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Bridges and Profits: A Historical Urban Economics of Tokugawa Japan

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Bridges and Profits

A Historical Urban Economics of Tokugawa Japan*

Yu Mandai† Masaki Nakabayashi‡

Abstract

Most of the existing major cities in Europe and Japan were planned and built in ancient to early modern times. Human activities in a city affect the valuation of the city in this period, and the current valuation affects investment for the next period. Layers of historically recursive activities and investments through periods have composed a live city. We focus on walking, the fundamental activity of people, and take the return on property as an objective measure of a city's prosperity. Specifically, we examine the return of property leases in Osaka, Japan, in early modern times, focusing on bridges that were corners of pedestrian flows. Through our archival work and analysis of the first-hand documents of the largest landlord, Mitsui, we find that the closer to a bridge a property was, the higher the rent and the profit rate of its lease was. Properties exposed to a greater flow of pedestrians around bridges delivered higher profit rates, supposedly enticed investments in such properties, and increased pedestrian flows further.

Keywords Lease property markets; pedestrian flows; bridge; hedonic approach; gentrification; machine learning; Tokugawa Japan

JEL classification codes R31; R21; R11; R14;O1; O18; N95

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1 Introduction

A city is a place where people can meet together. People walk around corners and meet, spending time and consuming goods and services. Such activities attract affect drinking and eating places and shops, form a layer of the city, increase the city's valuation, and attract investment in properties toward the next period. A layer of a city in a period is recursively formed depending on its historical path. Cumulative periods of walkers have composed a live city.

This is also true for revitalizing dead cities that have lost pedestrians. Stimulating pedestrian flows is essential for revitalizing a city center. Once pedestrians return to the city center, an adequate level of congestion or bustle increases the sales of retail shops and restaurants (Balsas 2019, 59–87). Improved walkability is associated with an increase in property valuation (Xie and Levinson (2009), 464–467; Pivo and Fisher (2011), 205–207; Rauterkus and Miller (2011), 34–37; Gilderbloom et al. (2015), 19; Ye and Becker (2017), 432; Ivey and Bereitschaft (2021), 53), notably for retail service properties (Sohn et al. 2012, 125), although Boyle et al. (2014) reported that walkability effects become insignificant once the neighborhood is controlled for (Boyle et al. 2014, 859), and Li et al. (2015) noted that the positive impacts of walkability on property valuation are more likely to be observed in already walkable neighborhoods (Li et al. 2015, 481).

For pedestrian flows, bridges are prone to gridlock but also work as corners of face-to-face communication such that the proximity to a bridge predicts a greater association of property prices between two blocks separated by a river (Tirtiroğlu and Clapp 1996, 376–377, 385–387). Obviously, this finding was truer in early modern cities, where the dominant means of mobility was walking (de Vivo 2016, 122–125). In both Europe and Japan, in early modern cities where channel networks were built, bridges were important for improving walkability between blocks surrounded by channels. Bridges functioned as key structures in early modern cities with respect to pedestrian flows.

In early modern Japan, corners adjacent to a bridge prospered as squares where eating and drinking places, retail shops haircutting salons were gathered. Originally, squares adjacent to bridges were planned for the bulletin boards (*kōsatsu*) to announce laws to the public and open spaces for fire prevention. Throughout early modern times, vendor stalls were opened in the squares, seeking and attracting pedestrian flows. The structure was inherited by modern city planning after the Meiji Restoration of 1868 (Watanabe (1972b), 2–5; Watanabe (1972a), 14–16; Watanabe (1973), 30–32; Itoh (1986), 199–207; Hein (2010), 466).

With modern motorization, the significance of walkability was mostly forgotten, although walking was the dominant form of mobility across socioeconomic statuses (Pooley et al. (2021); Pooley (2021), 215–217; Emanuel (2021), 250–254), until recently when it was rediscovered for the revitalization of city centers.

Figure 1 depicts the Tenmabashi bridge in the city of Osaka in Tokugawa Japan in the 1830s.

Figure 1: The Tenmabashi Bridge in the City of Osaka in the early nineteenth century.



Source: Katsushika Hokusai, "Sesshū Tenmabashi," c. 1833–1834. National Diet Library Digital Collections: https://dl.ndl.go.jp/pid/1302024 Accessed February 8, 2025.

Figure 2 is a picture of another large bridge, the Kōraibashi bridge, in the mid-nineteenth century. In a square adjacent to a large bridge, houses with a small tower (*yagura yashiki*) were built to appeal to customers (Miyamoto 1985, 129–130).

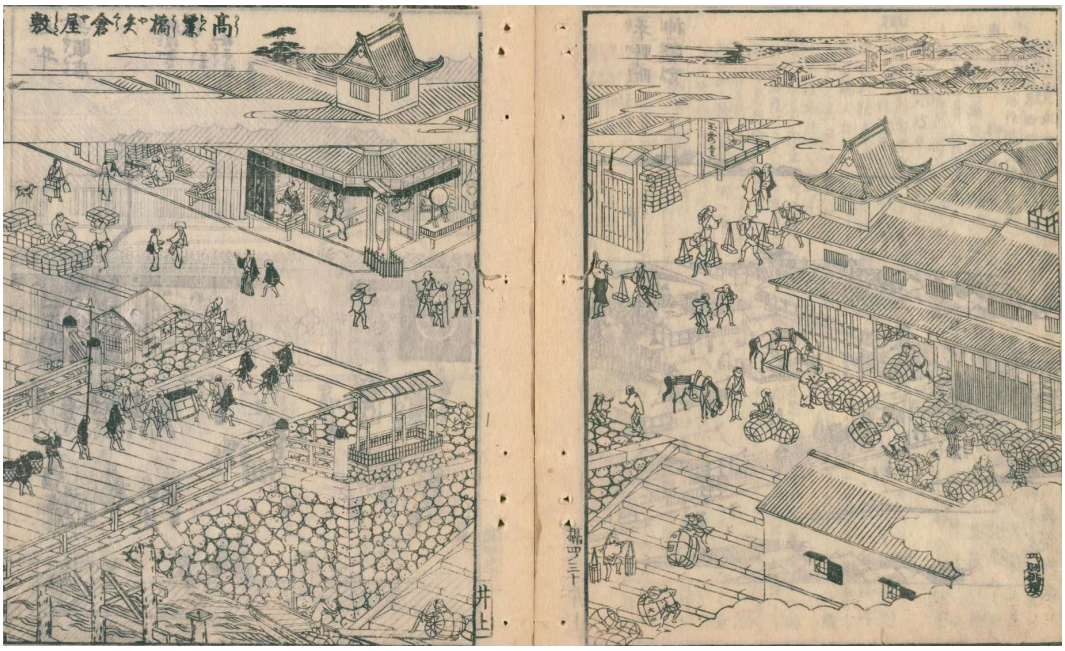
Figure 2: The Kōraibashi Bridge in the City of Osaka in the mid-nineteenth century.



Source: Hasegawa Sadanobu, "Kōraibashi" in Hasegawa Sadanobu, *Naniwa Hyakkei (One Hundred View of Osaka)*, Osaka: Ishikawaya Yasuke, the mid-19th century. National Diet Library Digital Collections: https://dl.ndl.go.jp/pid/1304728 Accessed February 7, 2025.

A bird's-eye view of the same Kōraibashi bridge is Figure 3. A house with a tower was open to pedestrians to attract customers.

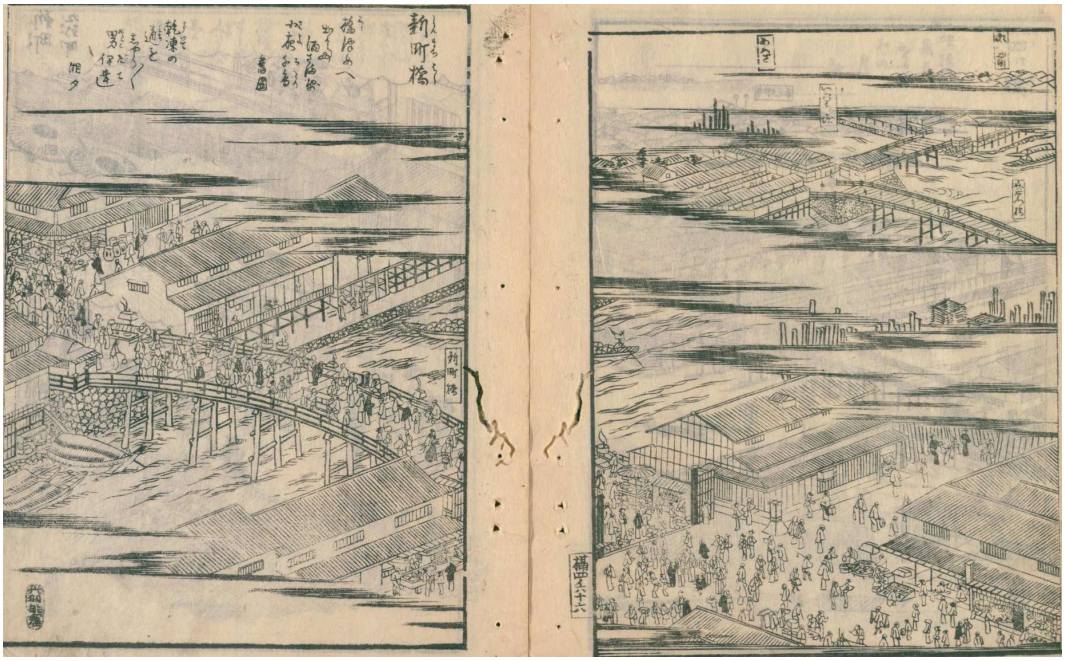
Figure 3: The Kōraibashi Bridge in the City of Osaka, a bird's-eye view in the late eighteenth century.



Source: Takehara Shunchōsai, "Kōraibashi yagura yashiki (Houses with a tower toward the Kōraibashi bridge)" in Akisato Riō, ed., *Settsu Meisho Zue Shi Jō (Pictures of the Sights in the State of Settsu), Volume 4, Part 1*, Kyoto: Ogawa Tazaemon, Kyoto: Tono Tamehachi, Osaka: Yanagihara Kihe-e, Osaka: Matsumura Kuhe-e, and Osaka: Morimoto Tasuke, 1798. National Diet Library Digital Collections: https://dl.ndl.go.jp/pid/2563462 Accessed February 7, 2025.

Figure 4 depicted another bridge, the Shinmachibashi bridge. Shops and stalls were open to pedestrians in the squares adjacent to the bridge.

Figure 4: The Shinmachibashi Bridge in the City of Osaka in the late eighteenth century.



