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Kazunobu HAYAKAWA* and
Kenmei TSUBOTA*

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Abstract

This study empirically investigates the effect of highways on retail prices of butter in Japan. We take into account the relocation of butter producers because of the development of highways. We found that highway construction increased transportation speed, but the average transportation time from the production site also increased dramatically due to the increase in transportation distance. The latter factor occurred because of the concentration of butter factories in limited regions. As a result, on average, the increase in transportation time during 1966–1980 raised the price of butter by 3.3%. While the increase in speed reduced the price by 2%, the increase in transportation distance increased it by 5.3%.

Keywords: Highways, Japan, Transportation Time
JEL classification: D04; H43; R42

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* Research fellow, Economic Geography Studies Group, Development Studies Center, Institute of Developing Economies, Japan External Trade Organization.
Correspondence: Kazunobu HAYAKAWA, kazunobu_hayakawa@ide.go.jp

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INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

The Impact of Highways on Commodity Prices: The Price of Butter in Japan[†]

Kazunobu HAYAKAWA[#] Kenmei TSUBOTA

Development Studies Center, Institute of Developing Economies, Japan

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1. Introduction

It is natural to assume that highways increase the speed of transportation by road. However, they do not necessarily decrease transportation time and cost. New highway construction may increase both the time and the cost of transporting goods. This contradiction is caused by the relocation of production factories that may be encouraged by the development of highways. Before the establishment of highways, factories were located in almost every region. The development of highways may result in concentrating production sites in one region and then distributing goods from that region to all regions. The transportation distance from a factory would therefore increase in most of the regions. If the increase in distance outweighs the increase in the speed of transporting goods, the total transportation time and cost will increase. Empirical literature has paid little attention to the possibility that infrastructure development may increase transportation time and cost.

This study empirically investigates the effect of highway construction on retail prices in Japan. The first section of Japanese highways opened in 1963. After that, many sections

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[#] Corresponding author: Kazunobu Hayakawa; Address: Wakaba 3-2-2, Mihama-ku, Chiba-shi, Chiba, 261-8545, Japan. Tel: 81-43-299-9500; Fax: 81-43-299-9724; E-mail: kazunobu_hayakawa@ide-gsm.org.

were rapidly constructed. There were 1,000 km of highway in 1973, 2,000 km in 1976, and 3,000 km in 1982. In 1991, the number had reached 5,000 km. During this period, the main mode of freight transportation changed from railways to trucks due to highway development. The construction of the highway might induce the production concentration, resulting in not only the decrease of producer prices through economies of scale but also the increase in the transportation time and cost. If the latter effect is large relative to the former effect, the highway construction might increase retail prices. It is important to investigate such an effect on retail prices because expansion of the gap between producer and retail prices prevents the realization of the law of one price (LOP) within a country.

We examined the difference in retail prices of butter across 46 cities in Japan during 1966–1980. Butter has some characteristics that make it ideal for our empirical analysis. The first is low import penetration. In 1962, 1970, and 1980, it was around 1%. Almost all butter consumed in Japan was produced domestically. Therefore, it was not necessary to consider the effects of butter imports on the domestic retail price of butter. Second, the location of a butter factory is likely to be affected by highways because butter requires careful management to ensure its freshness, and it is important to save transportation time. Thus, due to the increase in distance traveled over time created by the development of highways, butter factories tended to agglomerate in a limited number of regions. Indeed, in 1960, out of 46 prefectures, butter factories existed in 41 prefectures, consisting almost all prefectures in Japan. By 1980, on the other hand, the number of prefectures with butter factories had decreased to 28. Among them, only six prefectures were significant producers of butter (i.e., they had more than two factories).

In summary, a look at the measure of the σ-convergence in butter prices across cities revealed an increase of the average price gap during the study period. Second, as is consistent with our expectation, while the transportation speed rose, the average transportation time from the production site increased due to the dramatic increase in transportation distance. Third, we found that the increase in transportation time significantly raised the retail price of butter. Specifically, our instrumental variable (IV) method showed that a 1% increase in time raised the price by nearly 0.1%. This result implies that, on average, the increase in transportation time during 1966–1980 raised the price of butter by 3.3%. While the increase in speed decreased the price by 2%, the increase in transportation distance raised it by 5.3%. The construction of highways may lower the producer price of butter by encouraging the geographical concentration of production, but the net effect of highways on the retail price still remains unknown. At the very least, the effect of the transportation costs is found to raise the retail price.

This study contributes to at least two major bodies of literature. One is the literature on the LOP. There are many studies that investigate price deviation and convergence across countries or cities within a country. The examples include Engel and Rogers (2001), Goldberg and Verboven (2005), Andrabi and Kuehlwein (2010), Huang et al. (2012), Giri (2012), Hegwood and Nath (2013), Crucini et al. (2010, 2015), and Elberg (2016). By employing mainly macro-econometrics techniques, most of the studies in this literature examined whether prices converged or diverged, i.e., the existence of price convergence and how fast prices reacted to external shocks. In particular, Andrabi and Kuehlwein (2010) examined how infrastructure development affects the differences in prices across regions. They found that the construction of railways contributed slightly to the price convergence in the British Indian grain market. Similar to the study by Andrabi and Kuehlwein, we examined the impact of highways on the commodity price. However, we shed light on the price divergence effect of infrastructure development by taking into consideration the relocation of production factories.

