Social Network and Industrial Policy: Japan's Camphor Monopoly in Colonial Taiwan*

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Abstract

This paper examines how firm-official connectivity affects industrial policy's treatments and outcomes by combining micro-level data from Japan's Camphor Monopoly System in Taiwan with an industrialist-official network compiled from a newspaper archive. Using a recentered shift-share design, our reduced-form estimation finds that tighter firm-official connections lead to more favorable treatments but suggests little effects on productivity. We simulate a quantitative model based on the institutional design, finding that both excessively strong or weak connections hinder productivity improvements of firms, and that the authority's decision exhibits a mixture between favoring connected conglomerates and picking smaller but efficient firms.

Key Words: Industrial Policy, Social Network, Firm-Official Connectivity, Government Monopoly, East Asia, Camphor

JEL Code: L52, L78, N15, O25, P41

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1 Introduction

Many countries use industrial policies to enhance the performance of specific sectors. In East Asian countries these policies frequently feature "picking winners." Bureaucrats identify key industries as "strategic" and provide supports like subsidies, low-interest loans, and technology transfers to the firms. They promptly monitor these firms' performance, rewarding the best performers (winners) with additional support while reducing benefits for underperformers. This mode of industrial policy has cultivated several global market leaders, for example, Chaebols in South Korea, Zaibatsus in Japan, or semiconductor manufacturers in Taiwan, and is thought to be the driving force behind the East Asian miracle of economic development.

Usually, winners have strong political connections to the bureaucrats. Seminal studies like Evans (1995) proposed the idea of "embedded autonomy," arguing that such connections are crucial for successful industrial policies. The "embeddedness" refers to the intimate link between industrialists and officials facilitates the authority's decision making. The "autonomy" refers to the authority's ability to pursue policy objectives independent of external pressures. Both elements are essential for a successful industrial policy, as the absence of either leads to favoritism or expropriation.

Motivated by Evans (1995), this paper aims to unravel the roles of firm-official connectivity in industrial policies. Are well-connected firms receiving favorable policy treatments because they are efficient, or simply based on sheer favoritism? Does the variation in allocation of policy resources across firms align with the policy objective? Studying this will face challenges in accessing detailed data on firm-specific policy treatments, such as production targets and subsidies. Measuring the connections among industrialists and officials is also challenging because their interactions are hardly observable on a large scale. The Camphor Monopoly System in Taiwan during the Japanese colonial period (1895-1945) provides an opportunity to overcome these major challenges.

The Camphor Monopoly System was an example of picking-winner policies where colonial officials set production targets and subsidies for private firms. The system was implemented for gaining government profit since camphor was a strategic raw material primarily produced in Taiwan due to the limited global distribution of camphor trees. It featured a **monopsony** in the upstream crude camphor sector during 1899–1918, where firms participated by government approval and had to sell their output to the government at varying compensation prices. The government evaluated firm performances using the production quotas assigned to them as benchmarks, rewarding efficient firms with increased quotas and penalizing underperformers with reductions or market exit.

This institutional feature allows us to not only construct detailed establishment-level panel data, but also trace each private industrialist's social connections with government officials. Combining various historical archives and biographies, we compile a comprehensive list of individuals directly or indirectly involved in the camphor monopoly. We then construct a social network of these agents based on their interactions reported by news articles in the *Taiwan Daily News*, which further allows us to gauge the connectivity among them in terms of network distance.

Our analysis begins with an reduced-form estimation for identifying the effect of firm-official connectivity on the policy treatments of firms and productivity. Using the recentered shift-share design by Borusyak and Hull (2023), we estimate how improvements in firms' connections to government officials affect their compensation prices, production quotas, and productivity, accounting for firms' non-random exposure to network shocks. The results suggest the existence of favoritism: firms with increased connections to officials tend to produce less but are better compensated. However, the results show no significant impact on productivity from these connectivity shocks.

We develop a quantitative model based on the Camphor Monopoly System's design to explore firm-official connectivity's overall impacts on firms' performance and government income. The government maximizes its expected profit by selecting firms based on their connectivity and productivity. Each firm determines its expected productivity by an initial innovation effort, then bilaterally bargains with the government on the profit once being selected. Our estimation implies that better-connected firms enjoy higher profit shares from the bargaining process, which in this model would incentivize innovation efforts. We calibrate the model and simulate the government's decisions on granting permissions, the resulting productivity levels and government income.

Our simulation reveals a hump-shaped relationship between firm productivity and their connections with the authority, a finding not anticipated by Evans (1995). The finding explains the insignificant effects on productivity, as stronger connections may enhance productivity for some firms but impede it for others. We perform two counterfactual experiments to study the implications of the institutional design on government income. These experiments suggest that the Camphor Monopoly System combined both the selection of efficient firms and favoritism towards specific conglomerates.

Our work is closely related to studies on firm-politician connections and lobbying, including Akcigit, Baslandze, and Lotti (2023), Bai, Hsieh, Song, and Wang (2021), Bertrand, Bombardini, and Trebbi (2014), Bertrand et al. (2020), Bertrand et al. (2023), Nian and Wang (2023), and Saleh and Artunc (2022). Works by Akcigit et al. (2023), Nian and Wang (2023), and Saleh and Artunc (2022) characterize firm's connections to politicians using histories of firm employment or official turnover, and inspect how changes in these connections affect firms' performances in revenue, entry-exit dynamics, productivity, and stock values. Bertrand et al. (2014) investigate the role of lobbyists' political connections in influencing legislative decisions and their compensation received from interest groups. Relatedly, Bertrand et al. (2020, 2023) examine how corporations influence legislative decisions to their advantage through political activities. Our work complements these studies by focusing on the effect of connections on the design and outcome of an industrial policy based on a large social network constructed from semi-public interactions between individuals.

Our work also contributes to the literature on industrial policies, including place-based policies (Lu, Wang, and Zhu, 2019; Criscuolo et al., 2019), investment subsidies (Aghion et al., 2015), and policies to foster industrial growth (Barwick, Kalouptsidi, and Zahur, 2019; Lane, 2019). Our work is closely related to Barwick, Kalouptsidi and Zahur (2023), who assess the optimal policy instrument for China's shipbuilding industry. They evaluate whether China's White List policy, similar to Japan's camphor monopoly, effectively promotes production efficiency through simulation, finding that nearly half of the firms should not have been selected. Our study complements their research by incorporating the role of connections in our analysis.

The remainder of this paper is organized as follows. Section 2 provides the institutional background and data sources. Section 3 explores the relationship between firm ethnicity structure and policy treatments. Section 4 details the construction of a social network, reduced-form design and the empirical results. Section 5 models the Camphor Monopoly System and simulates the outcome. Section 6 concludes our analysis.

2 Background and Data

2.1 Background

Camphor was the primary input for producing celluloid, the first thermoplastics and was widely used to produce products including camera films, lacquer, and even explosives (Durham, 1932). As the industry expanded, camphor become one of the strategic raw materials (Grunge, 1939). Before World War I, nature camphor extracted from camphor trees dominated the global market due to the higher cost and lower quality of synthetic alternatives.[1] The production was heavily relied on the distribution of the trees, primarily found in Taiwan under the Japanese rule. Hashimoto (1932) documented that Taiwan held 77% of the world's camphor trees, with mainland Japan and Southern China holding 15% and 8%, respectively. Meanwhile, Taiwan alone supplied 60% of the global market and 90% of the U.S. market (Grunge, 1939).

Given the crucial role of camphor, in 1899 the Japanese colonial government implemented the Camphor Monopoly System for fiscal purposes. The Monopoly Bureau controlled downstream refining, retailing, and global distribution, while the upstream crude camphor sector operated as a **government monopsony** during 1899–1918, featuring intensive participation by private firms. Participation to the sector was based on government approval, and all approved firms must sell their output exclusively to the government at pre-determined prices, with their performances actively monitored. The output was then processed by the authority's facilities and exported globally.[2]

To enter the sector, firms had to submit detailed production plans for the Monopoly Bureau's approval. The authority issued production allowances (許可額, henceforth *quota*) to approved firms, which also served as benchmarks for evaluating firm perfor-

[1] See Matsushida (1924), pp. 474-475 and p. 850, and Nippon Senbai Kōsha (1956), pp. 846-847.
[2] Matsushida (1924, Ch. 4-5) and Tavares (2004, Ch. 3) provide reviews to the institution.

mances, and were flexibly adjusted at the authority's discretion. Firms that consistently failed to achieve their quotas risked quota cuts or expulsion. Conversely, firms that met or exceeded their quotas were considered efficient and could be rewarded with additional quotas.[3] The authority accounted for exogenous factors such as natural disasters and rebellions, and adjusted the quotas "intra-year" in response. For example, in 1907, the producers in Douliu faced cuts due to a labor shortage, while the producer in Taoyuan obtained additional quota as its output surpassed the goal for the year.

The producers had to exclusively sell the crude camphor they produced to the Monopoly Bureau at purchasing prices (補償金, literally *compensation*) determined and publicly declared by the colonial government. These prices depended on the location, quality, and product type, and were adjusted from time to time. There were 30 major adjustments in prices during 1904–18, which were mostly specific to prefectures and production sites, and were claimed to reflect remoteness and working conditions in these regions. The adjustments were mostly upwards, with only minor downward changes Notably, many of the upwards adjustments occurred in regions populated with Japanese producers, or following the exit of local and entry of Japanese firms.

Overall, the institution during 1899-1918 can be seen as an industrial policy featuring "picking-winner". The primary policy treatments were production quotas and compensation prices. The quotas represented the authority's *confidence* in a firm and served as benchmarks for evaluating its performance. Ideally, quotas were reallocated from less efficient firms to the more efficient ones. The compensation price acted as a reward for efficient production. However, these treatments could also reflect favoritism towards certain firms, potentially stemming from interactions between industrialists and top officials who could influence the Monopoly Bureau's decisions.

Interactions between industrialists and top officials due to camphor monopoly were frequently reported by the *Taiwan Daily News*, Taiwan's largest newspaper and official gazette. Examples include meetings initiated by either side, lobbying by industrialists, and regional visits by top officials. Industrialists also built connections beyond the crude camphor sector by participating in social events, such as festive events and banquets by political and business leaders, or joining organizations with official backgrounds.

[3] See Yearbook of Taiwan Government-General Monopoly Bureau, 7th Year (1910), pp. 30-31.

Through intensive interactions, industrialists gradually expanded their networks within the bureaucracy, gaining influence over government decisions. A firm thereby becomes more closely linked with the authority when it includes more well-connected stakeholders or when its stakeholders strengthen their connections with officials. Online Appendix A provides examples for these interactions.

2.2 Data

Our dataset for crude camphor producers comes from various issues of the *Yearbooks of Taiwan Government-General Monopoly Bureau (YMB)*, covering 1902–18. These yearbooks provide detailed firm-prefecture-level (also referred to as *establishment-level*) information, including quotas for camphor crystals and oil, amount of capital (camphor stoves), camphor wood and fuel wood usage (from 1906), amount of crystal and oil **produced**, and the amount **sold** to the government (at different quality levels for crystal). They also document the revenue from each product (from 1907), prefectures of operation and list of production sites, and ownership information, including the names of owners and the number of partners if operated by partnership.

Note that the quantities produced and sold are different concepts in the *YMB*. Firms were required to ship their output to local agencies for review by the Monopoly Bureau. The officials inspected these outputs for quality control, and determined quality of camphor crystals based on chemical concentration. The authority then purchased the qualified products at the declared prices. Because these procedures take time, the quantities produced may differ from those actually sold documented by the same yearbook, and data backlog for actual shipments and revenue happened in some years.

Gauging the effective camphor output is challenging because both camphor crystal and oil are simultaneously produced byproducts, and the quality of the crystals was not known before inspected by the authority. To address this, we use technical information from Matsushida (1924, p.175, 211 and 267) to construct an equivalent output. Camphor oil must be processed to extract crystals, at an approximately 0.5 conversion rate. The official compensation schedule for crystals included a 10% price reduction for a reduction in quality level, and the price for oil was set at 50% of the price of high-quality crystals. This suggests that the pricing was based on the chemical concentration benchmarked by high-quality crystals: one unit of oil equaled 0.5 units of high-quality crystal, and one unit of middle-quality (low-quality) crystal equaled 0.9 (0.81) units.

We compute the quality rate of an establishment as its share of crystals sold at different quality levels. We combine these rates with the conversion ratios and actual outputs to calculate each establishment's **high-quality-crystal-equivalence output** (*equivalence output*). The establishment's revenue is computed as the sum of those from crystals and oil, and the average compensation price is calculated by dividing the revenue by the equivalence output. We calculate the crystal-equivalent quota (both initial and finalized) as the sum of the crystal quota and the oil quota converted to crystal-equivalent units at the 0.5 conversion rate.

The yearbooks do not cover labor inputs, so we supplement this information from Matsushida (1924) and the *Statistical Abstract of the Taiwan Government-General* (henceforth *Statistical Abstract*). Matsushida (1924) provides expenditure data on firemen and porters per physical unit of output for most camphor producers during 1911–17, at the firm-prefecture level and, in some cases, the firm-prefecture-site level. We aggregate this data to the establishment-level by calculating simple averages. Missing values are imputed using averages from the immediate preceding and subsequent years when applicable. The *Statistical Abstract* offers wage rates by occupation for major settlements, allowing us to compute average wage rates for low-skilled workers in nearby areas to recover establishment-level labor (firemen plus porters) inputs. All monetary data are adjusted using the Producer Price Index (PPI, base year 1914) from Wu (1996).

We use news articles published by *Taiwan Daily News* to construct industrialist-official connectivity. It was a semi-state-owned daily newspaper and also the official gazette, frequently reporting business activities such as company foundations, and annual meetings, often disclosing the names of participants and stakeholders. Interactions between officials and industrialists such as semi-public communications and social events, and biographical profiles were also frequently published. Although it avoided judgmental or sensational reporting, the newspaper slanted towards the colonial government, focusing on Japanese officials, favored industrialists, and aligned Taiwanese. This slant is beneficial for our study, as well-connected individuals are more likely to be featured, whereas those with few or no appearances are considered less or unconnected.

We retrieve the articles from Hanzen's *Taiwan Daily News* Archive, which provides scanned copies for the *Taiwan Daily News* and its predecessor, the *Taiwan News*, covering the years 1896–1944. It uses the names of individuals and organizations as meta data, allowing users to search for all news that the entity of interest involved in by name. We can thus conduct keyword searches to retrieve the articles needed.

The *YMB* provides a comprehensive list of permitted firms in the system, including partner names for partnership-operated firms in certain years. When stakeholder names (partners, shareholders, board members) are not explicitly listed in the *YMB*, we supplement the information with news from the *Taiwan Daily News*. We also examine the biographies of the involved industrialists for details on their identities, backgrounds, and years of death when applicable. For Taiwanese we refer to *Biographies of Taiwanese Gentries* by Takatori (1916) on behalf of the authority, and for Japanese we use the *Japanese Who's Who* digitized by Nagoya University. Using the first available list of firm stakeholders (shareholders, partners, and top executives), we impute its time series by assuming that the stakeholders within firms remain the same for preceding and subsequent years until an updated list is available, and so on. The complete list of all ranks of officials in the Government-General is sourced from the *Official Directory in Taiwan Government-General* (henceforth *Official Directory*), an annual publication detailing all formally employed officials from the Governor-General to street-level police.

The *Statistical Abstract* provides both volume and value of Taiwan's camphor export since 1905. We recover the unit price of camphor on the downstream market by dividing the value with volume. We will use this information for our calibration in Section 5. Other subtle details on data processing are provided in the Online Appendix B.

3 Stakeholder Structure and Productivity

Given the colonial context, Japanese industrialists are expected to had better connections and interact more frequently with top bureaucrats than local Taiwanese. As a first step in our study, we examine how the ethnicity structure of a firm's stakeholders relates to its respective policy treatments and productivity. We classify the firm as Japanese-owned if over 50% of its stakeholders are Japanese.

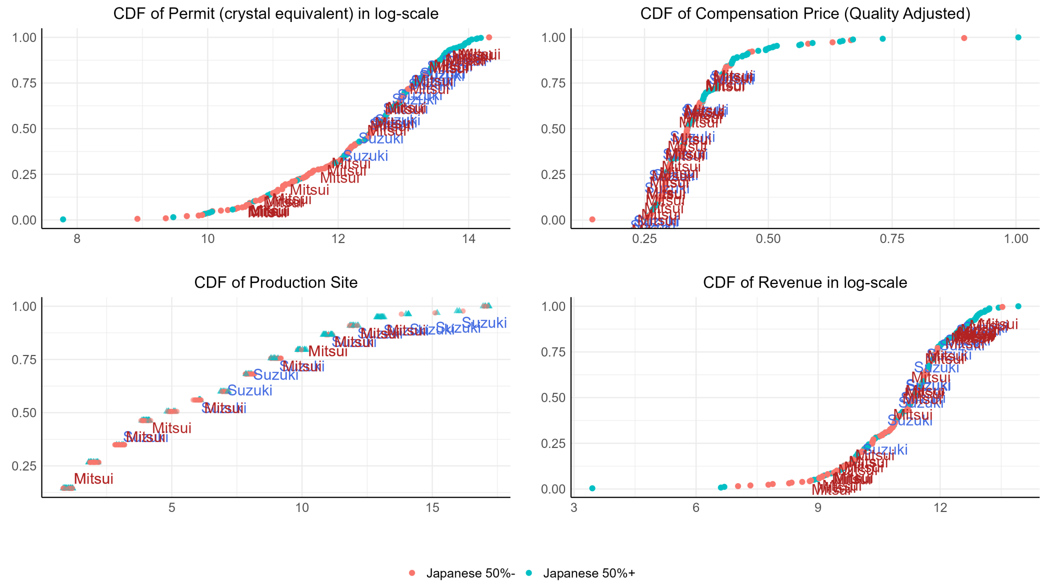

Figure 1: Empirical CDFs of Policy Treatments

Figure 1 presents the empirical cumulative distribution function (CDF) for establishment-level production quotas in crystal-equivalent, production sites, compensation prices, and revenue pooled over 1902–18, with labels indicating the owner's ethnicity structure and the largest conglomerates Mitsui and Suzuki. The figure shows that Japanese-owned establishments are highly concentrated among the top 20% of the distributions, particularly those owned by the conglomerates. Namely, firms with more Japanese owners are more likely to receive favorable policy treatments.

Turning to firm productivity, we start by estimating establishment level total factor productivity (TFP), focusing on the years 1911–17 due to data availability in labor, stoves, fuel and camphor wood usages. The production function for equivalence output of camphor is estimated using these inputs to obtain their input elasticities and the physical TFP. The establishment's revenue productivity (TFPR) is calculated by multiplying the TFP with the compensation price, following Foster, Haltiwanger, and Wolf (2016).

