Empirical Study on the Effects of Deregulation in the Japanese Taxi Market

Yusuke MIYOSHI\textsuperscript{a*}, Haruhiko TSUZUKI\textsuperscript{b}, Hiroaki ITAKURA\textsuperscript{c}

\textsuperscript{a} Advanced Institute of Industrial Technology, 1-10-40, Higashioi, Shinagawa-ku, Tokyo, 140-0011, Japan
\textsuperscript{b} The Faculty of Economics, Saga University, 1, Hon'eyomachikofyo, Saga, 840-8502, Japan
\textsuperscript{c} Advanced Institute of Industrial Technology, 1-10-40, Higashioi, Shinagawa-ku, Tokyo, 140-0011, Japan

Abstract

In this study, we conducted a disequilibrium analysis from data such as the number of vehicles and driver wages related to taxi mileage in order to verify whether excess demand has occurred in the taxi market as a result of government supply and demand adjustments. As a result, the policy of protecting drivers did not have a positive effect on taxi actual vehicle kilometers which we defined as the total distance of the taxi ride, but rather those kilometers could be increased by increasing the number of taxis. In particular, in urban areas where excess taxi demand is occurring, increasing the number of taxis will increase user convenience.

Keywords: Structural form estimation, GMM estimation, taxi market, disequilibrium analysis

1. Introduction

The number of users of public transportation such as taxis and buses has been decreasing year by year. Local public transportation is in danger of not only functioning as a foot for local residents but also its survival. This study examines whether deregulation in the taxi market has been responsible for the deterioration of the profit base of the taxi business and the working conditions of drivers due to the abolition of supply and demand adjustments. This deregulation is also suspected of impairing user convenience.

In February 2002, supply and demand adjustments were abolished. According to the “National Hire-Taxi Directory,” taxi transport personnel and operating revenues have been declining\textsuperscript{1}. In the taxi market, the abolition of supply and demand adjustments will deteriorate the profit base of taxi business and the working conditions of drivers, which may impair the convenience of users.

From the viewpoint of taxi drivers, working environment conditions have declined. [1] pointed out that because the taxi business is labor intensive and because fare competition is stiff between taxi companies, there has been a drop in the quality of service, including in safety. There have been problems between drivers and users and among users. In other words, incomplete information may cause market failure because consumers cannot accurately comprehend the fares and services. [2] presented a model of taxi service after deregulation in Japan. This model shows that when information is complete, taxi fares are higher than marginal costs as in a Nash bargaining solution.

\textsuperscript{1}Based on the data for the taxi business in Tokyo, [8] estimated the taxi demand function with waiting time.

After 2013, the government revised the Special Measures Act on the Optimization and Activation of the General Passenger Car Transportation Business in Specific Regions. This regulation includes the prohibition of new entries and the forced reduction of cars. As a result, the national supply and demand adjustment and fare regulations have revived. According to this law, the Minister of Land, Infrastructure and Transport will only accept an area where taxis are not fully functioning as a local public transport due to excessive supply and the case the head of a local public organization requests a specific area to the Minister. When there is an insufficient number of vehicles to meet transportation demand judging by the situation in the region, a new taxi company is permitted or more cars are approved for the specific area. The government has announced official fare range in specific areas or in subsections of specific areas. Companies were forced to adhere to the set minimum fare.

According to the Statistical Survey on Car Transportation and to the Freight/Passenger Area Flow Survey, until 2012 before the law revision, public transportation on buses had been declining nationwide. Recently, however, the mileage and number of transportation personnel have been gradually increasing. There has been an increase in bus ridership in the three major metropolitan areas (Saitama, Chiba, Tokyo, Kanagawa, Aichi, Kyoto, Osaka, and Hyogo). In the situation where there is an increase in demand for public transportation, the fact that the number of taxi users is not increasing means that taxis have not played a significant role as public transportation. The challenge is to determine what is causing this lack of demand.

