TECHNOLOGICAL LEADERSHIP AND LATE DEVELOPMENT: EVIDENCE FROM MEIJI JAPAN, 1868-1912

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Abstract

Large family-owned conglomerates known as zaibatsu have long been credited with leading Japanese industrialization during the Meiji Period (1868-1912), despite a lack of empirical analysis. Using a new dataset collected from corporate genealogies estimate of entry probabilities, I find that characteristics associated with zaibatsu increase a firm's likelihood of being an industry pioneer. In particular, first entry probabilities increase with industry diversification and private ownership, which may provide internal financing and risk-sharing, respectively. Nevertheless, the costs of excessive diversification may deter additional pioneering, which may account for the loss of zaibatsu technological leadership by the turn of the century.

Key Words: entrepreneurship, diversification, industrialization, Japan, late development, technology adoption

JEL Codes: L25, N85, O14, O33

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I

Japan's rapid industrialization starting in the late nineteenth century is commonly attributed to the leadership of large, family-owned conglomerates known as zaibatsu.¹ These firms had the advantages of size, which gave them sufficient scale to adopt capital-intensive technology; family ownership, which conferred autonomy from shareholders seeking short-term profit; diversified holdings, which spread risk and allowed for internal financing of investments; employment of well-educated salaried managers; and access to natural resources like metals and coal.² The benefits of these features were especially magnified in Japan during the Meiji Period (1868-1912), which shared with other late developing economies weak institutions, poor infrastructure, and immature capital markets.³ Consequently, it has been argued that these business groups '[provided] the impetus to the country's modern economic development', without which Japanese success would not have been nearly as rapid or assured.⁴

Belying these advantages, however, are some uncomfortable observations. First, Japanese industries were primarily labor-intensive during this period, with the economy transitioning to heavier sectors starting in the 1900s. This suggests that zaibatsu had few opportunities to exploit scale economies, especially given that many operated primarily in shipping or merchandising. While commerce did allow for economies of scope, the attributes of size and wealth are less meaningful.⁵ Second, despite their owners' substantial wealth, zaibatsu did not lead development of two important early sectors, cotton spinning and railways, which due to their scale required funding from issued stock.⁶ Evidence of zaibatsu leadership in developing new industries is also underwhelming: new data indicate that of the 106 new industries started with private capital in the Meiji Period, only 12 were pioneered by zaibatsu.⁷ Other scholars claim that these conglomerates owed their pathbreaking efforts to government patronage, not to their own merits or intrinsic qualities.⁸ More recent work

¹ The six largest zaibatsu that emerged in the first half of the Meiji Period, and are designated as such in the analysis, include Mitsui, Mitsubishi, Sumitomo, Yasuda, Okura, and Furukawa: see Frankl, 'Analysis', p. 997 and Morikawa, Zaibatsu, pp. 9-26. While the direct translation of zaibatsu is 'financial clique', they are more commonly known as business groups in existing literature; see Morck and Nakamura, 'Business groups'.
² Morikawa, Zaibatsu, pp. 12-14; Fruin, Japanese Enterprise, pp. 3-5; Morck and Nakamura, 'History', pp. 3-4.
³ Gerschenkron, Economic Backwardness.
⁴ Morikawa, Zaibatsu, p. xvii.
⁵ Scope economies differ from scale economies in their reliance on the savings from fixed costs (for example, shared facilities, distribution channels) rather than variable costs (for example, shared inputs, learning curves). Another way of distinguishing the two is that scope economies typically involve production of multiple, unrelated goods while scale economies are usually from increased production of the same (or similar) goods.
⁶ Ibid., p. 27.
⁷ See Table 1. This number excludes industries pioneered by the government or foreign capital.
⁸ Ibid., p. 23: Nakagawa, 'Business strategy', pp. 2-12.
suggests zaibatsu employed few university graduates during the Meiji Period and lagged their competitors in using new technology thereafter.\(^9\)

Notwithstanding these concerns, the visibility of zaibatsu has generated a substantial body of research. Like other countries at an early stage of development, '[Japan] lacked the basic commercial and financial infrastructure and the technical and managerial skills essential to introduce and operate Western industrial technology'.\(^10\) Consequently, numerous studies have asserted that zaibatsu led the introduction and use of foreign technology during Japan's industrial takeoff, supported mainly by anecdote, case studies, or cross-country comparisons.\(^11\) The few papers that use quantitative data to compare zaibatsu to other firms are limited to financial records primarily from the Taisho (1912-26) and early Showa (1926-89) periods, leaving what occurred in prior years unclear.

This paper attempts to fill in some of these gaps, particularly on the issues of industrial and technological leadership. I test whether characteristics typical of zaibatsu, namely diversification and concentrated private ownership, increase the likelihood of being an industry pioneer, which in turn may gauge how important these business groups were to technological adoption in Meiji Japan.\(^12\) My main finding is that diversification, and to a lesser extent private ownership, significantly affects a firm's probability of introducing new production technology.\(^13\) This is consistent with studies averring that diversification allows firms to take greater risks in their investments and subsidizes costs using revenues from existing operations and retained earnings. Private ownership also provides flexibility in financial choices and a potentially longer investment horizon. In the absence of developed financial markets, these features may have given zaibatsu the edge over smaller firms in leading technology adoption.\(^14\)

At the same time, there appears to be an optimal level of diversification, beyond which the probability of pioneering an industry decreases relative to less diversified firms. One explanation is that the administrative costs and managerial difficulties of entering, much less pioneering, new

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10 Morikawa, Zaibatsu, p. x.
11 See, for example, Matsumoto, ‘Zaibatsu’.
12 Notwithstanding the lack of consensus on additional zaibatsu-defining characteristics (e.g., political connections, family wealth), I include in Table 2 an indicator for zaibatsu affiliation to proxy for such unidentified factors. One problem with including such a variable in regression analysis is that since the designation is given ex post, there may be problems with endogeneity. Pointedly, Morikawa does not consider factors aside from family ownership and diversification in his definition: Morikawa, Zaibatsu, pp. xvii-xviii.
13 Firms, including those in multiple sectors, are assumed to be single establishments unless otherwise indicated in the genealogies. Multi-sector firms like zaibatsu are identified by individual establishment depending on industry to maintain consistency in units of observation. This does not pose an analytical problem as no single firm has multiple establishments in any given industry in the data: see Section V for further explanation.
14 Ibid., pp. 93-94.
sectors begin to outweigh the benefits of risk sharing. I find that highly diversified firms are less likely to pioneer additional industries as early as the 1880s, particularly in innovative sectors where their advantages should be more pronounced. This behavioral change corroborates other research that shows Meiji-era zaibatsu lagging other firms in technology adoption in the post-Meiji period, and may help to explain their later reorganization as multi-divisional holding companies.  

