's 47 prefectures into two groups: a treatment group of 18 prefectures that gained access during this period, and a control group of 29 prefectures that gained access either before 1884 or after 1894.[30] The starting year was selected based on data availability while the end year was selected as it precedes the First Sino-Japanese War (1894-1895), which contributed to a dramatic expansion of the public investment in armaments and public works with possible knock-on effects to firm activity. This year also marks the promulgation of the previous year's Railway Construction Act, which increased the scope of private investment in railways.

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 experience a change in 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, and the government explicitly promoted railway access over the whole of the country for national and strategic purposed.[31] 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]

The second condition for a causal interpretation is that the decision to extend the railway

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[30] Separate results are also reported for the two control subgroups of prefectures that gained access before 1884 and those after 1893.

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.

For the control group, the eleven that gained access before 1894 are Tokyo, Kanagawa, Hyogo, Osaka, Kyoto, Hokkaido, Shiga, Fukui, Saitama, Gunma, and Gifu. The remaining eighteen prefectures in the control group that gained access after 1893 are Akita, Chiba, Ehime, Kochi, Ishikawa, Kagoshima, Miyazaki, Nagasaki, Okinawa, Oita, Shimane, Tokushima, Tottori, Toyama, Wakayama, Yamagata, Yamaguchi, and Yamanashi.

[31] This may not have been true for Okinawa, which gained access to rail in 2003. This prefecture is also off the main islands of Honshu, Shikoku, Kyushu, and Hokkaido, where most commercial activity took place and government policy was focused. Robustness checks to exclude Okinawa and other outlier characteristics are included in the analysis.

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.[32] 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.[33] 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 Act, which presented the government's vision of a national railway system and proposed new lines identified for private investment.[34]

To address concerns about control group selection and endogeneity, the analysis has a number of additional specifications and robustness checks. These include separating the control group into the two subgroups that gained access prior to 1884 and 1894, as there may be unobserved differences between the two. There are also estimates that exclude outlier prefectures in terms of population size, coastline length, and surface area[35]; and those not located in the central island of Honshu.

IV. Results

The baseline results from the regression model are presented in Table 5, which compares estimates of annual firm counts aggregated across sectors for the entire period of 1883 to 1912 (columns A and B) and for the treatment window between 1883 and 1893 (columns C and D). Across all four specifications, the coefficient for rail access alone is negative and usually statistically significant, ranging from a loss of seven to 166 firms in the average prefecture for

[32] 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.

[33] 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).

[34] "[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.

[35] Outliers are identified as those exceeding one standard deviation from the mean of the variable for the combined control and treatment groups. In the case of surface area, Hokkaido is excluded from the mean and standard deviation calculations as it is two orders of magnitude larger than the other prefectures.

each year of the respective periods. Including interaction terms for each prefecture's population in 1882, coastline length, and surface area does not change the sign and the magnitudes are larger. The coefficient on the interaction of rail access and population is positive, however, which indicates that larger populations correspond to increased firm numbers. In contrast, both longer coastlines and, to a lesser extent, larger surface areas are negatively associated with firms. Evaluated at the combined group means, a Wald test of the linear combination of rail access and its interaction terms has a coefficient of -21.462, and is statistically significant at the one percent level. This indicates that the cumulative effect of rail access is negative on annual firm counts (ie, twenty-one fewer firms) for the average treatment prefecture.

[Table 5]

Tables 6a through 6c disaggregate firm activity at the major industry level, and give the results for total firm counts (6a), total prefecture capitalization (6b), and average firm capital (6c). As shown in Table 6a, the results from the aggregate firm series in Column A appear largely driven by the manufacturing sector in Column C, with similar signs and statistical significance. That is, larger populations and smaller coastlines are associated with higher manufacturing firm counts in rail-accessible prefectures, and a Wald test using group means gives a coefficient of -20.680 at five percent statistical significance for the cumulative rail effect. Other results differ in that only the individual rail effect is negative and statistically significant for primary sector firms while only the interaction between rail access and population is statistically significant and positive. Evaluated at the group means, the coefficients for the cumulative effect of both these series are not highly statistically significant.

In Table 6b, only the manufacturing series (Column C) has statistically significant rail access coefficients, and they correspond in sign and significance with those for the previous table. In other words, total capitalization decreases with rail access, although this is partially offset in more populous prefectures. The cumulative effect, while negative, is not statistically significant. Similarly, in Table 6c, rail access and its interaction with other control variables are not statistically significant individually or cumulatively.