Our establishment-level estimations of productivity use the OP (Olley and Pakes, 1996), LP (Levinsohn and Petrin, 2003) and ACF (Ackerberg, Caves, and Frazer, 2015) approaches. For OP we proxy with investment constructed as the first difference in log of stoves with a depreciation rate of 0.95. For LP and ACF we proxy with fuel wood usage. As the authority can flexibly adjust quotas in response to exogenous events

	Quota Approach	OP	LP (fuel wood)	ACF (fuel wood)
β_l (labor)	0.765***	0.771***	0.772***	2.215**
	(0.084)	(0.094)	(0.103)	(0.97)
β_w (camphor wood)	0.084	0.088	0.091	-0.587
	(0.121)	(0.102)	(0.162)	(1.079)
β_m (fuel wood)	0.134	0.14	-0.034	0.787
	(0.103)	(0.11)	(0.309)	(1.157)
β_k (stove)	0.036	0.075	0.264	-1.509
	(0.093)	(0.101)	(0.197)	(1.118)
Observations	142	126	142	142

Standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1: Input Elasticities

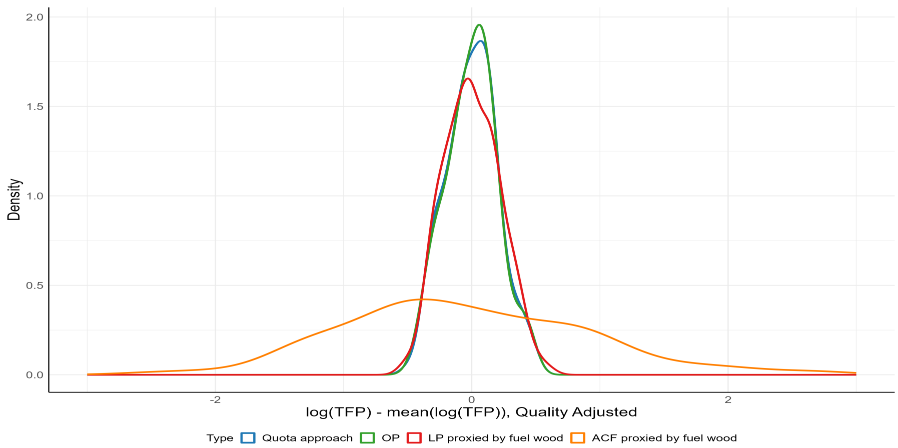

Figure 2: Empirical CDFs of Quality-Adjusted TFP and TFPR

affecting firm performances, this implies that (unobservable) interim shocks affect finalized quotas thereby output, but **not** the initial quotas. Based on this feature, we also estimate with the "quota approach" by performing an OP estimation proxied with the **initial** crystal-equivalent quota, which will be robust to the ACF's critique of OP.

Table 1 presents the input elasticities estimated with these approaches, and Figure 2 illustrates the implied densities of the demeaned log-TFP. All approaches find a positive and highly significant labor elasticity, and, except for ACF, entail similar TFP densities. We adopt the quota approach since it is estimated with more observations than OP, and the positive coefficients are more comprehensible than LP and ACF.

Figure 3 illustrates the CDFs for of both TFP and TFPR in the upper and lower panels. We mark the establishments owned by influential firms according to ethnicity and scale of operation. We choose Chien A-Niu (labeled as *Chien*) and Akaji Hatsutarō

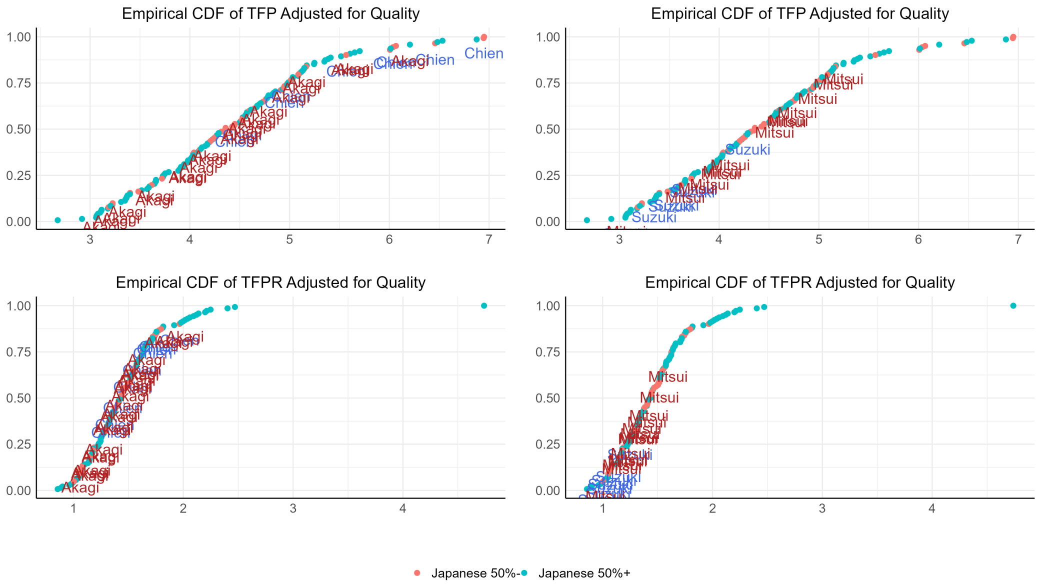

Figure 3: Empirical CDFs of Quality-Adjusted TFP and TFPR

(labeled as *Akaji*) to represent emerging firms in their ethnicity groups. Both started their businesses from scratch and expanded rapidly by collaborating with established enterprises in various fields. Mitsui and Suzuki are labeled for large conglomerates.

The upper panel of Figure 3 shows that Taiwanese establishments are more concentrated in the middle to the upper right tail of the TFP distribution, whereas Japanese establishments tend to be more dispersed and on average less productive. Notably, Chien outperformed Akaji and even Mitsui, whereas Suzuki's is surprisingly poor compared to smaller firms. Turning to TFPR, the lower panel indicates that Japanese establishments dominates the top 20% of the distribution, while Taiwanese are concentrated in the middle of the distribution. Along with the distributions of compensation price and revenue shown in Figure 1, the finding suggests that Japanese firms can obtain higher revenues despite lower productivity due to more favorable compensation prices. For example, Chien is outperformed by Akaji for TFPR.

In sum, the Monopoly Bureau may exhibit favoritism towards Japanese firms. This aligns with anecdotal accounts where Taiwanese producers complained of "quality and price" discriminations. The inclusion of Taiwanese firms indicates that the authority's financial objective may have also influenced policy treatments. This mixed effect of favoritism and financial goal motivates the analysis in Section 5.

4 Estimating the Connectivity Effect

This section examines how firms' connectivities with the authority affect the policy treatments they receive within the Camphor Monopoly System. We construct a network of industrialists and officials in the crude camphor sector, which further includes affiliates outside the monopoly to capture their influences. We define a connectivity index for firm-official connectivity, and estimate its effects on policy treatments.

4.1 Constructing the Network and Firm-Official Connectivity

To construct the social network, we search the *Taiwan Daily News* for 1896–1918 using the names of stakeholders (shareholders, partners, and top executives) and firms appearing in the *YMB*. We manually comb through about 2700 news article to identify social events and the individuals and organizations involved. We supplement the stakeholders showing in articles regarding camphor monopoly but not in the *YMB* to our list of stakeholders for our analysis throughout the paper. Some partner's names only show in news but not in the *YMB*, so we also search their names to ensure comprehensive network coverage. We focus on news articles that explicitly report events involving **multiple** individuals or organizations, specifically those related to business collaborations, social activities, or long-term relationships such as family ties or ethnicity-based associations.[4] We obtain about 700 news articles that go back to as early as 1897.

We construct the network based on events in each year, treating each as a "subnetwork" with all participants pair-wise connected. Each bilateral connections are maintained until a participant's death. We combine subnetworks from 1897–1900 to create a base layer, and form individual layers for each subsequent year by joining all subnetworks from that year. The social networks for 1901–18 are then built by recursively adding each year's layer on the previous one, on top of the base layer. We remove deceased individuals permanently as needed. When an event is covered in multiple news articles, we aggregate all related articles from the same year into a single event to include all mentioned participants. For events involving ethnic associations where membership is typically long-term, we include individuals who would have been members as participants based on relevant news mentions from surrounding years. Additionally,

[4] For example, an article about an individual planning to start a business is excluded, whereas an article reporting that an official has approved the individual's application is included.

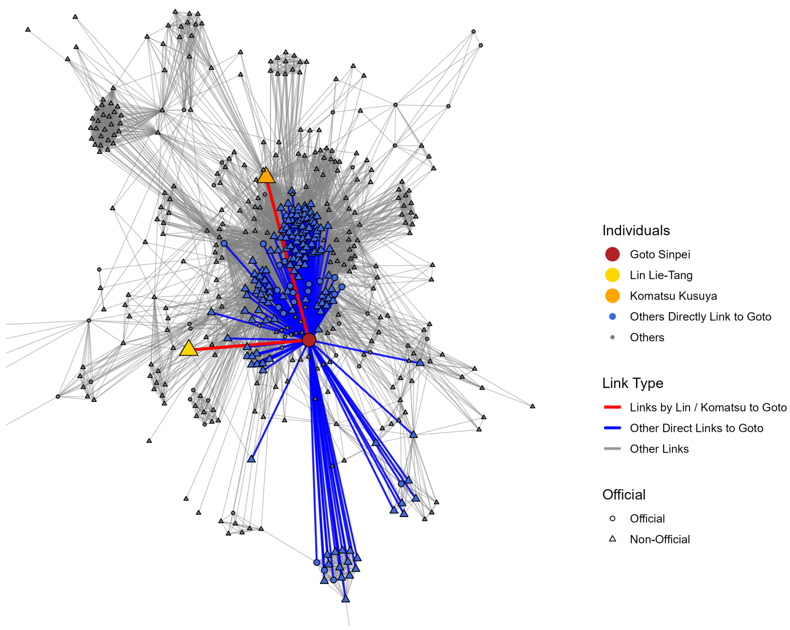

Figure 4: Network in 1901

we incorporate three partnership businesses documented in the *YMB* but not covered by the *Taiwan Daily News* into their respective yearly layers. The network expands over time, and involves 2531 individuals by 1918.

To motivate our idea for the connectivity index, consider the 1901 network for example. Figure 4 marks the network position of Gotō Sinpei who occupied the second-in-command position in the colonial government. Several prominent local and Japanese elites, for example the camphor producers Lin Lie-Tang and Komatsu Kusuya, connect directly to Gotō. Other industrialists have indirect connections with him through the elites. The number of intermediate *nodes* that a given individual needs to go through to link up with Gotō can thus be thought of as the connectivity of this individual to the then current second-in-command. Fewer nodes indicates a better connection.

The connection of an elite to the second-in-command position vary over time because the turnover of official is externally determined by the bureaucratic system hence beyond the elite's control. For example, the position was handed to an alternative official in 1906 following Gotō's reassignment to Manchuria. The existing elites may thus lose direct connections with the position if they are unfamiliar with the successor, whereas other industrialists may gain connections if they already know the successor.

Following the above discussions, we sketch how we construct the firm-official connectivity index based on the concept of *network distance* between individuals (detailed in Appendix A). The unweighted network distance between two individuals is defined as the path involving the fewest intermediate individuals. Some direct interactions disclosed by newspapers may be incidental and less reliable. To address this, we assign weights to direct connections based on the number of events where both individuals have participated. The more frequent individuals meet, the more likely they are familiar with each other, making the path more viable. A longer (weighted) network distance indicates a weaker connection, and is infinite for unconnected individuals. We convert the network distance to between $[0,1]$, where 0 represents a perfect connection and 1 stands for no connection.

To measure firm-official connectivity each year, we first compute the distances between stakeholders of camphor producers and officials involved in economic affairs within the "Central" Government-General, accounting for both direct and indirect connections. We then attempt to aggregate these distances to firm-level using the compiled list of stakeholders. However, direct aggregation could be problematic. First, the news articles may not comprehensively cover each stakeholders. Second, individual stakeholders may have private information regarding closely connected officials, allowing them to anticipate official turnover and accordingly adjust the decisions of their firms. To mitigate these issues, we define a group-to-group network distance based on the identity of industrialists and the rank of officials, then aggregate it to become the firm-official connectivity index using a shift-share design.

The group-to-group distance is computed as the distance between an average industrialist in a given identity group e and an average official at a given rank g. This assumes that individuals with similar backgrounds have similar network structures, making the average distance representative for group connectivity. The endogeneity due to individual's private knowledge is averaged out if it arises idiosyncratically. Let $d^g_{e,t}$ denotes the distance in year t, and $\omega_{i,e}$ for firm i's fraction of stakeholders in the initial year that it entered the system. We define the firm's connectivity by *rate of changes*:

$$d_{i,t}^{g} \equiv \sum_{e} \underbrace{\omega_{i,e}}_{share} \underbrace{\frac{d_{e,t+1}^{g} - d_{e,t}^{g}}{d_{e,t}^{g}}}_{shift},$$

where the *shift* part eliminates the linear time-invariant endogenous factors, and the *share* part captures cross-sectional time-invariant firm heterogeneity. A negative $d_{i,t}^{g}$ indicates a reduction in distance, an improvement in connection.

Turning to the definitions of the groups. Referring to the bureaucratic system and the *Official Directory* during 1895–1918, we classify the officials of interests into three different ranks $G01$, $G02$, and $G03$, corresponding to Government Head, Ministry Head, and Section Head ranks respectively. As an analogy to the modern system, the $G01$ rank comprises the top officials, similar to the President, Premier, and Parliament head, and the $G02$ rank consists of ministry heads in charge of economic-related affairs. The $G03$ rank is made of section heads right under the aforementioned ministries.

Industrialists are classified into four identity groups based on their ethnicity and nobility: Noble Japanese, Local Taiwanese Assistants (LTA), and Ordinary Japanese and Taiwanese. This classification reflects pre-determined characteristics, and is more of granted than earned. Ethnicity is clearly exogenous. Japanese Nobility was granted based on family background and historical achievements. The nobility equivalent for Taiwanese is LTA, which refers to individuals who were enrolled in the colonial government as councilors or local heads before 1904. These Taiwanese had established local influences prior to Japan's arrival and were conferred privileges by the Japanese for political needs, mainly in exchange for suppressing organized resistances during 1895–1902. This "nobility equivalent" was thus pre-determined.

Figure 5 illustrates the group-to-group distances from each identity group. Not surprisingly, Japanese are more connected to all ranks of officials than Taiwanese. The Japanese Nobility is particularly well-connected, with the shortest social distances compared to other identity groups. The LTA is distant from officials in the beginning similar to other Taiwanese, but they gradually gain familiarity and eventually become as connected as the Japanese Nobility.

The fraction of ethnicity groups within firms remained largely stable over time.

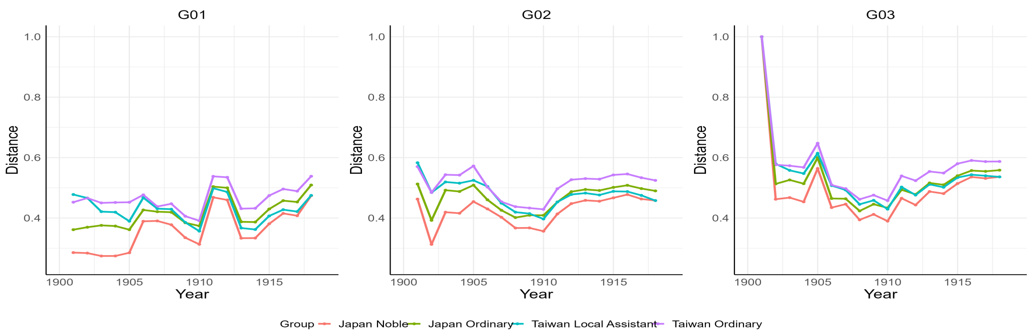

Figure 5: Time Series of Group-level Connectivity

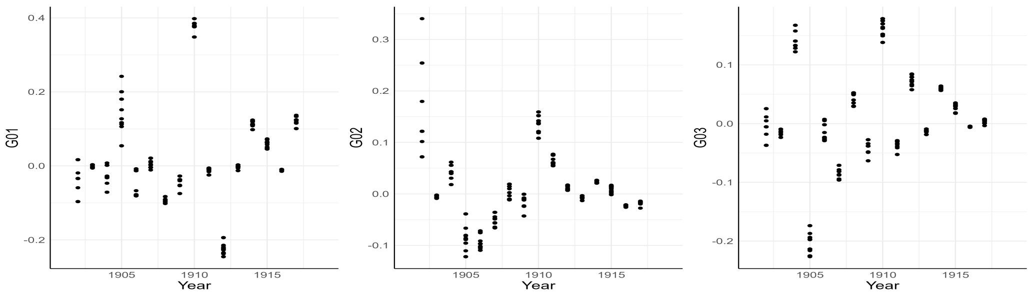

Figure 6: Shift-Share Connectivity

Among 57 unique firms in our data, only 9 experienced changes in their identity group composition. Most firms are composed of a single ethnicity: 20 (30) are entirely Japanese (Taiwanese). Of the Japanese firms, 6 include stakeholders with nobility titles, while nearly half of the Taiwanese firms have LTA group members. All 7 firms with mixed identities include stakeholders from either the Japanese Nobility or LTA groups. Overall, stakeholder composition is stable over time but varies across firms.

Figure 6 shows substantial variations in connectivity to official ranks $d_{i,t}^{jg}$ across firms and years. As discussed, the variation comes from official turnover and reforms in bureaucratic system. The connectivity changes for Ministry and Section Heads are highly correlated, suggesting that people tend to link to both ranks simultaneously. Collinearity issue could thus arise when including multiple connectivities in our regression.

4.2 Identification Strategy

Our empirical design is challenged by the non-random exposure to network shocks. Some Japanese noblemen and conglomerates are likely to receive better policy treatments than ordinary Taiwanese, regardless of political connections. This implies that even if an official equally connected to both groups were randomly replaced, establishments owned by the Japanese nobility or conglomerates might still obtain more favorable benefits than those owned by Taiwanese. Borusyak and Hull (2023) show that this entails an omitted variable bias that cannot be removed by a shift-share design alone.

We tackle this issue using the recentered shift-share design following Borusyak and Hull (2023). We construct a "systematic component" by simulating counterfactual scenarios in which officials are exogenously removed based on the contemporary mortality rate, then obtain the recentered shift-share as the difference between the original shift-share and the systematic component. The component represents a firm's average connectivity across network structures, thus the recentered variable captures the "shock".

Our network covers an average of 23 officials per year during 1901–18. For mortality rate, we refer to that in mainland Japan since the Taiwanese rate reflects its general population, most of which had less access to medical resources than Japanese officials. As documented by Mitchell (1998), Japan's mortality rate was approximately 2%, suggesting that about 8 officials may have died during this period. Our experiment randomly picks 8 officials who had ever taken a position in one of the ranks, permanently removing them from the network then compute the shift-share connectivity for this scenario. We repeat the experiment 500 times and averaging the results to obtain the systematic component $\mu^g_{i,t}$. The recentered shift-share connectivity is defined as

$$\dot{d}^{g,rc}_{i,t} \equiv \dot{d}^g_{i,t} - \mu^g_{i,t}.$$

Table 2 presents the summary statistics for the original and the recentered shift-share pooled over 1902–17. Figure 7 illustrates the correlation between the two shift-share variables. The recentered connectivity to $G01$ is more dispersed than for the others, and exhibits a strong negative correlation with the original one. This finding indicates non-random exposure to shocks for $\dot{d}^g_{i,t}$, that firms originally receiving positive (negative) shocks also tend to experience shocks to the same direction in the counterfactual scenarios, leading to an expected connectivity μ in the same direction. Namely, some firms always gain connections with top officials across the experiments.