Source: Takehara Shunchōsai, "Shinmachibashi" in Akisato Riō, ed., *Settsu Meisho Zue Shi Ge (Pictures of the Sights in the State of Settsu), Volume 4, Part 2*, Kyoto: Ogawa Tazaemon, Kyoto: Tono Tamehachi, Osaka: Yanagihara Kihe-e, Osaka: Matsumura Kuhe-e, and Osaka: Morimoto Tasuke, 1798. National Diet Library Digital Collections: https://dl.ndl.go.jp/pid/2563462 Accessed February 7, 2025.

Figures 1 to 4 indicate that bridges were corners of pedestrian flows in the city and properties near bridges were exposed to pedestrian flows. In particular, Figures 3 and 4 vividly paint commercial properties approaching customers in squares adjacent to bridges.

Another critical factor of active and safe cities is residents. If wealthy residents who have purchasing power leave the city center, the sales of retail shops and restaurants drop. The sole possible outcome is degradation; this is why city center revitalization often includes gentrification projects. Indeed, gentrification tends to attract higher-skilled residents (Baum-Snow and Hartley 2020, 12), be associated with the recovery of commercial activity (Glaeser et al. (2018b), 19–32; Glaeser et al. (2018a), 78–80), and be corporatized given the underlying risks (Smith and Graves 2005, 404–406), although the

accompanying social outcome of displacement is often controversial (Atkinson (2004), 111–117; Ehrenfeucht and Nelson (2020), 438–442).

Both bustling corners and residential districts are critical for vibrant cities and hence for property values; in this work, we test whether this was true historically by taking the city of Osaka in Tokugawa Japan, as an example. We create a novel dataset from original documents of the property leasing business operated by Mitsui, the largest city landlord. More specifically, we investigate the effects of proximity to a bridge, which captures pedestrian flow.

The origins of existing cities in advanced economies date back to early modern, medieval, or ancient times (Hein (2008), 79–82; Wahl (2016), 56–59; Nakabayashi et al. (2020), 153–158). The structural basis of most existing major cities in advanced economies was completed by city planning in early modern times. Such historical paths endorse the virtue of historical urban economics, and improvements in data availability have enabled them ((Sawada 2006), 222–226; Youngsang et al. (2015), 422–425; Hanlon and Heblich (2022), 3–6).

The remainder of this paper is organized as follows. Section 2 describes our case, early modern Osaka, and examines plans of typical properties owned by Mitsui in the city. Section 4 presents our estimation model, and Section 5 presents its results. Section 6 presents a robustness check of the primary results by means of semiparametric estimation via a machine learning algorithm. Section 7 describes a gentrification project considered by Mitsui to clarify the background of the estimated results. Finally, Section 8 concludes the paper.

2 Mitsui's properties in the city of Osaka

2.1 City of Osaka

Japan was a federation of lords under the Tokugawa shogunate from 1600–1868. While the shogunate assumed supreme command and diplomacy, the shogunate and lords assumed domestic sovereignty independently, including taxation. Under the Tokugawa shogunate regime, the shogunate and lords implemented large-scale reclamation of alluvial plains in the lower reaches of large rivers with investment in river improvement throughout the seventeenth century. The surging input of land drove rapid economic growth by an extensive margin. The shogunate and lords also completed cadastral surveys by the late seventeenth century and vested each stem farming household with property rights over the plot of the household cultivated. The establishment of property rights protection provided farmers with strong incentives to improve productivity (Nakabayashi et al. (2020), 174–176; Mandai and Nakabayashi (2018), 312–314; Nakabayashi (2020), 285–288; Nakabayashi (2021), 70–72). The per capita GDP rose from the late seventeenth century throughout the eighteenth and nineteenth centuries. In the process, Japan's per capita GDP surpassed that of China in the eighteenth century and caught up with that of peripheral European countries such as Poland and Portugal by the mid-nineteenth century (Nakabayashi et al. 2020, 170–171).

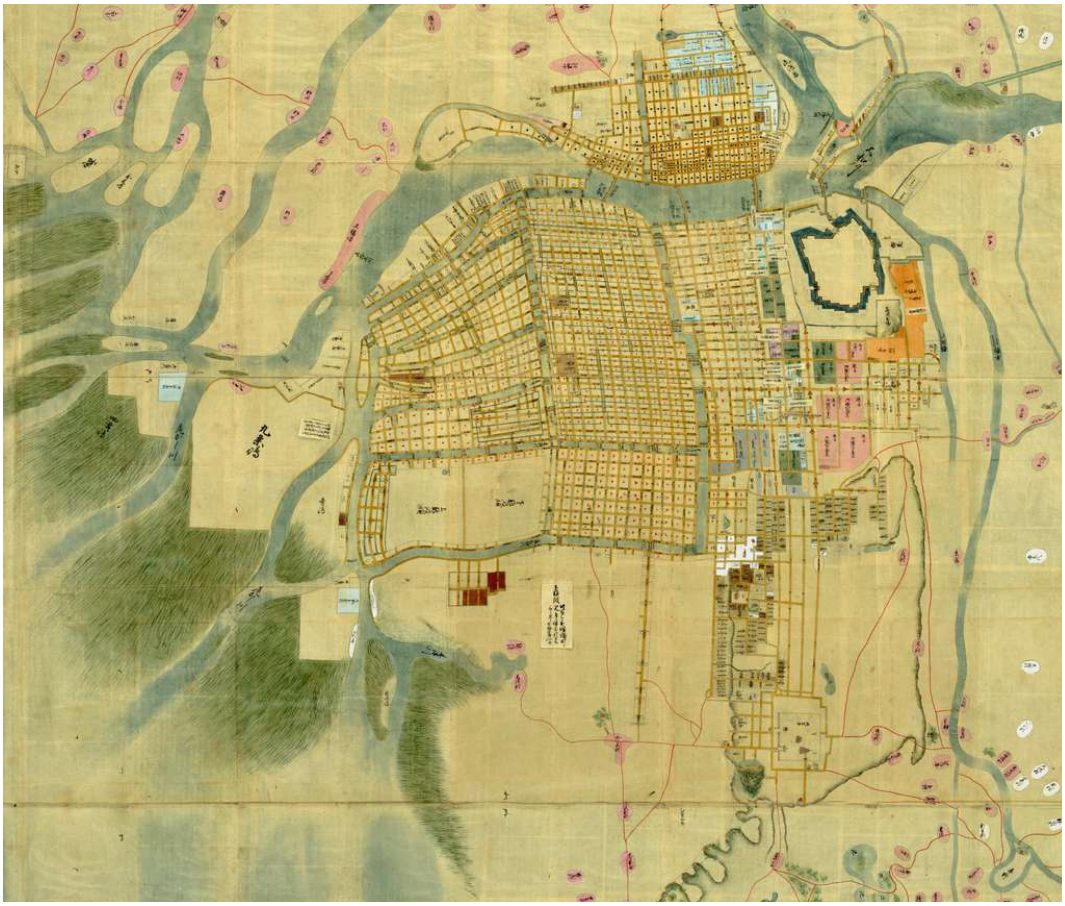
Another outcome of property rights protection was high state capacity. When the shogunate and lords vested farming households with property rights, they imposed land taxes in return for property rights protection. This scheme enables a high state capacity. The taxation rate, the tax revenue over the gross domestic product, reached 20% in the shogunate domain as of the late seventeenth century. Although the taxation rate declined with productivity improvement because increases in agricultural output were barely taxed, it was still approximately 14% in the mid-nineteenth century (Nakabayashi et al. 2020, 83–89). The taxation rate in the mid-nineteenth century was much higher

than those of other emerging economies, such as China's at 8% (Deng 2012, 342) and Turkey's at less than 8% (Pamuk 2012, 321). The advantage in the early modern state capacity is considered to have formed a condition of Japan's advancement in Asia's little divergence (Sng and Moriguchi (2014), 465–466; Koyama et al. (2018), 191–192).

One of the largest destinations of tax revenue in the early modern era was the large-scale reclamation of paddy fields across Japan. Another was city building. Japan's existing major cities' central districts were mostly planned and built from the seventeenth to eighteenth centuries, except for Kyoto. The city of Osaka is a significant example of infrastructure investment financed by high state capacity. Osaka was the second largest city and the center of commerce and finance in early modern Japan. The shogunate and lords shipped rice they collected as land tax to Osaka and lords exchanged it with the shogunate currency (Miyamoto 1999b,a).

Figure 5 is a map of the city of Osaka in the mid-seventeenth century: the north-western blocks were still under construction, and the southwestern blocks were under reclamation.

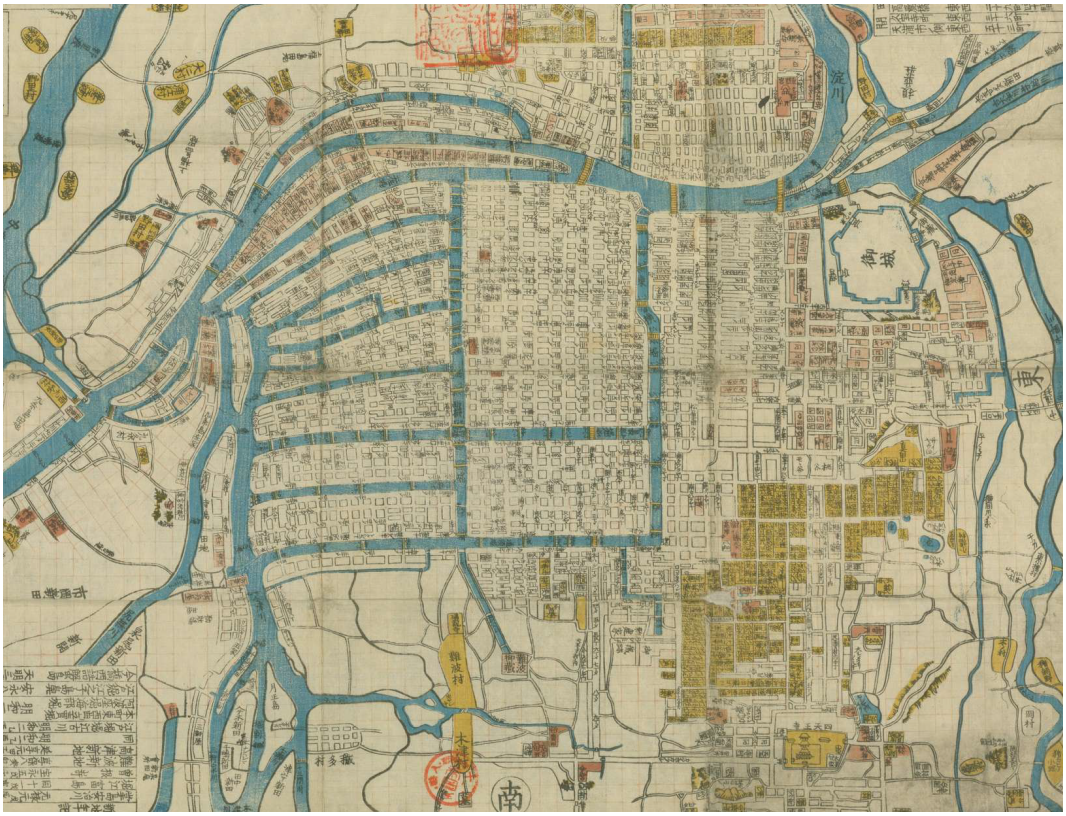
Figure 5: The City of Osaka, c. 1663–1673.