[Tables 6a through 6c]

Since it may be possible that including both prefectures that gained access before and after the treatment period may mask differences between the two groups, Tables 7a through 7c present separate results for each control subgroup along with the treatment group. The results across both control groups are similar in sign and significance as those for the combined control group in Tables 6a through 6c. The difference between the two control groups is largely in magnitudes, with the pre-1884 rail access group (ie, left hand column in each industry pair) results generally bigger. For firm counts (Table 7a), the statistically significant results in the aggregate firm series are found mostly in the manufacturing sector, and for both control groups the cumulative effect has negative and statistically significant coefficients. For total capitalization (Table 7b), the results for manufacturing in both control groups indicate a mild rail effect on individual coefficients, but neither series is significant evaluated at the group means. As seen earlier, few of the results for average firm capitalization in Table 7c are statistically significant individually, and none in combination.

[Tables 7a through 7c]

Given the importance of creating comparable treatment and control groups, I omit a number of prefectures based on observable exogenous characteristics. In Tables 8a through 8c, only prefectures within one standard deviation of the group means for population, coastline, and surface area are included. Since there are too few members in the pre-1884 control group to produce meaningful results, I report estimates for the combined control group in the left-hand side and the post-1893 rail access control group in the right-hand side in each column pair. Interestingly, for firm counts (Table 8a), both aggregate firm series in Column A have significant results while virtually none in the disaggregated sectors does, and are similar to those for the unrestricted prefecture groups. For both total capitalization (Table 8b) and average firm capital (Table 8c), the results are noticeably different.

For total capitalization, rail access itself and in interaction with coastline length give positive and statistically significant coefficients in the aggregate and services series; those for rail interacted with surface area are typically negative and significant in all but the primary sector series. This suggests rail access increased capitalization in the service sector (eg, banking), and was strong enough in turn to affect total and average firm capital levels in aggregate, whether compared to the combined control group or to prefectures that had no rail access during the treatment period. Moreover, the cumulative effect is both positive and highly statistically significant for both sets of series. Also striking are the results in average firm capitalization in Table 8c, where both manufacturing and services have positive and statistically significant cumulative effects (the former particularly surprising given the relative insignificance of individual coefficients).

[Tables 8a through 8c]

To check the robustness of the above estimates, I use another geographic constraint, namely location on the main island of Honshu. Assuming any impact from rail access would accrue more readily to areas that were physically connected to metropolitan Japan, this may be observed in prefectures located on the same island. The results are shown in Tables 9a through 9c, and largely conform to the earlier results of decreased firm counts and increased capitalization both for the prefecture as a whole and for the average firm.

[Tables 9a through 9c]

V. Conclusion and discussion

The findings from the difference-in-differences analysis suggest that rail access has a positive impact on economic development as measured through overall capitalization (particularly in services) and average firm scale (in manufacturing), even if the number of firms decreases relative to areas not yet gaining rail access. Also notable are the influences of initial population and geographic features, with more populated and landlocked areas inciting increased firm activity. These results are all consistent with predictions from economic geography, with industrial agglomeration occurring in larger markets at the same time as firms increase in size and reach.

That said, there are a number of caveats to taking these results at face value, however. The first relates to the dataset, which may exclude numerous undocumented firms that nevertheless contributed to local economies. One piece of evidence for this is the disparity in numbers between banks identified in the Cabinet Office data and the much larger values in contemporaneous data collected by the Japanese Bankers Association.[36] Thus, it may be useful to compare the results from these data with other sources such as firm genealogical data, which may also be more detailed in industry classification.[37]

With regard to the agglomeration finding, dispersive forces seem as likely to operate since entrepreneurs may not be able to fully capitalize on improved transportation infrastructure for industrial production. Contributing factors include private monopolies of regional track and the precedence of passenger over freight traffic, which led to excess demand for freight services.[38] 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,

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[36] See Tang (2013) for description of the latter dataset.
[37] Ibid and Tang (2010).
[38] Nagao (1929), pp. 18-19.

which is one of the qualifications of the Krugman model.[39] 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, and the use of coastline length as a proxy for shipping is crude at best.[40] 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.[41] Thus, a general equilibrium model that accounts for some of these features may provide clearer predictions for this setting.

In terms of economic significance, translating increases in capitalization to output is somewhat problematic at the subnational level. That said, if capital shares from a select group of prefectures can be used to extrapolate national capital stocks, then the results could correspond to a measure of economic growth. Further complementing this research would be to include disaggregated price data in prefectures both prior to and following rail access, allowing direct analysis of welfare impact.

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[39] 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).

[40] 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.

[41] Japan Statistical Association (1987), series 8-20.