Many Japanese taxi market surveys have conducted analyses of the causes of the change in the number of taxi businesses. The surveys indicated that excess profit was the factor for entry, and high driver wages was the factor for the increase in the taxi business. However, there have
been few studies that quantitatively analyzed the taxi market in Japan, especially for urban units.

Sweden and New Zealand are among the few other countries that have deregulated the taxi market. Sweden, for example, was deregulated in 1990. In this case, improvements were observed in terms of lower fare levels and shorter waiting times as a result of eliminating entry restrictions and price restrictions ([3]).

In the United States restriction of the industry occurs on the state level. For example, in Indianapolis, Indiana, the number of taxi companies and private taxi drivers who hate passengers with cheap increased fares as a result of the 1994 liberalization of entry restrictions in the taxi market. It was reported that the number of taxi drivers who pick up customers at the airport was decreasing at airports and hotels. As a result, more and more customers are waiting for taxis ([4]).

This study examines whether the taxi business must adjust supply and demand to determine if there is an excess of supply at the base of the problem. Next, we examine whether the effects of supply and demand adjustments are desirable for users.

Taxi market data was examined for a four-year period (2015–2018) in Japan. Data for each prefecture was obtained from the Ministry of Internal Affairs and Communications Statistics Bureau. Data was collected for populations, prefectural inhabitant incomes, population density, population over 65 years of age, and extended pavement per car. In addition, the automobile ownership statistics data of the Automobile Inspection and Registration Information Association was used to determine the number of private vehicles owned. The number of driver’s licenses was obtained from the driver's license statistics of the National Police Agency and was divided by the population of each area to obtain the rate of licensed drivers.

The Taxi Actual Car Kilometer Statistics Annual Report provided figures for the following. The source of the data was the Hire-Taxi Yearbook published by the General Hire-Taxi Federation. To supplement or verify some of the data, the National Hire-Taxi Directory issued by Tokyo Kotsu Shimbun, the Statistical Survey on Car Transportation, and the Freight/Passenger Area Flow Survey were also used. The number of car-sharing vehicle stations (number of car shares) was obtained from the Foundation for Promoting Personal Mobility and Ecological Transportation. This was added as an explanatory variable to determine if car-sharing is an alternative or complementary form of taxi transportation.

Table 1 shows the basic statistics of the variables used in this paper, and Table 2 shows the descriptive statistics for each of the taxi market and explanatory variables by region.

| Table 1 | Basic statistics | Obs | Min | Mean | Std. Dev. | Max | Min | Max | Sdf |
|---------|------------------|-----|-----|------|-----------|-----|-----|-----|-----|
| Actual taxi kilometers per car per day | 235 | 60,351.99 | 12,853.08 | 42.3 | 1,102 | 39,860.91 | 1,043 | 27,091.64 | 3,91 |
| Number of taxi drivers | 235 | 396,960.91 | 644,330.90 | 13 | 5,526 | 3,91 |
| Logarithmic number of taxis | 235 | 820,388.36 | 1,097,246 | 0.59 | 10,894,858 | 3.15 |
| Number of car shares | 235 | 186,906.91 | 509,608.90 | 0 | 6,79 | 67,900 |
| Bus transported passengers | 235 | 89,210.49 | 2,501.54 | 0 | 3,149,900 | 0.84 |
| Taxi driver hourly wage | 235 | 1,095.42 | 18,949.93 | 1,575 | 2,065 | 0.62 |
| Population density | 235 | 1,362,905 | 1,735,729 | 399.2 | 5,094,718 | 4.42 |
| Road transport rate | 235 | 853,500.94 | 412,729 | 111.3 | 2,677.42 |
| Car ownership | 235 | 1,690,519.43 | 333,978.67 | 6 | 2,13 |
| Preferential income per capita | 235 | 5,600,827.42 | 385,488.92 | 2,088 | 4,352 |
| License rate | 235 | 1,095.82 | 2,124.47 | 71,783 | 7,190,095 |
| Elderly rate | 235 | 27,730.91 | 2,695,000 | 17,7 | 5,347 |