The other body of literature is on the economic effects of infrastructures. Several studies recently investigated the impacts of various infrastructures, e.g., highways or railways, on economic variables at the municipality or firm level. Unlike the traditional studies on infrastructures, these recent studies uncovered the causal impacts of infrastructures. The examples include Ahlfeldt and Feddersen (2018), Donaldson (2018), Donaldson and Ghani et al. (2014), Hornbeck (2016), Faber (2014), Lin (2017), Mayer and Trevien (2017), Holl (2016), and Baum-Snow et al. (2017). These studies used a quasi-natural experiment or instruments to investigate the causal impacts of infrastructures on the economic variables. For example, Ghani et al. (2014) examined whether highways raised manufacturing firms' productivity in India and showed that the overall output increased from initial values by 49% in the average district located near a highway network. In this paper, we addressed this endogeneity issue by using the availability of materials for butter, i.e., raw milk, as an instrument. We then examined the price divergence effect of highways.

The rest of this paper is organized as follows. Section 2 discusses the background of the butter industry in Japan. Section 3 empirically examines how the transportation time for butter delivery from production site to consumers changed over time. In Section 4, we empirically investigate how the rise of transportation time affects the retail price of butter. Section 5 concludes this paper.

2. Background

In this section, we discuss highway development, the rationale for the choice of the product, butter, and its market structure in Japan. Then we discuss some theoretical predictions based on the relationship between transportation costs and the location of firms.

2.1. Highway Development in Japan

Express highways were planned in Japan in 1943, but they never came into being. Just after the end of the war, the road conditions were difficult, and the share of paved roads was only 1.2% of the total length of 0.89 million km. As the Japanese economy recovered substantially in the following decades, the number of cars and trucks increased rapidly.[1] Consequently, the need for roads for freight and passenger transportation increased substantially. However, the fiscal burden of highway construction was heavy. Such construction became possible through the introduction of a highway toll system, the conversion of the fuel tax into a tax for road construction, and a World Bank loan.[2]

Figure 1 shows the development of highway networks in 1970 and 1980. The first highway in Japan was completed in 1963 between Hyogo Prefecture (Amagasaki) and Shiga Prefecture (Ritto) through Osaka and Kyoto. In 1965, the routes between Aichi (Nagoya) and Osaka were connected.[3] In 1969, the highway between Tokyo and Nagoya was completed. In 1970, a highway connected the two largest cities in Japan, Tokyo and Osaka. In the 1970s, the highway networks were expanded to the local areas, including the Tohoku area (the northeastern part of Japan including Miyagi and Iwate) and Kyushu Island. As a result, the length of highways totaled 1,000 km in 1973, 2,000 km in 1976, and 3,000 km in 1982.

Insert Figure 1 Here

2.2. The Butter Industry in Japan

The main focus of this paper is the price change of goods through production concentration driven by transportation cost reduction and economies of scale. In order to highlight the production concentration due to the expansion of highway networks, we chose goods for which transportation is characterized by difficulties in keeping the products fresh and invulnerable to physical shocks and volatile temperatures. The production locations of these goods are sensitive to the availability of fast transportation modes, i.e., highways. Such perishable products include vegetables, meats, poultry, seafood, and dairy products. Among these, the most perishable products are raw milk and fresh meats. Therefore, dairy products processed from them would also be time sensitive in terms of delivery. We chose butter for our empirical analysis in this paper.

Butter production involves several steps. Raw milk is separated into raw cream and raw skim milk.[4] The raw cream is then pasteurized and further processed through aging, churning, and draining. Moreover, additional processing (e.g., washing, salting, or working)

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[1] According to automobile registration statistics, the number of vehicles (in millions) was 0.14 in 1945, 1.5 in 1955, 8.1 in 1965, and 29.1 in 1975. In 1950, the share of trucks was about 67.6%. As it became popular to own a private car, the share of trucks dropped to around 22.3% in 1980.

[2] For details, see *Editorial Committee for Fifty years' History of Express Highways* (2016).

[3] Names in parentheses indicate the names of cities.

[4] An available proxy figure of raw milk production is the number of milk cows from the *Statistical Survey on Livestock*. As Hokkaido has large farm fields, the share was about 25% in 1965 and 36% in 1980. The second largest milk-producing region is Kanto (Greater Tokyo) at 25% at 1965 and 21% in 1980. All other regions are around 3% to 9%.

can enhance preservation and consistency. The investment in machinery and facilities is considerable. In addition, a long transportation distance may increase the risk of damaging butter products through physical shocks and unstable temperatures. While normal butter softens at around 15°C, the average temperature can be above 15°C in many parts of Japan from late April to early November.[5] Thus, fast transportation in refrigerated trucks is necessary to deliver butter from the production location to consumers.

