Impacts of Highways on Commodity Prices: Evidence from Japan

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Abstract: In this study, we empirically investigate the effect of highways on retail prices of butter in Japan. In particular, we take into account the relocation of producers through the development of highways. We found that the construction of highways raised the transportation speed while the average transportation time from production site increased by the dramatic increase in transportation distance. The latter occurred 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%. Out of that, while the rise in speed decreased the price by 2%, the increase in transportation distance raised it by 5.3%. These results imply that at least in the butter market, the reallocation of production site may increase producer surplus while the rise of retail prices will worsen consumer welfare.

Keywords: Highways, Japan, Transportation Time

JEL Classification: D04; H43; R42

1. Introduction

The development of highways may *increase* the time and cost to transport goods. It is natural to suppose that highways increase the speed of transportation by road. However, it does not necessarily mean to decrease the transportation time and cost. This puzzling is because the development of highways may stimulate the relocation of production factories. For example, suppose that, before the establishment of highways, factories located in each of all regions. The development of highways may result in concentrating production site in one region and then distributing goods from that region to all regions. In this example, the transportation distance from a factory would increase in most of the regions. If the increase of distance overweighs the rise of speed, the total transportation time and cost result in increasing. The empirical literature has paid little attention to this possibility that the development of infrastructure increases the transportation time and cost.

This study empirically investigates the effect of highways on retail prices in Japan. The first section in Japan's highways opened in 1963. Afterward, many sections were rapidly constructed. The length of highways became 1,000 kilometers in 1973, 2,000 kilometers in 1976, 3,000 kilometers in 1982. In 1991, it reached 5,000 kilometers. In Japan, due to such

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development of highways, the main freight transportation mode changed from railways to trucks during this period. If transportation time increases through the production concentration as argued above, the increase in transportation costs raises the retail prices. It is important to investigate such an effect on retail prices due to at least two reasons. One is that the expansion of the gap between the producer and retail prices results in preventing the realization of "law of one price (LOP)" within a country. The other is that the rise of retail prices, i.e., consumer prices, results in worsening consumers' welfare. Namely, the establishment of highways may be bad for consumers at least in terms of prices.

Specifically, we examine the difference in retail prices of butter across 46 cities in Japan during 1966-1980. Butter has some ideal characteristics in our empirical analysis. The first is the low import penetration. In 1962, 1970, and 1980, it is around 1%. Almost all of the butter consumed in Japan are the one produced domestically. Therefore, we do not need to consider the effects of butter imports on the domestic retail price of butter. Second, the location of the butter factory is likely to be affected by highways because butter requires to carefully manage freshness and to save transportation time. Thus, due to the increase of distance per time by the development of highways, butter factory tended to be agglomerated in a limited number of regions. Indeed, in 1960, out of 46 prefectures, the butter factory existed in 41 prefectures, namely in almost all prefectures in Japan. In 1980, on the other hand, the number of prefectures with butter factories decreased to 28. Among them, only six prefectures kept significant production of butter (i.e., more than two factories).

Our findings can be summarized as follows. First, taking a look at the measure of so-called "σ-convergence" in butter prices across cities, we observed the increase of price gap on average during our sample period. Second, as is consistent with our expectation, while the speed rose, the average transportation time from production site increased by the dramatic increase in transportation distance. Third, we found that the increase in transportation time significantly raises the retail price of butter. Specifically, our instrumental variable (IV) method shows that a 1% increase in time raises the price by near 0.1%. This result implies that, on average, the increase in transportation time during 1966-1980 raised the butter price by 3.3%. Out of that, while the rise in speed decreased the price by 2%, the increase in transportation distance raised it by 5.3%. This result has a strong implication on welfare. At least in the butter market, the reallocation of production site may increase producer surplus while the rise of retail prices will worsen consumer welfare. Namely, once we take into account the relocation of producers, the development of infrastructures may have negative effects on consumers.