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Taxi actual vehicle kilometers is higher in Okinawa and the urban areas (Saitama, Tokyo, Kanagawa, Kyoto, and Osaka) than in other areas to a statistically significant degree. The hourly wages for taxi drivers are higher at a statistically significant level in Saitama and Tokyo than in other areas. However, in the remaining areas with higher actual vehicle kilometers, driver wages are not as high. This suggests that a policy to increase the hourly wage for...
taxi drivers may be working effectively in large cities such as Tokyo, but it does not necessarily contribute to increasing actual vehicle kilometers in regional areas. At present, both the number of taxis and drivers make up a small part of public transportation in urban areas. It is therefore clear that the lack of taxi drivers in urban areas compared to regional areas has led to a decrease in taxi ridership. It is necessary to distinguish between regional public transportation and the traffic situation around Tokyo. In other words, a comparison of differences in taxi usage between urban and regional areas is required.

Therefore, we considered the actual supply and demand balance of the taxi market using two-dimensional panel data that were both annual data and local data. The possibility of multicollinearity with the main explanatory variables is very low according to the variance inflation factor (VIF) test, so there is little concern about spurious correlations.

**Hypothesis 1**: The number of taxi vehicles should be increased instead of increasing drivers’ wages if the purpose is to increase taxi use by local residents (shift on the supply side).

### 2. Estimation Formula and Test Method

This disequilibrium analysis is characterized by the quantitative analysis of the disequilibrium state through the estimation of demand and supply functions and derivation of the equilibrium wage rate on the taxi market. This section first describes the sequential formulation of the demand and supply functions in a disequilibrium market. The estimation methods of [5] and [6] were followed. Each method defines a supply function and a demand function as follows.

We assumed that the actual taxi driver's hourly wage determination formula follows the partial adjustment model. For example, [7] refer to an unbalanced supply-demand allocation as a phenomenon that arises from the fact that endogenous variables (in this case, wage rate) do not immediately reach equilibrium levels. Whether such a phenomenon occurs can be determined by applying an unbalanced analysis.

\[
R_{i,t} = \mu R_{i,t-1} + (1-\mu_t)R^*_{i,t} \quad 0 < \mu_t < 1 \tag{4}
\]

\(\mu_t\) is the rate of adjustment of the wage rate and \(R^*_{i,t}\) is the equilibrium rate of wage in this period.

In other words, equation (4) assumes that the wage rate for this term is the weighted average of the actual level for the previous term and the equilibrium level for this term. If \(\mu_t = 0\), the wage rate is sufficiently elastic and the market supply and demand is always balanced.

On the other hand, \(\mu_t = 1\) means that wages are completely rigid and do not move from a certain level. In other words, if wages are not fully elastic, there is no guarantee that supply and demand will match, and the market is at least temporarily out of balance. In other words, information on both wage rate changes that help determine whether the market has excess demand or excess supply and on the rate of adjustment are important for the functional estimation and the equilibrium hypothesis test described below.

The test method of the equilibrium hypothesis by the reduced form and the structural form estimation method was conducted. Reduced equilibrium theory is a data-driven method that tries to explain an endogenous variable (the wage rate) with the exogenous variable \((X_{i,t}\) and \(Z_{i,t}\)) and the error term \((e_{i,t,1}, e_{i,t,2})\). Substituting the equilibrium wage rate Equation (3) solved for the supply-demand model into the wage adjustment equation (Equation (4)). This leads to a reduced form in which the wage rate is described only by the predecessor variables.
\[ R_{i,t} = \mu_i R_{i,t-1} + \frac{1 - \mu_i}{\alpha_1 - \beta_1} \left[ \sum_{j=2}^{N} \beta_j Z_{i,t-j} - \sum_{j=2}^{N} \alpha_j X_{i,t-j} + \varepsilon_{i,t-2} - \varepsilon_{i,t-1} \right] \quad (5) \]

In this reduced form, the estimated value of \( R_{i,t} \) is obtained by the least squares method, and the equilibrium hypothesis (\( \mu_i = 0 \)) can be statistically tested by a normal t test. However, just estimating this reduced form (Equation (5)) does not solve the problem of unknown coefficients of the demand function and supply function. Therefore, an estimation of the structure type was applied.