Due to the increased distance per time (e.g., kilometers/hour) through the development of highways, the butter factories tended to be agglomerated in a limited number of regions. Indeed, in 1960, out of 46 prefectures, butter factories existed in 41 prefectures. In 1980, on the other hand, the number of prefectures with butter factories had decreased to 28. Among them, only six prefectures had significant butter production (i.e., they had more than two factories), namely, Hokkaido, Iwate, Miyagi, Tokyo, Okayama, and Kagoshima. The changing distribution of butter factories and the size of production followed one of two trends: (1) near to large consumption markets (e.g., Tokyo, Miyagi, or Okayama) or (2) near to farming areas (e.g., Hokkaido or Iwate). Interestingly, there is an absence of large production plants in Central Japan around Aichi, which is the third-largest metropolitan area and is situated between two large markets, Tokyo and Osaka. As the first highway linked Aichi to Osaka and a subsequent highway linked Aichi to Tokyo, the accessibility of Aichi improved significantly. Thus, Central Japan is a typical example of a region being served by other regions due to better accessibility.

Firm-level changes were also followed. In Japan, there were three major brands of butter, Yukijirushi (27%), Meiji (19%), and Morinaga (11%). These accounted for about 57% of the total number of factories as in 1964.[6] While the number of factories decreased from 81 in 1964 to 41 in 1979, the market percentage of the major producers remained stable. As such, major producers operate multiple factories. With the exception of one firm operating three factories, nonmajor producers operated only one or two factories. There were 33 firms in 1964, and 15 firms remained in 1979, including 3 new entrants. All of the firms that exited the market were nonmajor producers. Among the three major producers, the concentration phenomenon was observed; there were 81 factories in 1964 and 41 in 1979, of which 52 were closed, 12 were newly established, and the rest were maintained. In terms of regional coverage of major producers, among the seven metropolitan areas that are the major consumption markets,[7] the number of metropolitan areas where plants were located within

[5] According to *Consumer's Behavior Survey*, the share of families that had refrigerators was 2.8% in 1957, 51.4% in 1965, and 96.7% in 1975. Similarly, a refrigerator car plays a key role in transporting butter. In Japan, the first refrigerator car appeared in the 1900s.

[6] The data on the number of factories is obtained from the *Yearbook of the Japanese Dairy Products Association*. The data was constructed from the list of butter producers inside and outside the association membership, which should cover most of the prominent producers.

[7] They are Sapporo (Hokkaido), Sendai (Miyagi), Kanto (Tokyo), Chukyo (Aichi), Kinki (Osaka), Hiroshima (Hiroshima), and Fukuoka (Fukuoka), where the name in parentheses indicates the name of the prefecture. This classification was defined in the *New Comprehensive National Development Plan* in 1969.

the prefecture or in neighboring prefectures was six for Yukijirushi, five for Meiji, and three for Morinaga. For the nonmajor producers, their locations varied across prefectures.

2.3. Theoretical Background

The market situation for butter is characterized by multiplant production and transportation costs. The interaction between transportation costs and firm organization is known as the proximity concentration trade-off in international trade literature. The early works on this subject include Krugman (1991), Markusen (1984), Markusen and Venables (2000), Ekholm and Forslid (2001), and Behrens and Picard (2007). In most models, exporting from a single plant (i.e., a single country) to other countries requires incurring trade costs, while operating multiple plants (i.e., supplying domestically from each country) can avoid trade costs but must incur fixed costs for operating an additional plant. Comparing these two costs, trade costs to export and additional fixed costs, firms choose their organization and location. When trade costs are high, firms operate multiple plants. As trade costs decrease, firms choose to concentrate their production in order to exploit economies of scale. Similar results were also obtained when introducing firm heterogeneity in terms of productivity into the models (e.g., Helpman et al., 2004; Grossman, Helpman, and Szeidl, 2006).

Production concentration may result in the rise of consumer prices in the country where all plants are closed. For simplicity, suppose there are no trade costs for intra-country transactions. When trade costs are high and plants exist in a country, goods are supplied domestically without incurring any trade costs, and their consumer prices are simply the factory-gate prices (if markets are segmented). On the other hand, when trade costs are low and all plants are closed in a country, goods are exported from another country where plants exist by paying trade costs. Therefore, consumer prices become the sum of trade costs and the factory-gate prices of the goods produced in the exporting country. If countries are symmetric, it is obvious that consumer prices rise because factory-gate prices are the same regardless of production countries. If there are wage gaps among countries and the production concentrates in the low-cost country, the factory-gate prices of the goods can possibly decrease. However, if the wage gaps are relatively small and the reduction of the factory-gate prices by the relocation is not large enough compared with trade costs, the consumer prices in that country will rise.