At the heart of the analysis is the assumption that the timing of an industry's initial appearance approximates when its production technology was introduced to Japan. As a latecomer to industrialization, Japan could borrow existing technologies without needing to develop them itself. Thus, it seems reasonable to consider the first Japanese firm in a new sector as the first adopter of the technology, with all the associated costs and risks. By extension, determining whether zaibatsu characteristics correspond to those of industry pioneers provides a way to evaluate claims of their purported leadership during Japan's industrialization.

One consequence of the 'first appearance, first adoption' assumption is that my analysis eschews the need for financial records, few of which existed before the twentieth century. Instead, I develop a new establishment-level dataset from the Meiji Period based on corporate genealogies. These genealogies arguably comprise the oldest source of firm information across industries for Japan, with some extending back to the seventeenth century or earlier. By focusing on the Meiji Period, when Japan began to industrialize, I avoid drawing anachronistic conclusions that use more detailed documentation from later years. Furthermore, I circumvent the distortions associated with the global depression in the 1920s and militarization in the 1930s.

Other departures from existing research include looking at features shared by Meiji-era zaibatsu, as opposed to individual zaibatsu, and using a broad range of industries in the economy. Given that discussions of Japanese industrial development refer to zaibatsu collectively, it makes sense to weigh the importance of their common features like diversification and private ownership. Similarly, considering a large cross-section of sectors allows comparisons across industries and corresponds with late development theory's emphasis on multi-sector coordination.

II

As a late developing economy with immature financial and legal institutions, Meiji Japan provides an ideal context for zaibatsu-led industrialization. In particular, given the need for capital

\[15 \text{ Frankl, 'Analysis', p. 1001; Morck and Nakamura, 'Business groups', pp. 558-559.} \]

\[16 \text{ That said, individual zaibatsu had different motivations for diversification and targeted sectors, which this paper abstracts away from; see Morikawa, } \text{ Zaibatsu, ch. 3. Moreover, it may be premature to consider zaibatsu as being zaibatsu in the first half of the Meiji Period, when they were less diversified and had not yet formally reorganized as holding companies. This motivates the paper's use of firm features like diversification and private ownership, which could apply to zaibatsu or not.} \]

\[17 \text{ Ibid.} \]
mobilization and broad-based development, zaibatsu attributes like diversified holdings, internal financing, family wealth and ownership, and access to both natural resources and skilled labor would be highly advantageous. Before World War II, these features allowed zaibatsu to import physical capital and technology from abroad; employ skilled foreigners and graduates from newly established Japanese universities; and expand into new markets.\textsuperscript{18} Independent firms, on the other hand, were typically under-capitalized due a wealthy merchant class reluctant to invest in unfamiliar technology; high dividend payments that left little retained earnings for expansion; and weak capital markets plagued with ill-defined property rights and high barriers to equity finance.\textsuperscript{19}

These factors notwithstanding, some scholarship questions whether zaibatsu were indeed technological leaders, or that if they were, how much owed to organizational and financial advantages versus government favoritism.\textsuperscript{20} For example, one study uses financial records for 130 firms between 1915 and 1937 to analyze the effect of zaibatsu affiliation on equity returns and risk profiles.\textsuperscript{21} It finds that Meiji-era zaibatsu had more volatile returns on equity than their competitors and were slow to adopt new technology or to enter new industries and markets. In contrast, others find the average zaibatsu outperforming independent firms and having less volatile returns, which the authors attribute to concentrated ownership and the holding company structure.\textsuperscript{22} It is also hard to overstate the importance of government intervention in the economy, whether through sponsored study trips and foreign employment; investment in roads, telegraphs, utilities and transport facilities; and subsidization of strategic sectors like shipping, construction, armaments, and mining. That many of these policies, in particular the privatization of public enterprises in the 1880s, benefited zaibatsu has not gone unnoticed, especially with the personal relationships between zaibatsu families and government officials.

Even so, both proponents and skeptics of zaibatsu leadership find difficulty substantiating their claims due to the paucity of firm-level data during the Meiji Period. It may be the case that none of the studies comparing zaibatsu to other firms are applicable since they postdate the period in question and omit smaller firms, thus introducing bias.\textsuperscript{23} Since non-traded firms were not required to document their finances, results that exclude them may not generalize for the economy. Preferential treatment by the government is also hard to prove, be it identifying the direction of

\textsuperscript{18} Fruin, \textit{Japanese Enterprise}, pp. 3-5; Morikawa, \textit{Zaibatsu}, pp. xvii-xxiv.
\textsuperscript{19} Morikawa, \textit{Zaibatsu}, pp. 4, 57, 93-94. This view has been challenged more recently, with studies that indicate that Japan had a more developed financial system and equity markets to support business investment than previously thought; see Franks et al, 'Equity markets', Okazaki et al, 'Emergence', and Teranishi, 'Were banks'.
\textsuperscript{20} Nakagawa, "Business strategy," pp. 3-12.
\textsuperscript{21} Frankl, 'Analysis', p. 1012.
\textsuperscript{22} Miyajima et al, 'Corporate governance', and Okazaki, 'Role'.
\textsuperscript{23} Frankl, 'Analysis', p. 1012.
causality or demonstrating that zaibatsu received benefits disproportionate to the risks involved.\textsuperscript{24} Moreover, public goods like education and infrastructure are non-excludable and thus were available to both zaibatsu and independent entrepreneurs. Others note that Japan's takeoff occurred toward the end of the century, after the government withdrew from most industrial activities.\textsuperscript{25}

Thus, it remains an open question whether zaibatsu were instrumental in Japan's industrial takeoff, especially with respect to adopting modern technology. Combined with ongoing improvements in legal and financial institutions and a surfeit of entrepreneurial opportunities, it is possible that any advantage that zaibatsu may have possessed would have been short-lived.\textsuperscript{26,27} As for their reputation of leadership, one may argue that it was acquired ex post, in light of their success and survival as well as the absence of detailed records from their less visible or fortunate competitors. What is needed is a more representative dataset of firms across sectors to clarify the role of zaibatsu during this period.

### III

Few developing countries have the capacity to create and maintain detailed information on industries and firms, and Japan in the nineteenth century was no exception. Official data on industrial development begin in 1887 and are only available at the national level.\textsuperscript{28} Given these constraints, it may be worthwhile to consider alternative sources for data, such as in corporate genealogies. These genealogies, or firm family trees, provide dates of establishment, ownership and source of setup finance, industry classification, and geographic location. Despite being less quantitative than financial reports, these data can be used to assess relationships between firms and sectors while controlling for the abovementioned characteristics. More importantly, they often represent the oldest reliable evidence of firm activity across the industrial spectrum. I use as my primary data source for this study the \textit{Shuyo Kigyo no Keifuzu}, a compilation of corporate genealogies edited by the business historians Shintaro Yagura and Yoshiro Ikushima. Additional