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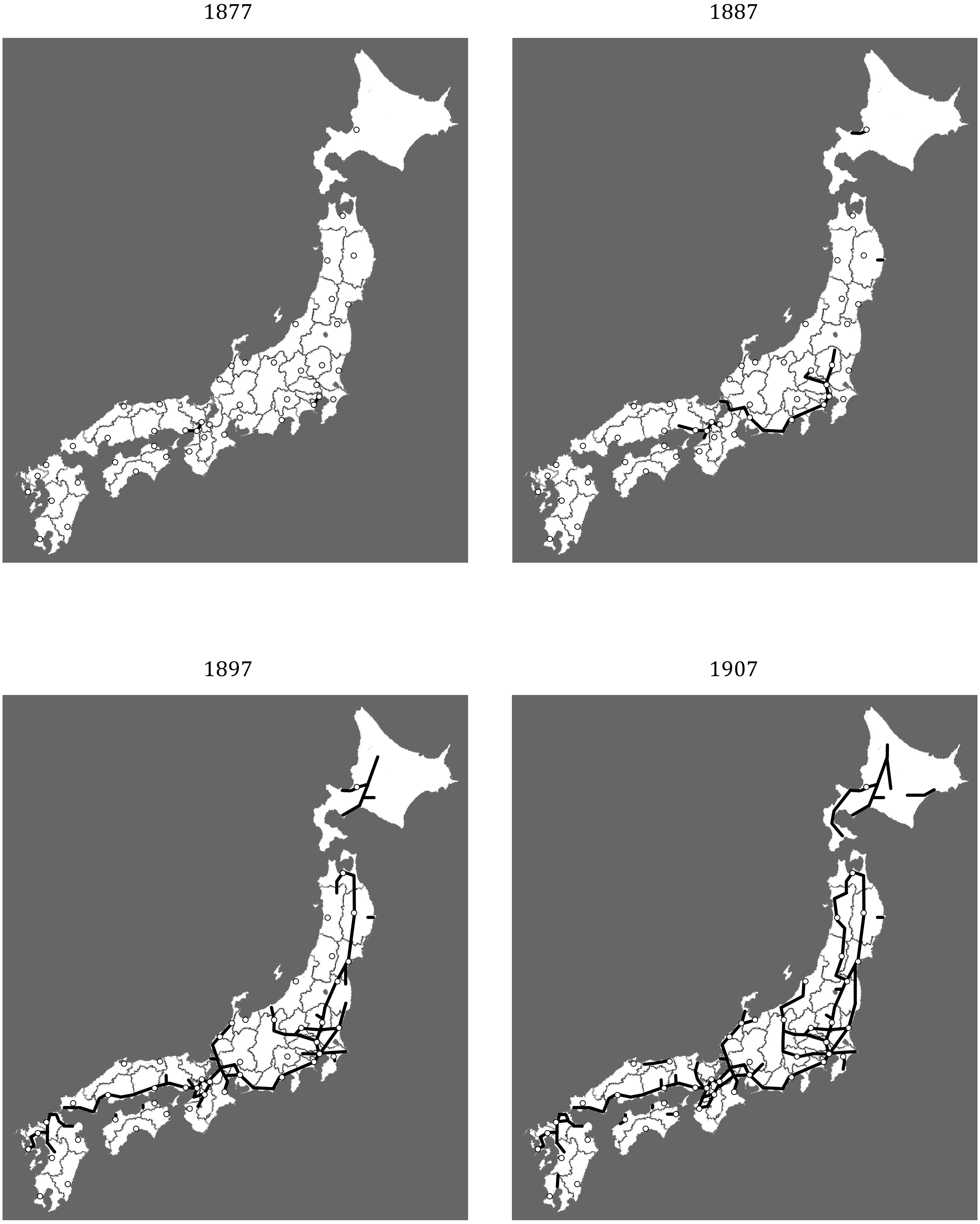
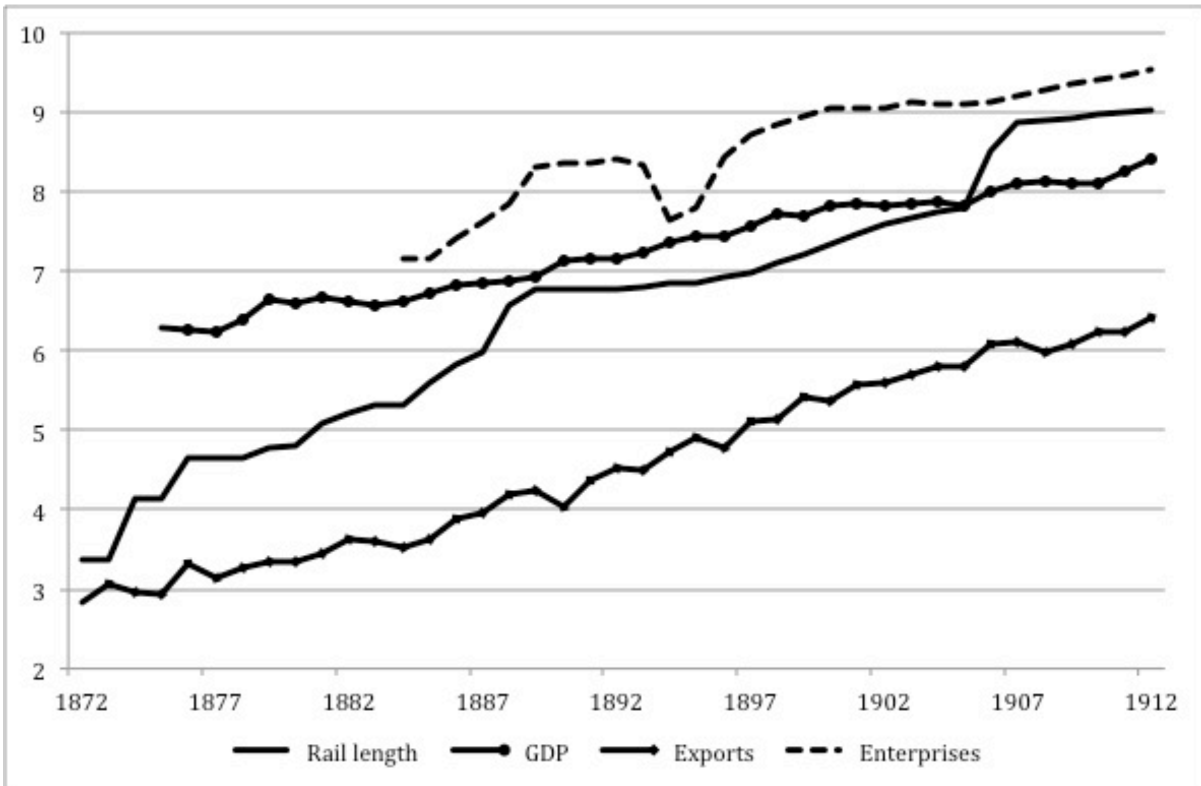
Figure 1: Japanese rail network expansion