Applying this discussion to the context of butter in Japan, it can be shown that the development of highways induced production concentration of butter factories. As found in Section 2.2, several prefectures lost butter factories. The total transportation costs rose when delivering butter from the factories to those prefectures because the supply base was moved. Such an increase in transportation costs was likely to raise the consumer prices of butter in those prefectures because we are considering the intra-national distribution of factories; thus, the wage gap was small across prefectures. If a large number of prefectures lose their butter factories, highway development may result in an increase in the average transportation costs from the production base to consumption sites in Japan.

3. Change in the Average Transportation Time

This section empirically examines how the transportation time to deliver butter from a production base to each prefecture in Japan changed. We first identified the location of butter factories using the *Census of Manufacture* compiled by the Ministry of International Trade and Industry. The census reports the number of butter factories in each prefecture. We defined prefectures with butter factories as those that have more than two factories. The transportation time was computed from the capital city of a prefecture to the capital city of the prefecture with butter factories that is nearest to that city. We assumed that butter is always supplied from the nearest factory in terms of transportation time.

The transportation time was computed with the National Integrated Transport Analysis System developed by the Ministry of Land, Infrastructure, Transport, and Tourism. This system enabled us to identify an optimal route between two points in Japan in terms of transportation time. Such routes can be identified for passengers and for freight separately, based on the availability of roads, railways, seaports, and airports in each year. According to this system, the construction of highways naturally reduces the time per distance. We calculated the minimum transportation time in all combinations of prefecture capital cities for freight by road and sea only. Based on these times, we identified the shortest transportation time from the prefecture with the butter production facility to each city.

We examined the average transportation time between all prefecture capital cities in Japan for 1966, 1971, 1976, and 1980. We focused on 46 prefectures but did not include Okinawa Prefecture because the United States governed it until 1972. One issue was that a different approach to computing transportation time was necessary when the prefecture being supplied is the same prefecture that produces a significant amount of butter (i.e., it had more than two butter factories). We could not compute within-prefecture transportation time with this approach because it simply becomes zero. There are some possible remedies to address this issue. In this paper, we used the shortest time among all combinations of prefecture capital cities for each year as the within-prefecture transportation time.

Figure 2 shows the average transportation time, distance, and travel speed from the nearest province with butter production. Speed was computed by dividing the distance by the time. Each variable was rescaled to have the value of 1 in 1966. Figure 2 indicates that transportation time did not change in the 1960s but increased dramatically in the 1970s. It also shows that due to the construction of highways, the average transportation speed gradually increased. Thus, consistent with the change in transportation distance, the reason for the increase in transportation time is the increase in transportation distance. The average transportation time increased because the transportation distance increased proportionately more than the speed. The increase in transportation distance was driven by the concentration of butter production sites. Indeed, the number of prefectures with butter factories decreased from 13 in 1966 to 11 in 1971 and to 6 in 1976.

Insert Figure 2 Here

4. Impacts of Transportation Time on Consumer Prices

In Section 3, we found an increase in transportation time in delivering butter to consumers. In this section, we empirically investigate how this increase in transportation time affects the consumer price of butter. After explaining our empirical framework, we report our estimation results.

4.1. Empirical Framework

The retail price (*RPrice*) is assumed to be a function of transportation time (*Time*) and producer price (*PPrice*). The estimation was conducted at the city-year level. However, our data included only one city per prefecture, and that city was the capital city of each prefecture. Furthermore, we identified producer prices at the prefecture level. Thus, our analysis is equivalent to the analysis at the prefecture-year level. Our estimation equation for city i in year t is specified as follows:

$$\ln RPrice_{it} = \alpha_1 \ln Time_{it} + \alpha_2 \ln PPrice_{it} + \mathbf{X}_{it}\boldsymbol{\beta} + \epsilon_{it} \quad (1)$$

$\mathbf{X}$ includes some control variables. ϵ_{it} denotes an error term. $PPrice_{it}$ and $Time_{it}$ are constructed based on the nearest prefecture with butter factories identified in Section 3. $PPrice_{it}$ is defined as the producer price in a province with butter factories in year t and nearest to city i. Similarly, $Time_{it}$ is defined as the transportation time from such a province to city i. The increases in both producer price and transportation time will result in a higher retail price.

We controlled for some elements that may affect the retail price. To control for demand size, we introduced regional GDP (RGDP) for the prefecture where city i is located. The geographical level at which the demand size should be measured is controversial. The use of demand size at the city level might underestimate the true demand size that affects the price at city i if the demand size in neighboring cities also affects the price. In this paper, partly due to data availability, we used the prefecture-level GRDP. We also introduced a *Sea* dummy variable, which takes the value of 1 if the product needs to be transported by sea in order to be delivered from the nearest prefecture to city i in year t and is 0 otherwise. This variable captures the difference across transportation modes. We also introduced city fixed effects and a time trend term.

We obtained the data on the retail price of butter at the city level from the “Report on the Retail Price Survey for Twenty Years,” compiled by the Statistics Bureau, Prime Minister’s Office, Japan. Originally, this dataset provided commodity price data from 1961 to 1980. In this report, there are 66 cities. As of 1961, there were 46 prefectures, meaning that some prefectures had multiple cities in the dataset. Some cities were not listed for all years, so for consistency across years and prefectures, we focused on the price in the capital city of each prefecture. The survey in each year was conducted in two steps for each city. First, regions within the city were stratified. Second, representative shops were selected to be visited. Then the prices of the specified products were collected by surveyors.