Estimation of the coefficient of the structural form is performed by using the balanced wage rate (Equation 3) and the wage adjustment equation (Equation 4). The actual taxi mileage is calculated only with variables that can explain the demand function and the supply function. However, in this reduced form, it is short of explaining the short-side principle explicitly. When explaining whether excess demand or supply occurs in the structural form, the short-side principle \( L_g = \min \{ L_{dL}, L_{dR} \} \) is required, which can be expressed as follows.

For example, we considered the case \( (L_g = L_{dL}) \) where excess demand occurs when the actual taxi mileage is equal to the actual taxi supply function. Adding \( L_{dL} - L_{dR} \) (= 0) to the right side, considering \( L_g = L_{dL} - (L_{dL} - L_{dR}) \), and expressing the explanatory variable of supply and demand only for the second term on the right side first, we obtained

\[ L_g = L_{dL} - \left[ \sum_{j=2}^{N} \beta_j Z_{i,t-j} - \sum_{j=2}^{N} \alpha_j X_{i,t-j} + \varepsilon_{i,t-2} - \varepsilon_{i,t-1} \right] + \left( \alpha_1 - \beta_1 \right) R_{i,t}. \quad (6) \]

However, as can be seen in Equation 5, there is a possible correlation, and the problem of simultaneous equation bias exists when estimating the coefficient concerning the endogenous variable by the structural form. Therefore, it is usually necessary to estimate using instrumental variable estimation. Furthermore, when describing the supply function, if the self-lag term is included on the right-hand side of Equation 1, it depends on the correlation between the variable on the right-hand side, which represents the individual effect of the error term, and there is always a correlation with individual effects (\( \text{cov}(L_{i,t-1}, \alpha_1) \neq 0 \)). To solve the problems arising from self-lag term and individual effects, we used generalized method of moments (GMM) estimation that utilized the instrumental variable method. We then used some predetermined variables and the instrumental variables (license rate, ratio of elderly people, and income per citizen in the prefecture) in the demand function of Equation 2. This was to identify whether the change in taxi kilometers was caused by the supply side or the demand side.

### 3. Empirical Analysis

In Table 3, although the coefficients of all variables have signs that were theoretically predicted, some were not statistically significant. The estimated value of the adjustment speed of the wage rate is 0.42. The hypothesis of \( \mu_i = 0 \) is rejected at the 1% significance level based on the standard deviation. In other words, as is evident from the reduced form, the hypothesis that the market is always in equilibrium is not supported. The wage rate, however, indicates that the actual value of the previous period is adjusted by approximately 60% to the equilibrium level of the current period. Because the adjustment of the wage rate in the taxi market might be considerably affected by factors other than market mechanisms, the degree of this effect was not be described at this stage.

| Dependent variable: hourly rate of taxi driver | Coef. | Std. Err. | P>|t| |
|------------------------------------------------|-------|-----------|------|
| Hourly wage of taxi driver one term ago | 0.421 | 0.073 | 0.000 |
| Number of taxi drivers | 0.000 | 0.000 | 0.157 |
| Logarithmic number of taxis | 0.036 | 0.022 | 0.104 |
| Population density | 0.000 | 0.000 | 0.365 |
| Road pavement rate | 0.000 | 0.000 | 0.659 |
| License rate | 0.005 | 0.006 | 0.437 |
| Elderly people ratio | 0.001 | 0.004 | 0.774 |
| Number of car share | 0.000 | 0.000 | 0.644 |
| Bus transport personnel | 0.000 | 0.000 | 0.599 |
| Prefectural income per capita | 0.000 | 0.000 | 0.007 |
| Constant term | -0.406 | 0.458 | 0.406 |
| Number of obs | 188 |
| Adj R-squared | 0.5666 |