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).

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: Industry statistics, 1883-1912

Year		Total firm count	Prefecture average	Capitalization (1000 yen)	Prefecture average
1883	All sectors	1,772	37.7	30,447	648
	Primary	220	4.7	3,182	68
	Industrial	942	20.0	15,311	326
	Services	610	13.0	11,954	254
1893	All sectors	4,133	87.9	209,865	4,465
	Primary	171	3.6	2,542	54
	Industrial	2,919	62.1	78,259	1,665
	Services	1,043	22.2	129,064	2,746
1903	All sectors	9,247	196.7	887,606	18,885
	Primary	249	5.3	3,197	68
	Industrial	2,441	51.9	170,346	3,624
	Services	6,557	139.5	714,068	15,193
1912	All sectors	13,887	295.5	1,756,610	37,375
	Primary	475	10.1	26,335	560
	Industrial	4,403	93.7	677,795	14,421
	Services	9,009	191.7	1,052,481	22,393

Source: Japanese Cabinet Statistics Bureau (1962)

Table 3: Prefecture statistics, 1882

	Prefectures	Population	Coastline (km)	Area (km2)
Japan	47	**37,017,302**	**33,889**	**381,808**
Average		787,602	7,210	8,124
Standard deviation		292,823	9,163	12,405
Main islands				
Honshu	34	28,405,996	14,536	230,217
Average		835,471	4,275	6,771
Standard deviation		290,209	3,753	3,504
Shikoku	4	2,690,414	3,281	18,768
Average		672,604	8,203	4,692
Standard deviation		135,381	4,999	2,249
Kyushu	7	5,376,273	10,043	41,982
Average		7,680	14,347	4,997
Standard deviation		2,676	14,407	2,308
Hokkaido	1	183,849	4,377	88,454
Okinawa	1	360,770	1,652	2,387

Source: Japanese Cabinet Statistics Bureau (1962), Japan Statistical Association (1987)

Table 4: Prefectural average comparison, 1883-1893

Year		Rail access Pre-1884	Rail access 1884-1893	Rail access Post-1893
	Prefectures	11	18	18
	Coastline (km)	659	541	939
	Area (km2)	12,400	7,722	5,912
1883	Population	849,906	891,262	670,007
	Firm count	50.4	43.4	24.2
	Primary	8.5	5.1	1.9
	Industrial	29.8	19.2	14.9
	Services	12.1	19.1	7.4
	Capitalization	1,976,863	238,171	245,218
	Primary	226,897	26,025	12,083
	Industrial	932,667	139,439	141,196
	Services	817,300	72,707	91,939
1893	Population	968,427	984,839	722,167
	Firm count	158.2	69.3	63.7
	Primary	5.7	2.8	3.2
	Industrial	118.4	44.9	44.9
	Services	34.1	21.6	15.6
	Capitalization	12,870,700	2,807,270	986,473
	Primary	55,028	31,812	75,793
	Industrial	4,195,588	1,143,546	640,180
	Services	8,620,087	1,631,912	270,500

Source: Japanese Cabinet Statistics Bureau (1962)