The data on the producer prices of butter were obtained from the Census of Manufacture compiled by the Ministry of International Trade and Industry. We computed the unit price of butter by dividing butter manufacturers’ total sales of butter by the quantity sold at a prefecture level. This price indicated the factory-gate price. One issue was that these figures were not disclosed after 1965 if a prefecture had only one or two factories although we could identify the number of factories even in such a case. Therefore, as in Section 3, we defined prefectures with butter production as those with more than two butter factories. In contrast, the data on the number of factories were not available before 1965. Therefore, for the consistency of the definition of the prefectures with butter production across years, we focused on the period after 1965. Our study years are 1966, 1971, 1976, and 1980. By using the data on transportation time, we calculated the unit price of butter in the province nearest to each city in terms of transportation time. In addition, the data on GRDP were drawn from the website of the Cabinet Office.

Figure 3 depicts the evolution of σ-convergence in the retail price of butter. It is defined as the standard deviation of logged butter prices among cities and is taken as a measure of price dispersion. The figure shows that the butter price diverged across cities from 1966 to 1971. Then σ-convergence then slightly decreased but kept a high divergence level in 1980 compared with that in 1966. In short, from 1966 to 1980, which is the period when highways were constructed in Japan, the butter price diverged across cities.

Insert Figure 3 Here

4.2. Empirical Results

Table 1 shows the results of Equation 1 by the ordinary least squares (OLS) method. All standard errors are clustered by cities. Column (I) shows the result of the equation, not including the GRDP and the *Sea* dummy. Transportation time indicated an insignificant coefficient, and producer price had a significant positive coefficient. For producer prices, a 1% rise in producer price raised the retail price by 0.06%. The transportation time coefficient became significantly positive when we controlled for GRDP and *Sea* dummy, as is shown in column (II). A 1% increase in transportation time raised the retail price by 0.03%. The coefficients for GRDP and *Sea* dummy were estimated to be significantly positive and negative, respectively. Thus, the retail price becomes higher in the prefectures with larger demand sizes or when butter is delivered by road and by sea.

Insert Table 1 Here

The results of some robustness checks are also reported in Table 1. In columns (III) and (IV), we used the retail price of butter in the nearest prefecture with butter production (*CPrice*) instead of the factory-gate price for the producer price. The difference between the factory-gate price and the retail price includes not only the intra-prefecture transportation costs but also the difference in the production process of butter products. Since *CPrice* indicates only the price of finished butter products as in the case of *RPrice*, the difference between the two prices would show only the costs of delivery between the two prefectures. The coefficients for this variable are positively significant and indicate a value near 1. Although the coefficient for GRDP is insignificant, the results in transportation time and *Sea* dummy are again significant. In columns (V) and (VI), we used *CPrice* to exclude cities where the nearest prefecture with butter production is the prefecture in which they are located. These cities were excluded because such cities have the same value for the dependent variable and *CPrice*. The results do not change qualitatively. The transportation time has a significantly negative impact on the retail price.

Next, we addressed the endogeneity issue in our empirical framework. First, both the retail and producer price of butter may follow a similar business cycle. For example, poor-quality raw milk may lower both prices. This creates a positive correlation between the error term and the producer price, yielding an upward bias and overestimating the coefficient for the producer price. To address this omitted variable bias, we used *CPrice* as the producer price and moved it to the left-hand side of the equation by setting the value of 1 as its coefficient. Therefore, the dependent variable becomes a proxy for inter-prefecture transportation costs. As a result, we estimated Equation 2.

$$\ln RPrice_{it} - \ln CPrice_{it} = \alpha_1 \ln Time_{it} + \mathbf{X}_{it}\boldsymbol{\beta} + \epsilon_{it} \qquad (2)$$

Because the coefficients for *CPrice* are estimated to be approximately 1 in Table 1, although they suffer from endogeneity bias, we still interpret the coefficient for transportation time as roughly indicating the elasticity of the retail price. The estimation results are shown in columns (I) and (II) in Table 2 and show that the coefficients for transportation time are again estimated to be significantly positive. The results are similar to the results in columns (IV) and (VI) in Table 1.

Insert Table 2 Here

Second, a transportation time variable may also be an endogenous variable. For example, the higher costs for inter-prefecture transportation may induce the relocation of a butter factory, lowering the transportation time. This simultaneity yields the negative correlation between the error term and the transportation time and, thus, underestimates the positive coefficient for the transportation time. To address this bias, we estimated Equation 2 by the IV method. The instrument was the amount of raw milk used daily for products in prefecture i and its interaction term with the time trend term. We used the availability of the material for making butter because the material-abundant prefecture is expected to attract more nearby butter manufacturers and, thus, to have a shorter transportation time. Moreover, because this relationship could change over time through the construction of highways, we introduced the interaction term with a time trend.