We estimate the impact of changes in firm i's connection on its policy treatment at

	$d_{i,t}^{jG01}$	$d_{i,t}^{jG02}$	$d_{i,t}^{jG03}$	$d_{i,t}^{jG01,rc}$	$d_{i,t}^{jG02,rc}$	$d_{i,t}^{jG03,rc}$
Mean	0.018	0.007	0.003	−0.003	0.000	−0.000
Standard Deviation	0.122	0.068	0.081	0.012	0.001	0.002
Min	−0.246	−0.122	−0.227	−0.048	−0.005	−0.004
Max	0.398	0.340	0.179	0.011	0.002	0.004
Median	−0.004	−0.002	−0.005	−0.000	0.000	0.000
Coefficient of Variation	6.677	9.276	30.647	−4.137	134.623	−3.352

Table 2: Summary Statistics for $d_{i,t}^{jg}$ and $d_{i,t}^{jg,rc}$

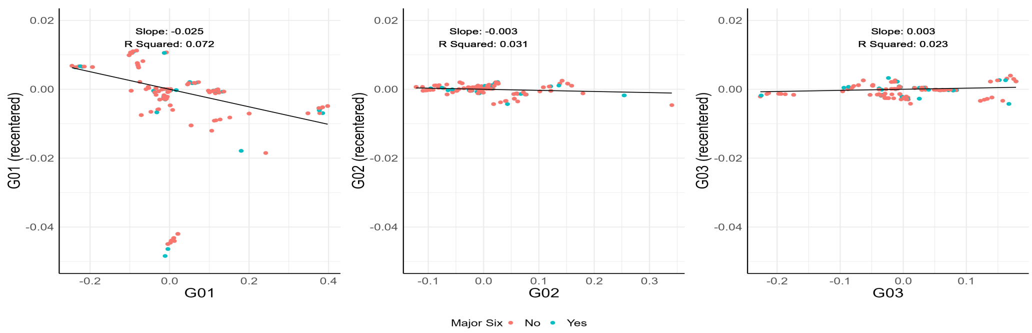

Figure 7: Recentered Shift-Share Connectivity

The Major Six refers to the six particularly large firms we identified in the quantitative analysis in Section 5.2.

location l with the following specification as in Borusyak and Hull (2023)

$$\dot{y}_{i,l,t} = \begin{cases} \beta_0 + \sum_g \beta_g d_{i,t}^{jg} + \gamma \mathbf{X} + T_t + P_l + \varepsilon_{i,l,t} & \text{original shift-share} \\ \beta_0 + \sum_g \beta_g d_{i,t}^{jg,rc} + \sum_g \alpha_g \mu_{i,t}^{g} + \gamma \mathbf{X} + T_t + P_l + \varepsilon_{i,l,t} & \text{recentered shift-share.} \end{cases}$$

The vector $\mathbf{X}$ includes firm-location current year controls: the fraction of Japanese stakeholders, and dummy variables indicating if the firm is state-owned, headquartered in mainland Japan, and producing crude camphor as a subcontractor for the authority.[5] The variables T_t and P_l denote the linear time trend and prefecture fixed effects and $\varepsilon_{i,l,t}$ is the unobserved error. The dependent variable $\dot{y}_{i,l,t}$ is the rate of change for compensation price and initial quota. We examine the effect on firm productivities by replacing the dependent variable as log-TFP and log-TFPR. Table 3 presents summary statistics for the outcome variables.

[5]During 1905–1910 the Monopoly Bureau also attempted to produce crude camphor directly, but the actual production was outsourced to privately owned firms on a contractual basis. See Matsushida (1924) pp. 139-148. In our data, only 8 observations are involved in this arrangement.

Outcome	Initial Quota	Compensation Price	log-TFP	log-TFPR
Mean	0.167	−0.022	1.508	0.400
Standard Deviation	1.134	0.143	0.175	0.249
Min	−1	−0.542	1.096	−0.155
Max	8.598	0.690	1.865	1.464
Median	−0.111	−0.024	1.524	0.384
Coefficient of Variation	6.786	−6.971	0.116	0.621

Both quota and compensation price are expressed in terms of the rate of change in decimal points. The compensation price, log-TFP and log-TFPR are quality-adjusted.

Table 3: Summary Statistics for Outcome Variables

4.3 Estimation Results

Table 4 presents the connectivity effect on the growth rate of compensation prices. We first examine settings with connections to only one official rank, and next the setting that includes all three ranks. Note that the later setting may suffer from collinearity issues. Columns (1) to (4) display the results with the original shift-share connectivity, while Columns (5) to (8) list the specifications with recentered shift-share connectivity.

The original shift-share setting yields negative coefficients when only one connectivity variable is included. Recall that a negative shift-share variable represents a reduction in social distance, the negative coefficients therefore suggest that a firm is better compensated following an improvement in connectivity. The coefficient for the Ministry Head ($G02$) is particularly significant even when all ranks are included. With only the Ministry Head included, Column (4) indicates that an improvement in connectivity by one standard deviation leads to a 5.5% (6.8% $\times$ 0.81) increase in compensation price, a significant effect compared to the average 2.2% decline reported in Table 3.

In the recentered specifications (Columns 5–8), the effect of the Ministry Head comes from the systematic component $\mu_{i,t}^{G02}$, rather than the connectivity shocks captured by $\tilde{d}_{i,t}^{G02,rc}$. Namely, firms already well-connected with Ministry Head officials tend to receive more favorable compensation, regardless of their connections with specific officials. However, we find negative and highly significant effects from the recentered connection with the Government Head ($G01$). When only one connectivity variable is considered, Column (8) indicates that an improvement in connectivity by one standard deviation results in a 4.5% (1.2% $\times$ 3.733) increase in the price. The effect remains robust when considering all three connectivities. In summary, better connections

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only	Original Shift-Share				Recentered Shift-Share			
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.018	-0.025	-0.011	-0.001	-3.877***	-3.818***	-3.823***	-3.733***
	(0.043)	(0.041)	(0.043)	(0.046)	(0.898)	(0.884)	(0.947)	(0.872)
$\mu_{i,t}^{G01}$					-0.087*	-0.094**	-0.094**	-0.083**
					(0.045)	(0.041)	(0.038)	(0.042)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-0.740***	-0.756***	-0.835***	-0.810***	9.814	9.670	12.456	12.062
	(0.157)	(0.154)	(0.163)	(0.164)	(9.496)	(9.768)	(10.007)	(11.095)
$\mu_{i,t}^{G02}$					-0.780***	-0.798***	-0.893***	-0.867***
					(0.156)	(0.154)	(0.170)	(0.170)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-0.360**	-0.364***	-0.354***	-0.346**	-0.802	-0.815	-7.147	-7.430
	(0.141)	(0.137)	(0.130)	(0.134)	(6.821)	(7.080)	(7.961)	(8.260)
$\mu_{i,t}^{G03}$					-0.356*	-0.360*	-0.286	-0.275
					(0.188)	(0.186)	(0.173)	(0.184)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.190***	0.184***	0.263***	0.270***	-4.429***	-4.242***	-2.840**	-2.700**
	(0.061)	(0.060)	(0.063)	(0.064)	(1.154)	(1.154)	(1.266)	(1.189)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-1.179***	-1.206***	-1.648***	-1.620***	9.467	8.300	-1.190	-1.389
	(0.167)	(0.175)	(0.206)	(0.201)	(17.677)	(19.497)	(19.879)	(21.918)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.104	0.125	0.317**	0.300**	-12.555*	-12.017*	-19.615**	-20.121**
	(0.166)	(0.164)	(0.143)	(0.149)	(6.529)	(7.073)	(7.938)	(8.261)
$\mu_{i,t}^{G01}$					0.007	0.008	0.155**	0.171**
					(0.066)	(0.061)	(0.077)	(0.080)
$\mu_{i,t}^{G02}$					-0.942***	-0.965***	-1.521***	-1.511***
					(0.265)	(0.288)	(0.363)	(0.369)
$\mu_{i,t}^{G03}$					0.537	0.539	0.789*	0.771*
					(0.378)	(0.439)	(0.452)	(0.456)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	207	207	207	207	207	207	207	207

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Compensation Price Growth Rate

imply better compensations when we account for non-random exposures to shocks.

Table 5 presents the effects of connectivity on the initial quota assigned to firms, with and without recentering. The original shift-share suggests that firms with better connections to Government Head officials receive more quota, with Column (4) indicating a 15.8% (12.2% $\times$ 1.297) increase in quota following a one standard deviation improvement in connectivity. However, the recentered specifications suggest that these effects are largely driven by the systematic component, i.e., well-connected firms naturally secured higher quota regardless. After accounting for this effect, the connectivity coefficients turn positive, indicating that a positive shock to a firm's connectivity actually leads to **fewer** quotas. For example, the full-specification in Column (8) shows that a one standard improvement in connectivity with the Government Head reduces the

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only		Original Shift-Share				Recentered Shift-Share		
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-1.289***	-1.360***	-1.296***	-1.297***	7.063	6.743	8.942	8.574
	(0.397)	(0.420)	(0.411)	(0.434)	(4.493)	(4.256)	(5.456)	(5.438)
$\mu_{i,t}^{G01}$					-1.109***	-1.182***	-1.048***	-1.058***
					(0.355)	(0.378)	(0.377)	(0.397)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-0.996	-1.089	-1.097	-1.527	11.201	10.070	37.655	33.746
	(0.854)	(0.878)	(0.892)	(0.965)	(42.854)	(42.238)	(51.018)	(56.183)
$\mu_{i,t}^{G02}$					-0.982	-1.076	-1.053	-1.484
					(0.870)	(0.895)	(0.918)	(0.995)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.101	0.011	0.195	0.008	77.976*	78.413*	81.352*	75.319*
	(0.578)	(0.565)	(0.597)	(0.684)	(42.785)	(42.833)	(43.793)	(44.001)
$\mu_{i,t}^{G03}$					-0.216	-0.311	-0.127	-0.283
					(0.652)	(0.633)	(0.639)	(0.722)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-1.260***	-1.324***	-1.211**	-1.135**	12.004*	12.116*	13.317*	13.851*
	(0.471)	(0.493)	(0.475)	(0.506)	(6.288)	(6.500)	(7.036)	(7.309)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-0.731	-0.671	-1.130	-1.669	-68.950	-69.341	-45.720	-49.865
	(1.491)	(1.553)	(1.560)	(1.596)	(83.306)	(85.203)	(86.222)	(91.640)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.796	0.674	1.034	1.097	149.906**	152.132**	148.099**	144.798**
	(0.913)	(0.917)	(0.948)	(1.006)	(69.065)	(70.322)	(70.205)	(69.220)
$\mu_{i,t}^{G01}$					-1.108*	-1.175**	-1.057*	-0.954
					(0.563)	(0.594)	(0.582)	(0.642)
$\mu_{i,t}^{G02}$					-1.730	-1.735	-2.171	-2.687
					(1.757)	(1.859)	(1.862)	(1.937)
$\mu_{i,t}^{G03}$					0.047	-0.057	0.305	0.347
					(0.930)	(0.931)	(0.882)	(0.969)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	260	260	260	260	260	260	260	260

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Initial Quota Growth Rate

quota by 16.6% (1.2% × 13.851).

Turning to productivities, Table 6 shows that the systematic component of Government Head and Ministry Head exhibit positive and significant relations with both log-TFP and log-TFPR. This finding indicates that, regardless of network structure, well-connected firms "shirk" from efficient production as their connections improve. The positive systematic component for TFPR indicates that the reduction in productivity dominates the higher compensation that the firm would receive. However, the recentered connectivity are mostly insignificant and not robust across settings, implying the effects on connectivity' shocks seem to be ambiguous.

Overall, we find a nuanced picture of connectivity's impacts on policy treatments. One the one hand, the results suggest favoritism: better connected firms received higher compensation. The systematic components, which represents firm's average connec-

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only		log-TFP				log-TFPR		
$d_{i,t}^{G01,rc}$	7.069	6.784	6.412	5.495	0.383	0.123	4.348	2.52
	(6.790)	(6.922)	(7.011)	(6.505)	(9.571)	(8.893)	(9.083)	(-7.781)
$\mu_{i,t}^{G01}$	0.368**	0.405**	0.367*	0.379**	0.371	0.306	0.737**	0.677***
	(0.179)	(0.185)	(0.210)	(0.188)	(0.267)	(0.263)	(-0.303)	(-0.254)
$G02$ only								
$d_{i,t}^{G02,rc}$	6.974	7.369	9.176	9.029	19.229	24.507	27.679	25.352
	(15.534)	(16.173)	(15.833)	(14.791)	(26.207)	(25.954)	(25.568)	(22.286)
$\mu_{i,t}^{G02}$	-0.416	-0.358	0.644	0.817	1.871**	2.222***	3.577***	3.447***
	(0.550)	(0.571)	(0.855)	(0.789)	(-0.839)	(0.772)	(1.109)	(0.946)
$G03$ only								
$d_{i,t}^{G03,rc}$	-13.121	-11.059	13.018	11.198	25.048	28.318*	26.801	24.693*
	(13.560)	(13.647)	(13.592)	(11.938)	(17.901)	(16.779)	(16.623)	(13.18)
$\mu_{i,t}^{G03}$	-0.001	0.042	0.063	0.017	0.301	0.267	0.251	0.186
	(0.426)	(0.446)	(0.434)	(0.435)	(0.628)	(0.621)	(0.633)	(0.571)
All Connectivity								
$d_{i,t}^{G01,rc}$	11.116	6.246	-22.641	-17.091	-19.978	-16.293	-41.616	-30.31
	(11.881)	(11.835)	(21.118)	(19.957)	(16.013)	(15.379)	(28.877)	(26.041)
$d_{i,t}^{G02,rc}$	-1.196	-23.463	-347.485	-269.055	-62.106	-17.904	-301.95	-148.641
	(44.063)	(45.521)	(210.777)	(210.795)	(58.062)	(58.676)	(274.391)	(257.134)
$d_{i,t}^{G03,rc}$	22.393	18.672	-35.097	-23.433	43.242**	49.825***	2.689	23.929
	(15.168)	(15.452),	(35.817)	(34.298)	(19.775)	(19.011)	(47.588)	(41.468)
$\mu_{i,t}^{G01}$	0.486**	0.515**	2.126**	1.741	0.541*	0.458	1.87	1.073
	(0.225)	(0.230)	(1.057)	(1.069)	(0.282)	(0.283)	(1.393)	(1.301)
$\mu_{i,t}^{G02}$	-0.074	-0.215	-10.097	-7.686	1.843**	2.479***	-6.184	-1.803
	(0.652)	(0.685)	(6.395)	(6.417)	(0.931)	(0.9)	(8.537)	(7.932)
$\mu_{i,t}^{G03}$	-0.291	0.594	10.779	8.361	3.370*	2.057	10.985	6.209
	(1.434)	(1.475)	(6.615)	(6.636)	(1.751)	(1.681)	(8.724)	(8.113)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	142	142	142	142	142	142	142	142

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Quality Adjusted Log-TFP / -TFPR with Recentered Shift-Share

tivity across network structures, also relate to higher quota but lower productivity. On the other hand, the recentered results of quota and productivity imply that improving connections has mixed effects. Higher compensation might incentivize firms to boost productivity, aligning with Evans (1995), but it could also destroy the incentives if these firms reduce efforts of improving output. This could explain the insignificant effects of connectivity shocks on both TFP and TFPR. Anticipating the potential "shirking," authorities may tighten quota grants to firms with improved connections.

5 Model and Simulations

The reduced-form estimates suggest that connections influence the policy treatment but affect firm productivity in an ambiguous way. To further explore this, we calibrate a quantitative model to examine how connections affect policy assignments, firm performance, and government income. Then we conduct simulations to inspect the implications of Evans (1995)'s embedded autonomy on the policy implementation.

5.1 Overview of Model and Calibration

Appendix B details a quantitative model based on the Camphor Monopoly System incorporating the role of firm-official connection. Potential firms differ in their bargaining powers against the government, which is related to their connections. Each firm i first determines its innovation effort $\varphi_{0,i}$, and then draws its productivity shocks at each location n from a common distribution. The productivities at each location $\varphi_{i,n}$ depend on its effort and shocks, and are publicly observable. If firm i is assigned to location n by the government, it produces a distinct camphor variety monopolistically and share the profit with the government through Nash bargaining. The government's profit share β_i (also bargaining power) declines when facing a more connected firm. At each location the government aims to maximize its income by choosing from the pool of potential firms given its observations to $(\beta_i, \varphi_{i,n})$.

Note that the government faces a tradeoff in its assignment. Choosing a highly connected firm directly reduces the government's profit share. However, a larger profit share for the firm may motivate its innovation efforts thereby enhancing productivities, leading to larger profits to be shared. Proposition 1 in Appendix B confirms this intuition, that a firm starting with a poor connection exerts higher innovation efforts as its connection improves. This echoes with the embeddedness by Evans (1995), suggesting that connection may serve as a mechanism to promote firm performance.

The model entails equilibrium objects that are useful for investigating the policy outcomes, including the winning rates r_i and innovation efforts $\varphi_{0,i}$ for firms, and the government's expected profit rate ι. In our setting the winning rate corresponds to the fraction of production sites assigned to each firm, and the innovation effort is proportional to the firm's average TFP up to a common constant. The government's profit rate is defined as the ratio of its share to the total industrial rent, reflecting the system's capability in generating government income. These objects can be simulated and compared with their empirical counterparts once β_i and model parameters are quantified.

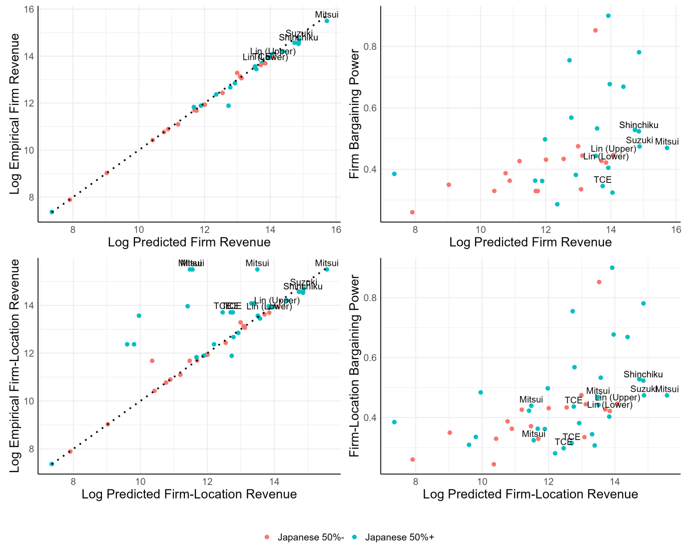

Figure 8: Connectivity-Predicted Revenue and Firm Bargaining Power

We relegate the calibration of model parameters and the construction of the empirical counterparts for r_i and $\varphi_{0,i}$ to Appendix B. Note that β_i correlates with connectivity and compensation price, where a better connection entails a higher price, thereby a larger profit share for the firm. Because of the constant returns to scale production technology, we can calibrate each firm's bargaining power $1-\beta_i$ as the ratio between its **connectivity-predicted revenue** and its inferred sales in the market. We first predict the establishment-level growth rate of compensation price as

$$\dot{p}^{comp,predict}_{i,t,l} = \gamma_{G01}\dot{d}^{G01,rc}_{i,t} + \kappa_{G01}\dot{\mu}^{G01}_{i,t},$$

where γ_{G01} and κ_{G01} are given by the single connectivity estimates in Column (8) of Table 4. Each establishment's predicted revenue is then recovered with its equivalence output and first-available compensation price as $p^{comp,predict}_{i,t,l} q_{i,l,t}$. The inferred sales in the final goods market is computed with its equivalence output and the price in the final goods market as $p_t q_{i,l,t}$. The (long-term) firm-level bargaining power is calibrated with the revenues pooled across years

$$1-\beta_i = \frac{\sum_l \sum_t p^{comp,predict}_{i,t,l} q_{i,l,t}}{\sum_l \sum_t p_t q_{i,l,t}}.$$

We set the ratio to 0.9 in the rare cases where the calibrated ratio exceeds 1. The bargaining power of the government β_i is accordingly obtained.

The left panels of Figure 8 plot the connectivity-predicted revenue against the empirical revenue with a 45-degree line, showing a strong similarity between the two at both firm- and establishment-levels. As the predicted revenue is by construction positively related to connectivity, this finding suggests that the empirical revenue is largely determined by connections, with better connected firms tend to be better compensated.