This study contributes to at least two large bodies of literature. One is the literature on the LOP. There are many studies that investigate the 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 the 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 the prices react to external shocks. In particular, Andrabi and Kuehlwein (2010) examine how infrastructure development affects the differences in prices across regions. They found that the construction of railways contributed slightly to the price convergence in British Indian grain market. Similar to this study, we examine the role of highways on the commodity price. However, we shed light on the price divergence effect of infrastructure development by taking into consideration the reallocation of production factories.

The other is the growing literature on the economic effects of infrastructures. Several studies recently investigate the impacts of infrastructures, e.g., highways or railways, on economic variables at the municipality- or firm-level. In particular, unlike the traditional studies in infrastructures, these recent studies uncover 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 use a quasi-natural experiment or instruments to investigate the causal impacts of infrastructures on the economic variables. For example, Ghani et al. (2014) examined if highways raised manufacturing firms' productivity in India and showed overall output increased from initial values by 49% in the average district located near the highway networks. In this paper, we address this endogeneity issue by using the availability of materials for butter, i.e., raw milk, as an instrument. Then, we examine 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 transportation time changes over time in delivering butter from production site to consumers. In Section 4, we empirically investigate how the rise of transportation time affects the retail price of butter. Section 5 concludes on this paper.

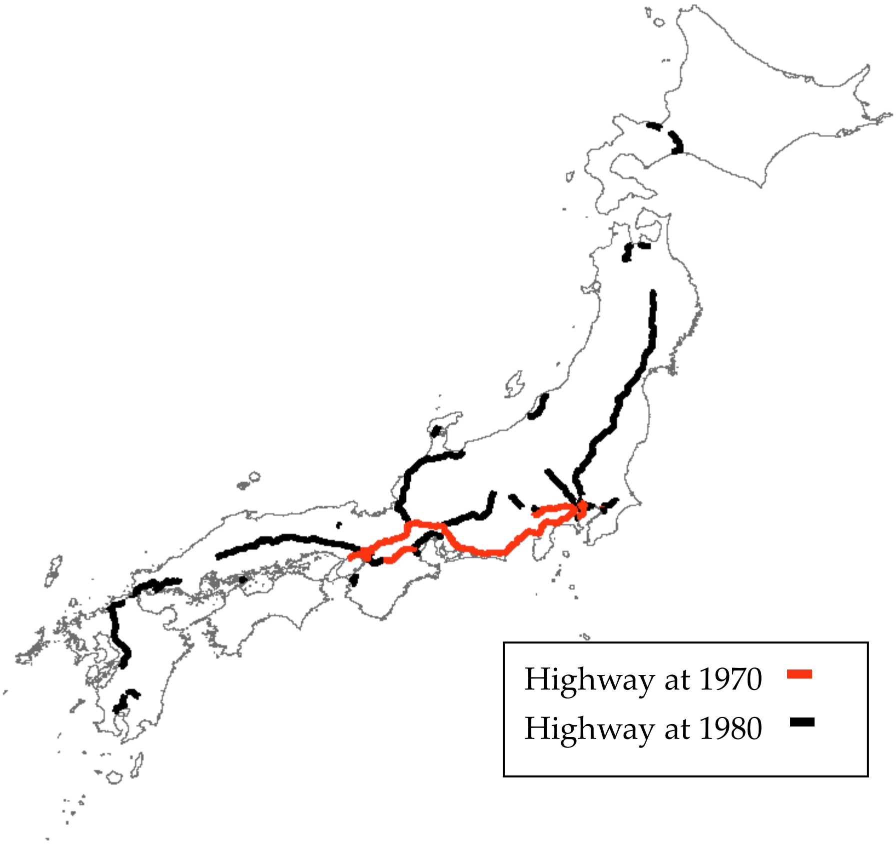
2. Background

In this section, we firstly overview the developments of the highway and discuss the rationale of the choice of the product, butter, and its market structure in Japan. Then we discuss some theoretical prediction on the relationship between transportation costs and location of firms.