Source: Ōsaka Machi Bugyō (Magistrate of Osaka), c. 1663–1673. National Diet Library Digital Collections: https://dl.ndl.go.jp/pid/1286224 Accessed February 8, 2025.

Figure 6 is a map of the city of Osaka in the mid-nineteenth century. The planning of the city's civilian districts is detailed by Yoshida and Matsuguchi (1993), Yoshida and Matsuguchi (1994), Matsuguchi and Yoshida (1996), Matsuguchi (2000), Matsuguchi (2001), Matsuguchi (2002), Ikeda et al. (2001), Ikeda et al. (2004), and Abe and Shinohara (2012).

Figure 6: The City of Osaka, 1847.



Source: Itamiya Zenbe-e, 1847. National Diet Library Digital Collections: https://dl.ndl.go.jp/pid/2543042 Accessed February 8, 2025.

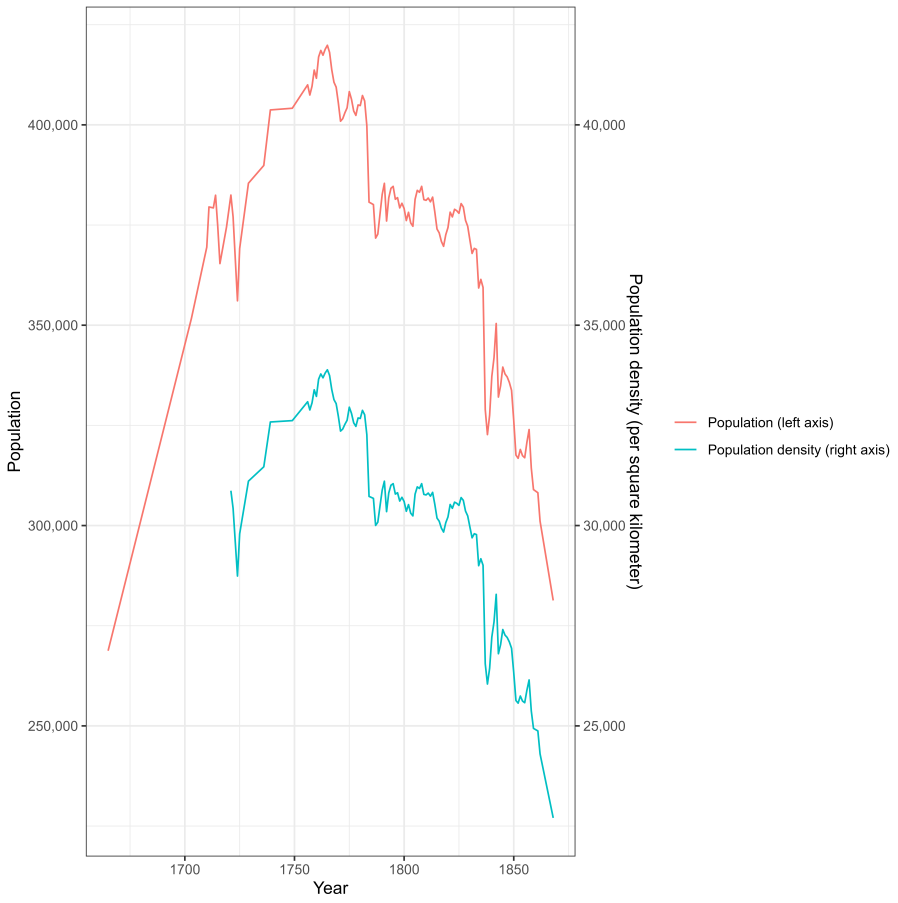
Figure 7 traces Figure 6. The "samurai" districts were exclusively for administration houses and samurai residences, the temple and shrine districts were for temples and shrines, and the civilian districts were for civilian residences and commerce. Properties in the samurai districts were not allowed to be pledged or sold to civilians. Properties in the civilian districts were registered, and property rights over them, including pledging and trading, were protected by the shogunate court and hence actively traded. Properties owned and leased by Mitsui were thus located in civilian districts.

Figure 7: City of Osaka in the mid-nineteenth century.



The civilian districts in Figure 6 planned by the shogunate contained three wards (*gumi*): Tempa ward (Tenma and Dōjima districts), Kita ward (Kita Senba and Nishi Senba districts), and Minami ward (Minami Senba, Horie, and Shimanouchi districts), and the civilian area of the three wards in total was 12.39 square kilometers (Kawabata 2004, 3). Figure 8 presents the city of Osaka's civilian population, whose residence registration was in the city. The population density is the population divided by the city area of 12.39 square kilometers.

Figure 8: Civilian population of the city of Osaka.



Source: Osakashi Sanjikai (1913), 370–371, 482–483, 602, 880–881; Osakashi Sanjikai (1914), 107, 180–181, 546, 758–759; Kawabata (2004), 3.
Notes: Linearly interpolated: 1666–1702, 1704–1710, 1717–1718, 1720, 1723, 1726–1728, 1730–1735, 1740–1748, 1750–1755, 1860, 1863–1867.

The civilian population of the city of Osaka reached more than 300 thousand in the late seventeenth century and was between 300 thousand and 400 thousand throughout the eighteenth and nineteenth centuries. The rise in the population from the seventeenth to the early eighteenth centuries was driven by the construction of new districts, namely, the Nishi Senba and Horie. The decrease from the late eighteenth century occurred because suburban towns were growing. While growth in the nonfarm sector was led by investment and consumption by the samurai class in the seventeenth century, it was

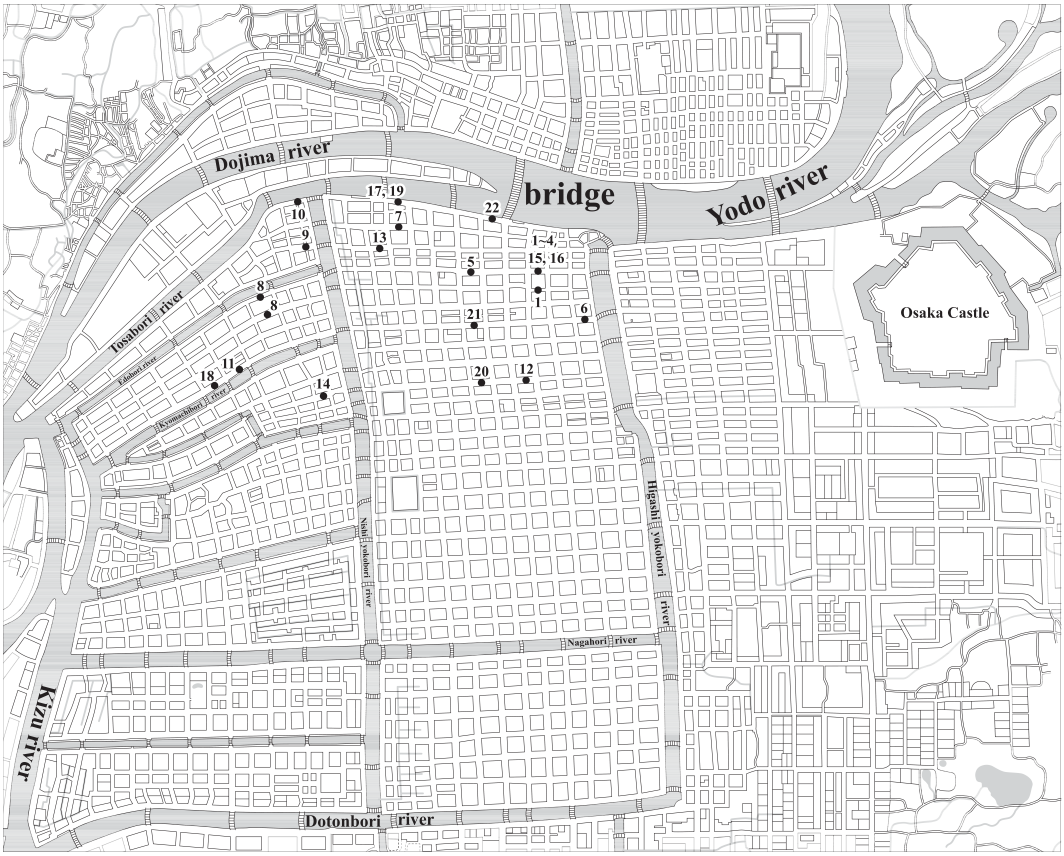
driven by production and consumption by farmers, who extended nonfarm businesses as side jobs to meet demand from farmers from the eighteenth century. Trades between farmers were clustered in suburban towns rather than in metropolises such as Osaka. In general, metropolises in early modern Japan failed to attain a perfect replacement level of fertility, and their civilian population depended on civilian population inflows from the hinterlands. As suburban towns absorbed the rural population joining the nonfarm sector, the populations of metropolises such as Osaka and Edo stagnated or shrank (Saito and Takashima (2016), 370–374; Saito and Takashima (2017), 75–86).

The relative decline of the central business district is expected to have affected the demand for tenanted properties. Thus, we control for the city's population in the estimations below.

2.2 Mitsui properties and our hypothesis

The Mitsui family operated two branches of property business in Osaka. One was Holdings (*ōmotokata*), which was in charge of investment in businesses under Mitsui. Holdings directly owned properties as part of their portfolio in Osaka, expecting rent earnings and using them as collateral when Mitsui received a contract for remittance services from the shogunate. Mitsui Holdings owned 21 properties for leasing throughout early modern times, as indicated in Figure 9.