The right panels of Figure 8 show that bargaining power is positively associated with predicted revenue at both firm- and establishment-levels, indicating that better-connected firms secure a greater share of profits. The major Japanese firms Mitsui, Suzuki, and Shinchiku Camphor Manufacturing (Shinchiku) are among the firms with the strongest bargaining power and generate the highest predicted revenue. Taiwanese firms generally have lower bargaining power and earnings, with the Upper and Lower Lin Clans, the largest Taiwanese incumbents, being the only exceptions. The firms with bargaining powers exceeding 0.6 are Japanese firms located in Southern and Eastern Taiwan. As these regions were considered undeveloped, the authority offered much higher compensation prices, which naturally lead to high calibrated bargaining powers.

5.2 Simulation and Counterfactual Experiments

We start with a simulation using the pooled sample for the years 1907–18, assigning the firm with the highest empirical TFP as the benchmark firm. Figure 9 compares the predicted winning rates, TFP rankings, and the relative TFP with their empirical counterparts for each firm, in which we label firms with TFP levels greater than 5 (corresponding to the top 25% of the TFP distribution), along with the regression lines that fit the empirical quantities with the theoretical outcomes. The regression coefficients and R-squares suggest alignment between our model and the real world allocations.

In the left panel of Figure 9, simulated winning rate resembles its empirical counterpart but displays a clustered pattern. Notably, the empirical rates are much higher than their theoretical predictions for six prominent firms (Major Six henceforth). These firms include Mitsui, Suzuki, the Upper and Lower Lin Clans, Shinchiku, and Taiwan Camphor Extraction (TCE), which together obtain approximately 55% of the production sites. For example, Mitsui alone obtains approximately 17% of the production sites, while the model predicts only around 2.5%. Conversely, some empirically productive

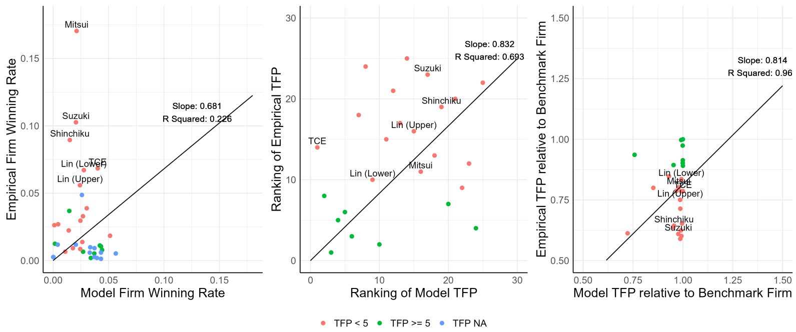

Figure 9: Empirical and Simulated Winning Rate, TFP Ranking, and Relative TFP over 1902–18

Taiwanese firms do not obtain as many production sites as predicted.

The middle and right panels of Figure 9 indicate that empirically more productive firms, primarily owned by Taiwanese industrialists, are also predicted to be more productive. While the Major Six outperform several Japanese firms, their empirical and simulated productivities are middle-low compared to the whole pool of firms. This discrepancy implies that the Monopoly Bureau's assignment leans towards the large firms, which are also highly connected firms as shown in Figure 8.

Turning to (expected) productivity and selection rates of firms, the left panel of Figure 10 shows a hump-shaped relationship between firm productivity and government bargaining power. This occurs because a higher profit share to the firm encourages its innovation but reduces the probability of being selected, which in turn discourages innovation. Proposition 1 in Appendix B shows that the former effect dominates the later when a firm starts with a lower profit share. This finding refines Evans (1995)'s concept of embeddedness: while stronger connections can enhance operational efficiency, excessively strong connections can lead to negative outcomes.

The right panel of Figure 10 nevertheless shows that firms with weaker bargaining positions are more likely to be selected and obtain more production sites. This implies that the government's financial objective is achieved mainly by extracting profits directly from the participating firms as the simulation yields similar productivity between firms. The simulated government's profit rate is about 42.3%.

We perform two counterfactual experiments to inspect how the pool of potential entrants affects the authority's decision in selecting firms and its ability in generating

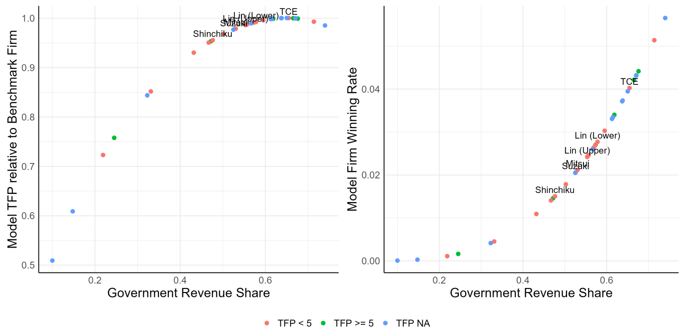

Figure 10: Simulated Allocations

income. We think of the experiments as preventing specific firms from accessing the monopoly system by assuming that they have no connections, implying that $\beta_i = 1$. These firms are never selected since (6) in Appendix B implies $\varphi_{i,n} = 0$.

Experiment 1: Accession by Major Six Only

To inspect the importance of Evans (1995)'s "autonomy," this experiment imposes that the monopoly system is only accessible by the Major Six. The colonial officials lose their "autonomy" and are limited to consider these most connected firms. We simulate the outcome by these firms' entry and exit according to the chronological order documented by the *YMB*. For comparison with the simulated winning rates, we construct the empirical winning rates in this scenario by rescaling the actual rates such that they sum to 1.[6] Figure 11 illustrates the simulated winning rates and productivity rankings as compared to their empirical counterparts.

Figure 11 shows that the theoretical and empirical allocations are highly aligned over the years. The profit rate initially drops from 39.3% in 1902–05 to 38.1% in 1908–12, as firms entering during this period either demanded high profit shares or were unproductive. Later, the rate increases to 40.1% following the entry of a firm demanding a lower profit share and the exit of a more demanding firm. Despite these fluctuations, the profit rate never exceeds that of our benchmark simulation because other productive but less connected firms are excluded. The alignment in allocations suggests that the Monopoly Bureau's decisions favored the Major Six. The lower profit

[6] For example, denote n_1, n_2 and M as sites granted to firm 1, firm 2 and all the other firms so that $r_i = n_i/(n_1+n_2+M)$. In the case where only firm 1 and firm 2 are able to access the monopoly system, the winning rates are rescaled such that $r_i^{new} = r_i/(r_1+r_2)$.

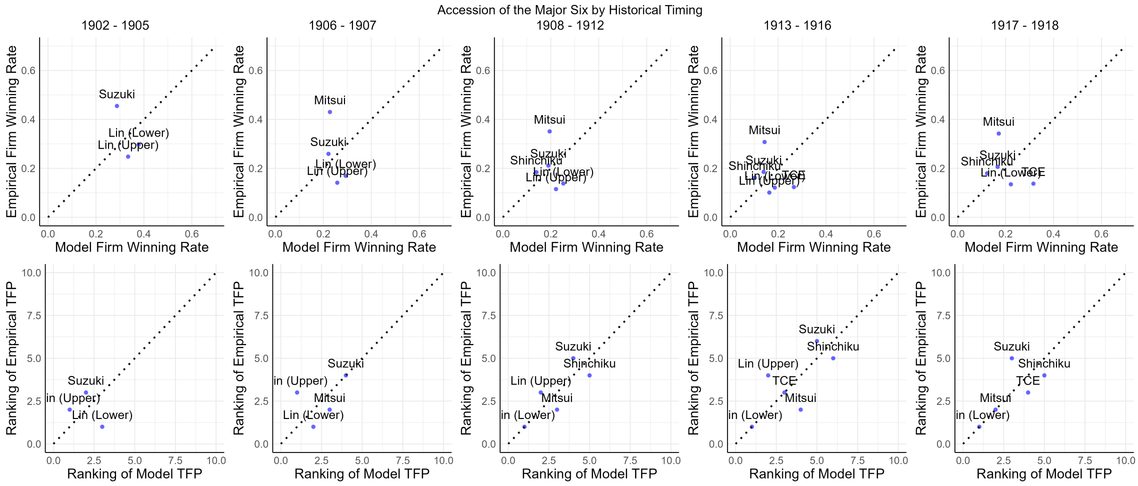

Figure 11: Counterfactual: Focusing on the Major Six

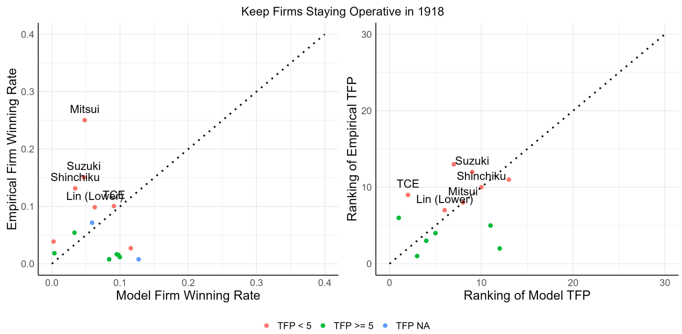

Figure 12: Counterfactual: Focusing on Firms that Survived until 1918

rate echoes with Evans (1995) that the authority's adherence to its financial objective, regardless of societal pressures, is essential for selecting potentially efficient firms.

Experiment 2: Accession by 1918 Survivors Only

This experiment investigates whether the authority truly picked winners as claimed in the official documents by imposing that the monopoly system is only accessible by those firms still surviving in the end of 1918. In a reform in 1919, the Monopoly Bureau merged all surviving firms into a single private-owned producer, aiming to "improve resource efficiency and gain a competitive advantage against artificial camphor." (Matsushida, 1924, pp. 98–101) The shareholder structure of the company was determined by the operating sizes of the firms operating in 1918. If the Monopoly Bureau indeed adheres with the picking-winner discipline, we expect that firms remained operative in 1918 and being merged in 1919 are more efficient among all potential entrants.

The results are presented in Figure 12. Compared with Figure 9, the clustered pattern of winning rate among the Major Six become less pronounced, and the simulated and empirical TFP ranking become more aligned. Moreover, the firms that remain active are mostly among the better-ranked firms in productivity in Figure 9. The simulated profit rate for the government becomes 44.3%, higher than in the benchmark simulation. This outcome suggests that the Camphor Monopoly System selected efficient firms. However, the authority's financial goal was undermined by favoritism, as the Major Six consistently secured more production sites despite their lower productivity.

6 Conclusion

We combine micro-level data from the Camphor Monopoly System with a social network of industrialist-official connections, constructed from historical news archives. Using the recentered shift-share approach, our reduced-form estimation shows that firms with stronger connections secure more favorable policy treatments from the Monopoly Bureau. We develop a model incorporating these connections, and evaluate the performance of the monopoly system through simulation. The results suggest that the system exhibits a mixture of picking-winner and favoritism towards specific conglomerates.

This study provides insights into resource allocation in regulated industries in modern economies. A contemporary example is China's rare earth industry, which supplies about 70% of the world's rare earths and production is highly regulated.[7] Due to its significant global share, China's regulations on rare earths potentially influence global prices to its advantage. This scenario mirrors the early 20th-century global camphor market. Our analysis helps understand how connections between industrialists and politicians can affect China's policies and firm performance in the rare earths industry.

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A Appendix: Constructing Firm-level Connectivity

The network distance between two individuals is defined by the *path that includes the least number of nodes* between them. To account for interaction intensities, each direct link is *weighted* by their respective tail probabilities of occurrences in the network. We weight by tail probability as it reflects the viability of traversing an *edge* relative to the entire network, with higher network occurrence corresponding to a lower value. It is unit free and easy to interpret. For example, a 5% tail probability means that the cost for the relevant individuals to meet each other is lower than 95% of others in the network. We us the formula $d \equiv x/(1+x)$ to convert the weighted network distances x into $[0,1]$ to avoid the problem of infinite distance due to unconnected individuals.

Figure 13 provides an example for the distance between A and C in a network composed of 5 edges. Without weighting, the distance is defined by the direct path $\overline{AC}$ as 1 (including C but excluding A). While the indirect path $\overline{ABC}$ is expected to be more viable due to high network occurrences, the length without accounting for weighting of this path is 2 since it takes two nodes. In contrast, our approach assigns a weight as $2/5$ to AB since only two out of five edges (AB and BC) are disclosed by the news for no less than twice. Similarly, the weight to BC is $1/5$, and is 1 for all other edges. The

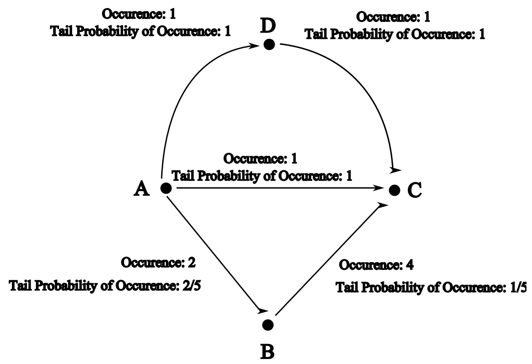

Figure 13: Example for Computing Social Distance

distance is therefore given by the length of indirect path $\overline{ABC} = 3/5$, since the length of the direct path is $\overline{AC} = 1$.

The group-to-group distance is calculated annually based on that year's network. For each year, we first compute an individual's (k) average distance to all g-ranked officials for each year $d^g_{k,t} \equiv \frac{\sum_{j\in g} d_{kj,t}}{\# j\in g}$, where d accounts for weights and is converted to be within $[0,1]$. The group-to-group distance is then defined as the simple average of d^g_k for all individuals k belonging to the same identity group e in the network for each year $d^g_{e,t} = \frac{\sum_{k\in e} d^g_{k,t}}{\# k\in e}$. Firm-official connectivity is accordingly computed for each year as $d^g_{i,t} \equiv \sum_e \omega_{i,e,t} \frac{d^g_{e,t+1} - d^g_{e,t}}{d^g_{e,t}}$.

We retrieve the list of officials of our interest for each year by referring to the *Official Directory* digitized by the Institute of Taiwan History, Academia Sinica. Each volume provides a full list of formally employed officials in detail to include street-level bureaucrats, e.g., police officers, teachers, and doctors. Each list includes the official's name, position and title, and the years in which the official was in office, allowing us to trace the turnover of a given position and the tenure history for each specific individual. The bureaucratic structure underwent several reforms from a flatter to a more vertical one, making some positions and titles no longer equivalent. We read the *Official Directory* and manually assigned the titles and positions to construct a more comparable list of official rankings at the "Central" Government-General level. Most officials at these ranks are included in our network, which on average consists of 2, 24 and 20 officials per rank, covering 97%, 53% and 63% of the officials listed in *Official Directory* each year, respectively. The mapping from positions to ranks are as follows:

Government Head (*G*01): Governor-General, Director of Internal Affairs or equivalent.

Ministry Head (*G*02): Secretaries of Governor-General, Directors of Sections under the Department of Internal Affairs (1896–1901), Directors of Agencies under the Bureau of Internal Affairs (1902–18), Directors of the Camphor Monopoly Bureau and Salt Monopoly Bureau (1900–01), Director of the Monopoly Bureau (1902–18), and Directors of their Sections and Branches or equivalent.

Section Head (*G*03): Managers of Sections under the Bureau of Internal Affairs and its agencies (1902–18).

For identity groups, we consider the following categories:

Japanese Nobility: Japanese with family ranks belonging to *Kazoku*, *Shizoku*, and Royal Family; holding nobility titles such as dukes and earls, or being elected into the House of Peers (the upper house) or the House of Representatives (the lower house).

Local Taiwanese Assistants (LTA): Taiwanese employed by Government-General as councilors or local heads **before 1904**.

Ordinary Taiwanese and Ordinary Japanese: Taiwanese and Japanese not belonging to the previous respective groups.

We assign individuals as Japanese or Taiwanese by reading their names. Japanese Nobility is assigned by joining the family rank and nobility titles listed in both the 1903 and 1915 editions of the *Japanese Who's Who*. We supplement the industrialists elected as legislators to this class according to their tenure, which covers three Japanese industrialists in Taiwan during the period of study. LTA is Taiwanese councilors and local heads listed in *Official Directory* before 1904.

B Appendix: Model and Calibration

Demand Structure and Firms

There is a unit mass of production sites for camphor (location). Each location n produces a **distinct** camphor variety q_n. Assume that the consumer's preference for camphor is characterized by CES as $U = \left(\int_0^1 q_n^{\frac{\sigma-1}{\sigma}} dn \right)^{\frac{\sigma}{\sigma-1}}$. The inverse demand function for each variety n is thus given by $p_n = \left(\frac{I}{P^{1-\sigma}} \right)^{\frac{1}{\sigma}} q_n^{-\frac{1}{\sigma}} \equiv A q_n^{-\frac{1}{\sigma}}$, where I is the exogenous total expenditure, $P \equiv \left(\int_0^1 p_n^{1-\sigma} dn\right)^{\frac{1}{1-\sigma}}$ is the price index, and $\sigma > 1$ is the elasticity of substitution. Note that both I and P are taken as given by all agents. The object $A \equiv I^{\frac{1}{\sigma}} P^{\frac{\sigma-1}{\sigma}}$ is thus an exogenous demand shifter that cannot be changed by individual firms or the government. As we will see later, the firm's decisions and the government's expected income are symmetric across varieties. The unit-mass-variety setting thus ensures that focusing on one variety is sufficient.

There are N potential entrants competing for the production permission at each site. A successful entrant i at a production site n produces the camphor variety using M inputs with the production technology $q_{i,n} = \varphi_{i,n} \prod_{j=1}^{M} m_{j,i,n}^{\alpha_j}$, where $m_{j,i,n}$ denotes the amount of input j used, $\varphi_{i,n}$ represents firm i's productivity at site n, and the input intensities α_j are such that $\alpha_j \in (0,1)$ and $\sum_{j=1}^{M} \alpha_j = 1$. The factor markets are perfectly competitive with prices w_j taken as given by all firms. The cost minimization problem yields production cost function as $C(q_{i,n}) = B\left(\prod_{j=1}^{M} w_j^{\alpha_j}\right) \varphi_{i,n}^{-1} q_{i,n}$, where $B \equiv \prod_{j=1}^{M} \alpha_j^{-\alpha_j}$.

Each entrant must exert an innovation effort $\varphi_{0,i}$ before obtaining any permissions. Then the firm observes its location-specific shocks $z_{i,n}$ across all locations, so that its location-specific productivities are realized as $\varphi_{i,n} = \varphi_{0,i} z_{i,n}$. Assume that $z_{i,n}$ follows a Fréchet distribution common across all firms and sites with a CDF $F(z_{i,n}) = e^{-z_{i,n}^{-\theta}}$ with the tail index $\theta > 1$. The expected productivity of firm i at location n is proportional to its innovation effort as $E(\varphi_{i,n}) = \varphi_{0,i} \Gamma\left(1 - \frac{1}{\theta}\right)$ where $\Gamma(.)$ is the gamma function.

We consider an infinite time horizon scenario, where the one-shot innovation effort $\varphi_{0,i}$ is made in the first period. In each follow-up period the shock $z_{i,n}$ is drawn randomly from $F(z_{i,n})$ so that the productivity level $\varphi_{i,n}$ in each period is realized. Then the firm chooses its output $q_{i,n}$ to maximize its operating profit $\pi_{f,i,n}(\varphi_{i,n})$ given the realization of $\varphi_{i,n}$ in each location for which it obtains the permission. The firm's innovation decision maximizes the present value of its expected profit given the innovation cost function $c(\varphi_{0,i})$. For tractability, we assume that the innovation cost function is given by $c(\varphi_{0,i}) = \varphi_{0,i}^{\zeta}$, where $\zeta > 1$. For simplicity we assume that the innovation efforts $\varphi_{0,i}$ and productivities in each subsequent period $\varphi_{i,n}$ are publicly observable.