2.1. Development of Highways in Japan

The plan of express highway in Japan was made in 1943 but never became into force. Just after the end of the war, the road condition was disruptive, and the share of the paved road was only 1.2% in the total length of 0.89 million km. As the recovery of the Japanese economy made substantial progress in the following decades, the number of cars and trucks increased rapidly about ten times and further increased.[1] Consequently, the needs of roads for freight and passenger transportation had increased substantially. However, the fiscal burden for the construction of the highway was heavy. It became possible by introducing a toll system for highway, converting fuel tax as purpose tax for road construction, and getting the World Bank loan.[2]

Figure 1. Highway Networks as of 1970 and 1980



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

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. Subsequently, in 1965, the entire routes between Aichi (Nagoya) and Osaka were connected.[3] It was in 1969 when the highway between Tokyo and Nagoya was completed. Namely, in 1970, the highway connected the two largest cities in Japan, i.e., Tokyo and Osaka. In the 1970s, the highway networks were expanded to the local areas including Tohoku area (northeastern part of Japan including

[1] According to registration statistics of automobiles, the number of vehicles (million) 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 having an own private car at home, the share dropped around 22.3% in 1980.

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

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

Miyagi and Iwate) and Kyushu island. As a result, the length of highways became 1,000 kilometers in 1973, 2,000 kilometers in 1976, and 3,000 kilometers in 1982.

2.2. Butter Industry in Japan

The main focus of this paper is the price change of goods through the production concentration driven by transportation cost reduction and economies of scale. In order to highlight the production concentration by the expansion of highway networks, we choose goods of which transportation is characterized by difficulties in keeping freshness and fragility in shock and volatile temperature. The production location of those goods will be sensitive to the availability of fast transportation modes, i.e., highways. Such perishable products include, for example, vegetables, meats, poultry, seafood, and dairy products. Among these, one of the most perishable products may be raw milk and fresh meats. Therefore, the dairy products processed from them would also be time-sensitive in delivery. For this reason, we choose butter for our empirical analysis in this paper.

The production of butter takes several steps. Raw milk can be separated into raw cream and raw skim milk.[4] Then, raw cream is pasteurized and is further processed through aging, churning, and draining. Also, additional processing (e.g., washing, salting, or working) can enhance preservative and consistency. For these manufacturing processes, the investments of machinery and facilities are not small. Also, importantly, the longer distance for transportation may increase the risk to make the butter products damaged by shocks and by unstable temperature. While normal butter can be softened from 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 by refrigerated trucks is necessary to deliver butter from the production location to consumers.

Due to the increase of distance per time by the development of highways, butter factory tended to be agglomerated in a limited number of regions. Indeed, in 1960, out of 46 prefectures, the butter factory existed in 41 prefectures, namely in almost all prefectures in Japan. In 1980, on the other hand, the number of prefectures with butter factories decreased to 28. Among them, only six prefectures kept significant production of butter (i.e., more than two factories). Those six prefectures include Hokkaido, Iwate, Miyagi, Tokyo, Okayama, and Kagoshima. The changing distribution of butter factories and the size of production had, at least, two trends; 1) near to the large consumption markets (e.g., Tokyo, Miyagi, or Okayama), 2) near to farming areas (e.g., Hokkaido or Iwate). Interestingly, there is an

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[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 is 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 of other regions are around 3% to 9%.

[5] According to Consumer's Behavior Survey, the share of family having refrigerator was 2.8% in 1957, 51.4% in 1965, and 96.7% in 1975.

absence of large production 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 subsequent highway linked Aichi to Tokyo, the accessibility of Aichi improved significantly. Thus, Central Japan is a typical example of the regions served by other regions due to better accessibility.