\textsuperscript{24} For example, Mitsui claims it invested in industries like coal mining, textiles, and machinery because of their anticipated importance to economic growth and potential profitability. Also, some zaibatsu came close to bankruptcy due to changes in political administration and public pressure for competition, and the government's privatizations may have had more to do with staunching treasury losses than with nepotism: see Morikawa, \textit{Zaibatsu}, pp. 20-26, 66.
\textsuperscript{25} Ohkawa and Rosovsky, \textit{Japanese Economic Growth}, p. 20.
\textsuperscript{26} Section IV includes analysis of how specific institutional changes affect entry probabilities.
\textsuperscript{27} Some specific legal and financial reforms include abolition of feudalism and land reform (1872), promulgation of new commercial (1893) and civil (1898) codes, the creation of modern banking system via national banking acts (1872, 1890), and the adoption of the gold standard (1897). See Hunter, 'Institutional change', for an in-depth discussion of institutional changes during the Meiji Period.
\textsuperscript{28} Ohkawa, ed., \textit{Historical Statistics}. 
data include firm financial reports from the *Eigyo Hokokusho Shusei* collection, Japanese industry indices, government records, and firm case studies.\(^\text{29}\)

The *Shuyo* compilation includes genealogies for 1,089 firms that were listed on the Tokyo Stock Exchange as of September 1984, contain over 14,000 unique establishment observations, and date back to the early nineteenth century or earlier. Partly mitigating the issue of survivor bias is the explicit identification of asset transfers from bankrupt or merged establishments to successful ones.\(^\text{30}\) Thus, despite firm failure or reorganization, both surviving and deceased firms remain on record. The authors also cross-reference establishments that appear in multiple genealogies and track the ancestry of failed establishments, providing a way to verify a firm's startup status. The inclusion of failed establishments is particularly relevant in manufacturing sectors since they typically leave behind transferable assets, unlike firms in some service industries that require little capital investment or equipment.\(^\text{31}\)

Industries are identified through the company name or editorial annotation, and I retroactively apply industry codes to each observation using the 1984 edition of the *Standard Industrial Classification for Japan* (JSIC) produced by the Japanese Statistics Bureau.\(^\text{32}\) Typically, company names in Japan have three parts: personal/geographic name + industrial activity + industrial operation/facility (for example, Ishitsuka + Bottle Manufacturing + Factory), although there are many that use a combination of only the first two identifiers. There are also some exceptions to the single-industry-per-establishment identification, excluding conglomerates. For example, Kotahara Coach and Rail is classified in both the Local Railway (JSIC four-digit code 4021) and Light Passenger Vehicle Transport (JSIC 4141) industries, thus appearing as an entrant in both sectors. For establishments without any industry indicator in the genealogies, which represent less than ten percent of the sample, I search for Japanese firm names in electronic databases as well as industry reports.

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30 See Section V for further discussion.

31 The representativeness of the dataset to the overall economy is hard to determine given the absence of production figures in the former and the lack of firm-level documentation before the early 1900s in the latter. However, aggregating the total number of startup firms (i.e., those established independently and without the transfer of assets from defunct or parent firms) indicates coverage of one tenth to one half of the number of firms, depending on industry, extant in the period 1903 to 1912, when official statistics on the number of registered firms are available; see Ohkawa, *Historical statistics*, Series 6-8/a.

32 The Japanese SIC system resembles the United States SIC system (replaced in 1997 with the North American Industry Classification System), but is not a one-to-one mapping. Like its American counterparts, the Japanese system classifies industries hierarchically, from broader industry groups (two-digits) to narrow ones (four-digits). For example, a two-digit code of 05 refers to Metal Mining; a three-digit code of 053 refers to Iron Ore Mining; and a four-digit code of 0534 refers to Chromium (a type of iron ore) Mining.
For my analysis, I use a maximum likelihood probit model to estimate relative likelihoods of first entry. That is, I set the entry outcome (first entry or not) as my dichotomous dependent variable. My main independent variables include a continuous measure of how diversified a firm is (e.g., the number of industries a firm operates in at the time of entry) and an indicator for ownership type (i.e., publicly traded or private-held), both considered essential differences between zaibatsu and independent firms. Since other differences like family wealth, employment of highly skilled labor, access to natural resources, and relationships with the central government are not identifiable with for all firms in the dataset, they are not considered in the analysis. To address this possible omitted variable bias, I use both a specification test and variable decomposition, described in the next section. To capture the decreasing marginal benefit of diversification, I include the square of the firm’s number of industries. I also use an indicator for technological innovation, which considers whether an industry uses technology new to the domestic market or similar to that of an existing industry. Besides interaction terms between each of these variables, I also account for factors like regulatory change, market demand, and industry preferences with year and industry fixed effects. The estimated equation takes the following form:

\[
\Pr(Y=1) = \Phi (X_i \beta_i + X_j \beta_j + X_k \beta_k + X_t \beta_t), \text{ where}
\]

- \(Y\) = JSIC four-digit industry pioneer
- \(\Phi\) is the cumulative normal distribution function
- \(X_i\) = firm-level variables (diversification, ownership)
- \(X_j\) = industry-level variables (innovativeness, JSIC indicators)
- \(X_k\) = interaction terms among \(X_i\) and \(X_j\)
- \(X_t\) = year indicators

By definition, a conglomerate is a multi-sector firm, and indeed the diversification variable increases in magnitude for zaibatsu over the period. However, independent firms that simultaneously enter multiple industries at the time of establishment can also be considered diversified, like the Kotahara example mentioned earlier. Since diversifying across industries reduces volatility in revenues and spreads industry-specific risk, it is reasonable to expect diversified firms as being more likely to pioneer new sectors.

On the other hand, having many different industry holdings, especially in technologically advanced and capital-intensive sectors, poses organizational and strategic challenges and may deter further diversification. This was the case in the nineteenth and early twentieth centuries, before multi-divisional enterprises and professional management became the norm.33 In other words,

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synergies may exist between certain firms and industries but not for others, and there may be an optimal number of industries for a single firm to operate in, past which the costs exceed the benefits. Examples include disputes between the directors of the Mitsui trading company and Mitsui bank over investment strategy and irrational investment choices by the founder of the Furukawa zaibatsu.\(^{34}\) I account for this decreasing marginal benefit by including the square of the diversification variable.

The variable for firm ownership type takes the value of one for publicly-traded, joint-stock firms and zero for privately-held, non-traded firms. Since one prominent characteristic of zaibatsu is their family ownership, this variable may indicate the desire for investment autonomy and to avoid public disclosure of their finances.\(^{35}\) That said, many zaibatsu also held controlling interests in publicly-traded firms and there were independent non-traded firms, so this variable only partly captures the difference between zaibatsu and non-zaibatsu firms. Anecdotal evidence suggests that equity-financed firms, unlike those with internal or debt-based financing, were small and undercapitalized by their need to pay dividends. Moreover, many listed firms were run for short-term profit and were incorporated for a predetermined time period, between three to ten years.\(^{36}\) Additionally, the ownership variable addresses the issue of corporate monitoring through holding companies, which became increasingly important later in the prewar era. Prior to the adoption of the 1893 Commercial Code, which standardized incorporation procedures and defined fiduciary responsibilities, the limited ability of outside investors to monitor management and dominant owners may have hindered the public listing of firms. Although incorporation existed since the 1860s, the lack of institutions governing business practice or protecting property rights remained until the 1890s. Based on these factors, I hypothesize that a positive correlation exists between non-traded ownership and first entry.