Government Monopoly

In each period for each location, the government grants the production permission to the firm that yields the highest government profit given its observations to $(\beta_i, \varphi_{i,n})$

across firms. Suppose that firm i obtains the permission at location n given its productivity $\varphi_{i,n}$, it acts as a monopolist and yields the operating profit:

$$\pi_{i,n}(\varphi_{i,n}) = Aq_{i,n}^{1-\frac{1}{\sigma}} - B\left(\prod_{j=1}^{M} w_j^{\alpha_j}\right)\varphi_{i,n}^{-1} q_{i,n}.$$

The profit is split between the government and the firm respectively as $\pi_{G,i,n} = \beta_i \pi_{i,n}(\varphi_{i,n})$ and $\pi_{f,i,n} = (1-\beta_i)\pi_{i,n}(\varphi_{i,n})$, where $\beta_i \in (0,1)$ denotes the government's profit share / bargaining power against firm i. Each permission lasts for one period only, hence the assignment process is repeated in each period.

The timing of the model is as follows:

1. In the initial period, each firm makes a one-shot innovation effort φ_0 that maximizes its expected present value.
2. In each infinitely repeated follow-up period, the government grants permission and production takes place in the following manner:
   (a) **Permission Stage:** Firm-site-specific shocks $z_{i,n}$ are independently realized and publicly observed. For each site n the government grants a permission that lasts for the current period to a firm that maximizes its return from the site $\pi_{G,n}$ based on the observations $\{\beta_i, \varphi_{i,n}\}$.
   (b) **Production Stage:** In each location the permitted firm, say, firm i, chooses the level of output $q_{i,n}$, and the profit is realized and shared with the government by a β_i fraction. The permission ends upon the realization of the profit.

Equilibrium

The model structure is stationary since all of the follow-up periods are similar. It is sufficient to study the equilibrium outcome in one period and then construct the present value of the expected profit in the first period. We solve the model backwards for each follow-up period.

In the Production Stage the permitted firm chooses $q_{i,n}$ to maximize its operating profit $\pi_{f,i,n}$, which yields the optimal output as $q_{i,n} = \left(\frac{A}{B}\right)^{\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\prod_{j=1}^{M} w_j^{-\sigma\alpha_j}\varphi_{i,n}^{\sigma}$. By the profit-sharing rule, the profits for both the government and firm i are respectively $\pi_{G,i,n} = \beta_i k \varphi_{i,n}^{\sigma-1}$ and $\pi_{f,i,n} = \frac{1-\beta_i}{\beta_i}\pi_{G,i,n}$, where $k \equiv \frac{A}{\sigma-1}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\left(\frac{A}{B}\right)^{\sigma-1}\prod_{j=1}^{M} w_j^{-(\sigma-1)\alpha_j}$.

In the Permission Stage, the government chooses the firm that yields the highest

$\pi_{G,n}$ given β and the realized firm-location productivity. Given this decision rule, the probability density (pdf) that a firm obtains the permission at the location is equivalent to the probability density that the firm yields the highest $\pi_{G,n}$ at this location. Since z is randomly drawn from a common Fréchet distribution and thus, the distribution of π_G given a firm's innovation effort is also Fréchet, for which a change of variable yields its cdf $G_{i,n}(\pi_G)$ and pdf $g_{i,n}(\pi_G)$:

$$G_{i,n}(\pi_G) \equiv \Pr(\pi_{G,i,n} \leq \pi_G) = e^{-k^{\frac{\theta}{\sigma-1}} \beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta} \pi_G^{-\frac{\theta}{\sigma-1}}}$$
$$g_{i,n}(\pi_G) = \frac{\theta}{\sigma-1} k^{\frac{\theta}{\sigma-1}} \beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta} \pi_G^{-\frac{\theta}{\sigma-1}-1} e^{-k^{\frac{\theta}{\sigma-1}} \beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta} \pi_G^{-\frac{\theta}{\sigma-1}}}.$$

Since z is drawn i.i.d., the probability density that firm i obtains the permission is

$$h_{i,n}(\pi_G) = g_{i,n}(\pi_G) \prod_{m \neq i} G_n(\pi_G) = \frac{\theta}{\sigma-1} k^{\frac{\theta}{\sigma-1}} \beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta} \pi_G^{-\frac{\theta}{\sigma-1}-1} e^{-k^{\frac{\theta}{\sigma-1}} \pi_G^{-\frac{\theta}{\sigma-1}} \sum_m \beta_m^{\frac{\theta}{\sigma-1}} \varphi_{0,m}^{\theta}}$$

Firm i's winning probability $r_{i,n}$ and expected operating profit at the location are

$$r_{i,n} \equiv \int_0^{\infty} h_{i,n}(\pi_G)\, d\pi_G = \frac{\beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta}}{\sum_m \beta_m^{\frac{\theta}{\sigma-1}} \varphi_{0,m}^{\theta}} \tag{1}$$
$$E\left(\pi_{f,i,n}\right) = \frac{1-\beta_i}{\beta_i} \frac{\beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta}}{\left(\sum_m \beta_m^{\frac{\theta}{\sigma-1}} \varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}} k\Gamma\left(1-\frac{\sigma-1}{\theta}\right), \tag{2}$$

where we require $\theta > \sigma - 1$ for $\Gamma\left(1-\frac{\sigma-1}{\theta}\right)$ to be finite. The derivations are provided in the end of the Appendix B. We omit the location notations thereafter since $G_{i,n}(\pi_G)$, $g_{i,n}(\pi_G)$ and $h_{i,n}(\pi_G)$ and equations (1) and (2) are symmetric across all locations n. We denote the firm's expected profit $E\left(\pi_{f,i,n}\right)$ by $\overline{\pi}_{f,i}$.

In the first period, each firm chooses its innovation effort $\varphi_{0,i}$ to maximize the present value of expected profit $V_{i,n}(\varphi_{0,i})$. Since $\overline{\pi}_{f,i}$ in each period is the same and symmetric across locations, firm i's expected present value is therefore the same across locations as $V_{i,n}(\varphi_{0,i}) \equiv V_i(\varphi_{0,i}) = \frac{\overline{\pi}_{f,i}}{1-\delta}$, where $\delta \in (0,1)$ is the discount factor. Its total expected value from the monopoly system is therefore

$$\int_0^1 V_i(\varphi_{0,i})\, dn - c(\varphi_{0,i}) = \frac{\overline{\pi}_{f,i}}{1-\delta} - c(\varphi_{0,i}).$$

The first- and second-order conditions (FOC and SOC) define the interior solution

$$\frac{d\overline{\pi}_{f,i}}{d\varphi_{0,i}} = (1-\delta)\,\zeta\,\varphi_{0,i}^{\zeta-1} \tag{3}$$
$$\frac{d^2\overline{\pi}_{f,i}}{d\varphi_{0,i}^2} < (1-\delta)\,\zeta\,(\zeta-1)\,\varphi_{0,i}^{\zeta-2}. \tag{4}$$

Proposition 1 provides the condition for the unique existence of the interior solution, and examines the role of firm-official connections in innovation efforts.

Proposition 1. *The interior solution of* $\varphi_{0,i}$ *exists and is unique if* $(\theta-\delta)/(1-\delta)<\zeta$. *A lower bargaining power of the government against firm i,* β_i*, incentivizes the firm to engage in higher innovation efforts if* $\beta_i > 1-\frac{\sigma-1}{\theta}$.

Proof. See **Proof of Proposition 1**. □

Proposition 1 shows that connections can encourage innovation efforts as the government shifts more profits to the firm. Because the government's objective is to maximize its profit from the monopoly system, it prefers firms with either high innovation efforts or weak bargaining powers against it (weak connections) as shown in (1). From the firm's view, a weaker bargaining power reduces its share of the monopoly profit, which in turn discourages innovation. In other words, better-connected firms are also incentivized to innovate.

The discussion above explains why winning firms under industrial promotion programs tend to be well-connected with the policymakers. However, picking efficient firms requires the government to shift more profits in order to incentivize the firms to be so. Due to this tradeoff, the government *might* not always pick the most innovative firms. That is, the most innovative firms might not have the highest winning probability and contribute the most to the government's (present value) expected profit.

The government's present value of expected income from location n is given by

$$
\begin{aligned}
E\left(V_{G,n}\right) =& \sum_i \frac{1}{1-\delta}\int_0^\infty \pi_G \frac{\theta}{\sigma-1} k^{\frac{\theta}{\sigma-1}} \beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta} \pi_G^{-\frac{\theta}{\sigma-1}-1} e^{-k^{\frac{\theta}{\sigma-1}} \pi_G^{-\frac{\theta}{\sigma-1}} \sum_m \beta_m^{\frac{\theta}{\sigma-1}} \varphi_{0,m}^{\theta}} d\pi_G \\
=& \left(\sum_i \beta_i^{\frac{\theta}{\sigma-1}} \varphi_{0,i}^{\theta}\right)^{\frac{\sigma-1}{\theta}} \frac{k}{1-\delta}\Gamma\left(1-\frac{\sigma-1}{\theta}\right),
\end{aligned}
$$

which is symmetric across all locations. The government's total income from the monopoly system is therefore $E\left(V_G\right)=\int_0^1 E\left(V_{G,n}\right)dn = E\left(V_{G,n}\right)$. In the industrial equilibrium we have

$$
\begin{aligned}
k =& \frac{I}{\sigma}\left[\sum_i \frac{\beta_i^{\frac{\theta}{\sigma-1}-1}\varphi_{0,i}^{\theta}}{\left(\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}}\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\right]^{-1} \\
\Rightarrow E\left(V_G\right) =& \frac{1}{\sigma}\frac{I}{1-\delta}\frac{\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}{\sum_m \beta_m^{\frac{\theta}{\sigma-1}-1}\varphi_{0,m}^{\theta}}. \qquad (5)
\end{aligned}
$$

The proof is relegated to the end of Appendix B. A firm's expected profit net of innovation cost is similarly obtained as

$$V_i(\varphi_{0,i}) - c(\varphi_{0,i}) = \frac{1}{\sigma}\frac{I}{1-\delta}\frac{1-\beta_i}{\beta_i}\frac{\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}{\sum_m \beta_m^{\frac{\theta}{\sigma-1}-1}\varphi_{0,m}^{\theta}} r_i - \varphi_{0,i}^{\zeta}.$$

Note that equation (3) can be written as

$$\frac{1-\delta}{I}\frac{\sigma}{\theta}\zeta\varphi_{0,i}^{\zeta} = (1-\beta_i)\left[1-\left(1-\frac{\sigma-1}{\theta}\right)\frac{\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}}{\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}\right]\frac{\beta_i^{\frac{\theta}{\sigma-1}-1}\varphi_{0,i}^{\theta}}{\sum_m \beta_m^{\frac{\theta}{\sigma-1}-1}\varphi_{0,m}^{\theta}}. \quad (6)$$

We can rewrite the system of equilibrium conditions (3) and (1) as

$$\widehat{\varphi}_{0,i}^{\zeta} = \frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{1-\left(1-\frac{\sigma-1}{\theta}\right)r_1}\widehat{(1-\beta_i)}\widehat{\beta}_i^{\frac{\theta}{\sigma-1}-1}\widehat{\varphi}_{0,i}^{\theta}$$

$$r_i = \frac{\widehat{\beta}_i^{\frac{\theta}{\sigma-1}}\widehat{\varphi}_{0,i}^{\theta}}{\sum_m \widehat{\beta}_m^{\frac{\theta}{\sigma-1}}\widehat{\varphi}_{0,m}^{\theta}},$$

where $\widehat{x}_i \equiv x_i/x_1$ denotes the firm-level variable relative to the benchmark firm ($i=1$). With this formulation, we can solve for the relative firm-level innovation $\widehat{\varphi}_{0,i}$ and the winning probabilities r_i given the parameters $(\beta_i, \theta, \sigma, \zeta)$. Note that while the discount factor δ does not enter the equations directly, Proposition 1 shows that it affects the permissible set of ζ for the unique existence of the equilibrium. The parameters to be calibrated are therefore $(\beta_i, \theta, \sigma, \zeta, \delta)$.

We can further rearrange (5) as

$$\iota \equiv \frac{E(V_G)}{I/(1-\delta)} = \frac{1}{\sigma}\frac{\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}{\sum_m \beta_m^{\frac{\theta}{\sigma-1}-1}\varphi_{0,m}^{\theta}} = \frac{\beta_1}{\sigma}\frac{\sum_m \widehat{\beta}_m^{\frac{\theta}{\sigma-1}}\widehat{\varphi}_{0,m}^{\theta}}{\sum_m \widehat{\beta}_m^{\frac{\theta}{\sigma-1}-1}\widehat{\varphi}_{0,m}^{\theta}}.$$

Note that $I/(1-\delta)$ is the present value of market expenditure on camphor products. We can interpret the ratio ι as the authority's profit rate since in the context of the monopoly system the market expenditure equals the total sales revenue of the authority.

Quantifying Model Parameters and Empirical Moments

Here we detail how the parameters $\{\sigma, \theta, \zeta\}$ are calibrated. Note that monopolistic pricing and the CES preference together imply that σ is related to the price markup in the final goods market as $\sigma = \frac{p/c}{p/c-1}$, where c is the constant marginal cost of production. The marginal cost of production at the firm-location-year level is given by $c_{i,l,t} = B\left(\prod_{j=1}^{M} w_{j,t}^{\alpha_j}\right)\varphi_{i,l,t}^{-1}$, where $B\left(\prod_{j=1}^{M} w_{j,t}^{\alpha_j}\right)$ is the price index of the input factors and can be thought of as the PPI. We can therefore calibrate the markup rate as the average PPI-deflated market price of camphor weighted by firm productivity as $E\left(\frac{p}{c}\right)=E\left(\frac{p_t}{B\left(\prod_{j=1}^{M} w_{j,t}^{\alpha_j}\right)}\varphi_{i,l,t}\right)\approx 3.44$, implying that $\sigma\approx 1.41$. The tail index θ is set to 1.2 to be consistent with the power law in firm size. The discount factor δ is set to 0.95 as in various studies. Our parameterization thus requires that $\zeta>5$ hold for the unique existence of the equilibrium. We therefore set ζ to 5.1.

Next we construct empirical counterparts of $\widehat{\varphi}_{0,i}$ and r_i over the years. The firm-level expected productivity needed for $\widehat{\varphi}_{0,i}$ is given by the average of a firm's empirical TFP across locations and years, weighted by equivalence output. The long-run fraction of production site is computed as $r_i^{emp}=\frac{\sum_t\sum_l \#site_{i,l,t}}{\sum_i\sum_t\sum_l \#site_{i,l,t}}$.

Derivation of (1) and (2)

Let $x\equiv k^{\frac{\theta}{\sigma-1}}\pi_G^{-\frac{\theta}{\sigma-1}}\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}$ and note that $x\in(0,\infty)$, we obtain

$$dx=-\frac{\theta}{\sigma-1}k^{\frac{\theta}{\sigma-1}}\pi_G^{-\frac{\theta}{\sigma-1}-1}\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}d\pi_G$$

$$\pi_G=kx^{-\frac{\sigma-1}{\theta}}\left(\sum_m \beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{\frac{\sigma-1}{\theta}}.$$

Therefore,

$$\begin{aligned}\int_0^\infty h_i(\pi_G)\,d\pi_G&=\int_0^\infty \frac{\theta}{\sigma-1}k^{\frac{\theta}{\sigma-1}}\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}\pi_G^{-\frac{\theta}{\sigma-1}-1}e^{-k^{\frac{\theta}{\sigma-1}}\pi_G^{-\frac{\theta}{\sigma-1}}\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}d\pi_G\\&=\int_0^\infty \frac{\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}}{\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}e^{-x}dx=\frac{\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}}{\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}\\E\left(\pi_{f,i,n}\right)&=\frac{1-\beta_i}{\beta_i}\int_0^\infty \pi_G\frac{\theta}{\sigma-1}k^{\frac{\theta}{\sigma-1}}\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}\pi_G^{-\frac{\theta}{\sigma-1}-1}e^{-k^{\frac{\theta}{\sigma-1}}\pi_G^{-\frac{\theta}{\sigma-1}}\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}d\pi_G\\&=\frac{1-\beta_i}{\beta_i}\frac{\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}}{\left(\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right).\end{aligned}$$

We require $\theta>\sigma-1$ for $\Gamma\left(1-\frac{\sigma-1}{\theta}\right)$, and hence for the expected profit to be finite.

Proof of Proposition 1

Unique Existence of Equilibrium We first study the first- and second-derivatives of $V_i(\varphi_{0,i})$ and provide the condition for the interior solution to be optimal if it exists. Let $\psi_i\equiv\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}$:

$$\begin{aligned}\frac{d\overline{\pi}_{f,i}}{d\varphi_{0,i}}&=\frac{d}{d\varphi_{0,i}}\frac{1-\beta_i}{\beta_i}\frac{\psi_i}{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\\&=k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\frac{1-\beta_i}{\beta_i}\frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\psi_i\varphi_{0,i}^{-1}.\end{aligned}$$

The equation above is positive because $r_i \in (0,1)$ and $\theta > \sigma - 1$. The interior solution is thus

$$k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\frac{1-\beta_i}{\beta_i}\frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m \psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\psi_i\varphi_{0,i}^{-1} = (1-\delta)\,c'\left(\varphi_{0,i}\right).$$

For the SOC, note that

$$\begin{aligned}
\frac{d^2\overline{\pi}_{f,i}}{d\varphi_{0,i}^2} - (1-\delta)\,c''\left(\varphi_{0,i}\right) =& \frac{1-\beta_i}{\beta_i}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m \psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\left(\theta-1\right)\psi_i\varphi_{0,i}^{-2} \\
&-\frac{1-\beta_i}{\beta_i}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\left(1-\frac{\sigma-1}{\theta}\right)\frac{2-\left(2-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m \psi_m\right)^{1-\frac{\sigma-1}{\theta}}}r_i\theta^2\psi_i\varphi_{0,i}^{-2} \\
&-(1-\delta)\,c''\left(\varphi_{0,i}\right) \\
=&\frac{1-\beta_i}{\beta_i}\frac{\theta\psi_i\varphi_{0,i}^{-2}}{\left(\sum_m \psi_m\right)^{1-\frac{\sigma-1}{\theta}}}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right]\left(\theta-1\right) \\
&-\frac{1-\beta_i}{\beta_i}\frac{\theta\psi_i\varphi_{0,i}^{-2}}{\left(\sum_m \psi_m\right)^{1-\frac{\sigma-1}{\theta}}}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\left(1-\frac{\sigma-1}{\theta}\right)\left[2-\left(2-\frac{\sigma-1}{\theta}\right)r_i\right]r_i\theta \\
&-(1-\delta)\,c''\left(\varphi_{0,i}\right).
\end{aligned}$$

Combining this with the FOC yields

$$\begin{aligned}
\frac{d^2\overline{\pi}_{f,i}}{d\varphi_{0,i}^2} - (1-\delta)\,c''\left(\varphi_{0,i}\right) =& \frac{c'\left(\varphi_{0,i}\right)\varphi_{0,i}^{-1}}{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}\left\{\left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right]\left(\theta-1\right)-\left(1-\frac{\sigma-1}{\theta}\right)\left[2-\left(2-\frac{\sigma-1}{\theta}\right)r_i\right]r_i\theta\right\} \\
&-(1-\delta)\,c''\left(\varphi_{0,i}\right) \\
=&c'\left(\varphi_{0,i}\right)\varphi_{0,i}^{-1}\left[\left(\theta-1\right)-\left(\theta-\sigma+1\right)K\left(r_i\right)\right]-(1-\delta)\,c''\left(\varphi_{0,i}\right) \\
<&c'\left(\varphi_{0,i}\right)\varphi_{0,i}^{-1}\left(\theta-1\right)-(1-\delta)\,c''\left(\varphi_{0,i}\right) \\
K\left(r_i\right) \equiv& \left(1+\frac{1-r_i}{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}\right)r_i \geq 0 \because \theta > \sigma-1.
\end{aligned}$$

This implies that the SOC holds globally if

$$\theta - 1 < \varphi_{0,i}\left(1-\delta\right)\frac{c''\left(\varphi_{0,i}\right)}{c'\left(\varphi_{0,i}\right)}.$$

Since $c\left(\varphi_{0,i}\right) = \varphi_{0,i}^{\zeta}$, the above inequality holds strictly when $\left(\theta-\delta\right)/\left(1-\delta\right) < \zeta$. This condition ensures that $V_i\left(\varphi_{0,i}\right)$ is **strictly** concave in $\varphi_{0,i}$, hence the interior solution is optimal.