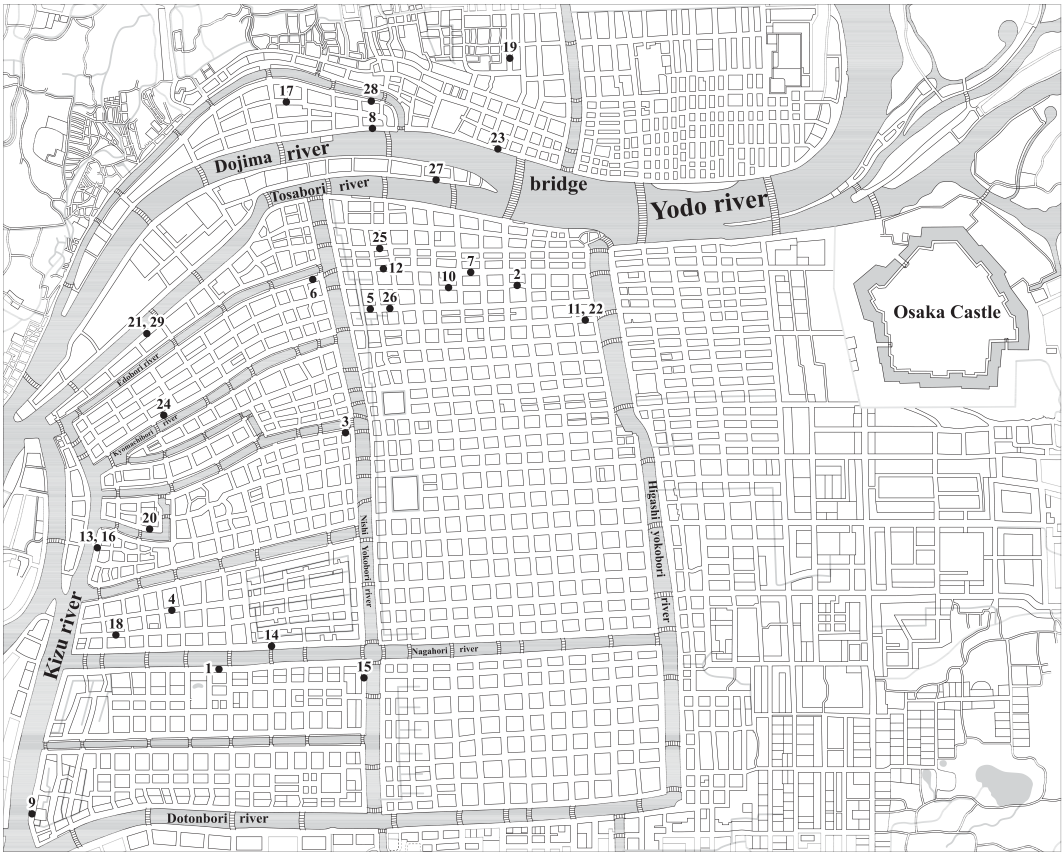
Figure 9: Properties of Mitsui Holdings.



Note: Properties 1 to 14 are included in our data for the analyses described in Section 3 below. Properties 15 to 22 are not included because information about the cost and rent is not available.

The other property business was Osaka Money Changer (*ryōgaedana*). The primary businesses of Money Changer were banking and remittance for settlement. When a house was pledged for a loan contract and the borrower failed to repay the debt, the house was foreclosed, and ownership was transferred to Money Changer. Money Changer leased the foreclosed house for rent earnings, maintained and improved it, and sold it for capital gain. Money Changer owned a total of 20 properties for leasing throughout early modern times, as indicated in Figure 10.

Figure 10: Properties of Mitsui Osaka Money Changer.



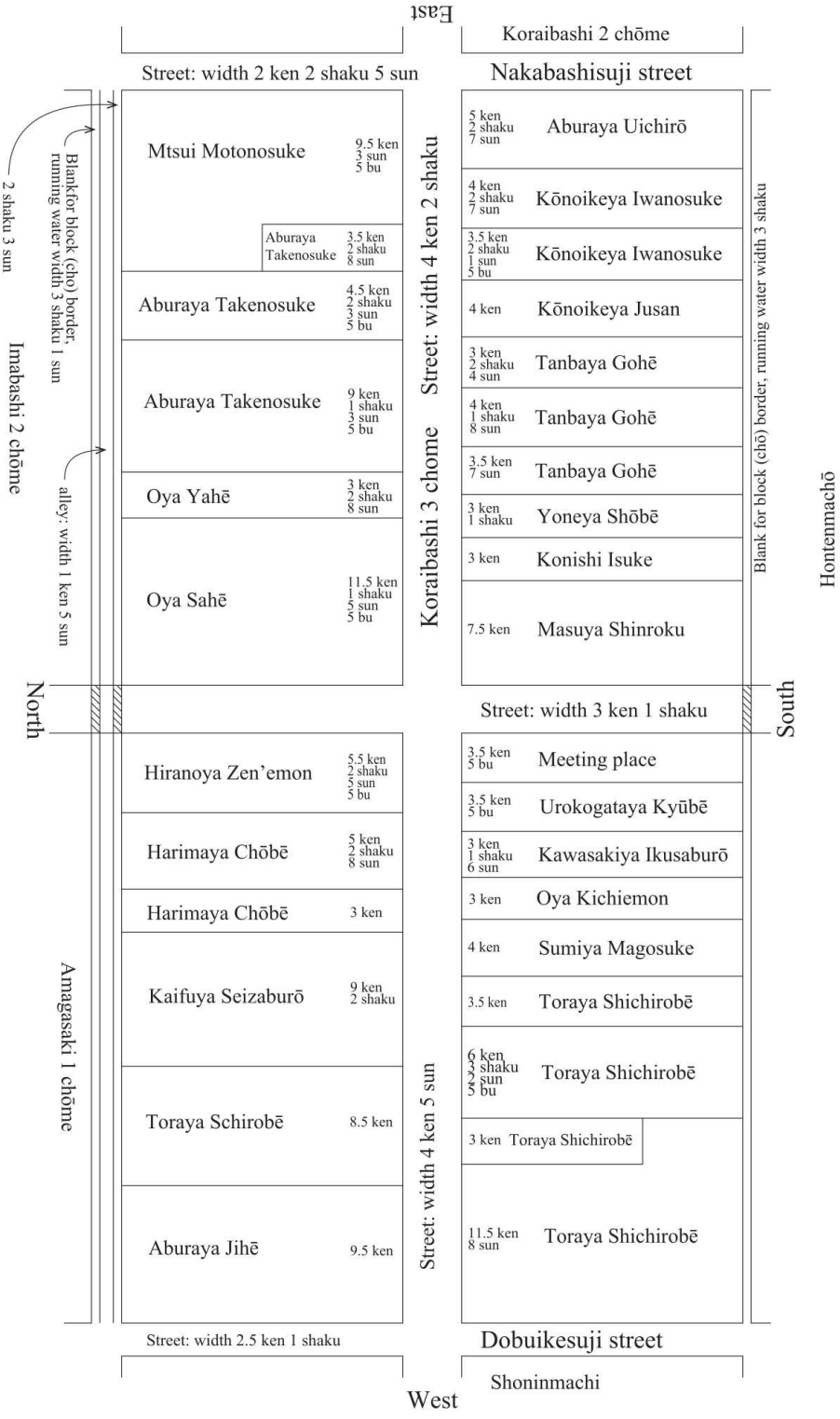
Note: Properties 1 to 22 are included in our data for the analyses described in Section 3 below. Properties 23 to 29 are not included because information about the cost and rent is not available.

The properties managed by Holdings tended to be held for a longer term than those managed by Osaka Money Changer (Mandai 2020, 36). The reason was that the properties managed by Mitsui Holdings were often pledged as collateral when Mitsui needed to raise large amounts of funds. For example, high finances for the shogunate and Lord Tokugawa of the State of Kii, where the Mitsui family's address was registered, were critical to maintaining Mitsui's businesses, such as remittance services of the shogunate tax revenue. Mitsui Holdings raised funds by pledging properties to meet demands for high finance, saving retained cash. Properties whose valuations were high and rents tended to be stable were chosen for this purpose (Mandai 2020, 81–82).

From Figures 9 and 10, we can manually measure the walking distance along the roads between each property and the closest bridge and channel. Among the geographical characteristics, we focus on the proximity to a bridge, conditional on the walking distance to the closest channel. While bridges are corners of pedestrian flows, access to channels improves water-load transportation (Oda et al. 2001, 219–222). We identify the effects of proximity to a bridge while controlling for proximity to a channel to differentiate the effects of pedestrian flows from those of convenient water-load transportation.

All the properties were one-story wooden houses or lots of land for leasing. When Mitsui leased a lot of land, either the tenant or a third party had built and owned a house. Each property included multiple rooms. Figure 11 is a trace of the original plan of property No. 5 of Mitsui Holdings in Figure 9. Property No. 5 was composed of four houses on both sides of two square streets. Each was a wooden one-story house and had several rooms; each room was leased out to a tenant. All rooms of this property faced toward a street.

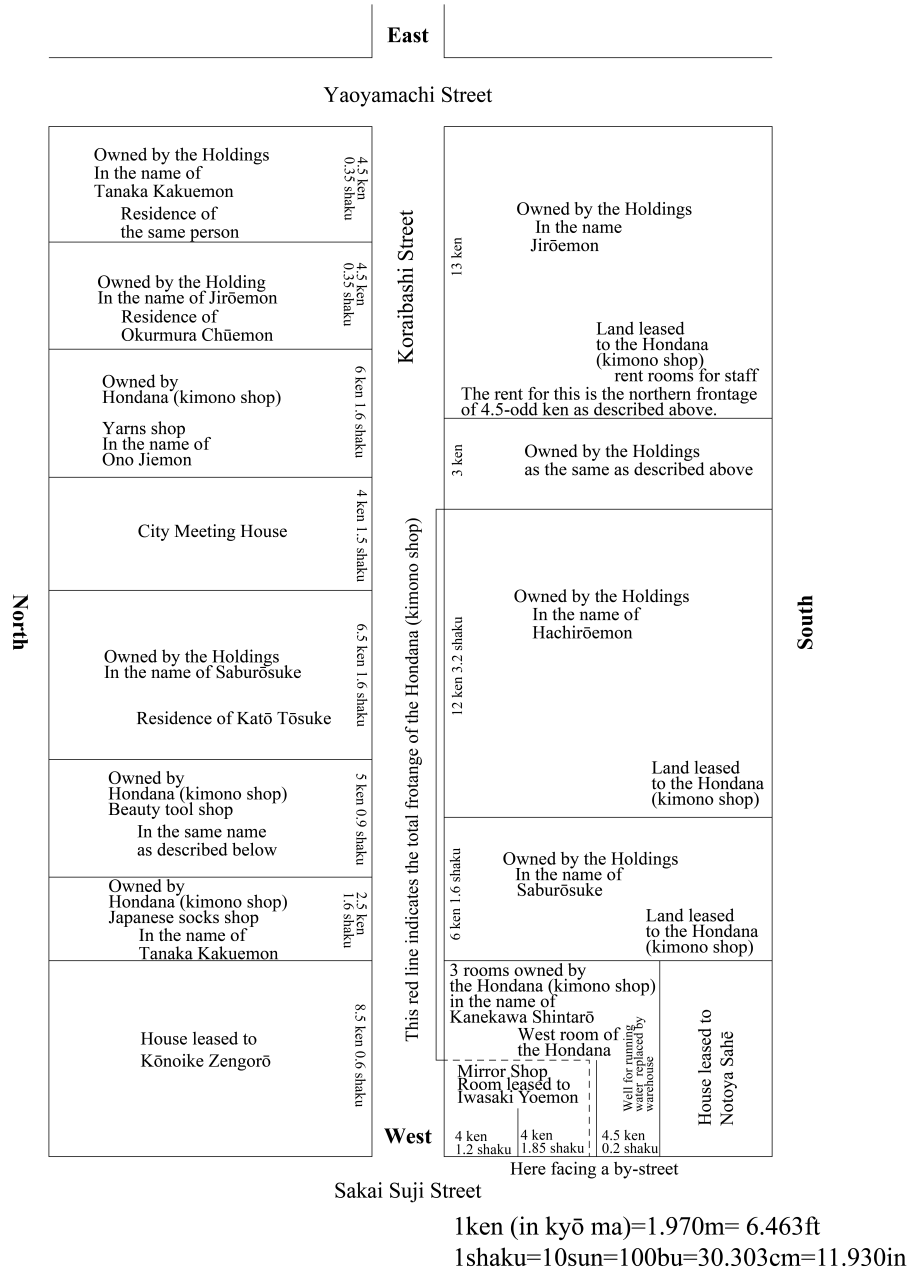
Figure 11: An example of a property: Property No. 5 of Mitsui Holdings as of 1867.