Table 5: Difference-in-differences baseline results

DV: Number of firms	[A]	[B]	[C]	[D]
Rail access	-64.116**	-165.882***	-7.427	-51.528***
	(29.610)	(43.087)	(10.196)	(16.978)
Rail x 1882 Population (10^6)		186.609***		82.311***
		(40.755)		(11.748)
Rail x Coastline (10^3 km)		-31.665***		-32.137***
		(11.019)		(11.731)
Rail x Surface area (10^4 km)		-23.690		-14.267*
		(22.991)		(8.227)
Cumulative effect		-60.984**		-21.462**
		(29.803)		(8.792)
Prefectures				
Pre-1884 rail access	11	11	11	11
1884-1893 rail access	18	18	18	18
Post-1893 rail access	18	18	18	18
Year coverage	1883-1912	1883-1912	1883-1893	1883-1893
Observations	1,410	1,410	517	517
R-squared	0.461	0.481	0.431	0.450
F-statistic	9.77	17.39	8.23	18.70

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 6a: Difference-in-differences baseline results, industry firm count

DV: Number of firms	[A] All sectors	[B] Primary	[C] Manufacturing	[D] Services
Rail access	-51.528***	-3.949**	-37.454**	-11.592
	(16.978)	(1.881)	(14.792)	(11.921)
Rail x 1882 Population (10^6)	82.311***	1.510	48.825***	35.130**
	(11.748)	(1.403)	(13.441)	(13.171)
Rail x Coastline (10^3 km)	-32.137***	0.102	-36.547**	-2.200
	(11.731)	(1.331)	(16.754)	(10.061)
Rail x Surface area (10^4 km)	-14.267*	1.143	5.750	-17.678*
	(8.227)	(0.907)	(12.038)	(8.806)
Cumulative effect	-21.462**	-1.758*	-20.680**	0.129
	(8.792)	(0.998)	(7.824)	(3.881)
Prefectures				
Pre-1884 rail access	11	11	11	11
1884-1893 rail access	18	18	18	18
Post-1893 rail access	18	18	18	18
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893
Observations	517	470	517	517
R-squared	0.450	0.256	0.354	0.268
F-statistic	18.70	8.17	13.82	8.26

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 6b: Difference-in-differences baseline results, industry capitalization

DV: Total capital (million yen)	[A] All sectors	[B] Primary	[C] Manufacturing	[D] Services
Rail access	-2.323	-0.046	-1.379**	-0.915
	(2.039)	(0.036)	(0.682)	(1.444)
Rail x 1882 Population (10^6)	4.511	-0.041	1.934**	2.660
	(3.457)	(0.051)	(0.935)	(2.570)
Rail x Coastline (10^3 km)	-0.093	-0.013	-0.484	0.363
	(1.397)	(0.069)	(0.374)	(1.135)
Rail x Surface area (10^4 km)	-3.078	0.089	-0.520	-2.624
	(2.356)	(0.075)	(0.625)	(1.762)
Cumulative effect	-1.337	-0.015	-0.626	-0.689
	(1.300)	(0.025)	(0.423)	(0.938)
Prefectures				
Pre-1884 rail access	11	11	11	11
1884-1893 rail access	18	18	18	18
Post-1893 rail access	18	18	18	18
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893
Observations	517	470	517	517
R-squared	0.133	0.049	0.142	0.112
F-statistic	2.00	2.70	2.39	1.98

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 6c: Difference-in-differences baseline results, average firm capitalization

DV: Capital per firm (10,000 yen)	[A] All sectors	[B] Primary	[C] Manufacturing	[D] Services
Rail access	4.579	0.120	-0.053	0.072
	(3.278)	(1.030)	(0.928)	(0.059)
Rail x 1882 Population (10^6)	0.318	-0.729	1.102	0.018
	(2.815)	(0.743)	(1.188)	(0.063)
Rail x Coastline (10^3 km)	-0.367	-0.637	0.775	0.015
	(2.594)	(0.712)	(0.868)	(0.063)
Rail x Surface area (10^4 km)	-3.990*	0.786	-1.590	-0.087*
	(2.149)	(0.578)	(1.232)	(0.046)
Cumulative effect	1.313	-0.275	0.077	0.025
	(1.035)	(0.414)	(0.424)	(0.027)
Prefectures				
Pre-1884 rail access	11	11	11	11
1884-1893 rail access	18	18	18	18
Post-1893 rail access	18	18	18	18
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893
Observations	515	470	514	512
R-squared	0.076	0.023	0.130	0.062
F-statistic	1.62	0.97	2.67	1.07

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 7a: Separate control groups results, industry firm count