The rationale for including industry innovativeness is that pioneering sectors using technologies similar to those already in the market incurs less entry risk and demonstrates less leadership.\(^{37}\) This presumably is because another firm had already borne the cost of foreign adoption, which presumably is more than adapting technology from a domestic source. Furthermore, firms using derivative technology are aware of how the original has been received by the market and some of its operational difficulties. I differentiate between these two types of industries with an indicator variable for technology innovativeness, which takes a value of one for an industry that is the first to be established out of its broader industry grouping and zero for others in the group. An example of this is the three-digit industry grouping ‘251: Glass Manufacturing’, which includes the

\(^{34}\) Ibid., pp. 66, 74.
\(^{35}\) Ibid., p. 43.
\(^{36}\) Fruin, *Japanese Enterprise*.
\(^{37}\) This outcome is predicted by a game-theoretic model of entry; see Tang, 'Entrepreneurship'.
related four-digit industries of '2511: Plate Glass', '2514: Glass Container', and '2515: Scientific Glassware'. If there were no glass manufacturing industries prior to 1871, when the Ishitsuka Bottle Manufacturing Factory was founded, then the four-digit industry 2514 would be coded as innovative.\(^{38}\)

Scarce private capital and financial intermediation suggest problems mobilizing investment funding for capital-intensive industries, which play to the advantages of zaibatsu affiliation. However, since no data exist to quantitatively measure the capital intensity of Japanese industries during this period, I use major industry dummies to account for inter-industry differences and cluster standard errors by four-digit industry to control for random industry shocks. To identify shared influences, I interact pairs of the following independent variables: zaibatsu affiliation, diversification, diversification\(^2\), ownership, and industry innovativeness. I also include year indicator variables to capture temporal shocks to institutions and market conditions.

As for exclusions, I remove government firms from the sample on the grounds that the behavior of such firms is not obviously driven by market factors. I also remove all sectors that were established prior to the Meiji Period since they are less well-documented and unlikely to use technology borrowed from abroad: these include primary sector activities, traditional apparel/food manufacture, retailing, and other miscellaneous services. For duplicate appearances in the dataset due to changes in name or ownership, only the first appearance is included in the analysis. Establishments in foreign countries are omitted as well. These exclusions reduce the number of zaibatsu affiliates from 89 to 32 in the dataset, and I omit the 173 establishments that could not be identified by industry. Furthermore, in cases where an indigenous industry may have incorporated modern methods (e.g., industrial chemicals in leather tanning, mechanized brewing of soy sauce), I err on the conservative side and exclude them from analysis.\(^{39}\)

\section*{IV}

Between 1868 and 1912, 1,958 entrants could be identified by a four-digit JSIC code. Entrants include both individual firms as well as industry divisions within multi-industry companies (e.g., conglomerates). With the restrictions mentioned above, the dataset reduces to 1,478 entrants, of which 1,446 were independent firms and 32 were affiliated with zaibatsu.\(^{40}\) Of the 106 new

\(^{38}\) It is reasonable to expect the proportion of innovative industries, and thus the number of their pioneers, to decrease over time. This consideration does not affect the analysis, however, since the data are pooled across years and the results focus on relative probabilities, not level quantities. In addition, the inclusion of year fixed effects removes temporal idiosyncrasies that may bias the results.

\(^{39}\) Note that including these pseudo-modern sectors does not qualitatively change the results in Section IV.

\(^{40}\) I define zaibatsu affiliation based on appearance in their genealogies or the company histories listed earlier as references. The regression analysis does not make this distinction, but only on firm
industries started with private funding, 12 were pioneered by zaibatsu and 94 by independent entrepreneurs. Additional summary statistics are in Table 1, including breakdowns by firm affiliation for various firm- and industry-level characteristics and the numbers of industry pioneers in parentheses. In particular, the number of new industries pioneered by either zaibatsu or independent firms is given in parentheses in their respective columns.

[Tables 1 and 2 here]

The large disparity between the absolute number of independent and zaibatsu establishments belies substantial behavioral and organizational differences at the industry level. For example, zaibatsu are disproportionately represented in innovative industries (75 percent of establishments) compared to independent firms (23 percent). As expected, zaibatsu are nearly seven times as diversified as independent firms and more likely to have closed, privately-held ownership. Pair-wise correlations in Table 2 are largely consistent with the summary statistics, with first entry being positively correlated with diversification, private ownership, and zaibatsu affiliation in general. Zaibatsu are positively correlated with diversification, closed ownership, and both innovative and heavy industries.41

[Table 3 here]

However, as mentioned earlier, it may be more informative to know why zaibatsu were able to lead the adoption of new technology than simply whether they were more likely to do so. To account for multiple shared features and to identify contributions from individual variables, I use the probit model detailed in the previous section. Regression results, given in Table 3, suggest that features associated with zaibatsu increase the likelihood of industry first entry. To ease interpretation, coefficients are reported as marginal effects, which measure the change in probability for an infinitesimal change in continuous variables and a discrete change in categorical variables. I control for data heteroskedasticity by estimating and reporting Eicker-White standard errors, which are clustered by four-digit industry to account for industry-specific shocks.

Column 1 includes the firm-level variables of diversification and private ownership as well as their interactions, and column 2 adds industry innovativeness and its interactions. Both

attributes of diversification and ownership (which happen to overlap with zaibatsu affiliation, as indicated in the correlation coefficients).

41 Heavy industries include chemicals, machinery, metal processing, and utilities, while light sectors include food processing, ceramics and glass, paper and wood products, textiles, and miscellaneous manufactures. The remainder are grouped together as non-manufacturing sectors. See Rosovsky, *Capital formation*, p. 29.
specifications indicate that diversification and private ownership each increases the probability of first entry. However, column 2 also suggests that high levels of diversification, particularly when interacted with private ownership, decrease this likelihood. Columns 3 and 4 add indicator variables for major industry groups and year to the first two specifications, respectively, to reduce biases owing to differences between types of industries and changes in economic environment over time. The coefficients in these columns are qualitatively similar to the earlier ones, although only diversification consistently confers an advantage to first entry at a statistically significant level; this decreases, however, among innovative sectors at high levels of diversification.

To consider the cumulative effect of all control variables, I calculate probabilities based on the features of a representative Meiji-era zaibatsu (privately-held, 7.3 industries) and a contemporaneous unaffiliated firm (joint-stock, single sector). Accounting for all statistically significant variables in column 4, a typical zaibatsu is 11.5 percent more likely to lead entry into a non-innovative sector compared to its independent rival; however, for innovative sectors, it is 13.4 percent less likely to be a pioneer. These percentages obtain from taking the difference in first entry probabilities between the reference zaibatsu and independent firm, with a positive number indicating a higher relative likelihood for zaibatsu.