Source: Kagawa and Higuchi (1983), 237.

Figure 12 is a trace of the original plan of property No. 1 of Mitsui Holdings, whose rooms also all faced a street. This property was owned by Mitsui Holdings, and 3 rooms were rented to Mitsui's kimono store as a shop, and other rooms were rented as other stores and managers' residences of Mitsui.

Figure 12: An example of a property: Property No. 1 of Mitsui Osaka Money Changer as of 1867.



Source: Keiō san nen shigatsu jō (Records of April 1867), "Osaka iekata shoyō dome ni (Memorandum of Osaka property management, Number 2)", 1839, held by Mitsui Bunko, Document number: Betsu 1579.

Figure 13 is a perspective illustration of rooms rented to the Mitsui kimono store

(*gofukudana*) as a shop.

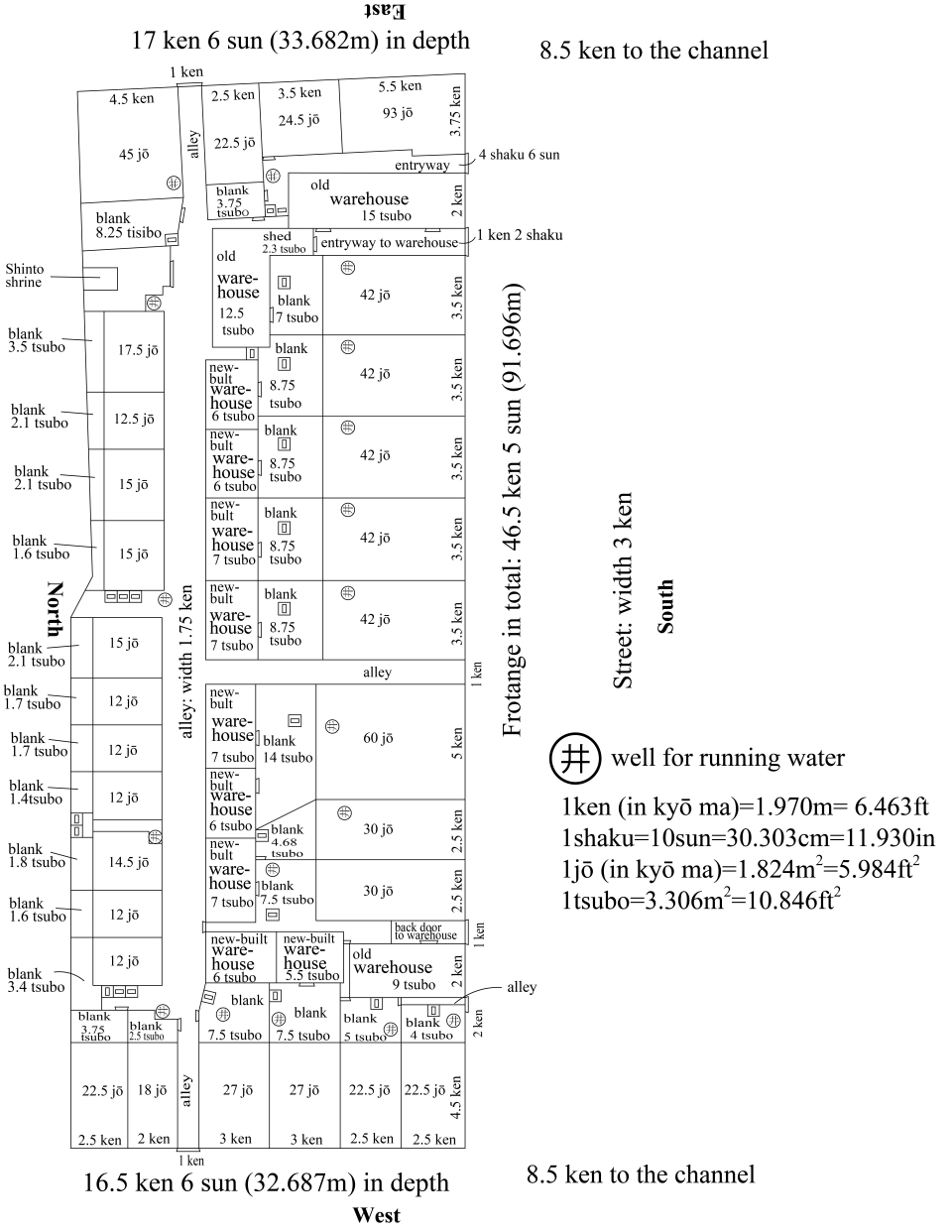
Figure 13: Mitui kimono store (*gofukudana*).



Source: Utagawa Kunikazu, "Mitsui Gofukudana (Mitsui Kimono Shop)" in Utagawa Kunikazu, Nakai Yoshitaki and Mori Yoshiyuki, *Naniwa Hyakkei (One Hundred View of Osaka)*, Osaka: Ishikawaya Yasuke, the mid-19th century. Osaka Municipal Library Digital Archives: https://image.oml.city.osaka.lg.jp/da/detail?tilcod=0000000021-OSK0166470 Accessed February 7, 2025.

Figure 14 is a trace of the original plan of property No. 14 of Money Changer in Figure 10. The property comprised a wooden one-story house that faced three streets and had rooms facing the street, warehouses, rear tenements (rooms in the backyard), and alleys to the rear tenements and warehouses in the backyard. The rooms facing the streets were rented to affluent people and businesses, and rear tenements were typically rented to less affluent residents, such as craftsmen, hawkers, and workers of other service jobs (Saito (1987), 112–113; Tani et al. (1990), 71–72)

Figure 14: An example of a property: Property No. 14 of Mitsui Osaka Money Changer as of 1810.



Source: "Nagahori Tondaya chō shin tate ezu (Plan of the new-built house at Nagahori Tondaya cho)," 1810. Document number: Betsu 1581.

Most of the properties shown in Figures 9 and 10 were originally collateral when Mitsui Osaka Money Changer made loan contracts and, when the debtors defaulted, were foreclosed and acquired by Mitsui. Before concluding a loan contract, Mitsui Osaka Money Changer implemented credit investigations. The investigations focused on applicants' businesses, personalities, and activities and the environments of the potential collateral properties (Mandai (2024a), 97–203; Mandai (2024b)).

A typical mention regarding potential collateral properties was whether the property was adjacent to a bridge (*hashizume*) and the walking distance from the closest bridge.[1] This finding is consistent with those of Watanabe (1972b,a, 1973) and Itoh (1986), who reported that corners adjacent to a bridge tended to be bustling corners. Among geographical characteristics, Mitsui Osaka Money Changer considered adjacency or proximity to a bridge a factor that affected the property's collateral value. While channels were used for transportation, bridges were corners of pedestrian flows that linked blocks on both sides of channels. Proximity to a bridge was thus supposedly associated with exposure to denser pedestrian flows. We therefore suggest the following hypothesis regarding rent and profit rate, which is profit over acquisition value of the property, as follows:

Hypothesis 1. *1. Proximity to the closest bridge was associated with the rent of leased properties, conditional on property characteristics, the walking distance to the closest channel, and the acquisition value.*

2. Proximity to the closest bridge was associated with the profit rate of the leased properties, conditional on the property characteristics and the walking distance to the closest channel.

[1] *Sources*: "*Kime chō* (Books for decisions)," Tsui 37–45, Zoku 785–786, held by the Mitsui Bunko (Archives of the Mitsui Group).

3 Data

We use the data of 36 properties owned by either Mitsui Holdings or Mitsui Osaka Money Changer. The sample period spans 1770–1871, depending on the timing of the acquisition and sale of each property (Mandai 2020, 30–39). The total number of observations is 3,150.

Our data include information about property characteristics, acquisition valuation, biannual costs, and biannual rents for each property but not for each room. Therefore, we combine the information about valuation, costs, and rents for each property with property characteristics such as whether the property had rooms facing the street, rear tenements, alleys, and warehouses, as well as walking distances to the closest bridge and the closest channel, which is measured by plotting properties in Figures 9 and 10 to Figure 7. The walking distance to the closest bridge is expected to capture the effects of access to a corner of pedestrian flow around a bridge on rents and profit rates. The walking distance to the closest channel is a variable used to measure the effects of waterload transportation on rent and profit rates. Among our samples, 41% of the total observations (the number of properties $\times$ the number of observed periods) were located in the Kita Senba district, which was the city center, and another 41% were in the Nishi Senba district, which was extended into the seventeenth century (Figures 5 and 7). To control for neighborhood characteristics, we control for whether a property was located in either the Kita Senba district or the Nishi Senba district.

Note that possible endogenous relationships between an increase in pedestrian flow and bridge construction are irrelevant to our identification strategy. Our data coverage is from the early 1770s, when the city building, including bridge construction, was completed.

On the basis of this information, we estimate equations to predict the rent per frontage, the profit rate, which is the profit over the acquisition value, and, in the Appendix Section A 1, the acquisition value per frontage. Table 1 shows descriptive

statistics of our sample. The profit is calculated as the rent revenue from which operational costs are subtracted, and the profit rate is defined as the profit divided by the acquisition value of the property.