In our empirical framework, the amount of raw milk available will have an influence on the retail price of butter only by affecting the location of the butter factory and, therefore, the transportation time. For example, if the amount of raw milk is larger in the prefectures with the larger demand, those prefectures have not only the higher butter price but also the larger amount of raw milk. However, because our model includes GRDP as a proxy for the demand size, this path does not violate the exclusion restriction. The data on raw milk are drawn from the "Milk and Milk Products Statistics" compiled by the Ministry of Agriculture, Forestry, and Fisheries.

The IV estimation results are reported in columns (III) and (IV). Both columns show that the under-identification test is rejected as found in the Kleibergen–Paap rk LM statistic. Thus, the rank condition is satisfied, and the equation is identified. Moreover, Hansen J statistics show a rather small value, and thus the overidentification test is not rejected in both columns, providing no evidence of misspecification. On the other hand, in column (III), the Kleibergen–Paap rk Wald F statistic shows a small value, indicating that our IV estimates may suffer from bias due to weak instruments. Because the F statistics in column (IV) show the higher value close to 10 (Staiger & Stock, 1997), we preferred the result in this column although the coefficient results are very similar between the two columns. The transportation time coefficient is significantly positive. As expected, its magnitude increases dramatically. Thus, the estimates by the OLS are underestimated. The IV results indicate that a 1% increase in transportation time increases the retail price by 0.075%.

The more intuitive illustration of the effect of transportation time on price is provided by using the estimates in transportation time in columns (II) and (IV) in Table 2. To this end, we first decomposed $\ln Time_{it}$ into the logs of transportation distance and speed. Second, we calculated their respective means in 1966 and 1980. Last, we multiplied the estimates in transportation time by the difference between the two means. Those log differences in transportation distance and speed were 0.7114 and 0.2694, respectively. The resulting numbers indicate how much the increase in transportation distance and speed during 1966–

1980 contributed to changing the price of butter. These numbers are reported in Figure 4. The results based on the IV estimation—column (IV) in Table 2—shows that, on average, the increase in transportation distance raised the butter price by 5.3%, while the increase in speed gained through the construction of highways lowered the butter price by 2.0%. The net increase in total transportation time increased the price of butter by 3.3%.

Insert Figure 4 Here

5. Concluding Remarks

In this study, we empirically investigated the effects of highways on the retail prices of butter in Japan. In particular, we took into account the relocation of producers due to the development of highways. We found that highway construction increased the transportation speed, while the average transportation time from the production site also increased due to the dramatic increase in transportation distance. Transportation time increased because of the concentration of butter factories in a limited number of regions. As a result, on average, the increase in transportation time during 1966–1980 raised the butter price by 3.3%. While the increase in speed reduced the price by 2%, the increase in transportation distance raised it by 5.3%. The total effect of highways on the retail price should be evaluated by considering the changes in transportation cost and producer prices. We did not examine the effect of highways on the producer prices; therefore, the total effect still remains unknown. However, the effect caused by transportation costs was found to increase the retail price of butter.

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Table 1. Baseline Results by the OLS Method

	(I)	(II)	(III)	(IV)	(V)	(VI)
ln Time	0.02	0.028*	0.011***	0.012***	0.025**	0.027**
	[0.017]	[0.016]	[0.004]	[0.005]	[0.012]	[0.012]
ln PPrice	0.061***	0.060***				
	[0.009]	[0.008]				
ln CPrice			0.984***	0.978***	0.968***	0.959***
			[0.024]	[0.025]	[0.033]	[0.034]
ln GRDP		0.159***		0.029		0.039*
		[0.049]		[0.018]		[0.022]
Sea dummy		-0.135***		-0.019*		-0.022*
		[0.029]		[0.011]		[0.012]
Prod. = Cons.	Included	Included	Included	Included	Excluded	Excluded
R-squared (Within)	0.910	0.914	0.993	0.993	0.991	0.991
Number of obs.	184	184	184	184	148	148