DV: Number of firms	[A] All sectors		[B] Primary		[C] Manufacturing		[D] Services	
Rail access	-70.478***	-34.170**	-5.187*	-2.306	-51.941***	-24.834*	-15.377	-7.835
	(20.978)	(16.537)	(2.551)	(1.741)	(18.355)	(13.980)	(12.154)	(11.905)
Rail x 1882 Population (10^6)	82.356***	83.950***	1.663	1.516	49.636***	49.417***	35.063**	35.556***
	(11.697)	(12.101)	(1.518)	(1.387)	(13.487)	(13.569)	(12.985)	(13.140)
Rail x Coastline (10^3 km)	-31.067**	-35.131***	0.303	-0.381	-37.050**	-37.639**	-1.263	-3.443
	(12.108)	(12.307)	(1.440)	(1.315)	(16.929)	(17.233)	(9.882)	(9.927)
Rail x Surface area (10^4 km)	-13.674	-14.899*	1.312	0.947	5.586	5.738	-17.299*	-17.922*
	(8.195)	(8.253)	(0.959)	(0.924)	(11.998)	(12.188)	(9.001)	(8.940)
Cumulative effect	-30.655**	-8.595	-2.329	-0.802	-25.545*	-14.134**	-2.312	4.688
	(14.540)	(6.231)	(1.581)	(0.914)	(13.608)	(6.129)	(0.5803)	(4.227)
Prefectures								
Pre-1884 rail access	11		11		11		11	
1884-1893 rail access	18	18	18	18	18	18	18	18
Post-1893 rail access		18		18		18		18
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893
Observations	319	396	290	360	319	396	319	396
R-squared	0.489	0.554	0.275	0.322	0.404	0.429	0.283	0.259
F-statistic	20.97	32.03	9.04	7.04	12.19	13.34	7.31	10.47

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 7b: Separate control groups results, industry capitalization

DV: Total capital (million yen)	[A] All sectors		[B] Primary		[C] Manufacturing		[D] Services	
Rail access	-4.848	-0.106	-0.066	-0.035	-2.316**	-0.582	-2.480	0.490
	(3.096)	(1.475)	(0.058)	(0.033)	(1.035)	(0.504)	(2.154)	(1.077)
Rail x 1882 Population (10^6)	4.530	4.719	-0.053	-0.022	1.981**	1.945*	2.654	2.834
	(3.559)	(3.520)	(0.063)	(0.045)	(0.939)	(0.965)	(2.665)	(2.604)
Rail x Coastline (10^3 km)	0.044	-0.531	0.011	-0.046	-0.458	-0.593	0.447	0.070
	(1.506)	(1.411)	(0.089)	(0.057)	(0.396)	(0.400)	(1.207)	(1.138)
Rail x Surface area (10^4 km)	-2.993	-3.207	0.091	0.090	-0.483	-0.568	-2.581	-2.704
	(2.376)	(2.387)	(0.076)	(0.080)	(0.618)	(0.647)	(1.787)	(1.775)
Cumulative effect	-3.758	0.929	-0.019	-0.030	-1.335	0.044	-2.381	0.909
	(2.374)	(0.825)	(0.049)	(0.022)	(0.788)	(0.214)	(1.672)	(0.658)
Prefectures								
Pre-1884 rail access	11		11		11		11	
1884-1893 rail access	18	18	18	18	18	18	18	18
Post-1893 rail access		18		18		18		18
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893
Observations	319	396	290	360	319	396	319	396
R-squared	0.193	0.301	0.070	0.139	0.205	0.414	0.165	0.226
F-statistic	1.84	7.25	2.97	2.32	2.90	5.56	1.70	3.84

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 7c: Separate control groups results, average firm capitalization

DV: Capital per firm (10,000 yen)	[A] All sectors		[B] Primary		[C] Manufacturing		[D] Services	
Rail access	4.178	4.866	0.085	-0.174	-0.375	0.214	0.063	0.078
	(3.471)	(3.252)	(1.126)	(0.984)	(1.018)	(0.914)	(0.063)	(0.058)
Rail x 1882 Population (10^6)	0.146	0.597	-0.793	-0.763	1.096	1.053	0.016	0.024
	(2.959)	(2.799)	(0.818)	(0.731)	(1.204)	(1.229)	(0.066)	(0.062)
Rail x Coastline (10^3 km)	-0.438	-0.695	-0.514	-0.596	0.761	0.671	0.012	0.010
	(2.707)	(2.629)	(0.775)	(0.637)	(0.920)	(0.893)	(0.065)	(0.063)
Rail x Surface area (10^4 km)	-3.936*	-4.121*	0.815	0.872	-1.553	-1.600	-0.086*	-0.089*
	(2.191)	(2.139)	(0.599)	(0.604)	(1.238)	(1.239)	(0.046)	(0.045)
Cumulative effect	0.310	1.937	-0.125	-0.673	-0.459	0.506	0.001	0.044
	(1.047)	(1.232)	(0.623)	(0.491)	(0.530)	(0.428)	(0.026)	(0.033)
Prefectures								
Pre-1884 rail access	11		11		11		11	
1884-1893 rail access	18	18	18	18	18	18	18	18
Post-1893 rail access		18		18		18		18
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893
Observations	319	396	290	360	319	396	319	396
R-squared	0.098	0.240	0.036	0.065	0.177	0.125	0.083	0.174
F-statistic	2.88	1.30	1.56	2.70	4.46	2.23	2.07	1.56