The firm-level changes are the following. In Japan, there were three major brands of butter, Yukijirushi (27%), Meiji (19%) and Morinaga (11%), accounting about 57% of a total number of factories as of 1964.[6] While the number of factories was decreasing from 81 in 1964 to 41 in 1979, the composition of the producers was stable. As such, major producers operate multiple factories. Except for one firm operating three factories, non-major producers operate single or double factories only. In terms of the entry and exit of firms, there were 33 firms in 1964, and 15 firms remained in 1979, including three new entrants. All of the firms exited were non-major producers. Among the three major producers, the concentration of production was observed; there were 53 factories in total during the period, of which 53% were closed, 13% were newly established, and the rest were maintained. In terms of regional coverage, among the seven metropolitan areas which are the major consumption markets,[7] the number of metropolitan areas where plants were located within or neighboring prefectures is 6 for Yukijirushi, 5 for Meiji, and 3 for Morinaga. For the non-major producers, their location varied across prefectures.

2.3. Theoretical Background

The above-explained market situation can be characterized by multiplant and transportation costs. The interaction between transportation costs and the organization of firms is known as the proximity-concentration tradeoff in international trade literature. The early works include Krugman (1991), Markusen (1984), Markusen and Venables (2000), Ekholm and Forslid (2001), Behrens and Picard (2007), and others. In most of their models, exporting from a single plant (i.e., a single country) to other countries require to incur trade costs while operating multiplant (i.e., supplying domestically from each country) can avoid trade costs but need to 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 in multiplant. As trade costs decrease, firms choose to concentrate their production in order to exploit economies of scale. The similar results can also be obtained when introducing firm heterogeneity in terms of

[6] The data on the number of factories is obtained from the Yearbook of Japanese Dairy Products Association. The data was constructed from the list of butter producers within and outside the membership of the association, 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 names in parentheses indicate the name of prefecture. This classification was defined in New Comprehensive National Development Plan in 1969.

productivity into the models (e.g., Helpman et al., 2004; Grossman, Helpman, and Szeidl, 2006).

This production concentration may result in the rise of consumer prices in the country where all plants are closed. For simplicity, suppose 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. As a result, consumer welfare in that country would be worsened.

Applying this discussion to our context of butter in Japan, it can be shown that the development of highways induces the production concentration of butter factories. As found in the previous subsection, many prefectures lost butter factories. The total transportation costs will rise in delivering butter from the factories to those prefectures because of switching the supply base. Such a rise in transportation costs leads to increasing the consumer prices of butter in those prefectures though the net effect on the consumer prices depends on the extent of the decrease in factory-gate prices. If a large number of prefectures lose the butter factories, the development of highway may result in raising the average transportation costs from production base to consumption site in Japan.

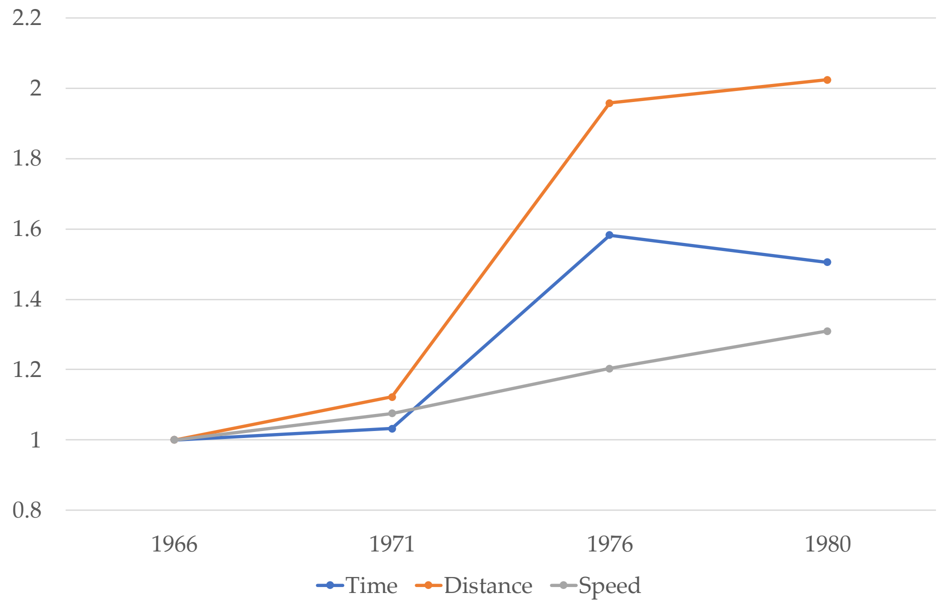
3. Change of the Average Transportation Time