Since these oppositely-signed likelihoods, with zaibatsu favoring non-innovative sectors and independent firms innovative ones, obtain from using average diversification across years, they may hide considerable variation over time as zaibatsu became more diversified. To show possible changes in first entry likelihoods, I substitute actual zaibatsu diversification by year and recalculate the probabilities. That is, I use the statistically-significant coefficients of the dependent variables in column 4 of Table 3 and the average annual diversification level to calculate changes in pioneering probabilities; these are plotted in Figure 1. These trends show that while a hypothetical zaibatsu had an advantage in pioneering both types of industries early on, it loses its lead over time, first in innovative sectors (1876) and then non-innovative ones (1905). While it would be heroic to consider these year estimates as anything more than suggestive, the trends nevertheless indicate that zaibatsu may have lost their technological leadership earlier than previously suspected.

To check whether the model is correctly specified, I use a Wald test of significance to see if the coefficients are jointly different from zero. All specifications pass at the one percent level of significance. I also test for functional form and omitted variable bias with a specification link test. This test takes the fitted values of the residual from the original regression, squares them, and

42 See Table 1, row 4.
reinserts them into the model as an additional variable. The modified model is estimated to check for significance in the new variable. The null is that the model has no omitted variables, and if correctly specified, the squares of the residuals should not be significant (since they would not show a pattern that could be explained with additional control variables). A significance level above five percent is generally interpreted as failure to reject the hypothesis (in other words, model is not incorrectly specified). All specifications are above this threshold, which means that the null hypothesis of no omitted variables cannot be rejected.

How robust are these results, especially considering economic and institutional differences over time and in firm characteristics? For example, in 1893 the government enacted a commercial code that defined corporate liabilities and improved property rights protection, which should have made it easier for entrepreneurs to obtain external investment finance. Along with other institutional reforms like gold standard adoption (1897), renegotiation of foreign treaties, and military successes against China (1895) and Russia (1905), it seems reasonable to expect diminishing returns to the zaibatsu advantages in risk sharing and internal financing, even without possible problems associated with overdiversification.44

To test whether these characteristics still provide a first entry advantage in later years, I take subsets of the data after various threshold years and rerun the column 4 specification in Table 3. In column 5, I use only establishments in new industries dating from 1876, when a firm with representative zaibatsu characteristics (i.e., diversification, private ownership) should still retain a first entry advantage in non-innovative industries, but not in innovative ones. This hypothesis fails to be rejected, as the variables for diversification and private ownership continue to increase the probability of industry pioneering at statistically significant levels, but not when interacted with the variable for industry innovativeness. Similar results (not reported) are obtained with the starting years of 1888, when the government largely completed its privatization program and deflationary measures, as well as 1893, when the commercial code was promulgated.45

With regard to firm characteristics, how much first entry advantage can be attributed to diversification and ownership versus differences in the distributions of these variables? A common method used to isolate individual contributions between two groups is via Blinder–Oaxaca decomposition, which uses a single set of coefficient estimates in separate regressions for both group

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44 See Soyeda, *History of banking*, and Mitchener and Ohnuki, 'Institutions', for a description of the evolving financial system during this period. The abovementioned institutional changes and foreign policy achievements may have served to reduce Japanese borrowing costs on international capital markets (i.e., bond premia) and increase international trade; see Sussman and Yafeh, *Institutions*, and Mitchener et al, 'Why did countries'.

45 See Morck and Nakamura, 'Business groups', Table 1 for privatization dates of government-owned enterprises. The sample size after 1905, when zaibatsu firms lose their non-innovative first entry advantage, is too small to analyze.
Taking the difference between the two resulting predictions for each variable allows one to assign the percentage that can be explained solely by an individual variable that is uncontaminated by group distributional dissimilarities. Fairlie decomposition extends this methodology to nonlinear estimation, which I use to obtain the results in column 6 in Table 3. To calculate variable contribution, I use coefficients estimated from the pooled sample of zaibatsu and independent firms and match pairs of observations from the two groups. Given the smaller number of zaibatsu firms, I take 1,000 random samples of 32 independent firms to match with the zaibatsu observations and report the average from these samples. To ease interpretation and obtain meaningful estimates from each firm group, I do not include interaction terms in the probit regression; otherwise, the specification is the same as that in column 5 from Table 3. As shown in row 12 of column 6, the difference in predicted first entry likelihoods between the two firm groups is 0.308, of which the net effect of diversification explains nearly all the total difference (0.295). Since the individually calculated differences are sensitive to the order of variables in the specification, I randomize all the independent variables to obtain estimates that are qualitatively similar to those in column 6. Finally, instead of assuming a normal distribution for the data, I substitute a logit model for the probit and obtain comparable results. Together, the Fairlie decomposition results are consistent with the hypothesis that zaibatsu characteristics like diversification facilitated their (early) technological leadership via industry pioneering.

Although this paper supports the view that zaibatsu had a disproportionate impact on Japanese industrialization, as indicated in the summary statistics, its results also challenge the notion that they were vanguards of innovation, especially in the latter half of the period. What accounts for these omissions in earlier research? Besides data unavailability, another explanation may be the reliance on case studies and their emphasis on individual firms instead of generalizable determinants of leadership. This paper itself begins with stylized facts about zaibatsu’s preponderant size and resource access deemed critical to innovation and industrial expansion. These, however, may be anachronistic and misleading given changes to the external environment and to zaibatsu themselves. By using a more representative dataset and controlling for firm- and

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47 See Fairlie, ‘Absence’.
48 Unlike in previous regressions, I use an indicator for zaibatsu affiliation to separate the two groups of firms: affiliation is obtained from genealogies and zaibatsu histories (see Yagura and Ikushima, Shuyo; Morikawa, Zaibatsu; Russell, House of Mitsui; Mitsubishi Public Affairs Committee, Brief history; Hideki, Sumitomo; Tsunehiko, ed., Yasuda; and Furukawa Industries, Sogyo).
industry-level features as well as time, this analysis presents a more robust and nuanced interpretation of the role of zaibatsu than can be found in other studies.

One concern is that while zaibatsu may have been more likely to lead entry, their absolute number of first entrants is small, questioning their overall impact. This observation assumes, however, that zaibatsu and independent firms were similar when conventional wisdom suggests anecdotally a single zaibatsu affiliate was much larger and more productive. Since this paper employs qualitative measures of industrial activity, it does not directly address this point. Nevertheless, as listed in the appendix, many industries that zaibatsu pioneered were capital-intensive or large scale, and thus out of reach for most independent investors. These industries may also have been important for other sectors (for example, metal mining for machine manufacture), providing an alternative means for zaibatsu to lead industrialization regardless of establishment numbers or first entry. Additional study of inter-industry synergies, their degree of relatedness, and their sequence of entry during this period would be fruitful extensions of this paper's research, helping to identify firm behavior and industry activity at various stages of economic development.