We show that the interior solution exists and is unique. First note that the FOC can be expressed as

$$\begin{aligned}
\frac{\zeta}{\theta}\frac{\beta_i}{1-\beta_i}\frac{1-\delta}{k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)} =& \frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m \psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\psi_i\varphi_{0,i}^{-1}\varphi_{0,i}^{1-\zeta} \\
=& \frac{1-\left(1-\frac{\sigma-1}{\theta}\right)\frac{\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}}{\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}+\sum_{m\neq i}\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}}{\left(\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}+\sum_{m\neq i}\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}}\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta-\zeta} \equiv RHS.
\end{aligned}$$

Note that the condition $\theta < 1 + (1-\delta)(\zeta - 1)$ implies that $\theta < \zeta - \delta(\zeta - 1) < \zeta$ since $\zeta > 1$. It is readily checked that

$$\lim_{\varphi_{0,i}\to\infty} RHS = \frac{\sigma-1}{\theta}\beta_i^{\frac{\theta}{\sigma-1}} \lim_{\varphi_{0,i}\to\infty}\left[\varphi_{0,i}^{\zeta-\theta}\left(\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta} + \sum_{m\neq i}\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}\right]^{-1} = 0$$

$$\lim_{\varphi_{0,i}\to 0} RHS = \beta_i^{\frac{\theta}{\sigma-1}}\left(\sum_{m\neq i}\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{\frac{\sigma-1}{\theta}-1} \lim_{\varphi_{0,i}\to 0}\frac{1}{\varphi_{0,i}^{\zeta-\theta}} = \infty$$

under the assumption that $(\theta-\delta)/(1-\delta) < \zeta$ and $\theta > \sigma - 1$. This ensures the existence of the interior solution of $\varphi_{0,i}$ because the left-hand-side of the FOC is a constant.

For the uniqueness of the interior solution, note that $V_i(\varphi_{0,i})$ is continuous and twice-differentiable in $\varphi_{0,i}$. Our analysis of the SOC shows that the expected profit is concave at the interior solution. Suppose that there are two interior solutions $\varphi_{0,i}^A$ and $\varphi_{0,i}^B$, we know that $V_i(\varphi_{0,i})$ reaches local maxima at both $\varphi_{0,i}^A$ and $\varphi_{0,i}^B$ and is strictly concave at these interior points. Assuming that $\varphi_{0,i}^A < \varphi_{0,i}^B$ without loss of generality, the continuity of $V_i(\varphi_{0,i})$ implies that there exists at least one $\varphi_{0,i}^C$ on the interval $\left[\varphi_{0,i}^A, \varphi_{0,i}^B\right]$ such that $V\left(\varphi_{0,i}^C\right) \le V(\varphi_{0,i})$ for all $\varphi_{0,i} \in \left[\varphi_{0,i}^A, \varphi_{0,i}^B\right]$. The differentiability of $V_i(\varphi_{0,i})$ implies that $V_i'\left(\varphi_{0,i}^C\right) = 0$ and $V_i''\left(\varphi_{0,i}^C\right) \ge 0$ holds, but this contradicts the fact that $V_i(\varphi_{0,i})$ is concave at all interior solutions. Hence the interior solution must be unique.

Bargaining Power and Innovation Effort Here,

$$\begin{aligned}
\frac{d}{d\beta_i}\frac{d\pi_{f,i}}{d\varphi_{0,i}} =& \frac{d}{d\beta_i}k\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\frac{1-\beta_i}{\beta_i}\frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\psi_i\varphi_{0,i}^{-1} \\
\propto& \frac{1-\beta_i}{\beta_i}\frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\frac{\theta}{\sigma-1}\psi_i\beta_i^{-1}\varphi_{0,i}^{-1} - \frac{1}{\beta_i\beta_i}\frac{1-\left(1-\frac{\sigma-1}{\theta}\right)r_i}{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\psi_i\varphi_{0,i}^{-1} \\
&-\frac{1-\beta_i}{\beta_i}\left(1-\frac{\sigma-1}{\theta}\right)\frac{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}\frac{dr_i}{d\beta_i} + \left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right]\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}-1}\frac{d\psi_i}{d\beta_i}}{\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}\left(\sum_m\psi_m\right)^{1-\frac{\sigma-1}{\theta}}}\theta\psi_i\varphi_{0,i}^{-1} \\
\propto& \frac{\theta}{\sigma-1}(1-\beta_i)\left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right] - \left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right] \\
&-\left(1-\frac{\sigma-1}{\theta}\right)\frac{\theta}{\sigma-1}(1-\beta_i)r_i\left\{(1-r_i)+\left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right]\right\} \\
=& \left[\frac{\theta}{\sigma-1}(1-\beta_i) - 1 + (1-\beta_i)r_i\left(1-\frac{\theta}{\sigma-1}\right)\right]\underbrace{\left[1-\left(1-\frac{\sigma-1}{\theta}\right)r_i\right]}_{+} \\
&\underbrace{-(1-\beta_i)(1-r_i)\left(\frac{\theta}{\sigma-1}-1\right)r_i}_{+}.
\end{aligned}$$

The equation above is negative if

$$\frac{\theta}{\sigma-1}(1-\beta_i)-1+(1-\beta_i)r_i\left(1-\frac{\theta}{\sigma-1}\right)<0,$$

which is equivalent to requiring that

$$r_i>\frac{\frac{\theta}{\sigma-1}(1-\beta_i)-1}{(1-\beta_i)\left(\frac{\theta}{\sigma-1}-1\right)}\equiv\bar{r}_i.$$

Because r_i is the winning probability, the inequality above holds if $\beta_i>1-\frac{\sigma-1}{\theta}$, where $1-\frac{\sigma-1}{\theta}\in(0,1)$ by the requirement that $\theta>\sigma-1$. We can therefore conclude that

$$\frac{d}{d\beta_i}\frac{dV_i(\varphi_{0,i})}{d\varphi_{0,i}}=\frac{1}{1-\delta}\frac{d}{d\beta_i}\frac{d\overline{\pi}_{f,i}}{d\varphi_{0,i}}<0$$

holds globally if $\beta_i>1-\frac{\sigma-1}{\theta}$ holds, indicating that a lower β_i (better connection) entails a higher marginal benefit from innovation.

Derivation of (5)

Recall and $q_i=\left(\frac{A}{B}\right)^{\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\prod_{j=1}^{M}w_j^{-\sigma\alpha_j}\varphi_i^{\sigma}$ and $\pi_{G,i}=\beta_i k\varphi_i^{\sigma-1}$, we obtain $p_i^{1-\sigma}=B^{1-\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1}\prod_{j=1}^{M}w_j^{(1-\sigma)\alpha_j}\frac{\pi_{G,i}}{\beta_i k}$ from the inverse demand function. By the definition of the price index and the procedure for equation (1):

$$\begin{aligned}P^{1-\sigma}=E\left(p^{1-\sigma}\right)=&\sum_i\frac{B^{1-\sigma}}{\beta_i k}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1}\prod_{j=1}^{M}w_j^{(1-\sigma)\alpha_j}\int_0^{\infty}\pi_G h_i(\pi_G)\,d\pi_G\\ =&B^{1-\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1}\prod_{j=1}^{M}w_j^{(1-\sigma)\alpha_j}\frac{\sum_i\beta_i^{\frac{\theta}{\sigma-1}-1}\varphi_{0,i}^{\theta}}{\left(\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}}\Gamma\left(1-\frac{\sigma-1}{\theta}\right).\end{aligned}$$

Recall that $A\equiv I^{\frac{1}{\sigma}}P^{\frac{\sigma-1}{\sigma}}$ and $k\equiv\frac{A}{\sigma-1}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\left(\frac{A}{B}\right)^{\sigma-1}\prod_{j=1}^{M}w_j^{-(\sigma-1)\alpha_j}$, we have

$$k\equiv\frac{A}{\sigma-1}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\left(\frac{A}{B}\right)^{\sigma-1}\prod_{j=1}^{M}w_j^{-(\sigma-1)\alpha_j}=\left[\sigma\frac{\sum_i\beta_i^{\frac{\theta}{\sigma-1}-1}\varphi_{0,i}^{\theta}}{\left(\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}\right)^{1-\frac{\sigma-1}{\theta}}}\Gamma\left(1-\frac{\sigma-1}{\theta}\right)\right]^{-1}I$$

$$\Rightarrow E(V_G)=\left(\sum_i\beta_i^{\frac{\theta}{\sigma-1}}\varphi_{0,i}^{\theta}\right)^{\frac{\sigma-1}{\theta}}\frac{k}{1-\delta}\Gamma\left(1-\frac{\sigma-1}{\theta}\right)=\frac{1}{1-\delta}\frac{I}{\sigma}\frac{\sum_m\beta_m^{\frac{\theta}{\sigma-1}}\varphi_{0,m}^{\theta}}{\sum_m\beta_m^{\frac{\theta}{\sigma-1}-1}\varphi_{0,m}^{\theta}}.$$

Online Appendix of "Social Network and Industrial Policy: Japan's Camphor Monopoly in Colonial Taiwan"

A Historical Supplements

In Section 2.1 we mentioned the differentiated implementation of camphor monopoly between local and Japanese producers, and various types of interactions between industrialists and top officials. In this section we provide a comprehensive list of sources as examples.

Compensation prices are more favorable for Japanese: Matsushida (1924, pp. 176-197) provides a comprehensive list for historical price adjustments along with official statements. Referring to this list, for example, during 1905–07 prices in present-day Taipei experienced several increases, while prices in Taichung Prefecture remained stable. During these years, Japanese producers gradually replaced local producers in the Taipei region, whereas in Taichung most producers were still Taiwanese. Another case occurred in 1909 when the authority raised prices in the Jiji and Zhushan regions immediately after Japanese producers took over sites previously owned by local producers, though the official claimed that the adjustments are for reflecting the remoteness in these regions. In Southern and Eastern Taiwan, regions that were considered as remote but populated with Japanese producers, prices rose nearly 50% higher than in other regions following multiple rounds of adjustments.

Interactions between industrialists and officials due to camphor: For example, a news article from May 30, 1901, reports that Ishizuka Eizo, the Director of Internal Affairs, summoned Komatsu Kusuya, responsible for crude camphor production at the *Suzuki Zaibatsu*, to discuss policies regarding the crude camphor sector (製脳業者の石塚長官代理訪問, 19010530, *Taiwan Daily News*, Japanese Edition, p. 2). An earlier article from June 17, 1898, revealed that Nasu Yoshimoto, a major crude camphor producer, organized a lobbying with other producers to influence reforms to the camphor tax system (樟腦油稅則改正の請願, 18980717, *Taiwan Daily News*, Japanese Edition, p. 2). Additionally, Lin Lie-Tan, the leader of the Upper Lin Clan in Taichung, was reported to have visited high officials at the Monopoly Bureau regarding his camphor businesses (林紳來北,19031027, *Taiwan Daily News*, Japanese Edition, p. 3).

Visits by top officials: The Governor-General and other senior officials were also frequently reported visiting major producers. Examples include Governor-General Kodama Gentarō's visit to crude camphor producers in Douliu Prefecture (總督南巡（第四報）, 19060111, *Taiwan Daily News*, Taiwanese Edition, p. 2), visits to Arai Taiji's camphor business in Southern Taiwan by the Director of the Monopoly Bureau Miyao Shunji (蕃薯寮製腦地近況, 19061109, *Taiwan Daily News*, Taiwanese Edition, p. 3) and Governor-General Sakuma Samata (總督抵甲仙埔, 19071224, *Taiwan Daily News*, Taiwanese Edition, p. 2).

Joining festive activities: Examples include the celebration for Mikado's birthday (天長節夜會招待者, 19071106, *Taiwan Daily News*, Taiwanese Edition, p. 3) and religious activities at the Taiwan Shrine (臺灣神社祭典 記念祭と例祭, 19121030, *Taiwan Daily News*, Japanese Edition, p. 7). Several businessmen such as Komatsu Kusuya along with high-ranking officials were found in the list of participants.

Joining organizations with official backgrounds: For example, Lin Lie-Tan joined the Red Cross as an honored member (十字社特別社員, 19030715, *Taiwan Daily News*, Japanese Edition, p. 4).

Party and banquets: For example, the Lin Clan and other local elites held a welcoming party for Gotō Sinpei's visit to Taichung (臺中後藤男歡迎會（二十二日臺中電話）, 19121023, *Taiwan Daily News*, Japanese Edition, p. 2), and a farewell party for Oosima Kumaji organized by Arai Taiji and other businessmen (招讌前方伯, 19100817, *Taiwan Daily News*, Taiwanese Edition, p. 5) despite the fact that Oosima was just being prosecuted due to corruption. Officials may also invite industrialists for their private banquet, such as Kada Ginsaburō being invited to a banquet by Governor-General Sakuma Samata (佐久間總督招宴（以上五日門司電）, 19141207, *Taiwan Daily News*, Japanese Edition, p. 3), and members of the Lin Clan and board members of Mitsui being invited to the banquet held by the Director of Internal Affairs Shimomura Hiroshi at his official residence (督邸招宴, 19171215, *Taiwan Daily News*, Japanese Edition, p. 5).

Event covered by multiple news articles: For example, in 1917 Kada Ginsaburō and the local elite had a dispute for their joint business in coal mining and reached a consensus in reforming their organization by introducing new partners in early 1918. The whole story was intensively followed by *Taiwan Daily News* since its onset.

B Processing Camphor Monopoly Data

The data primarily come from the *Yearbooks of Taiwan Government-General Monopoly Bureau (YMB)*. Figure 2 displays the sample pages. In Section 2.2 of the main text we discussed how crystal-equivalent output, the compensation price, and labor inputs are computed from the data. However, the original data in the *YMB* are not harmonized against adjustments in jurisdictions and names of permitted industrialists/organizations. In this section, we detail the procedure adopted to harmonize the data. The major challenges include adjustments in prefecture borders, mapping the names of permitted individuals to the corresponding enterprises, handling the backlog of data provision, and supplementing settlement-level wages to prefecture-firm-level data for computing labor inputs.

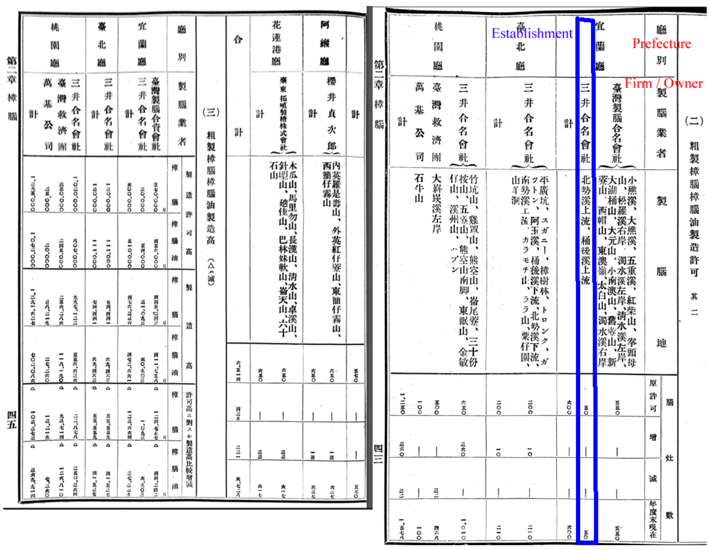

Figure 2: Sample Pages of the *YMB*

Hamonizing Prefectures We create a harmonized prefecture variable to account for changes in the local jurisdiction, which will be used for prefecture fixed effects in our empirical analysis. Some of the adjustments, from the perspective of the camphor monopoly, involve simply renaming existing prefectures. We harmonize the affected prefectures by renaming them according to the prefecture names in 1918: renaming Shenkeng Prefecture (深坑廳) as Taipei Prefecture (臺北廳), Miaoli Prefecture (苗栗廳) as Hsinchu Prefecture (新竹廳), and Fanshuliao Prefecture (蕃薯寮廳) as Aho Prefecture (阿猴廳).

Other adjustments involve merging and breaking existing prefectures. Specifically, Taitung Prefecture (臺東廳) was broken down into Taitung and Hualien Prefectures (臺東廳 and 花蓮港廳) in 1909. Judging from the list of production sites, Taitung Prefecture before 1908 actually corresponds to Hualien Prefecture from 1909 onwards. Therefore, we recoded Taitung Prefecture as Hualien Prefecture for the earlier observations. Another case is Douliu Prefecture (斗六廳), which was merged into Nantou and Chiayi Prefectures (南投廳 and 嘉義廳, mostly the former) in 1908. Note that before 1906, observations in Nantou and Taichung Prefectures were frequently reported in a pooled manner by the Monopoly Bureau, possibly because the prefectures are geographically close to each other with common permitted firms. In our empirical analysis we therefore recode the harmonized prefecture for establishments in Douliu, Nantou, and Taichung prefectures as the Central Taiwan region.

Mapping Industrialists to Firms The permission data reports the names of enterprises, organizations and industrialists (for single and cooperated businesses). There are instances where the same permitted firm is reported with different names in different years. For example, the permission might subsume the representative's name in the previous year but use the enterprise's name thereafter, leading to several aliases for the same permitted firm.

To harmonize this issue, we refer to the introductory section in the *YMB* and the *Taiwan Daily News* archive to construct a list of known stakeholders for each of the relevant firms and harmonize the reported names with the names of the corresponding firms. The mapping is as follows: Saito Kichijyurō (斎藤吉十郎) is mapped to Mitsui; Arai Taiji (荒井泰治) in Fanshuliao Prefecture to Taiwan Camphor Extraction and Development (臺灣採脳拓殖合資会社); Akaji Hatsutarō to Taiwan Camphor Extraction (臺灣採脳株式会社); Lin Lie-Tang (林烈堂) in Chiayi Prefecture is mapped to Chiayi Camphor Manufacturing (嘉義製脳組合) and otherwise, except for his cooperated business in Hualien, to the Upper Lin Clan (林家頂厝); Sakurai Tsutomu (桜井勉) to Shinchiku Camphor Manufacturing (新竹製脳株式会社); Lin Chi-Shang (林季商), Lin Rue-Teng (林瑞騰), and Lin Tzu-Bin (林資彬) to the Lower Lin Clan (林家下厝); Taiwan Camphor Production (臺灣製脳合名会社), Komatsu Kusuya (小松楠弥), and Suzuki Iwajiro (鈴木岩次郎) in Yilan (宜蘭) to Suzuki.

Aliases were also found in the original data. For instance, Chien A-Niu's (簡阿牛) business in Yilan is reported in one entry, except in 1916, where his business was reported in two separate entries. We combine the two observations by summing up the relevant variables. Another alias is due to a change in the business type of firms, resulting in the same firm being reported using a slightly different name. For such cases, we manually recode the names of firms to ensure consistency. Lastly, the business of Arai Taiji in Shenkeng/Taipei prefecture was handed to Tsuchigura Ryujirō (土倉竜次郎) before the end of the year but *YMB* only reports pooled values for the relevant variables. We attribute this observation to Arai Taiji as the change in ownership takes place at the very end of his permitted year.

Data Backlog *YMB* provides the actual production amount of camphor and the actual quantities shipped to the Monopoly Bureau (thus the total revenue of the firm) are provided in separated tables. Possibly due to prolonged administration procedures, occasionally a firm's actual shipment to the government and the compensation it received are officially documented in the yearbook for the **following year**. Some cases become even more complicated due to adjustments in jurisdictional borders in the subsequent year. In such cases, we supplement these backlogs to the corresponding observation in the previous year where we consider both the adjustments in borders and the aliases of documented owner names.