This section empirically examines how transportation time changes over time in delivering butter from a production base to each prefecture in Japan. To this end, we first identify the location of butter factories by employing the Census of Manufacture complied by the Ministry of International Trade and Industry. The census reports the number of butter factories in each prefecture. Due to some reasons mentioned in the next section, we define "prefectures with butter factories" as those that have at least more than two factories. Then, the transportation time in the capital city of a prefecture is computed as the one from the capital city of the prefecture with butter factories nearest to that city. Namely, we assume that butter is always supplied from the nearest factory in terms of transportation time.

More specifically, the transportation time is computed with the National Integrated Transport Analysis System (NITAS) developed by the Ministry of Land, Infrastructure, Transport, and Tourism. This system enables us to identify an "optimal" route between two points in Japan in terms of transportation time. Such a route can be identified for passengers and freight separately, based on the availability of road, railways, sea, and air in each year. Thus, in this system, the construction of highways results naturally in reducing the time per distance. By using this system, we compute the minimum transportation time in all combinations of prefecture-capital cities for freights by only road and sea. Then, based on this time, we identify the shortest transportation time from the prefecture with the butter production to each city.

We examine the average transportation time between capital cities of all prefectures in Japan for 1966, 1971, 1976, and 1980. We focus on 46 prefectures and do not include Okinawa prefecture since the U.S. governed it until 1972. One issue is that the different approach to computing transportation time is necessary when the own prefecture produces a significant amount of butter (i.e., have more than two butter factories). With the above approach, we cannot compute within-prefecture transportation time (or it becomes simply zero). There would be some possible remedy to address this issue. In this paper, we use the shortest time among all combinations of prefecture-capital cities in each year as within-prefecture transportation time.

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



Source: Authors' compilation.

Notes: This figure shows the average transportation time, distance, and speed from the nearest province with butter production. Each variable is rescaled to be the value of one as of 1966.

Figure 2 shows the average transportation time, distance, and speed from the nearest province with butter production. The speed is computed by dividing the distance by time. Each variable is rescaled to be the value of one as of 1966. The figure indicates that the transportation time did not change in the 1960s but dramatically increased in the 1970s. It also shows that due to the construction of highways, the average transportation speed gradually increased. Thus, as is consistent with the change in transportation distance, the reason for the increase in transportation time is the increase in transportation distance. Namely, the average transportation time increased because the transportation distance increased more greatly than speed. The increase in transportation distance is driven by the concentration of the production site of butter. Indeed, the number of prefectures with butter factories decreased from 13 in 1966 to 11 in 1971 and 6 in 1976 and 1980.

4. Impacts of Transportation Time on Consumer Prices

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

4.1. Empirical Framework

We begin with simply assuming that the retail price (denoted by *RPrice*) is a function of transportation time (*Time*) and producer price (*PPrice*). The estimation is conducted at a city-year level. However, our data include only one city per prefecture, and that city is the capital city of each prefecture. Furthermore, we can identify producer price at a prefecture-level. Thus, our analysis is equivalent to the one at a prefecture-year level. Our estimation equation for city i in year t is specified as follows.