Other issues concerning the data are survivor bias and missing firms since the genealogies are not comprehensive. It was mentioned earlier that the genealogies mitigate this bias by recording firms whose assets were transferred to those who in some form survived to the present. Thus, these data are an improvement on existing sources due to their inclusion of firms that have no other historical record; furthermore, they provide disaggregation by industry, ownership, and location as well as cover a longer period. More to the point, given the focus of this paper the ultimate consideration is whether there is evidence that otherwise unknown firms entered modern industries prior to well-documented zaibatsu, and the genealogical data clearly indicate that this had occurred.

Since this study examines primarily the zaibatsu that emerged before or during the first half of the Meiji Period, it would be worthwhile to explore their relation to and differences with newer zaibatsu in the later Meiji and post-Meiji periods. The implication that zaibatsu may have lost their technological leadership over the period may owe to the second wave of conglomerates usurping their role, and were in turn replaced by even newer zaibatsu thereafter. Whether this is due to the paper's finding of an optimal level of diversification or to unaccounted for differences in productivity and organization between firms is something difficult to say since the data are too qualitative. At the least, the time fixed effects should remove changes in these two aspects occurring over the period, but it is certainly worthwhile to consider these issues in future work, possibly later in the period when more firm-specific documentation is available.

49 The second wave of Meiji-era zaibatsu include Suzuki, Kawasaki, Iwai, Nomura, Fujita, and Asano, and the post-Meiji group of 'shinko' zaibatsu like Nissan, Nisso, Nichitsu, and Riken, although there is some disagreement on classification: see Frankl, 'Analysis', p. 998 and Morikawa, Zaibatsu, p. 126.
This paper also remains silent on two important influences: government and trade. Among other policies, the government sponsored model factories at the beginning of the Meiji Period to jump-start industrialization. As mentioned above, it later privatized these enterprises (with many purchased by zaibatsu) and indirectly supported industry through subsidies and contracts. A major impediment to assessing the government’s contribution is the difficulty in disentangling direct and indirect support. Nevertheless, it may be possible to use this dataset to compare the evolution of sectors started by public versus private investment, looking into differences in their rates of entry or factor intensities. One can then better judge the efficacy of state-led industrialization during early economic development.

Also important is the international context in which Japan industrialized, particularly since its rapid growth relied on technology imports and commodity exports. Using commodity trade flow and Meiji firm establishment data, one can measure the importance of trade through extensive firm growth and industry export shares. Whether a relationship exists may help to explain the resilience of traditional sectors that grew in tandem with the country's increasingly advanced industries. Foreign investment and entry into the Japanese market, beginning in earnest after the renegotiation of the country's tariff treaties in 1899, may have aided the transfer of technology as well.\textsuperscript{50}

These considerations indicate that much remains to be learned about early Japanese industrialization, whose underlying mechanisms have been largely asserted or framed in qualitative terms. Through the use of a new dataset, this paper offers additional insight into the technological leadership of zaibatsu, hitherto taken on faith by many historians, finding that characteristics like diversification indeed confer advantages to industry pioneering, although with diminishing returns. Whether there are other qualifications to received wisdom about Japan’s formative period, and consequently to emerging economies based on its model, remain to be seen.

\textsuperscript{50} See Miyajima, \textit{Economic history}. 
## Appendix: List of New Industries in Meiji Period