Table 1. Descriptive statistics.

Characteristic	**N = 3,150** Mean (SD) [Maximum, Minimum]; n (%)
Value per frontage (monme/ken)	675(371)[1,599, 159]
Unknown	12
Rent per frontage (monme/ken)	18(10)[127, 0]
Profit rate	0.023(0.035)[0.410, -1.020]
Duration of possession (years)	99(43)[182, 3]
Walking distance to the closest bridge (kilometers)	
0	142 (4.5%)
0.025	784 (25%)
0.05	440 (14%)
0.075	119 (3.8%)
0.1	8 (0.3%)
0.15	297 (9.4%)
0.175	81 (2.6%)
0.2	705 (22%)
0.25	74 (2.3%)
0.3	142 (4.5%)
0.325	180 (5.7%)
0.375	59 (1.9%)
0.45	119 (3.8%)
Walking distance to the closest channel (kilometers)	
0	1,439 (46%)
0.025	295 (9.4%)
0.1	166 (5.3%)
0.15	297 (9.4%)
0.2	547 (17%)
0.25	74 (2.3%)
0.275	12 (0.4%)
0.3	261 (8.3%)
0.375	59 (1.9%)
Leased land without a house	504 (16%)
House with alleys (=1 if yes)	119 (3.8%)
Unknown	43
House with rear tenements (=1 if yes)	2,130 (69%)
Unknown	43
House with a warehouse (=1 if yes)	1,999 (63%)
House in Kita Senba (=1 if yes)	1,284 (41%)
House in Nishi Senba (=1 if yes)	1,276 (41%)
House in Dōjima (=1 if yes)	239 (7.6%)
House in Tenma (=1 if yes)	63 (2.0%)
House in Horie (=1 if yes)	288 (9.1%)

Notes: Monme is the unit of silver coins. 1 monme = 3.75 grams = 0.1322774 oz. 1 kyōma (kyoma) = 1.970 m = 6.463 ft.

4 Estimation model

We estimate the rent and profit rates by pooling the panel data. For rent, we first estimate

$$\log \text{Rent}_{i,t} = \mathbb{C} + \beta_1 D_i^{\text{bridge}} + \beta_2 D_i^{\text{channel}} + \boldsymbol{\alpha}\boldsymbol{x}_i + \boldsymbol{\gamma}\boldsymbol{z}_t + \epsilon_{i,t}, \tag{1}$$

where $\text{Rent}_{i,t}$ denotes the rent per frontage of property i in the half-year term t, D_i^{bridge} denotes the walking distance from property i to the closest bridge, and D_i^{channel} denotes the walking distance to the closest channel. $\boldsymbol{x}_i$ represents the time-invariant property characteristics of property i, whether it was leased land without a house, whether it included an alley to the backyard, rear tenements, or warehouse, whether it was located in the Kita Senba district or the Nishi Senba district, and acquisition value per frontage. As Boyle et al. (2014) argued that walkability effects are insignificant when the neighborhood is controlled, we control for locations in the Kita Senba district, the city center, and the relatively newly developed Nishi Senba district. $\boldsymbol{z}_t$ are time-variant common shocks such as the civilian population of the city of Osaka (Figure 8), interest rates (Mandai 2020, 113–132), consumer prices and gross domestic product (Nakabayashi et al. 2020). The walking distance to the closest channel is inserted to control for convenience in water-load transportation via boats. Next, we estimate

$$\log \text{Rent}_{i,t} = \mathbb{C} + \beta_1 D_i^{\text{bridge}} + \beta_2 D_i^{\text{channel}} + \boldsymbol{\alpha}\boldsymbol{x}_i + \mu_t + \epsilon_{i,t}, \tag{2}$$

which controls for the period fixed effects μ_t alternatively to $\boldsymbol{z}_t$ to control for other unknown common time variant characteristics and then examine whether the results of Equations (1) and (2) are consistent.

For the profit rate, we first estimate

$$\log \text{Profit}_{i,t} = \mathbb{C} + \beta_1 D_i^{\text{bridge}} + \beta_2 D_i^{\text{channel}} + \boldsymbol{\alpha}\boldsymbol{x}_i + \boldsymbol{\gamma}\boldsymbol{z}_t + \epsilon_{i,t}, \tag{3}$$

where $\text{Profit}_{i,t}$ denotes the profit rate of property i in the half-year term t. We next estimate

$$\log \text{Profit}_{i,t} = \mathbb{C} + \beta_1 D_i^{\text{bridge}} + \beta_2 D_i^{\text{channel}} + \boldsymbol{\alpha}\boldsymbol{x}_i + \mu_t + \epsilon_{i,t}, \tag{4}$$

which controls for the period fixed effects μ_t, and examine whether the results of Equations (3) and (4) are consistent. In Equations (3) and (4), $\boldsymbol{x}_i$ does not include the acquisition value per frontage, as it is the denominator of the dependent variable.

5 Results

Table 2 presents the results of Equation (1) in Specifications (1) to (5) and those of Equation (2) in Specification (6). While Specification (1) in Table 2 fails to reject the null hypothesis of the Breusch–Pagan test so we do not have evidence of possible estimation bias due to heteroskedasticity [2], we adopt the heteroskedasticity-robust standard errors (HC1/stata) clustered by property, deploying the *estimatr* package for R (Blair et al. 2022).

Including an alley to the backyard and warehouses, which were fireproof houses, was associated with higher rent. An alley to such warehouses was also weakly associated with higher rents. The acquisition value per frontage was positively associated with rents, as expected. Being located in the Nishi Senba district was significantly negatively associated with lower rents. The acquisition value per frontage has an insignificant coefficient Specification (5) when the location at the Nishi Senba district is controlled for because the location at the Nisihi Senmba district absorbs discounts for location at the

[2]The studentized Breusch–Pagan test: BP = 3.193, df = 2, p value = 0.20276.

newly developed district as a significantly negative coefficient of Specifications (1) and (3) in Table A1 in Section A 1 when determinants of acquisition values are estimated. Although we tried to insert a dummy variable of another newly developed district, Horie, as a control, the Horie dummy variable never had a significant coefficient, in contrast to the Nishi Senba dummy variable. It is considered because of the shogunate's zoning regulations. While "teahouses" where waitresses provided sexual services to customers were allowed to operate in the southern blocks of the Horie and Shimanouchi districts, and outside of the city border such as the Sonezaki Shinchi and Nanba Shinchi, they were not in the Nishi Senba district (Tsukada (2006); 84–105; Yoshimoto (2019), 230–238). Therefore, "teahouses" began to concentrate in southern blocks in the Horie and Shimanouchi districts in the early eighteenth century, until when the development of Horie had been completed (Sugimoto 2024, 60–61). In the Horie district, there was likely to be a downward pressure on rents due to being a newly developed district and also an upward pressure due to being amusement blocks. They supposedly canceled off each other. Mitsui did not own a property for lease in the Shimanouchi district, so we do not have evidence for the district.

The coefficient of the walking distance to the closest bridge, which is the estimate of interest, is negative from Specifications (2) to (6) and significantly negative in Specifications (5) and (6) at the 5 percent level. Hypothesis 1–1, the closer to a bridge, the higher the rent, is supported by the consistent results of Specification (5) corresponding to Equation (1) and Specification (6) corresponding to Equation (2).

The acquisition value per frontage of property tends to be greater for properties whose distance to the closest bridge was greater in Specifications (1) and (3) in Table A1 in Appendix Section A 1. This is supposedly because some premium houses were located in quiet inner blocks. Conditional on this tendency, Specifications (5) and (6) in Table 2 report that a shorter distance to a bridge was associated with higher rents.

Table 2. Results: Rent per frontage.

Dependent variable: log(Rent per frontage)						
	(1)	(2)	(3)	(4)	(5)	(6)
Walking distance to the closest bridge	0.425	−0.031	−0.487	−0.636	−1.272*	−1.128*
	(0.694)	(0.595)	(0.532)	(0.510)	(0.505)	(0.486)
Walking distance to the closest channel	−0.053	0.071	0.310	0.591	0.277	−0.143
	(0.799)	(0.682)	(0.872)	(0.865)	(0.606)	(0.560)
Land lease without a house			0.275+	0.483**	0.320*	0.103
			(0.148)	(0.167)	(0.128)	(0.130)
House with alleys			0.254	0.421**	0.319*	0.206
			(0.174)	(0.152)	(0.156)	(0.145)
House with rear tenements			−0.193	−0.043	−0.002	−0.138
			(0.138)	(0.155)	(0.074)	(0.093)
House with a warehouse			0.503***	0.576***	0.441***	0.353***
			(0.115)	(0.162)	(0.119)	(0.099)
Kita Senba					0.010	0.053
					(0.162)	(0.123)
Nishi Senba					−0.571**	−0.533**
					(0.196)	(0.165)
log(Acquisition value per frontage)		0.442***	0.402***	0.392***	0.165	0.212*
		(0.130)	(0.108)	(0.113)	(0.113)	(0.106)
log(Population)			0.471	2.789**	2.961***	
			(0.642)	(0.883)	(0.851)	
Consumer price index			0.001***	0.001	0.002	
			(0.000)	(0.002)	(0.002)	
Interest rates				2.410	1.906	
				(2.064)	(1.902)	
log(GDP)				2.158*	2.918**	
				(0.954)	(0.908)	
$\mathbb{C}$	2.659***	−0.095	−6.222	−87.905**	−106.528***	
	(0.154)	(0.816)	(7.955)	(29.130)	(28.498)	
Period fixed effects	No	No	No	No	No	Yes
Num.Obs.	3150	3138	3052	1674	1674	3107
R^2	0.006	0.159	0.366	0.367	0.496	0.555
R^2 Adj.	0.005	0.158	0.364	0.362	0.492	0.523
AIC	5949.8	5294.5	3683.1	1904.6	1525.6	2876.1
BIC	5974.0	5324.8	3749.3	1975.1	1606.9	2936.5
RMSE	0.62	0.56	0.44	0.42	0.38	0.38
Std.Errors, clustered by	property	property	property	property	property	property

Notes: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 3 presents the results of Equation (3) in Specifications (1) to (4) and those of Equation (4) in Specification (5). While Specification (1) in Table 3 fails to reject the null hypothesis of the Breusch–Pagan test[3], which indicates that we do not have evidence of bias concerns due to heteroskedasticity, we cluster standard errors by property.

[3]The studentized Breusch–Pagan test: BP = 3.3751, df = 2, p value = 0.185.

Table 3. Results: Profit rates.