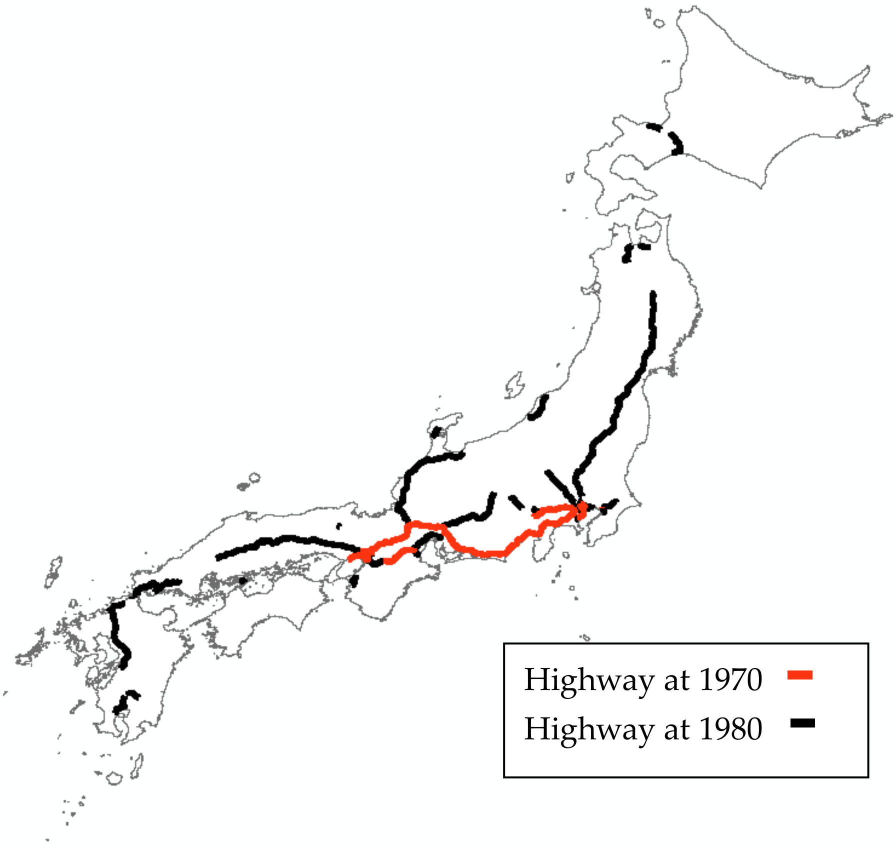
Notes: The dependent variable is a log of the retail price of butter. ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Standard error is clustered by cities and indicated in parentheses. All specifications were controlled for city fixed effects and time trends. In columns (V) and (VI), cities that were located in a prefecture ("Cons.") with butter production ("Prod.") were excluded.

Table 2. Extended Models

	(I)	(II)	(III)	(IV)
ln Time	0.011**	0.022**	0.075*	0.075**
	[0.004]	[0.011]	[0.042]	[0.033]
ln GRDP	0.027	0.034*	0.041*	0.041*
	[0.017]	[0.020]	[0.023]	[0.022]
Sea dummy	-0.016	-0.016	-0.058	-0.017**
	[0.011]	[0.012]	[0.045]	[0.007]
Method	OLS	OLS	IV	IV
Prod. = Cons.	Included	Excluded	Included	Excluded
Kleibergen-Paap rk LM statistic			6.162	9.354
Kleibergen-Paap rk Wald F statistic			3.907	9.811
Hansen J statistic			0.168	0.233
R-squared (Within)	0.048	0.060		
Number of observations	184	148	184	148

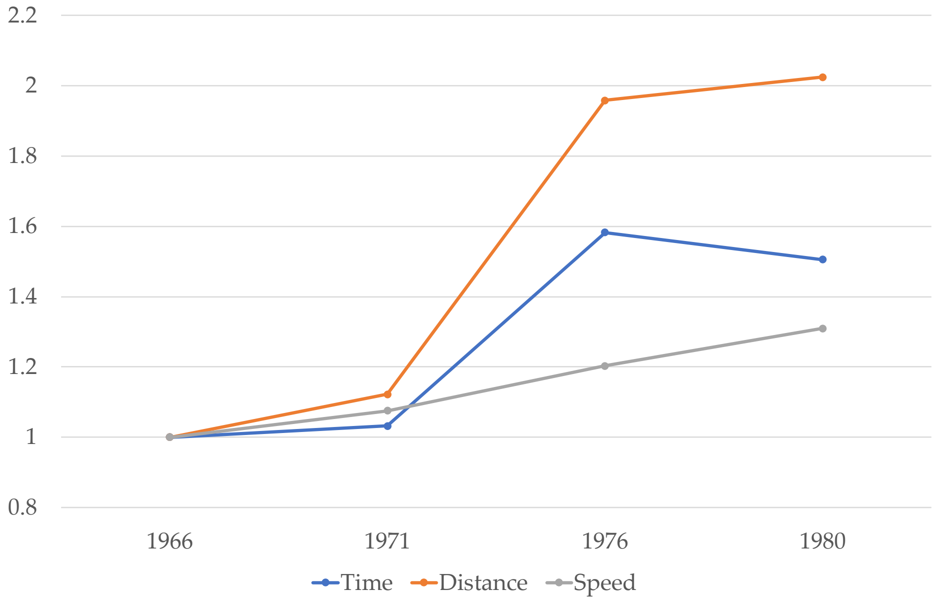
Notes: The dependent variable is the log difference between the retail prices in a designated city and the nearest prefecture with butter production. ***, **, and * indicate 1%, 5%, and 10% significance, respectively. Standard error is clustered by cities and included in parentheses. All specifications were controlled for city fixed effects and time trends. In columns (II) and (IV), we excluded cities that were located in a prefecture ("Cons.") with butter production ("Prod.").

Figure 1. Highway Networks in Japan in 1970 and 1980



Source: Authors' compilation using National Land Numerical Information Expressway Time-Series Data.