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>JSIC4</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td>1322</td>
<td>1869</td>
</tr>
<tr>
<td>Foreign exchange bank</td>
<td>6124*</td>
<td>1869</td>
</tr>
<tr>
<td>Joint-stock life insurance company</td>
<td>6711*</td>
<td>1869</td>
</tr>
<tr>
<td>Machine-reeled raw silk</td>
<td>1411*</td>
<td>1870</td>
</tr>
<tr>
<td>Glass containers</td>
<td>2514*</td>
<td>1871</td>
</tr>
<tr>
<td>Coastwise freight transport</td>
<td>4323*^</td>
<td>1871</td>
</tr>
<tr>
<td>Postal services</td>
<td>4711*</td>
<td>1872</td>
</tr>
<tr>
<td>Water supply installation, draining work</td>
<td>1133*</td>
<td>1873</td>
</tr>
<tr>
<td>Ocean transport</td>
<td>4311^</td>
<td>1873</td>
</tr>
<tr>
<td>Ordinary bank</td>
<td>6121^</td>
<td>1873</td>
</tr>
<tr>
<td>Fired bricks</td>
<td>2551*</td>
<td>1875</td>
</tr>
<tr>
<td>Foreign style paper</td>
<td>1821</td>
<td>1876</td>
</tr>
<tr>
<td>General civil engineering, building works</td>
<td>911*</td>
<td>1877</td>
</tr>
<tr>
<td>Rice cleaning</td>
<td>1261</td>
<td>1879</td>
</tr>
<tr>
<td>Nitric, phosphoric fertilizers</td>
<td>2011*</td>
<td>1879</td>
</tr>
<tr>
<td>Credit cooperative association</td>
<td>6313*</td>
<td>1879</td>
</tr>
<tr>
<td>Joint-stock fire/marine insurance company</td>
<td>6721*^</td>
<td>1879</td>
</tr>
<tr>
<td>Flat glass</td>
<td>2511</td>
<td>1880</td>
</tr>
<tr>
<td>Water supply</td>
<td>3911*^</td>
<td>1880</td>
</tr>
<tr>
<td>Overseas loan and investment institution</td>
<td>6142*</td>
<td>1880</td>
</tr>
<tr>
<td>Credit association and related federation</td>
<td>6312^</td>
<td>1880</td>
</tr>
<tr>
<td>Merchandise forwarding</td>
<td>4621*</td>
<td>1881</td>
</tr>
<tr>
<td>Commercial and industrial cooperative bank</td>
<td>6314</td>
<td>1881</td>
</tr>
<tr>
<td>Paperboard</td>
<td>1822</td>
<td>1882</td>
</tr>
<tr>
<td>Small business finance corporation</td>
<td>6315</td>
<td>1882</td>
</tr>
<tr>
<td>Securities exchange</td>
<td>6631</td>
<td>1882</td>
</tr>
<tr>
<td>Medical product preparations</td>
<td>2062*</td>
<td>1883</td>
</tr>
<tr>
<td>Canned seafood, seaweed</td>
<td>1221*</td>
<td>1884</td>
</tr>
<tr>
<td>Manufactured ice</td>
<td>1341*</td>
<td>1884</td>
</tr>
<tr>
<td>Hemp spinning mill</td>
<td>1425</td>
<td>1884</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>JSIC4</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper smelting and refining, primary</td>
<td>2711*^</td>
<td>1884</td>
</tr>
<tr>
<td>Power station</td>
<td>3611*</td>
<td>1884</td>
</tr>
<tr>
<td>Soda bicarbonate</td>
<td>2021*</td>
<td>1885</td>
</tr>
<tr>
<td>Dairy products</td>
<td>1212*</td>
<td>1886</td>
</tr>
<tr>
<td>Other paper products</td>
<td>1849</td>
<td>1886</td>
</tr>
<tr>
<td>Other electricity establishment</td>
<td>3619</td>
<td>1886</td>
</tr>
<tr>
<td>Lead and zinc metal mining</td>
<td>522*^</td>
<td>1887</td>
</tr>
<tr>
<td>Steel pipes and tubes</td>
<td>2644</td>
<td>1887</td>
</tr>
<tr>
<td>Lead pencils</td>
<td>3443*</td>
<td>1887</td>
</tr>
<tr>
<td>Crude petroleum extraction</td>
<td>711*</td>
<td>1888</td>
</tr>
<tr>
<td>Twisting yarns</td>
<td>1431*</td>
<td>1888</td>
</tr>
<tr>
<td>Paints</td>
<td>2054*</td>
<td>1888</td>
</tr>
<tr>
<td>Watches, clocks, and parts, not watchcases</td>
<td>3271*</td>
<td>1888</td>
</tr>
<tr>
<td>Other musical instruments</td>
<td>3429*</td>
<td>1888</td>
</tr>
<tr>
<td>Local railway</td>
<td>4021*</td>
<td>1888</td>
</tr>
<tr>
<td>Light vehicle passenger transport</td>
<td>4141*</td>
<td>1888</td>
</tr>
<tr>
<td>Silk spinning mill</td>
<td>1424</td>
<td>1889</td>
</tr>
<tr>
<td>Building brick</td>
<td>2532*</td>
<td>1889</td>
</tr>
<tr>
<td>Unrefined sugar</td>
<td>1251</td>
<td>1890</td>
</tr>
<tr>
<td>Soft drinks, carbonated water</td>
<td>1311*</td>
<td>1890</td>
</tr>
<tr>
<td>Transport agency</td>
<td>4631*</td>
<td>1890</td>
</tr>
<tr>
<td>Textile sanitary fabric</td>
<td>1498*</td>
<td>1892</td>
</tr>
<tr>
<td>Machine dyed/finished silk, rayon fabrics</td>
<td>1462</td>
<td>1893</td>
</tr>
<tr>
<td>Mutual life insurance company</td>
<td>6712</td>
<td>1894</td>
</tr>
<tr>
<td>Plastics</td>
<td>2037*</td>
<td>1895</td>
</tr>
<tr>
<td>Asbestos mining</td>
<td>892*</td>
<td>1896</td>
</tr>
<tr>
<td>Sugar refining</td>
<td>1252</td>
<td>1896</td>
</tr>
<tr>
<td>Wool fabric weaving</td>
<td>1443</td>
<td>1896</td>
</tr>
<tr>
<td>Printing ink</td>
<td>2055</td>
<td>1896</td>
</tr>
<tr>
<td>Railroad cars</td>
<td>3121</td>
<td>1896</td>
</tr>
<tr>
<td>Industry Name</td>
<td>JSIC4</td>
<td>Year</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>Long term credit bank</td>
<td>6123</td>
<td>1896</td>
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<tr>
<td>Development financial institution</td>
<td>6143</td>
<td>1896</td>
</tr>
<tr>
<td>Agricultural cooperative</td>
<td>6231*</td>
<td>1896</td>
</tr>
<tr>
<td>Canvas products</td>
<td>1593*</td>
<td>1897</td>
</tr>
<tr>
<td>Printing, not mimeograph</td>
<td>1931</td>
<td>1897</td>
</tr>
<tr>
<td>Synthetic dyes, organic pigments</td>
<td>2036</td>
<td>1897</td>
</tr>
<tr>
<td>Petroleum refining</td>
<td>2111*</td>
<td>1897</td>
</tr>
<tr>
<td>Wire drawing</td>
<td>2648</td>
<td>1897</td>
</tr>
<tr>
<td>Coke</td>
<td>2131*^</td>
<td>1898</td>
</tr>
<tr>
<td>Aluminum smelting and refining, primary</td>
<td>2716</td>
<td>1899</td>
</tr>
<tr>
<td>Trust bank</td>
<td>6122*</td>
<td>1899</td>
</tr>
<tr>
<td>Basic petrol chemicals</td>
<td>2031</td>
<td>1900</td>
</tr>
<tr>
<td>Taxicab operators</td>
<td>4112</td>
<td>1900</td>
</tr>
<tr>
<td>Other industrial organic chemicals</td>
<td>2039</td>
<td>1902</td>
</tr>
<tr>
<td>Motor vehicle bodies and trailers</td>
<td>3112</td>
<td>1896</td>
</tr>
<tr>
<td>Bicycles and parts</td>
<td>3131*</td>
<td>1903</td>
</tr>
<tr>
<td>Metallic springs</td>
<td>2899*</td>
<td>1904</td>
</tr>
<tr>
<td>Power and distribution transformer</td>
<td>3012</td>
<td>1904</td>
</tr>
<tr>
<td>Compound chemical fertilizers</td>
<td>2012*^</td>
<td>1905</td>
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<tr>
<td>Nails</td>
<td>2871*</td>
<td>1905</td>
</tr>
<tr>
<td>Other metal smelting and refining, secondary</td>
<td>2729*^</td>
<td>1906</td>
</tr>
<tr>
<td>Electric bulbs</td>
<td>3031</td>
<td>1906</td>
</tr>
<tr>
<td>Sulfur mining</td>
<td>831*</td>
<td>1907</td>
</tr>
<tr>
<td>Distilled alcohol</td>
<td>1324</td>
<td>1907</td>
</tr>
<tr>
<td>Basic livestock feed</td>
<td>1352*</td>
<td>1907</td>
</tr>
<tr>
<td>Looms, knitting machinery</td>
<td>2952</td>
<td>1907</td>
</tr>
<tr>
<td>Dyeing and finishing machinery</td>
<td>2953</td>
<td>1907</td>
</tr>
<tr>
<td>Generators, motors, rotating electrical machinery</td>
<td>3011</td>
<td>1907</td>
</tr>
<tr>
<td>Tramway</td>
<td>4022</td>
<td>1907</td>
</tr>
<tr>
<td>Refrigerated warehousing</td>
<td>4521*</td>
<td>1907</td>
</tr>
<tr>
<td>Fire and marine reinsurance company</td>
<td>6724</td>
<td>1907</td>
</tr>
<tr>
<td>General sawing and planning mill</td>
<td>1611</td>
<td>1908</td>
</tr>
<tr>
<td>Rayon, acetate fiber</td>
<td>2041</td>
<td>1908</td>
</tr>
<tr>
<td>Coating metal products</td>
<td>2862*</td>
<td>1908</td>
</tr>
<tr>
<td>Medical material preparations</td>
<td>2061</td>
<td>1910</td>
</tr>
<tr>
<td>Call loan and bill brokerage, not securities</td>
<td>6411</td>
<td>1909</td>
</tr>
<tr>
<td>Pastries, cakes</td>
<td>1272</td>
<td>1910</td>
</tr>
<tr>
<td>Other fabric weaving</td>
<td>1449</td>
<td>1910</td>
</tr>
<tr>
<td>Compressed, liquefied gases</td>
<td>2024</td>
<td>1910</td>
</tr>
<tr>
<td>Soaps and synthetic detergents</td>
<td>2052</td>
<td>1910</td>
</tr>
<tr>
<td>Internal combustion engine</td>
<td>2913*^</td>
<td>1910</td>
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<tr>
<td>Other chemical fertilizer mining</td>
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<td>1911</td>
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<td>Organic fertilizer</td>
<td>1353</td>
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<td>Other industrial inorganic chemicals</td>
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<td>1912</td>
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<tr>
<td>Fatty acids, hydrogenated oils, glycerin</td>
<td>2051</td>
<td>1912</td>
</tr>
<tr>
<td>Ferroalloys</td>
<td>2623</td>
<td>1912</td>
</tr>
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</table>

Source: see text.
*: innovative industry
^: zaibatsu pioneered
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Morikawa, H., *Zaibatsu, the rise and fall of family enterprise groups in Japan* (Tokyo, 1992).