Dependent variable: Profit rate					
	(1)	(2)	(3)	(4)	(5)
Walking distance to the closest bridge	−0.056**	−0.068**	−0.064**	−0.059*	−0.066**
	(0.022)	(0.024)	(0.024)	(0.027)	(0.021)
Walking distance to the closest channel	0.025	0.044	0.038	0.010	0.034
	(0.027)	(0.033)	(0.033)	(0.033)	(0.029)
Land lease without a house		0.004	0.012	0.010	0.005
		(0.007)	(0.009)	(0.010)	(0.007)
House with alleys		−0.009+	−0.007	−0.008	−0.013*
		(0.005)	(0.006)	(0.007)	(0.005)
House with rear tenements		0.000	0.002	0.006	−0.001
		(0.006)	(0.007)	(0.007)	(0.006)
House with a warehouse		0.014*	0.013*	0.011	0.013*
		(0.006)	(0.007)	(0.008)	(0.006)
Nishi Senba				−0.001	
				(0.011)	
Kita Senba				0.010	
				(0.010)	
log(Population)		0.041	−0.012	−0.020	
		(0.034)	(0.041)	(0.041)	
Consumer price index		0.000	0.000	0.000	
		(0.000)	(0.000)	(0.000)	
Interest rates			0.125	0.128	
			(0.096)	(0.094)	
log(GDP)			−0.075	−0.071	
			(0.062)	(0.066)	
$\mathbb{C}$	0.029***	−0.502	1.966	1.960	
	(0.005)	(0.436)	(1.866)	(1.962)	
Period fixed effects	No	No	No	No	Yes
Num.Obs.	3150	3052	1674	1674	3107
R^2	0.020	0.086	0.081	0.095	0.136
R^2 Adj.	0.020	0.083	0.075	0.088	0.074
AIC	−12 275.5	−13 564.4	−7625.7	−7647.5	−12 517.1
BIC	−12 251.3	−13 504.2	−7560.6	−7571.5	−12 474.8
RMSE	0.03	0.03	0.02	0.02	0.03
Std.Errors, clustered by	property	property	property	property	property

Notes: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

The coefficient of the walking distance to the closest bridge is significantly negative across Specifications (1) to (4), which correspond to Equation (3), and in Specification (5), which corresponds to Equation (4), which is consistent. The closer to a bridge, the higher the profit rates are, which supports Hypothesis 1–2. Given the insignificant coefficients of the walking distance to the closest channel, the higher profitability was not attributable to neither access to water-load transportation nor access to water in the case of a fire. Higher profitability was hence significantly associated with proximity

to a bridge, regardless of property type and distance to a channel.

In summary, Table 2 supports Hypothesis 1–1 regarding the positive association between rents and proximity to a bridge in consistently Specification (5) for Equation (1) and Specification (6) for Equation (2). Table 3 demonstrates that Hypothesis 1–2 on the positive association between profit rates and proximity to a bridge is supported consistently across Specifications (1) to (4) for Equation (3) and in Specification (5) for Equation (4).

6 Robustness check

As a robustness check of the result for rent by Specification (6) in Table 2 and that for profitability by Specification (5) in Table 3, we deploy a semiparametric estimate, the R-Learner algorithm (Robinson 1988, Nie and Wager 2021), with a focus on β_1 in Equations (2) and (4), as follows.

1. Predict the independent variable, namely, the walking distance to the closest bridge $\widehat{D^{\text{bridge}}}$, using characteristics taken for the specification to be tested and the SuperLearner algorithm (Polley et al. 2021), in which we specify "SL.lm" (OLS) and "SL.ranger" (random forest) with cross-validation as 2 folds.

2. Predict the dependent characteristics, namely, the rent, $\widehat{\text{Rent}}$/the profit rate, $\widehat{\text{Profit}}$, using the aforementioned variables via the SuperLearner algorithm, specifying "SL.lm" and "L.ranger" with cross-validation as 2 folds.

3. Regress the residuals of the dependent variable, $(\text{Rent}_{i,t} - \widehat{\text{Rent}})/(\text{Profit}_{i,t} - \widehat{\text{Profit}})$, on the residual of the independent variable, $(D_i^{\text{bridge}} - \widehat{D^{\text{bridge}}})$, by means of simple OLS specifications.

The procedure tests whether the significant coefficients of D^{bridge} in Specification (6) of Table 2 and Specification (5) in Table 3 depend on specific Equations (2) and (4),

namely, whether they are delivered as a result of overfitting of Equations (2) and (4).

To test Specification (6) of Table 2, we predict rent per frontage $\widehat{\text{Rent}}$ using the walking distance to the closest bridge, walking distance to the closest channel, whether the property was leased land without a house, whether it had alleys, whether it had rear tenements, whether it had a warehouse, whether it was located in the Kita Senba district, whether it was located in the Nishi Senba district, the acquisition value per frontage in the logarithmic term, and period, and predict the walking distance to the closest bridge, $\widehat{D^{\text{bridge}}}$, using the same characteristics except for the walking distance to the closest bridge D^{bridge} itself. We then regress the residual of rent per frontage, $\text{Rent}_{i,t} - \widehat{\text{Rent}}$, on the residual of the walking distance to the closest bridge, $D_i^{\text{bridge}} - \widehat{D^{\text{bridge}}}$. Table 4 presents the results. The estimate is significant at the 1 percent level.

Table 4. Robinson estimate: Rent per frontage.

Dependent variable: $\text{Rent}_{i,t} - \widehat{\text{Rent}}$	(1)
$D_i^{\text{bridge}} - \widehat{D^{\text{bridge}}}$	−3.582**
	(1.251)
Num.Obs.	2771
R^2	0.004
R^2 Adj.	0.004
AIC	1648.2
BIC	1660.1
RMSE	0.33

Notes: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

To test Specification (5) of Table 3, we predict the profit rate, $\widehat{\text{Profit}}$, using the walking distance to the closest bridge, walking distance to the closest channel, whether the property was leased land without a house, whether it had alleys, whether it had rear tenements, whether it had a warehouse, and period, and predict the walking distance to the closest bridge D^{bridge} using the same characteristics other than D^{bridge} itself. We then regress the residual of the profit rate, $\text{Profit}_{i,t} - \widehat{\text{Profit}}$, on the residual of the walking distance to the closest bridge, $D_i^{\text{bridge}} - \widehat{D^{\text{bridge}}}$. Table 5 presents the results.

Table 5. Robinson estimate: Profit rate.

Dependent variable: $\text{Profit}_{i,t} - \widehat{\text{Profit}}$	(1)
$D_i^{\text{bridge}} - \widehat{D^{\text{bridge}}}$	−0.090***
	(0.013)
Num.Obs.	2771
R2	0.005
R2 Adj.	0.005
AIC	−10 676.9
BIC	−10 665.0
RMSE	0.04

Notes: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

The estimate is significant at the 0.1 percent level.

The significant results in Tables 4 and 5 indicate that the significantly positive associations between rent and proximity to a bridge in Specification (6) of Table 2 and between the profit rate and proximity to a bridge in Specification (5) of Table 3 are unlikely to be driven by parametric specifications.

7 An anecdote: Gentrification and the risk of fire.

To better understand determinants of rent and profitability, let us introduce a gentrification project of Mitsui Holdings property No. 11 in Figure 9. As shown in Figure 9, Mitsui Holdings property No. 11 was close to a bridge; hence, according to our prediction, its potential profitability was high.

Indeed, Mitsui's management planned a reconstruction of this property in 1813 to improve profitability. The property manager requested approval from Holdings, predicting improvement in profitability, as follows.[4]

> ..., while this is quite an old house, and so minor repairs have been handled and they have been rented out as much as possible, it has suffered a lot,

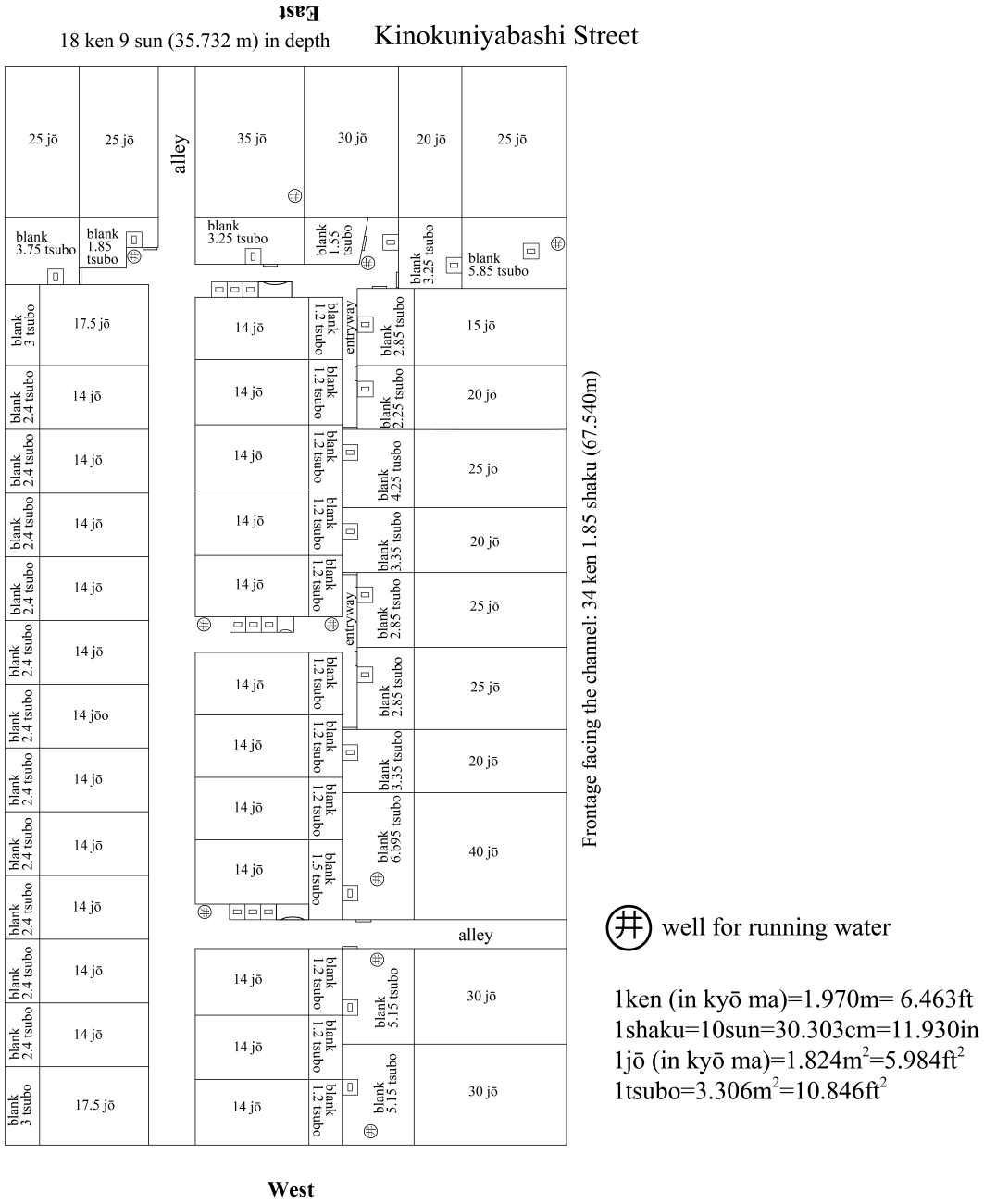
[4]"Bunka 10 nen 4 gatsu jō (On April 1813)," in "Osaka iekata shoyō dome ichi (Memorandum of Osaka property management, Number 1), held by the Mitsui Bunko, Betsu–1578.