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

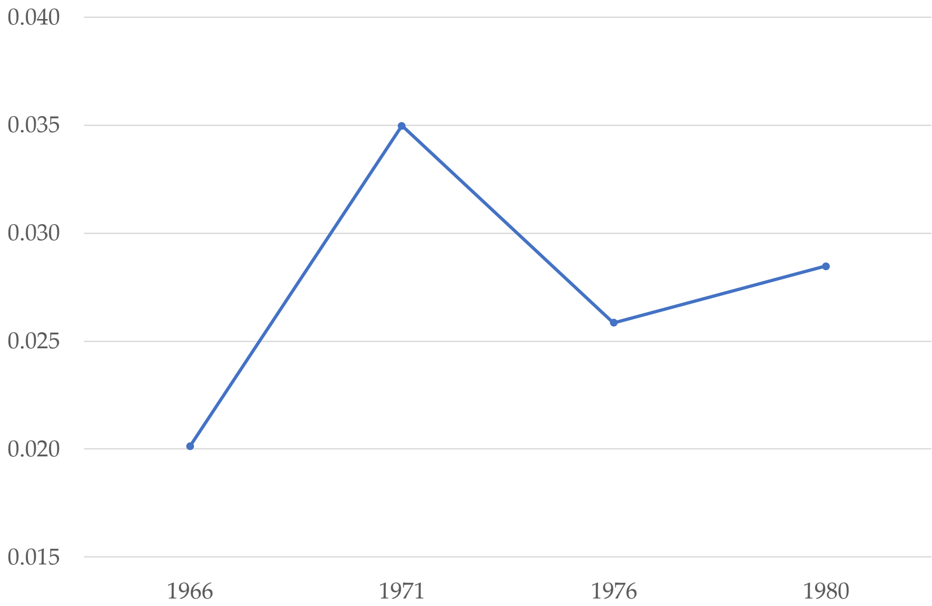
$\mathbf{X}$ includes some control variables. ϵ_{it} denotes an error term. $PPrice_{it}$ and $Time_{it}$ are constructed based on the nearest prefecture with butter factories that are identified in the previous section. The former is defined as the producer price in a province with butter factories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

We control for some elements that may affect the retail price. To control for demand size, we introduce regional GDP (GRDP) in the prefecture where city i belongs. There will be controversial at which geographical level the demand size should be measured. The use of demand size at a city level might underestimate the true demand size that affects the price at city i if the demand size in neighboring cities also affects it. In this paper, partly due to the data availability, we simply use the prefecture-level GRDP. We also introduce Sea dummy variable, which takes the value one if it needs sea transportation to deliver from the afore-mentioned nearest prefecture to city i in year t and zero otherwise. This variable is to capture the difference across transportation modes. We also introduce city fixed effects and a time trend term.

Our data sources are as follows. We obtain the data on the retail price of butter at a 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 provides the commodity price data from 1961 to 1980. In this report, there are at most 66 cities. As of 1961, there were 46 prefectures, meaning that some prefectures have multiple cities in the dataset. As some cities were not always listed in all years, for consistency across years and prefectures, we focus on the price in the capital city of each prefecture. The survey is conducted in two steps at each city. Firstly, regions within the city are stratified, and secondly, representative shops are selected to be visited. Then the prices of the specified products are collected by surveyors.

The data on producer price of butter are obtained from the Census of Manufacture complied by the Ministry of International Trade and Industry. We compute the unit price of butter by dividing butter manufactures' total sales of butter by its quantity, at a prefecture-level. One issue is that these figures are not disclosed after 1965 if a prefecture has only one or two factories though we can identify the number of factories even in such a case. Therefore, as in the previous section, we define as prefectures with butter production, those with more than two butter factories. In contrast, the data on the number of factories are not available before 1965. Therefore, for the consistency of definition of the prefectures with butter production across years, we focus on the period after 1965. Specifically, our sample years include 1966, 1971, 1976, and 1980. By using the data on transportation time, we use the unit price of butter in the province nearest to each city in terms of transportation time. In addition, the data on GRDP are drawn from the website of the Cabinet Office.

Figure 3. σ-convergence



Source: Authors' compilation by 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.