Nakagawa, K., 'Business strategy and industrial structure in pre-World-War-II Japan', in K. Nakagawa, ed., *The International Conference on Business History: Strategy and Structure of Big Business I* (Shizuoka, 1974).


Table 1. Summary statistics

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<tr>
<td><strong>Industry breakdown</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>New JSIC4 sectors</td>
<td>1,472</td>
<td>106</td>
<td>32</td>
<td>20 (12)</td>
<td>1,440</td>
<td>101 (94)</td>
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<td>Innovative sectors</td>
<td>335</td>
<td>51</td>
<td>24</td>
<td>16 (8)</td>
<td>311</td>
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<tr>
<td>Average diversification</td>
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<td>7.3</td>
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<td><strong>Capital intensity</strong></td>
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<tr>
<td>Heavy</td>
<td>99</td>
<td>40</td>
<td>8</td>
<td>7 (6)</td>
<td>91</td>
<td>36 (34)</td>
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<tr>
<td>Light</td>
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<td>31</td>
<td>0</td>
<td>0 (0)</td>
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<td>31 (31)</td>
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<tr>
<td>Non-manufacturing</td>
<td>1,228</td>
<td>35</td>
<td>24</td>
<td>13 (6)</td>
<td>1,204</td>
<td>34 (29)</td>
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<tr>
<td><strong>Firm ownership</strong></td>
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<tr>
<td>Joint-stock</td>
<td>1014</td>
<td>88</td>
<td>6</td>
<td>4 (2)</td>
<td>1008</td>
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<tr>
<td>Non-traded</td>
<td>164</td>
<td>62</td>
<td>26</td>
<td>17 (10)</td>
<td>138</td>
<td>51 (30)</td>
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<tr>
<td>Unknown</td>
<td>294</td>
<td>32</td>
<td>0</td>
<td>0 (0)</td>
<td>294</td>
<td>32 (17)</td>
</tr>
</tbody>
</table>

Notes: Industries are classified at the four-digit level.

* Sectors may include establishments from each of the three ownership categories.

Source: see text.

Table 2. Correlations

<table>
<thead>
<tr>
<th></th>
<th>FIRST</th>
<th>DIV.</th>
<th>NONTR</th>
<th>ZAIB</th>
<th>INNOV</th>
<th>HEAVY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry pioneer</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diversification</td>
<td>0.181*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-traded ownership</td>
<td>0.256*</td>
<td>0.263*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zaibatsu affiliation</td>
<td>0.189*</td>
<td>0.830*</td>
<td>0.325*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovative sector</td>
<td>0.154*</td>
<td>0.196*</td>
<td>0.158*</td>
<td>0.193*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Heavy sector</td>
<td>0.380*</td>
<td>0.178*</td>
<td>0.191*</td>
<td>0.106*</td>
<td>0.199*</td>
<td>1</td>
</tr>
<tr>
<td>Light sector</td>
<td>0.160*</td>
<td>-0.056</td>
<td>0.169*</td>
<td>-0.057</td>
<td>0.319*</td>
<td>-0.108*</td>
</tr>
</tbody>
</table>

Significance level: * five percent

Source: see text.
Table 3. Probit Results

<table>
<thead>
<tr>
<th>Dependent variable: Pr(Y=industry pioneer)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversification****</td>
<td>0.072*</td>
<td>0.193***</td>
<td>0.067***</td>
<td>0.062***</td>
<td>0.321**</td>
<td>0.383***</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
<td>(0.080)</td>
<td>(0.037)</td>
<td>(0.033)</td>
<td>(0.160)</td>
<td>(0.104)</td>
</tr>
<tr>
<td>Diversification**</td>
<td>0.005</td>
<td>-0.028**</td>
<td>-0.006***</td>
<td>-0.007*</td>
<td>-0.098</td>
<td>-0.088***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.012)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.076)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>Non-traded ownership</td>
<td>0.296***</td>
<td>0.177***</td>
<td>0.185***</td>
<td>0.023</td>
<td>0.153**</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>(0.118)</td>
<td>(0.096)</td>
<td>(0.162)</td>
<td>(0.029)</td>
<td>(0.102)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Innovative sector</td>
<td>0.067</td>
<td>-0.024**</td>
<td>-0.077</td>
<td>-0.088**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.050)</td>
<td>(0.016)</td>
<td>(0.065)</td>
<td>(0.038)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Interaction terms

| Diversification · Non-traded              | -0.048      | -0.007      | -0.047**    | -0.011      | -0.165      |
|                                          | (0.040)     | (0.029)     | (0.035)     | (0.017)     | (0.152)     |
| Diversification^2 · Non-traded           | 0.003       | -0.182***   | 0.005**     | 0.002       | 0.096       |
|                                          | (0.003)     | (0.089)     | (0.003)     | (0.002)     | (0.076)     |
| Diversification · Innovative             | -0.000      | -0.040*     | -0.115      |             |             |
|                                          | (0.003)     | (0.024)     | (0.109)     |             |             |
| Diversification^2 · Innovative           | 0.028***    | 0.005       | dropped     |             |             |
|                                          | (0.013)     | (0.004)     |             |             |             |
| Non-traded · Innovative                  | -0.024      | -0.004      | -0.054      |             |             |
|                                          | (0.033)     | (0.016)     | (0.046)     |             |             |

Industry fixed effects included
Year fixed effects included
Explained difference from firm affiliation included

| Observations                              | 1,178       | 1,178       | 1,111       | 1,111       | 393         | 1,178       |
| Pseudo-R^2                                | 0.109       | 0.153       | 0.387       | 0.433       | 0.333       | 0.421       |

Significance level: * ten percent  ** five percent  *** one percent
Notes: Results in columns 1 to 5 reported as marginal effects, with robust standard errors in parentheses and clustered by four-digit industry. Fairlie decomposition in column 6 based on contributions averaged from 1,000 random samples, with standard errors in parentheses and calculated using the delta method.
Source: see text.
Figure 1. Zaibatsu Industry Pioneer Probabilities

Source: see text.