> wooden pillars have been rotten to decomposition, and it has become so dangerous that there are rooms that are hard to live inside the property, once it has come to this, it is difficult to repair it, and because this is an old house, tenants have been those whose identities are not qualified, there are many poor people, and naturally they tend to fail to pay rents, and troubles never stop, and so the manager feels difficulty in managing it; although repairs have been discussed by the municipality since it is a large house, renovation could be so costly, and so we have left it as it is an old house, but now, we cannot leave it as it is anymore; if further troubles occur, it would be hard to deal with the municipality; therefore, we estimate the cost for construction as presented in an accompanying sheet; this time, if we newly construct both rooms facing the street and rear tenements, tenants' identities would improve, and we would extend each rear tenement to the boundary and reduce the number of rooms; unsurprisingly, better tenants would be found.

In short, in property No. 11 of Mitsui Holdings as of 1813, many impoverished tenants often failed to pay rent and indulged in quarrels. The suggested plan was to construct a new house, replace the incumbent poor residents, and accommodate new tenants whose identities were qualified and whose incomes were higher; thus, this was a gentrification plan for a block of downtown Osaka in the early nineteenth century to displace poor and trouble-making residents and to house higher-qualified tenants.

The proposal was approved by Mitsui Holdings, and the reconstruction project was completed in 1814. The plan of the new house of property No. 11 of Mitsui Holdings is presented in Figure 15.

Figure 15: An example of a property: Property No. 11 of Mitsui Holdings as of 1814.



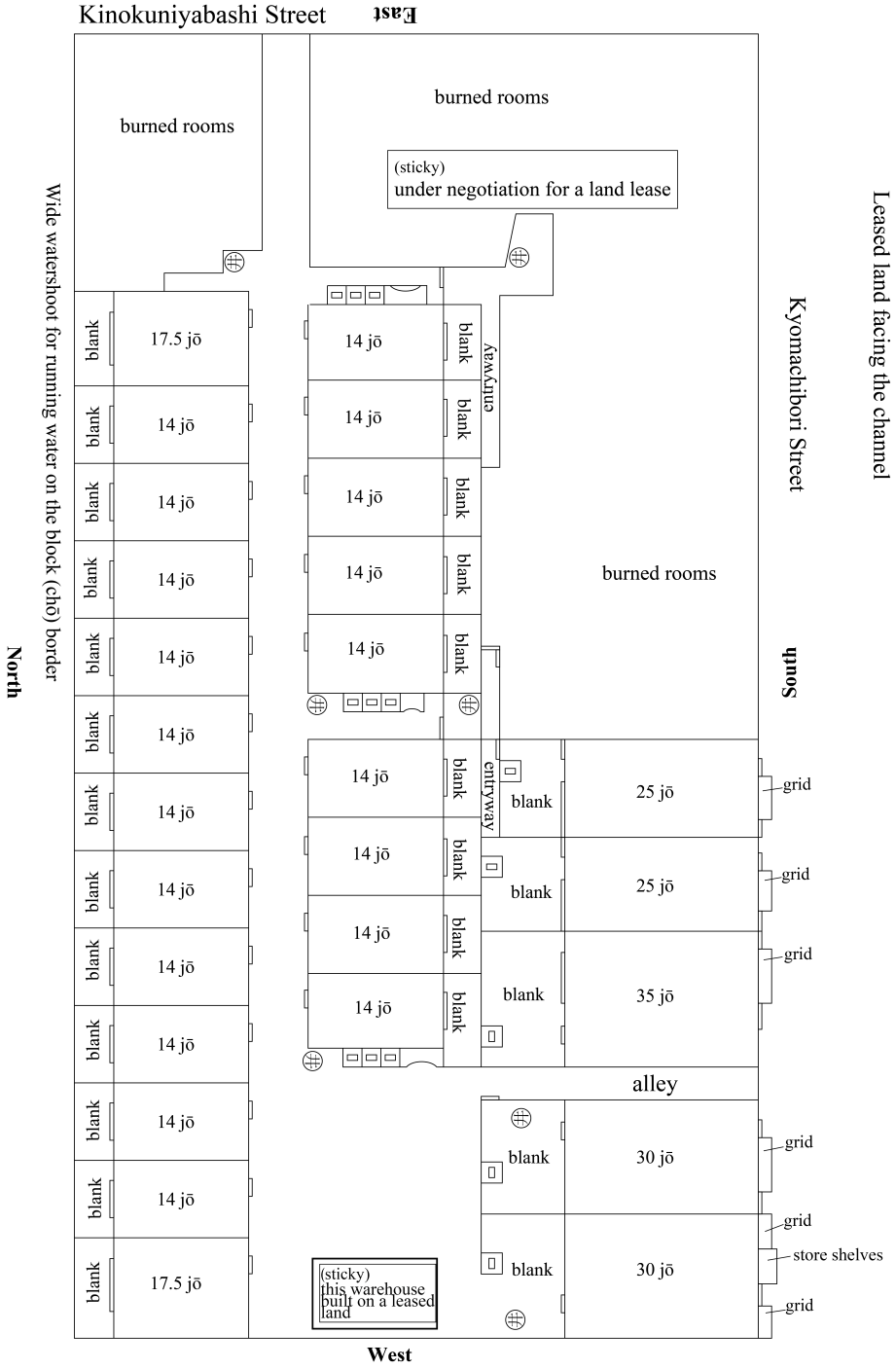
Source: "Bunka 11 nen kanoe inu 2 gatsu shin date Kyōmachibori 4 chōme shakuya ezu Osaka iekata (Figure of the newly built rent house at Kyomachibori 4 chome: Osaka House Manager)," February 1814. Document number: Zoku 1526–9–1.

However, early modern Japanese cities composed of wooden houses were always at

risk of fire. The city of Osaka experienced several massive fires during early modern times. In 1724, 59.9% of the city burned; in 1792, 9.6% of the city burned; in 1838, 13.1% of the city burned; in 1846, 3.5% of the city burned; in 1852, 1.5% of the city burned; and in 1865, 16.3% of the city burned (Kawabata et al. 2004, 5).

Later, the southeastern part of the property burned, as presented in Figure 16.

Figure 16: An example of a property: Property No. 11 of Mitsui Holdings as of 1852.



Source: "Kyōmachibori kakaeyashiki zumen (Figure of the Kyomachibori rent house)," October 1852. Document number: Zoku 1646–5–2.

8 Conclusion

On the basis of Hypothesis 1, we tested whether proximity to a bridge was associated with the property's rent (Hypothesis 1–1) and whether proximity to a bridge was associated with the property's profitability (Hypothesis 1–2). Both Hypotheses 1–1 and 1–2 were supported, as shown in Tables 2 and 3, by the data of properties in Osaka owned by Mitsui Holdings and Mitsui Osaka Money Changer. Since bridges were corners of pedestrian flow, we interpret the results as indicating that properties near bustling corners around bridges earned higher rents and were more profitable to lease out. The results are likely to be robust against estimate specifications, as shown in Tables 4 and 5.

This historical urban economics study of an early modern city has profound implications for the revitalization of centers of major cities in advanced economies. Major cities in advanced economies were mostly structured in early modern times when they were planned or rezoned and when pedestrians dominated. The hollowing of city centers occurred as motorization interrupted or eliminated pedestrian flows. A recovery of walkability to revitalize city centers is thus unambiguously a rediscovery of early modern urban economies depending on pedestrian customers and residents. Put directly, as major cities recover pedestrian flow on the structures formed in early modern times, they will be revitalized like those in early modern times.

Table A1. Results: Acquisition value per frontage.

Dependent variable: log(Acquisition value per frontage)				
	(1)	(2)	(3)	(4)
Walking distance to the closest bridge	1.104*	0.069	1.294*	0.360
	(0.523)	(0.918)	(0.590)	(0.792)
Walking distance to the closest channel	−0.163	−1.160	−1.302	−1.608
	(0.979)	(1.358)	(1.102)	(1.239)
Land lease without a house			−0.103	−0.255
			(0.315)	(0.289)
House with alleys			1.142***	0.857***
			(0.169)	(0.253)
House with rear tenements			−0.439*	−0.286
			(0.202)	(0.195)
House with a warehouse			−0.091	−0.226
			(0.161)	(0.148)
Kita Senba		0.146		0.049
		(0.354)		(0.302)
Nishi Senba		−0.606+		−0.581*
		(0.313)		(0.287)
$\mathbb{C}$	6.226***	6.654***	6.636***	7.029***
	(0.149)	(0.316)	(0.226)	(0.348)
Num.Obs.	3138	3138	3107	3107
R^2	0.046	0.290	0.252	0.407
R^2 Adj.	0.046	0.289	0.251	0.405
AIC	5042.2	4120.3	4263.2	3545.9
BIC	5066.4	4156.7	4311.5	3606.3
RMSE	0.54	0.47	0.48	0.43
Std.Errors, clustered by	property	property	property	property

Notes: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

A 1 Appendix

In this section, we estimate

$$\log \text{Value}_i = \mathbb{C} + \beta_1 D_i^{\text{bridge}} + \beta_2 D_i^{\text{channel}} + \boldsymbol{\alpha} \boldsymbol{x}_i + \boldsymbol{\gamma} \boldsymbol{z}_t + \epsilon_{i,t}, \tag{A1}$$

where Value_i denotes the acquisition value per frontage of property i, which is constant over period t, for reference. Table A1 presents the estimation results of equation (A1). In Specifications (1) and (3), $\beta_1 > 0$; that is, the more distant the property is, the higher the valuation. The result is robust when controlling for property characteristics and the walking distance to the closest channel. The results arguably suggest that quiet inner blocks were highly valued.

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