Before reporting our estimation results, let us take an overview of our variables. 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, the σ-convergence 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.

4.2. Empirical Results

Table 1. Baseline Results

	(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. In the parenthesis is the standard error clustered by cities. In all specifications, we control for city fixed effects and time trend. In columns (V) and (VI), we exclude cities where their nearest prefecture with the butter production ("Prod.") is their prefecture ("Cons.").

We report the estimation results. The result of equation (1) by the ordinary least square (OLS) method is shown in Table 1. All standard errors are clustered by cities. Column (I) shows the result of the equation not including GRDP and Sea dummy. It indicates an insignificant coefficient for the transportation time and a significantly positive coefficient for producer price. In the latter, a 1% rise in producer price raises the retail price by 0.06%. The coefficient for transportation time becomes significantly positive when we control for GRDP and Sea dummy, as is shown in column (II). A 1% rise in transportation time raises the retail price by 0.03%. The coefficients for GRDP and Sea dummy are estimated to be significantly positive and negative, respectively. Thus, the retail price becomes higher in the province with the larger demand size or when butter is delivered by using not only the road but also sea.

The results of some robustness checks are also reported in Table 1. In columns (III) and (IV), we use the retail price of butter in the nearest prefecture with butter production (denoted by *CPrice*) as producer price. The coefficients for this variable are positively significant and indicate almost the value one. Although the coefficient for GRDP turns out to be insignificant, the results in transportation time and Sea dummy are qualitatively unchanged. In columns (V) and (VI), by using *CPrice*, we exclude cities where their nearest prefecture with the butter production is their prefecture. This exclusion is because such cities result in having 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.

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 concerned city and the nearest prefecture with butter production. ***, **, and * indicate 1%, 5%, and 10% significance, respectively. In the parenthesis is the standard error clustered by cities. In all specifications, we control for city fixed effects and time trend. In columns (II) and (IV), we exclude cities where their nearest prefecture with the butter production ("Prod.") is their prefecture ("Cons.").

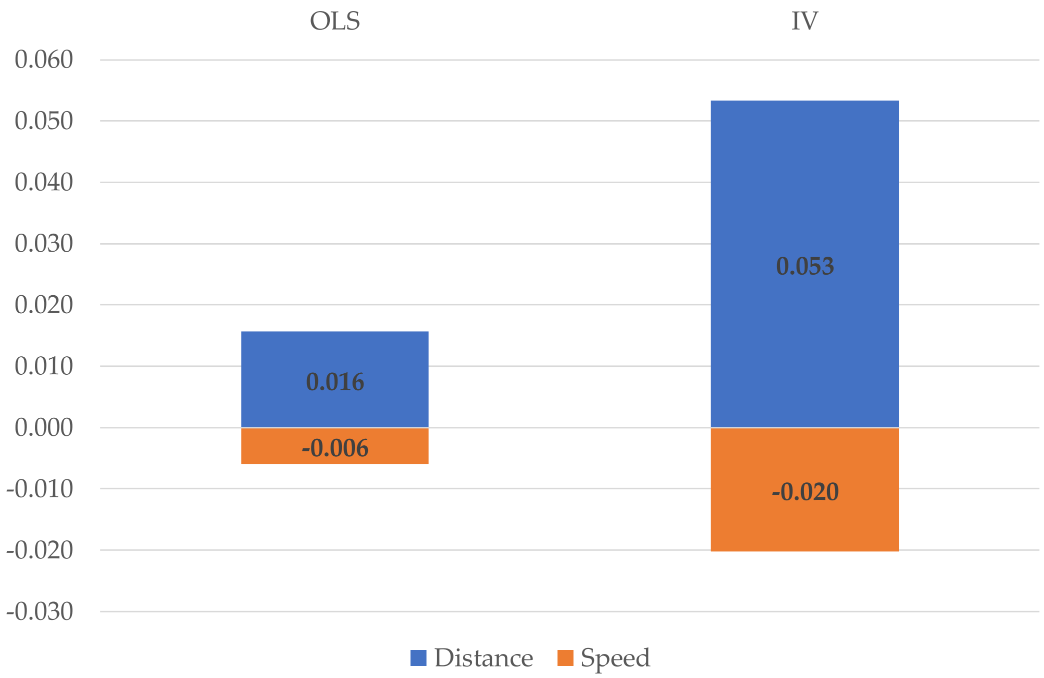
Next, we address the endogeneity issue in our empirical framework. First, both the retail and producer price of butter may follow a similar business cycle. Namely, unobservable elements may affect both two prices. To address this bias, we simply move the producer price to the left-hand side of the equation and set its coefficient to the value one. Based on the result in Table 1 that the coefficient for *CPrice* is almost the value one, we use *CPrice* as the producer price though its coefficient may suffer from the endogeneity bias. As a result, we estimate the following equation.