Supplementing Wages The wage data are retrieved from *Statistical Abstract* for 1911–17, under the tables entitled either 賃錢 or 賃銀 (which refers to wages in Japanese). It provides wages for various occupations for major cities and settlements, at daily frequency if not explicitly mentioned. The titles of occupations are self-descriptive and allow us to tell whether an occupation is low-skilled. By reading the titles, we define low-skilled workers as farmers, fishermen, miners and servants. We convert the wages of these jobs into a daily rate if needed, and then compute low-skilled wages at the city- / settlement-level by averaging across daily wages paid for these low-skilled jobs.

We supplement the city- / settlement-level low-skilled wages paid by firms by inspecting the geographic proximity of production sites to these settlements. For the Shenkeng / Taipei, Yilan, Taichung and Chiayi Prefectures, the corresponding wages are exactly those for settlements / cities taking the same names. The *Statistical Abstract* only provides wages for Hualien City after 1909. Since camphor production in Taitung Prefecture before 1908 occurred mainly in regions that became Hualien Prefecture later on, we use the wage for Taitung City as that for Taitung Prefecture. For Hualien Prefecture we proxy its wage with that of Taitung City before 1908, and with the average wage between Taitung and Hualien Cities afterwards. For the harmonized Aho Prefecture, the *Statistical Abstract* provides wages in Aho City throughout, but Fanshuliao Town only before 1906. Since the production took place near Fanshuliao Town throughout, we use the wage in Fanshuliao Town for the harmonized Aho Prefecture before 1906, and the average wage of geographically close settlements (Fengshan / Takao, Aho and Tainan Cities) for the later years.

For the harmonized Central Taiwan Prefecture, we supplement the wages for each of the establishments based on the nearest settlements to their production sites. Specifically, wages for firms operating in the Nantou and Taichung Prefectures are respectively given by those for Nantou and Taichung Cities. For firms operating in Douliu Prefecture, the wages faced by Yunlin Colonial Development (雲林拓殖合名会社), Chutai Sugar Manufacturing (沖臺製糖拓殖合名会社), Tainan Sugar Manufacturing (臺南製糖株式会社), and Lin Yue-Ding (林月汀) are given by those for Douliu Town while the wages for the rest of the firms are given by Nantou City. The same reasoning is adopted for firms operating in Taoyuan, Hsinchu, and Miaoli Prefectures: The wages faced by Chen Guo-Zhi (陳國治), Mitsui in Taoyuan Prefecture, and Banki Company are given by the average of Taoyuan and Hsinchu Cities. The wages faced by Chou Yuan-Bao

(周源寶) in Taoyuan Prefecture are given by that for Hsinchu City as the sites are near the prefecture border. The wages for Shinchiku Camphor Manufacturing, Xu Tai-Shin (徐泰新) and Chiu Guo-Zhen (邱國禎) are given by the average of Hsinchu and Miaoli Cities. For the other firms operating in the Taoyuan, Hsinchu and Miaoli Prefecture the wages are given by the cities taking the same names.

Market Price of Camphor The *Statistical Abstract* reports the value and volume of camphor exported by Taiwan. Taiwan's export of camphor crystal and oil to the Japanese mainland are reported starting from the 11th volume (1907), and the export to the rest of the world has been recorded since the 9th volume (1905). To compute the total export value, we sum the values exported across different destinations for each year. For the crystal-equivalent of total export volume, we first multiply the volume of camphor oil by 0.5 to obtain its crystal equivalent, as explained in the main text. We then sum up the volumes of crystal and oil (in crystal equivalent) across destinations. The market price of camphor in each year is determined by dividing the total value by the total volume.

Supplementary Information for *Taiwan Daily News* and Official Coverages

The *Taiwan Daily News* was a semi-state-owned daily newspaper and official gazette published during 1898–1944, with a dedicated Chinese edition published during 1905–11. It was first funded as the *Taiwan Daily (臺灣日報)* in 1896, which soon became the official gazette three weeks later, and then merged with the *Taiwan News (臺灣新報)* in 1898 to become the *Taiwan Daily News*. It was the largest newspaper in Colonial Taiwan, publishing a wide range of news, including official activities, entrepreneurs, business and economic events, government and enterprise announcements, interviews, and entertainment. It frequently discloses industrial activities and interactions between officials and industrialists.[8] Figure 3 displays sample news entries retrieved from the *Taiwan Daily News* archive, with news titles and names respectively marked by green and red boxes. Table 2 lists the officials in each rank covered by our social network, and their coverage rate among the same rank in *Official Directory*.

[8] Readers may refer to the Wikipedia entry for more details: https://en.wikipedia.org/wiki/Taiwan_Daily_News

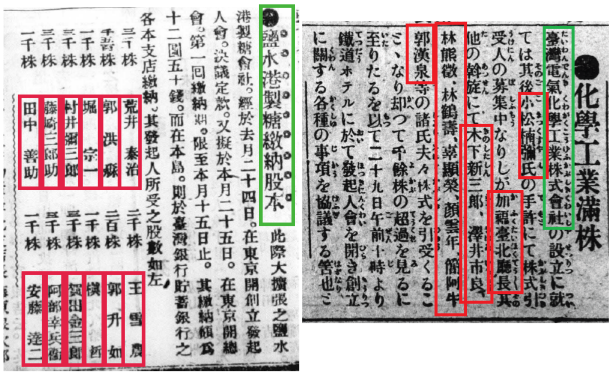

Figure 3: Sample News Entries in the *Taiwan Daily News*

	*G*01		*G*02		*G*03	
Year	# Official	Coverage Rate	# Official	Coverage Rate	# Official	Coverage Rate
1901	2	1	28	0.357	-	-
1902	2	1	28	0.143	15	0.333
1903	2	1	21	0.238	16	0.375
1904	2	1	21	0.238	15	0.267
1905	2	1	40	0.25	15	0.533
1906	2	1	23	0.522	18	0.722
1907	2	1	16	0.688	18	0.889
1908	2	0.5	21	0.571	18	1
1909	2	1	32	0.5	24	0.833
1910	2	1	22	0.409	17	0.706
1911	2	1	22	0.364	20	0.6
1912	2	1	25	0.48	23	0.739
1913	2	1	23	0.565	22	0.864
1914	2	1	25	0.48	21	0.81
1915	2	1	22	0.455	22	0.591
1916	2	1	22	0.5	24	0.5
1917	2	1	22	0.455	21	0.429
1918	3	1	25	0.44	29	0.448

Table 2: Officials and Network Coverage

C Control Function with Production Quota

In this section we propose an estimation framework for firm TFP by exploiting the timing implied by the institutional design of the Camphor Monopoly System. The central idea is to use the "intra-year" adjustments in production quota by the authority to construct the control function for identifying firm TFP.

C.1 Estimation Approach

We assume that for each establishment i for firm j in region n at time t the relationship between output and inputs is determined by an underlying establishment production function f and a Hicks neutral productivity shock v_{ijnt}. Let $\{y_{it}, l_{it}, k_{it}, w_{it}, m_{it}\}$ represent the log-values of quantity of output, labor, capital, camphor wood, and fuel wood, respectively,[9] and assume that the establishment production function is given by

$$y_{it} = \alpha_l l_{it} + \alpha_k k_{it} + \alpha_w w_{it} + \alpha_m m_{it} + v_{it}.$$

Following the control function literature, we also decompose v_{it} into $v_{it} = \alpha_0 + \omega_{it} + \varepsilon_{it}$ where α_0 is a constant term and ω_{it} is the persistent productivity shock observed by establishments in period t but unobserved by econometricians, while ε_{it} is the ex-post shock realized after the establishments made production decisions.[10] The difference between persistent shocks and ex-post shocks lies in whether they are included in the firms' information set at time t. We assume that the firms' information set at time t, denoted as $\mathbb{I}_{it}$, includes current and past productivity shocks $\{\omega_{i\tau}\}_{\tau=0}^{t}$ but does not include future productivity shocks. The ex-post shocks for time t, ε_{it}, are not included in $\mathbb{I}_{it}$ and thus satisfy $E\left[\varepsilon_{it}|\mathbb{I}_{it}\right] = 0$.

The identification assumptions for our approach is similar to those in OP, except that our approach uses production quota as the proxy variable instead of investment in OP:

Assumption 1. *The assumptions for our estimation approach are as follows:*

1. *First-order Markov evolution of productivity: persistent productivity shocks evolve according to the distribution $p\left(\omega_{it-b}|\mathbb{I}_{it-1}\right) = p\left(\omega_{it-b}|\omega_{it-1}\right)$ and $p\left(\omega_{it}|\mathbb{I}_{it-b}\right) = p\left(\omega_{it}|\omega_{it-b}\right)$. The distribution is known to firms and is stochastically increasing in ω_{it}.*
2. *Timing of Input Choices: The firms' capital accumulation is determined by the investment function $k_{it} = \kappa\left(k_{it-1}, \mathbb{I}_{it-1}\right)$ where k_{it} is determined by investment decisions made in $t-1$. The variable inputs $x_{it}^{v} \in \{l_{it}, w_{it}, m_{it}\}$ are non-dynamic and chosen at $t-b$, that is, $x_{it}^{v} = \mathscr{G}_t^{x^v}\left(\omega_{it-b}, k_{it-b}\right)$.*
3. *Scalar Unobservable: Firms' quota assignments are governed by $q_{it} = \ell_t\left(\omega_{it}, k_{it}\right)$.*
4. *Strict Monotonicity: $\ell_t\left(k_{it}, \omega_{it}\right)$ is strictly increasing in ω_{it}.*

By the third and forth points of assumptions 1, $q_{it} = \ell_t\left(\omega_{it}, k_{it}\right)$ is strictly increasing

[9] Each establishment can simultaneously produce camphor crystal and oil, and that camphor crystal differ by quality level. These simultaneously produced output are combined to become the crystal-equivalent output following our discussions in Section 2.2.

[10] In some papers, the notation ω_{it} also subsumes α_0. In practice, α_0 is the constant term estimated in the empirical model, and we may interpret it as mean productivity across firms and periods.

in ω_{it} for all pairs of (k_{it}, q_{it}). We can then construct an inverse function of the quota function to control for ω_{it}, as $\omega_{it} = \ell_t^{-1}(q_{it}, k_{it})$. Substituting it into the production function we have

$$\begin{aligned} y_{it} &= \alpha_0 + \alpha_l l_{it} + \alpha_k k_{it} + \alpha_w w_{it} + \alpha_m m_{it} + \omega_{it} + \varepsilon_{it} \\ &= \alpha_0 + \alpha_l l_{it} + \alpha_k k_{it} + \alpha_w w_{it} + \alpha_m m_{it} + \ell_t^{-1}(q_{it}, k_{it}) + \varepsilon_{it} \\ &= \alpha_l l_{it} + \alpha_w w_{it} + \alpha_m m_{it} + \phi_t(q_{it}, k_{it}) + \varepsilon_{it} \end{aligned}$$

where $\phi_t(q_{it}, k_{it}) = \alpha_0 + \alpha_k k_{it} + \omega_{it}$. Then our estimation procedure relies on two sets of moment conditions $E[\xi_{it} + \varepsilon_{it} | \mathbb{I}_{t-1}] = 0$ and

$$E[\varepsilon_{it} | \mathbb{I}_{it}] = E[y_{it} - \alpha_l l_{it} - \alpha_w w_{it} - \alpha_m m_{it} - \phi_t(q_{it}, k_{it}) | \mathbb{I}_{it}] = 0.$$

We implement a two-stage procedure to estimate factor elasticity. The coefficients of the variable inputs are estimated in the first stage, and the coefficient of capital is estimated in the second stage. The standard errors are bootstrapped.

C.2 Discussions

Our timing assumption is based on the institutional arrangements of the Japanese camphor monopoly. The authority needed to determine who could produce before firms actually engaged in production, thus both permissions of operation and initial production quota must be issued to firms before they actually engaged in production. At this moment the productivity shock during production ω_{it} is not fully revealed. Recall from Section 2.1 that the authority may adjust production quota well after firms have obtained production permissions and started with their productions in response to unexpected sub-period shocks such as natural disasters and rebellions. We can therefore utilize this difference in timing between permitting production operations and deciding the "finalized" quota for each establishment to control persistent productivity, ω_{it}. We assume that the government granted permissions for running business and initial quota at time $t-b$, $b \in (0,1)$, a period that can be though of as the beginning of a year. The government later decides the quota at time t after observing ω_{it}. We also assume that firms started to "demand variable inputs" when they were permitted for running business at time $t-b$ by observing only ω_{it-b} because they needed to organize labor and prepare intermediate inputs ahead of producing crude camphor.

This empirical strategy differs from OP's method in two aspects. First, we have a different timing assumption of choosing inputs, which is close to ACF's modified data generating process for OP's estimator. We assume that the permission to engage in operation was made at time $t-b$, and that firms started to recruit workers at $t-b$. However, once these producers entered the deep mountains, because of the costs of transportation and recruitment, they could not adjust the number of workers and other variable inputs. It would take a sub-period from $t-b$ to t to fully realize the total factor productivity shocks, but the colonial officials could immediately adjust the finalized quota when they saw the full shocks. Second, we use the quota function, instead of the investment function of OP, to control for ω_{it}. Our behavioral assumption is that the quota function is also monotonic with ω_{it} being conditional on other state variables and thus we can invert productivity from final quota with assumptions similar to those of OP.

Using the quota function as a proxy for total productivity allows us to avoid other problems of the investment function in OP's original estimator. To illustrate, first note that much of the data exhibits zero investments for firms, which poses challenges for OP's investment function approach as this approach cannot account for firms making no investments. For our data all firms with permissions would acquire positive quota, so the quota function does not suffer from the similar problem. Additionally, ACF points out that the investment function approach suffers from another problem: if some unobservables directly affect the investment function, such as the adjustment cost of capital, the inversion of the investment function becomes problematic. The quota function avoids the problem as well as the officials can quickly adjust quota immediately after observing full productivity shocks, ω_{it}.

D Other Empirical Results

This section investigates the effects of connectivity on additional outcome variables. We examine how changes in connectivity impact firm performances, including revenue, equivalence output, the quality rate, and the achievement rate against the production target/quota. For recentered connectivity, we do not find significant and robust effects of connectivity changes. In some specifications, firms with better connections with the Government Head and Ministry Head even seem to produce less, and even fall short of quota granted.

Table 3: Revenue Growth Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
*G*01 only		Original Shift-Share				Recentered Shift-Share		
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-1.078*	-1.107*	-1.001*	-0.914*	5.347	5.465	11.295	12.701
	(0.621)	(0.598)	(0.556)	(0.522)	(6.287)	(7.447)	(11.615)	(13.427)
$\mu_{i,t}^{G01}$					-0.963*	-0.987*	-0.732*	-0.614
					(0.542)	(0.506)	(0.439)	(0.438)
*G*02 only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-2.194**	-2.096*	-2.653*	-2.321*	129.623*	126.629*	147.126*	137.987
	(1.099)	(1.097)	(1.366)	(1.319)	(72.894)	(68.951)	(79.437)	(86.471)
$\mu_{i,t}^{G02}$					-2.699**	-2.607**	-3.306**	-2.943*
					(1.236)	(1.223)	(1.579)	(1.503)
*G*03 only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.256	0.235	0.333	0.442	1.323	2.782	-53.945	-61.456
	(0.778)	(0.863)	(0.937)	(1.025)	(35.229)	(45.823)	(82.128)	(81.459)
$\mu_{i,t}^{G03}$					0.247	0.210	0.876	1.063
					(0.943)	(1.161)	(1.544)	(1.638)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-1.043	-1.104	-0.689	-0.662	4.066	4.438	17.618	19.503
	(0.819)	(0.783)	(0.690)	(0.701)	(8.821)	(9.404)	(20.200)	(23.159)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-3.466**	-3.122	-5.453*	-5.019	83.760	98.620	9.435	-6.023
	(1.722)	(1.932)	(3.190)	(3.263)	(104.484)	(99.789)	(122.754)	(134.417)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	3.312*	3.157	4.167	3.999	41.366	46.775	-24.636	-31.959
	(1.874)	(2.096)	(2.605)	(2.649)	(44.471)	(47.470)	(76.635)	(76.055)
$\mu_{i,t}^{G01}$					-0.939	-1.011	0.372	0.537
					(0.847)	(0.781)	(1.419)	(1.577)
$\mu_{i,t}^{G02}$					-2.362	-1.783	-7.003	-7.021
					(2.328)	(2.731)	(6.609)	(6.863)
$\mu_{i,t}^{G03}$					0.896	0.338	2.693	2.748
					(2.427)	(2.793)	(3.764)	(3.522)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	207	207	207	207	207	207	207	207

HC3 robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Equivalence Output Growth Rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only		Original Shift-Share				Recentered Shift-Share		
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.301	-0.346	-0.293	-0.225	6.000	5.720	13.432*	13.741
	(0.617)	(0.600)	(0.598)	(0.559)	(6.510)	(6.969)	(7.902)	(8.846)
$\mu_{i,t}^{G01}$					-0.159	-0.209	0.028	0.102
					(0.536)	(0.504)	(0.520)	(0.497)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-3.199	-3.279	-2.242	-1.710	151.916**	152.953**	151.626**	129.683*
	(2.082)	(2.038)	(1.753)	(1.521)	(73.340)	(68.596)	(68.205)	(67.090)
$\mu_{i,t}^{G02}$					-3.540	-3.662*	-2.628	-2.060
					(2.155)	(2.104)	(1.803)	(1.527)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-2.085	-2.185	-1.129	-0.789	31.226	35.326	3.332	7.546
	(1.898)	(1.891)	(1.798)	(1.606)	(40.410)	(43.916)	(50.938)	(58.142)
$\mu_{i,t}^{G03}$					-2.352	-2.500	-1.174	-0.871
					(2.093)	(2.108)	(2.109)	(1.964)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.203	0.129	0.112	0.102	18.575**	18.067**	19.841**	20.251**
	(0.748)	(0.735)	(0.725)	(0.669)	(8.247)	(8.539)	(8.961)	(9.767)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-2.453	-2.273	-2.592	-2.149	168.596	184.411	145.502	111.820
	(1.723)	(1.824)	(1.926)	(1.991)	(119.476)	(112.381)	(105.019)	(105.811)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-0.861	-1.034	0.224	0.322	89.440	95.191	71.998	75.399
	(2.005)	(2.046)	(2.077)	(2.050)	(60.312)	(61.258)	(60.820)	(68.779)
$\mu_{i,t}^{G01}$					0.170	0.031	0.181	0.272
					(0.777)	(0.728)	(0.720)	(0.703)
$\mu_{i,t}^{G02}$					-1.031	-0.789	-1.212	-1.165
					(2.159)	(2.233)	(2.313)	(2.551)
$\mu_{i,t}^{G03}$					-4.089	-4.449	-2.995	-2.642
					(2.958)	(2.944)	(2.849)	(2.747)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	238	238	238	238	238	238	238	238