Next, we used the GMM estimation that utilized the instrumental variable method in order to satisfy the consistency of the estimation formula of Equation 6. Table 4 presents those results.

| Instrumental variables (GMM) regression | Coef. | Robust Std.Err. | P>|t| |
|----------------------------------------|-------|----------------|------|
| Dependent variable: taxi actual vehicle kilometer | 2.979 | 0.029 | 0.000 |
| Population density | 0.003 | 0.001 | 0.000 |
| Number of taxi drivers | 0.000 | 0.001 | 0.772 |
| Logarithmic number of taxis | 4.569 | 0.015 | 0.000 |
| Number of car share | -0.002 | 0.002 | 0.224 |
| Bus transport personnel | 0.000 | 0.000 | 0.000 |
| Constant term | 14.508 | 0.729 | 0.136 |

Hansen’s J chi2(3) = 35.6936 (p = 0.0000) Endogenous variables: hourly wage for taxi drivers Variables describing the instrument variables: taxi driver’s hourly rate, license rate, Ratio of elderly people, income per prefectural citizen R-squared = 0.6997 Number of obs = 188

The signs of the estimated coefficients were as predicted. Most coefficients were consistent with the

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3Because the null hypothesis is rejected at the 5% significance level based on the Wu-Hausman test, \( R_{i,t} \) is regarded as endogenous and does not satisfy consistency in the OLS estimation. Although there are problems of the own-lag term and individual effects, the results of instrumental variable estimation of a fixed model are presented in Table 4 for comparison with the GMM estimation.
theory. Some variables, however, were not statistically significant. For instance, the effects of the number of taxi drivers, the wage rate, and car shares on the supply function were not a significant value. The signs of the number of taxi drivers and the wage rate were positive, contrary to the prediction. This did not increase taxi actual vehicle kilometers even when the wage rates of taxi drivers were increased. On the other hand, when the number of taxis increased, the actual distance of the taxis increased. Therefore, hypothesis 1 is accepted.

Both estimation methods show that the complementary relationship between buses and taxis is statistically significant. If this is the result of a cooperative relationship between buses and taxis that had been adjusted for interests, there may seem to have more passengers in a densely populated area. Due to other factors, such as congestion phenomena, this indicates that taxi passengers are using other means of transportation, such as buses.

Sargan’s overidentification restriction test in the assessment of these estimation methods is not satisfied at the 5% significance level, suggesting that the overidentification restriction of the instrumental variables used in the GMM estimation is satisfied. Therefore, the GMM estimate is a consistent estimate.

The transportation choice problem assumes the place of residence when choosing which form of transportation to use. For this reason, it is logical to think that local transportation continues because of the reasonable behavior of local traffic users. However, analyzing people's transportation choices without considering these decision-making issues can lead to misleading regional transportation.

4. Conclusion

In this study, despite the current excess demand and lack of supply in the taxi market, we have shown that introducing regulations to protect the taxi industry would distort the market. This analysis finds that increasing the number of taxis could increase taxi actual vehicle kilometers. In particular, in urban areas where excess taxi demand is occurring, increasing the number of taxis will increase user convenience. Until now, the effort to limit the number of taxis comes from the desire to secure the profit base of the taxi business and to protect the working environment for drivers. However, from the perspective of the convenience of taxi users, there is currently excess demand the taxi market. Given the road traffic situation, it is time for local governments to entrust the role of public transport services to taxis rather than running buses that meet the needs of conventional mass transit, where the number of passengers is declining.

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