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

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. Naturally, the results are similar to those in columns (IV) and (VI) in Table 1.

Second, a variable of transportation time may also be an endogenous variable. For example, if the higher retail price tends to attract the butter producers, the transportation time is likely to be smaller, i.e., reverse causality. To address this issue, we estimate equation (2) by the IV method. As instruments, we use the amount of raw milk for daily products and its interaction term with the time trend term. Namely, we use the availability of the material for butter because the material-abundant province is expected to attract more butter manufacturers and thus to have shorter transportation time. Also, since this relation may change over time through the construction of highways, we introduce the interaction term with a time trend. Such material will have an influence on the retail price of butter only through butter production. The data on raw milk are drawn from the "Milk and Milk Products Statistics" complied by the Ministry of Agriculture, Forestry, and Fisheries.

Figure 4. Impacts of the Changes of 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 butter price. We first decompose a log of transportation time into the logs of transportation distance and speed. Second, we compute their respective sample means in 1966 and 1980. Last, we multiply the estimates in transportation time in Table 2 by the difference in those means between 1966 and 1980. In "OLS" and "IV," we use the estimates in transportation time in columns (II) and (IV) in Table 2, respectively.

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. Also, Hansen J statistics show a rather small value, and thus the over-identification test is not rejected in both columns. On the other hand, in column (III), Kleibergen-Paap rk Wald F statistic shows a bit small value, i.e., weak identification. Therefore, we see the result in column (IV) though the results in coefficients are very much similar between two columns. In particular, the coefficient for transportation time is significantly positive, indicating that a 1% rise in transportation time increases the retail price by 0.075%.

The more intuitive picture on the effect of transportation time on the price is provided by using the estimates in transportation time in columns (II) and (IV) in Table 2. To this end, we first decompose $\ln Time_{it}$ into the logs of transportation distance and speed. Second, we compute their respective sample means in 1966 and 1980. Last, we multiply the estimates in transportation time by the difference of those means between 1966 and 1980. The resulting numbers indicate how much the increases of transportation distance and speed during 1966-1980 contributed to changing the butter price. These numbers are reported in Figure 4. The result based on the IV estimation, i.e., (IV) in Table 2, shows that, on average, the increase of transportation distance raised the butter price by 5.3% while the rise of speed by the construction of highways lowered it by 2.0%. In net, the increase of total transportation time results in raising the price by 3.3%.

5. Concluding Remarks

In this study, we empirically investigated the effect of highways on retail prices of butter in Japan. In particular, we took into account the relocation of producers through the development of highways. We found that the construction of highways raised the transportation speed while the average transportation time from production site increased by the dramatic increase in transportation distance. The latter occurred 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%. Out of that, while the rise in speed decreased the price by 2%, the increase in transportation distance raised it by 5.3%. These results imply that at least in the butter market, the reallocation of production site may increase producer surplus while the rise of retail prices will worsen consumer welfare. Thus, there might be symmetric effects of the development of infrastructures between consumers and producers.

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