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 8a: Constrained prefecture group results, industry firm count

DV: Number of firms	[A] All sectors		[B] Primary		[C] Manufacturing		[D] Services	
Rail access	-120.663**	-120.347**	-15.209	-16.063**	2.670	4.235	-105.855	-109.840
	(50.182)	(51.448)	(9.078)	(6.918)	(34.568)	(34.907)	(70.644)	(71.904)
Rail x 1882 Population (10^6)	74.823***	74.729***	1.562	1.599	27.404	25.963	44.590	45.941
	(15.574)	(16.247)	(4.245)	(3.768)	(29.908)	(29.981)	(33.040)	(33.435)
Rail x Coastline (10^3 km)	-30.605**	-30.592**	2.181	2.780	-10.830	-11.060	-22.459*	-21.623
	(12.490)	(13.152)	(2.392)	(1.866)	(8.980)	(9.132)	(12.997)	(13.295)
Rail x Surface area (10^4 km)	110.396	112.543	15.764	18.691**	-37.965	-35.302	131.608	132.250
	(64.639)	(67.322)	(10.032)	(7.890)	(41.864)	(42.709)	(95.459)	(97.366)
Cumulative effect	-15.422*	-12.428*	-3.600**	-1.324	-4.496	-4.994	-6.877	-5.993
	(8.738)	(6.398)	(1.584)	(0.920)	(7.137)	(5.300)	(8.740)	(6.812)
Prefectures								
Pre-1884 rail access	5		5		5		5	
1884-1893 rail access	7	7	7	7	7	7	7	7
Post-1893 rail access	10	10	10	10	10	10	10	10
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893
Observations	242	187	220	170	242	187	242	187
R-squared	0.581	0.693	0.212	0.455	0.394	0.498	0.446	0.523
F-statistic	26.13	164.80	8.40	25.47	9.80	12.39	21.85	39.27

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 8b: Constrained prefecture group results, industry capitalization

DV: Total capital (million yen)	[A] All sectors		[B] Primary		[C] Manufacturing		[D] Services	
Rail access	11.473***	11.438**	0.062	-0.070	1.068	1.144	10.433**	10.367**
	(4.069)	(4.149)	(0.191)	(0.086)	(0.745)	(0.726)	(3.946)	(4.014)
Rail x 1882 Population (10^6)	1.200	1.065	-0.060	-0.041	0.726	0.649	0.535	0.476
	(1.799)	(1.817)	(0.074)	(0.038)	(0.584)	(0.579)	(1.752)	(1.794)
Rail x Coastline (10^3 km)	1.979*	1.942*	-0.030	0.005	0.164	0.137	1.825**	1.808**
	(0.997)	(1.010)	(0.054)	(0.023)	(0.240)	(0.238)	(0.840)	(0.848)
Rail x Surface area (10^4 km)	-18.787***	-18.542***	0.062	0.168*	-2.390**	-2.306**	-16.548***	-16.429***
	(5.846)	(5.975)	(0.150)	(0.091)	(0.969)	(0.954)	(5.562)	(5.649)
Cumulative effect	2.459***	1.971***	0.036	0.007	0.312*	0.298***	2.140***	1.674***
	(0.667)	(0.467)	(0.045)	(0.010)	(0.155)	(0.093)	(0.579)	(0.433)
Prefectures								
Pre-1884 rail access	5		5		5		5	
1884-1893 rail access	7	7	7	7	7	7	7	7
Post-1893 rail access	10	10	10	10	10	10	10	10
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893
Observations	242	187	220	170	242	187	242	187
R-squared	0.564	0.630	0.060	0.140	0.466	0.564	0.501	0.520
F-statistic	14.39	18.46	6.38	5.38	26.35	48.19	19.41	77.75

Source: see text.

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

Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 8c: Constrained prefecture group results, average firm capitalization