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Quality Rate Change - Low

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only	Original Shift-Share				Recentered Shift-Share			
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.003	-0.004	-0.005	-0.006	0.098	0.088	0.048	0.023
	(0.012)	(0.012)	(0.012)	(0.013)	(0.368)	(0.362)	(0.371)	(0.379)
$\mu_{i,t}^{G01}$					0.000	-0.002	-0.004	-0.006
					(0.015)	(0.015)	(0.016)	(0.016)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	0.032	0.027	0.020	0.030	1.545	1.718	1.726	1.522
	(0.049)	(0.046)	(0.040)	(0.040)	(2.616)	(2.659)	(2.668)	(2.759)
$\mu_{i,t}^{G02}$					0.029	0.022	0.016	0.026
					(0.050)	(0.047)	(0.040)	(0.041)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.010	0.006	-0.003	0.004	-0.831	-0.714	-0.463	-0.364
	(0.043)	(0.041)	(0.036)	(0.038)	(1.556)	(1.543)	(1.661)	(1.717)
$\mu_{i,t}^{G03}$					0.016	0.012	0.001	0.008
					(0.049)	(0.047)	(0.044)	(0.046)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.013	-0.014	-0.014	-0.017	-0.030	-0.028	-0.049	-0.104
	(0.014)	(0.015)	(0.014)	(0.016)	(0.447)	(0.447)	(0.447)	(0.459)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	0.073	0.071	0.074	0.084	3.621	4.013	4.458	4.328
	(0.057)	(0.058)	(0.059)	(0.061)	(3.794)	(3.880)	(3.944)	(4.091)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-0.025	-0.028	-0.039	-0.035	-1.581	-1.370	-1.105	-1.123
	(0.053)	(0.052)	(0.051)	(0.052)	(1.612)	(1.649)	(1.758)	(1.803)
$\mu_{i,t}^{G01}$					-0.020	-0.022	-0.023	-0.028
					(0.017)	(0.017)	(0.017)	(0.019)
$\mu_{i,t}^{G02}$					0.118	0.118	0.123	0.130
					(0.081)	(0.083)	(0.085)	(0.086)
$\mu_{i,t}^{G03}$					-0.047	-0.056	-0.072	-0.064
					(0.091)	(0.093)	(0.096)	(0.099)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	238	238	238	238	238	238	238	238

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Quality Rate Change - Middle

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only	Original Shift-Share				Recentered Shift-Share			
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.017	-0.017	-0.020	-0.019	1.787**	1.657**	1.402*	1.467*
	(0.050)	(0.050)	(0.052)	(0.052)	(0.771)	(0.770)	(0.831)	(0.826)
$\mu_{i,t}^{G01}$					0.024	0.021	0.013	0.016
					(0.051)	(0.050)	(0.055)	(0.055)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	0.218	0.205	0.148	0.119	4.406	5.467	5.541	6.106
	(0.176)	(0.171)	(0.150)	(0.142)	(10.590)	(10.814)	(10.825)	(10.506)
$\mu_{i,t}^{G02}$					0.209	0.193	0.135	0.103
					(0.186)	(0.183)	(0.161)	(0.151)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.257*	0.241*	0.204	0.183	-3.005	-2.226	-1.173	-2.024
	(0.150)	(0.144)	(0.131)	(0.120)	(5.570)	(5.719)	(6.194)	(6.561)
$\mu_{i,t}^{G03}$					0.283*	0.261	0.218	0.205
					(0.166)	(0.161)	(0.155)	(0.149)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.030	-0.030	-0.029	-0.025	1.261	1.183	1.129	1.237
	(0.066)	(0.065)	(0.065)	(0.063)	(0.975)	(0.995)	(1.017)	(1.004)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-0.109	-0.090	-0.079	-0.100	-5.890	-4.081	-2.901	-2.142
	(0.307)	(0.310)	(0.316)	(0.331)	(14.785)	(15.095)	(15.249)	(15.187)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.322	0.296	0.255	0.244	2.492	2.813	3.517	2.885
	(0.234)	(0.229)	(0.233)	(0.240)	(6.449)	(6.640)	(6.859)	(7.103)
$\mu_{i,t}^{G01}$					0.014	0.007	0.002	0.010
					(0.064)	(0.063)	(0.066)	(0.067)
$\mu_{i,t}^{G02}$					-0.142	-0.115	-0.102	-0.110
					(0.373)	(0.376)	(0.383)	(0.407)
$\mu_{i,t}^{G03}$					0.259	0.226	0.182	0.158
					(0.344)	(0.340)	(0.345)	(0.347)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	238	238	238	238	238	238	238	238

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Quality Rate Change - High

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
*G*01 only	Original Shift-Share				Recentered Shift-Share			
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.019	0.022	0.025	0.026	-1.885*	-1.745*	-1.450	-1.490
	(0.050)	(0.049)	(0.051)	(0.052)	(0.990)	(0.981)	(1.034)	(1.020)
$\mu_{i,t}^{G01}$					-0.024	-0.018	-0.009	-0.010
					(0.054)	(0.053)	(0.057)	(0.056)
*G*02 only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-0.250	-0.232	-0.168	-0.148	-5.951	-7.184	-7.267	-7.629
	(0.172)	(0.166)	(0.146)	(0.140)	(10.664)	(10.958)	(10.977)	(10.757)
$\mu_{i,t}^{G02}$					-0.238	-0.215	-0.150	-0.128
					(0.181)	(0.178)	(0.157)	(0.149)
*G*03 only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-0.266*	-0.246*	-0.201	-0.187	3.836	2.940	1.636	2.389
	(0.145)	(0.138)	(0.126)	(0.118)	(5.482)	(5.606)	(6.016)	(6.330)
$\mu_{i,t}^{G03}$					-0.299*	-0.273*	-0.219	-0.213
					(0.161)	(0.154)	(0.150)	(0.145)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.043	0.044	0.043	0.042	-1.231	-1.155	-1.080	-1.134
	(0.066)	(0.065)	(0.065)	(0.062)	(1.206)	(1.220)	(1.234)	(1.217)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	0.036	0.018	0.005	0.015	2.269	0.068	-1.557	-2.186
	(0.303)	(0.306)	(0.312)	(0.324)	(14.548)	(14.897)	(15.033)	(14.998)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-0.297	-0.268	-0.216	-0.209	-0.912	-1.444	-2.412	-1.762
	(0.229)	(0.223)	(0.228)	(0.234)	(6.041)	(6.259)	(6.451)	(6.673)
$\mu_{i,t}^{G01}$					0.006	0.015	0.021	0.018
					(0.066)	(0.064)	(0.066)	(0.067)
$\mu_{i,t}^{G02}$					0.024	-0.004	-0.021	-0.020
					(0.369)	(0.372)	(0.378)	(0.399)
$\mu_{i,t}^{G03}$					-0.212	-0.170	-0.110	-0.095
					(0.333)	(0.330)	(0.336)	(0.338)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	238	238	238	238	238	238	238	238

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Achievement Rate Change – Crystal

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only	Original Shift-Share				Recentered Shift-Share			
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.205	0.209	0.248	0.245	0.090	0.039	1.061	1.265
	(0.306)	(0.291)	(0.250)	(0.252)	(3.813)	(3.878)	(4.814)	(4.802)
$\mu_{i,t}^{G01}$					0.202	0.206	0.267	0.269
					(0.322)	(0.299)	(0.256)	(0.263)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	1.078	1.111	1.120	1.152	37.219	37.312	52.654**	53.369*
	(0.953)	(0.985)	(1.000)	(1.006)	(34.562)	(33.478)	(25.622)	(27.360)
$\mu_{i,t}^{G02}$					1.112	1.145	1.175	1.213
					(0.949)	(0.982)	(1.006)	(1.012)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-0.268	-0.268	-0.204	-0.200	-69.874	-69.795	-69.089	-69.434
	(0.432)	(0.389)	(0.335)	(0.357)	(43.696)	(43.829)	(44.962)	(46.673)
$\mu_{i,t}^{G03}$					0.008	0.012	0.066	0.066
					(0.496)	(0.453)	(0.407)	(0.435)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	-0.053	-0.061	-0.038	-0.050	-6.826	-7.272	-6.655	-6.564
	(0.541)	(0.527)	(0.479)	(0.473)	(6.184)	(6.508)	(7.014)	(7.202)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	2.748	2.845	2.756	2.828	146.699**	148.186**	160.838**	161.438**
	(2.775)	(2.743)	(2.564)	(2.544)	(67.683)	(68.814)	(64.334)	(67.849)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	-1.600	-1.656	-1.584	-1.602	-145.244**	-146.231**	-148.966**	-149.119**
	(1.499)	(1.446)	(1.294)	(1.283)	(71.276)	(71.882)	(71.390)	(74.058)
$\mu_{i,t}^{G01}$					-0.262	-0.277	-0.220	-0.230
					(0.529)	(0.518)	(0.490)	(0.499)
$\mu_{i,t}^{G02}$					4.310	4.432	4.258	4.340
					(3.010)	(3.004)	(2.902)	(2.928)
$\mu_{i,t}^{G03}$					-1.483	-1.520	-1.365	-1.389
					(1.528)	(1.477)	(1.330)	(1.307)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	257	257	257	257	257	257	257	257

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Achievement Rate Change – Oil

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only	Original Shift-Share				Recentered Shift-Share			
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.595**	0.612**	0.666**	0.659*	4.910	4.823	6.554	6.737
	(0.283)	(0.291)	(0.323)	(0.351)	(4.828)	(4.511)	(4.791)	(4.903)
$\mu_{i,t}^{G01}$					0.688**	0.705**	0.809**	0.807**
					(0.317)	(0.318)	(0.370)	(0.388)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	2.326	2.412	2.424	2.493	1.158	1.009	14.934	16.595
	(1.478)	(1.503)	(1.512)	(1.547)	(62.717)	(62.795)	(70.097)	(70.543)
$\mu_{i,t}^{G02}$					2.324	2.411	2.438	2.510
					(1.467)	(1.492)	(1.504)	(1.536)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	1.720	1.763	1.894	1.915	-55.832	-55.691	-54.126	-53.979
	(1.244)	(1.263)	(1.305)	(1.320)	(44.165)	(46.100)	(44.883)	(55.302)
$\mu_{i,t}^{G03}$					1.948	1.995	2.114	2.130
					(1.317)	(1.350)	(1.408)	(1.432)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.344	0.361	0.455	0.435	-3.585	-3.932	-2.959	-3.042
	(0.392)	(0.393)	(0.427)	(0.464)	(6.768)	(6.280)	(5.892)	(7.589)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	0.754	0.823	0.468	0.552	47.412	48.973	68.898	70.876
	(1.298)	(1.271)	(1.331)	(1.408)	(83.649)	(83.745)	(96.459)	(107.248)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	1.249	1.257	1.545	1.530	-92.466	-93.977	-98.286	-98.929
	(1.226)	(1.225)	(1.309)	(1.329)	(61.261)	(63.470)	(67.513)	(86.523)
$\mu_{i,t}^{G01}$					0.348	0.359	0.450	0.427
					(0.478)	(0.465)	(0.490)	(0.510)
$\mu_{i,t}^{G02}$					1.504	1.600	1.326	1.417
					(1.777)	(1.721)	(1.641)	(1.643)
$\mu_{i,t}^{G03}$					1.416	1.439	1.684	1.672
					(1.402)	(1.424)	(1.462)	(1.525)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	257	257	257	257	257	257	257	257

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Number of Production Sites

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$G01$ only		Original Shift-Share				Recentered Shift-Share		
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.099	0.060	0.050	0.070	3.662	2.771	2.150	1.917
	(0.203)	(0.220)	(0.219)	(0.230)	(2.277)	(2.171)	(2.565)	(2.542)
$\mu_{i,t}^{G01}$					0.183	0.125	0.102	0.116
					(0.207)	(0.222)	(0.221)	(0.234)
$G02$ only								
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	0.693	0.429	0.291	0.252	27.110	35.865	36.415	34.466
	(0.445)	(0.445)	(0.520)	(0.548)	(41.682)	(42.581)	(42.353)	(43.786)
$\mu_{i,t}^{G02}$					0.631	0.336	0.193	0.153
					(0.432)	(0.427)	(0.488)	(0.507)
$G03$ only								
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.621	0.413	0.305	0.246	32.003	38.763*	42.727*	36.605
	(0.377)	(0.357)	(0.444)	(0.463)	(20.540)	(21.716)	(24.981)	(26.589)
$\mu_{i,t}^{G03}$					0.369	0.091	-0.106	-0.104
					(0.426)	(0.424)	(0.585)	(0.617)
All Connectivity								
$d_{i,t}^{G01}$ / $d_{i,t}^{G01,rc}$	0.048	0.038	0.039	0.063	4.004	3.890	3.645	3.208
	(0.242)	(0.258)	(0.259)	(0.271)	(3.181)	(3.308)	(3.261)	(3.235)
$d_{i,t}^{G02}$ / $d_{i,t}^{G02,rc}$	-0.045	-0.103	-0.090	-0.087	-1.492	14.659	20.816	21.890
	(0.666)	(0.681)	(0.670)	(0.698)	(55.767)	(56.347)	(53.269)	(56.458)
$d_{i,t}^{G03}$ / $d_{i,t}^{G03,rc}$	0.632	0.458	0.342	0.274	46.256	53.538	56.952	48.020
	(0.521)	(0.494)	(0.525)	(0.544)	(31.172)	(33.397)	(35.802)	(37.888)
$\mu_{i,t}^{G01}$					0.100	0.041	0.018	0.039
					(0.270)	(0.290)	(0.277)	(0.296)
$\mu_{i,t}^{G02}$					-0.323	-0.333	-0.302	-0.235
					(0.939)	(0.965)	(0.940)	(0.994)
$\mu_{i,t}^{G03}$					0.174	-0.154	-0.382	-0.383
					(0.660)	(0.632)	(0.624)	(0.638)
Share of Japanese		Yes	Yes	Yes		Yes	Yes	Yes
Officially Owned		Yes	Yes	Yes		Yes	Yes	Yes
Mainland Based		Yes	Yes	Yes		Yes	Yes	Yes
Subcontraction		Yes	Yes	Yes		Yes	Yes	Yes
Time Trend			Yes	Yes			Yes	Yes
Prefecture FE				Yes				Yes
Observations	245	245	245	245	245	245	245	245

HC3 robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

E Simulation Appendix

Regional Simulations The simulation in the main text does not account for the heterogeneity across different prefectures. As discussed, Eastern and Southern Taiwan are regarded as harsh and undeveloped regions, requiring additional policy support for firms to be willing to operate in these regions. Apart from the Monopoly Bureau's higher compensation prices, other agencies in charge of economic development such as the Colonial and Industrial Bureau also offer various programs to encourage industrial development, covering forestry, agriculture, and infrastructure in these regions.

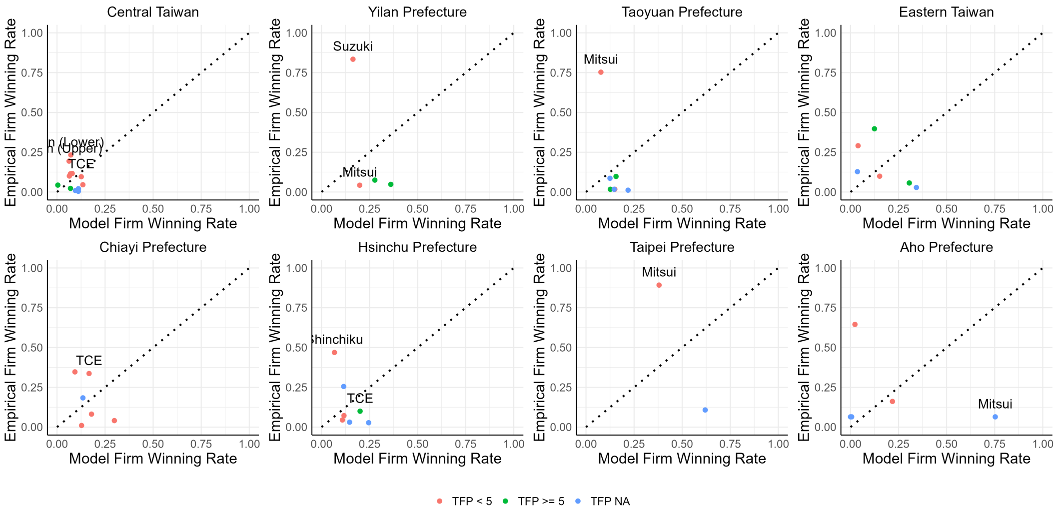

Figure 4: Empirical and Simulated Winning Rates for 1902–1918 within Regions

Consequently, firms operating in these areas tend to be more resilient to tough market conditions rather than being efficient in specific sectors.

To explore these possibilities, we perform simulations for each region. Within each region, we aggregate firm-year allocations to form firm-level allocations, and assign the firm with the highest empirical TFP as the benchmark. Due to jurisdictional adjustments, Taichung, Nantou, and Douliu are merged into the Central Taiwan region for our simulation. The results are illustrated in Figures 4 and 5.

The regional simulations indicate a closer alignment between empirical and model-implied allocations compared to Figure 9, suggesting that our model captures the authority's permission-granting decisions once regional heterogeneities are controlled for. However, Japanese-owned firms, notably those belonging to the Major Six, still obtain more production sites than predicted in each region. This deviation is particularly pronounced for Suzuki, Mitsui, and Shinchiku Camphor Manufacturing. For instance, in Yilan Prefecture (宜蘭廳) Suzuki was empirically ranked the lowest in terms of TFP, but obtained over 75% of the production sites than model prediction (approximately 15%) given its low TFP ranking.

Chronological Simulations This experiment inspects the consequence of the Monopoly Bureau's firm selection decisions in chronological order. For each year we perform a simulation by assigning $\beta_i = 1$ to firms that are not selected by the Monopoly Bureau

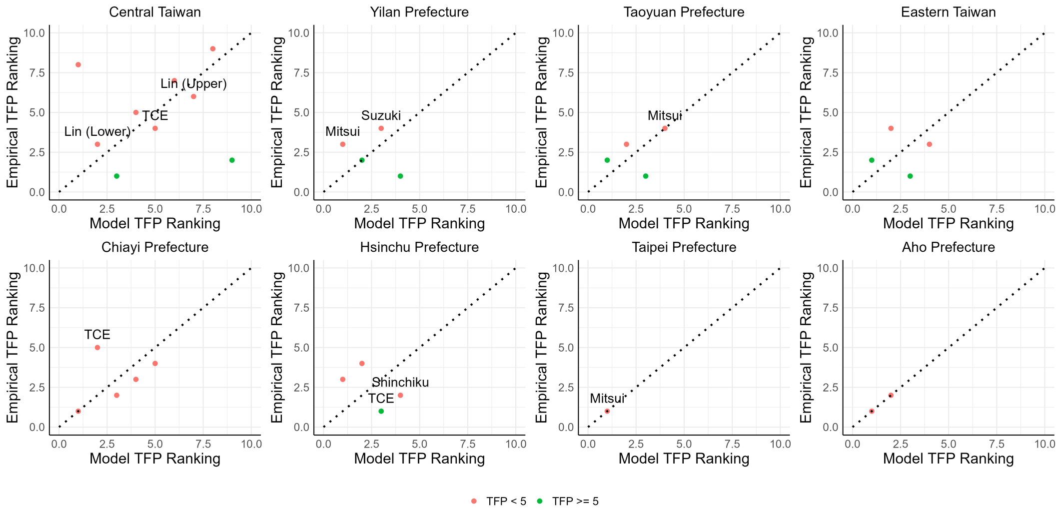

Figure 5: Empirical and Simulated TFP Rankings for 1902–1918 within Regions

in the data. The bargaining powers are not available for firms that appear only before 1906 due to the lack of revenue data. We therefore perform our analysis for the years 1907–1918. Table 11 presents the simulated profit rates for each year. The profit rate was declining in 1907–1910 due to the accession of Shinchiku Camphor Manufacturing and the removal of several firms owned by local industrialists. Nevertheless, the profit rate started to increase following the accession of several better-performing firms such as Chien A-Niu and the TCE. This finding suggests that the Monopoly Bureau's choice of firms adheres to its picking-winner discipline, at least in later years.

Table 11: Simulated Profit Rates for 1907–1918

Year	ι
1907	0.420
1908	0.393
1909	0.385
1910	0.382
1911	0.383
1912	0.403
1913	0.406
1914	0.409
1915	0.417
1916	0.417
1917	0.435
1918	0.443