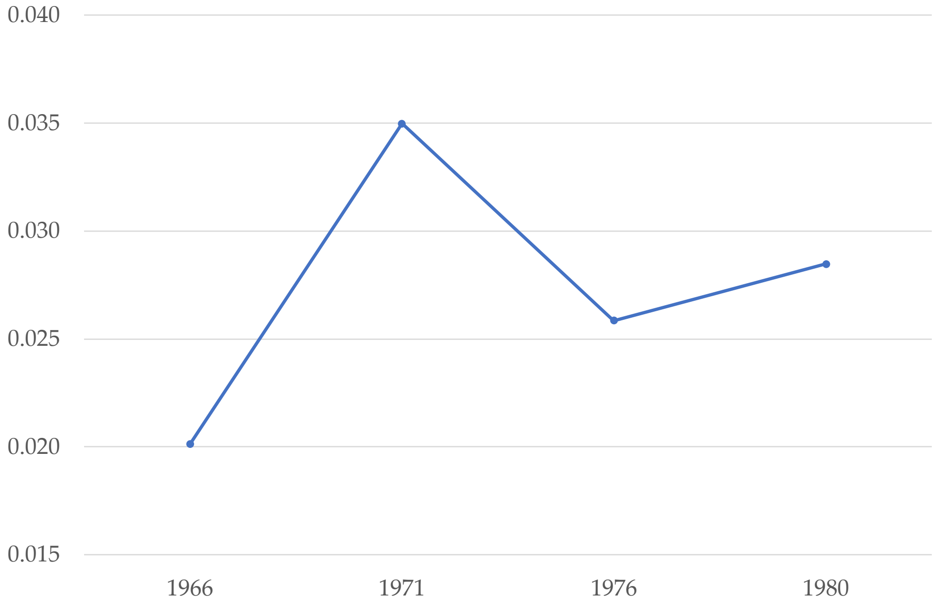
Figure 2. Evolution of Time, Distance, and Speed in Butter Transportation



Source: Authors' compilation.

Note: This figure shows the average transportation time, distance, and speed from the nearest province with butter production. Each variable is rescaled to have the value of 1 in 1966.

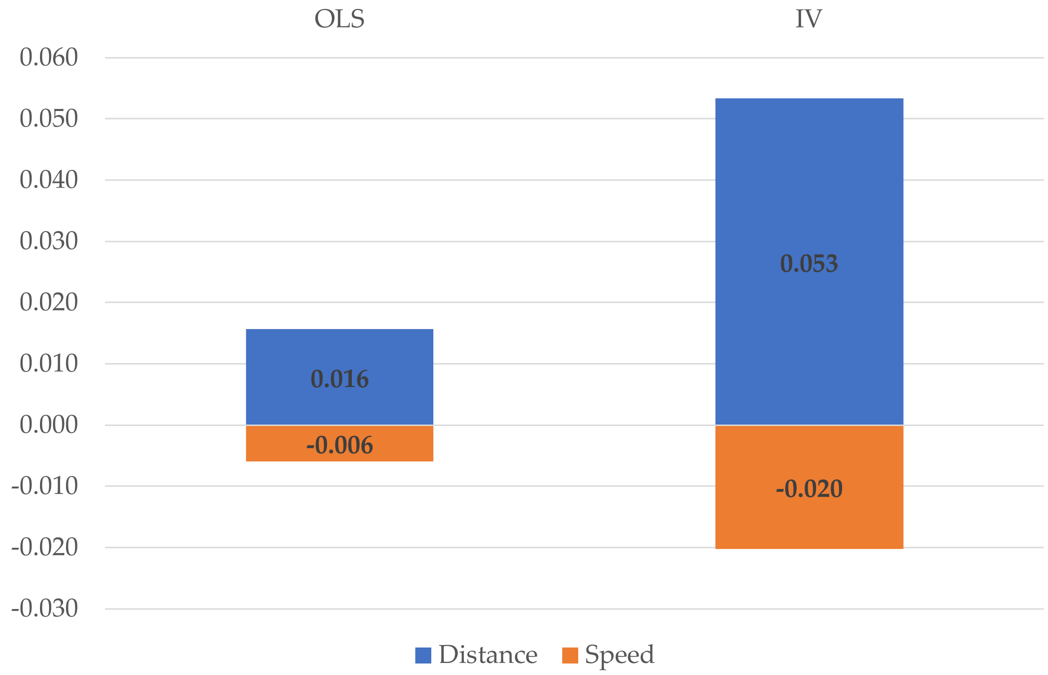
Figure 3. The Evolution of σ-convergence in the Retail Price of Butter



Source: Authors' compilation using the "Report on the Retail Price Survey for Twenty Years," compiled by the Statistics Bureau, Prime Minister's Office, Japan.

Note: This figure shows the evolution of the standard deviation of logged butter prices among cities.

Figure 4. Impacts of the Changes in Distance and Speed on Butter Prices during 1966–1980



Source: Authors' compilation.

Notes: This figure shows, on average, how much the increases in transportation distance and speed during 1966–1980 contributed to raising the price of butter.