DV: Capital per firm (10,000 yen)	[A] All sectors		[B] Primary		[C] Manufacturing		[D] Services	
Rail access	24.989***	24.827***	0.798	0.433	4.075	4.093	0.669***	0.669***
	(6.689)	(6.786)	(2.644)	(2.526)	(2.662)	(2.603)	(0.195)	(0.199)
Rail x 1882 Population (10^6)	-0.444	-0.558	-0.574	-0.662	0.491	0.403	0.006	0.001
	(3.659)	(3.734)	(1.848)	(1.794)	(2.180)	(2.147)	(0.087)	(0.089)
Rail x Coastline (10^3 km)	3.773**	3.764**	-0.804	-0.732	1.087	1.121	0.110**	0.108**
	(1.673)	(1.701)	(0.822)	(0.797)	(0.879)	(0.875)	(0.043)	(0.043)
Rail x Surface area (10^4 km)	-36.751***	-36.470***	-0.594	1.021	-6.811**	-6.513**	-1.031***	-1.026***
	(9.669)	(9.838)	(2.323)	(2.270)	(2.887)	(2.867)	(0.276)	(0.281)
Cumulative effect	5.170***	4.116***	0.272	0.074	1.050*	1.079**	0.129***	0.101***
	(1.122)	(0.825)	(0.449)	(0.309)	(0.538)	(0.435)	(0.031)	(0.023)
Prefectures								
Pre-1884 rail access	5		5		5		5	
1884-1893 rail access	7	7	7	7	7	7	7	7
Post-1893 rail access	10	10	10	10	10	10	10	10
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893	1883-1893
Observations	242	187	220	170	242	187	242	187
R-squared	0.567	0.595	0.072	0.092	0.193	0.187	0.320	0.327
F-statistic	8.42	8.51	3.32	10.53	36.01	209.57	46.03	89.42

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 9a: Honshu robustness check, industry firm count

DV: Number of firms	[A] All sectors	[B] Primary	[C] Manufacturing	[D] Services
Rail access	-168.137***	-6.333	-18.616	-135.619*
	(27.861)	(11.032)	(53.400)	(74.489)
Rail x 1882 Population (10^6)	89.918***	-0.985	34.603	53.990
	(17.019)	(4.923)	(29.386)	(43.193)
Rail x Coastline (10^3 km)	-17.847**	-0.496	-5.360	-14.091
	(7.601)	(3.180)	(6.630)	(10.139)
Rail x Surface area (10^4 km)	151.657***	7.174	-21.133	159.683*
	(33.125)	(11.627)	(61.149)	(90.433)
Cumulative effect	-19.623**	-3.160**	-6.746	-8.277
	(9.201)	(1.474)	(9.289)	(8.341)
Prefectures				
Pre-1884 rail access	5	5	5	5
1884-1893 rail access	6	6	6	6
Post-1893 rail access	6	6	6	6
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893
Observations	187	170	187	187
R-squared	0.583	0.220	0.409	0.464
F-statistic	155.69	15.42	14.48	57.20

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 9b: Honshu robustness check, industry capitalization

DV: Total capital (million yen)	[A] All sectors	[B] Primary	[C] Manufacturing	[D] Services
Rail access	9.344**	0.261	0.664	8.606**
	(4.027)	(0.275)	(1.083)	(3.965)
Rail x 1882 Population (10^6)	1.850	-0.113	0.873	1.070
	(2.329)	(0.100)	(0.658)	(2.300)
Rail x Coastline (10^3 km)	2.567**	-0.085	0.277	2.327**
	(1.141)	(0.080)	(0.273)	(0.908)
Rail x Surface area (10^4 km)	-16.899***	-0.108	-2.113*	-14.847***
	(5.222)	(0.182)	(0.119)	(5.059)
Cumulative effect	2.130***	0.074	0.233	1.875***
	(0.725)	(0.072)	(0.205)	(0.588)
Prefectures				
Pre-1884 rail access	5	5	5	5
1884-1893 rail access	6	6	6	6
Post-1893 rail access	6	6	6	6
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893
Observations	187	170	187	187
R-squared	0.600	0.073	0.508	0.537
F-statistic	193.02	16.87	291.78	674.85

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.

Table 9c: Honshu robustness check, average firm capitalization

DV: Capital per firm (10,000 yen)	[A] All sectors	[B] Primary	[C] Manufacturing	[D] Services
Rail access	22.755***	3.949	6.027**	0.572***
	(7.446)	(2.275)	(2.850)	(0.193)
Rail x 1882 Population (10^6)	0.187	-1.509	-0.035	0.033
	(4.377)	(1.134)	(1.660)	(0.113)
Rail x Coastline (10^3 km)	4.397**	-1.681**	0.511	0.137**
	(2.025)	(0.693)	(0.926)	(0.049)
Rail x Surface area (10^4 km)	-34.709***	-2.178	-8.985**	-0.941***
	(9.647)	(2.537)	(3.654)	(0.248)
Cumulative effect	4.786***	0.790*	1.033	0.114***
	(1.273)	(0.430)	(0.619)	(0.032)
Prefectures				
Pre-1884 rail access	5	5	5	5
1884-1893 rail access	6	6	6	6
Post-1893 rail access	6	6	6	6
Year coverage	1883-1893	1883-1893	1883-1893	1883-1893
Observations	187	170	187	187
R-squared	0.599	0.049	0.283	0.341
F-statistic	53.61	5.55	72.82	295.10

Source: see text.
Significance levels: *10%, **5%, ***1%
Note: all specifications include prefecture and year fixed effects. Robust standard errors are clustered by prefecture. Cumulative effect calculated using averages of 1882 population, coastline, and surface area across included prefectures.