Detecting Demand-Supply Situations of Hotel Opportunities: An Empirical Analysis of Japanese Room Opportunities Data*

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Abstract. This study analyzes the availability of room opportunity types collected from a Japanese hotel booking site. The status of opportunity type is empirically analyzed from a comprehensive point of view. We characterize demand-supply situations of room prices at each region with both room availability and average room rate. The average room rate decreases in terms of the room availability in many districts. However, it is found that the average room rate increases with respect to the room availability in some districts. This is an evidence that the theory of demand and supply is not always satisfied in Japanese hotel industry.

Keywords: Japanese Hotel Booking Data, Demand-Supply Situation, Comprehensive Analysis.

1   Introduction

Recent technological developments enable us to purchase various kinds of items and services via E-commerce systems. The emergence of Internet applications has had an unprecedented impact on our life style regarding the purchase of goods and services. From the availability of items and services at such E-commerce platforms, one can estimate utilities of agents in socio-economic systems.

Demand and supply drive the price of goods or services. If there are a plenty of people who want to buy goods or services, then the price normally goes up. Namely, both demand-supply curves determine the equilibrium price. This results in an economic equilibrium for price and quantity in microeconomics. However, some assumptions are necessary for the validate of the standard model of demand and supply: that supply and demand are independent and that supply is constrained by a fixed resource. This is known as Sraffa's critique [1]. Also if goods have several kinds of properties, then the theory of demand and supply

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may not always be true. It is probable to observe that they are purchased with low price in the low supply.

Here we study the demand for rooms related to temporal migration. I examine that stay capacities of hotels included in areas may provide insights on relationship between the social wealth and the migration process. In this article, I also investigate regional dependence of social wealth based on the data on Japanese hotel industry with geographical information. By using data on room capacities as proxy variables of the regional dependence of demand-supply situations, I propose a method to characterize a spatial density of Japanese economy.

In Japan, there are over 54,000 accommodations [2], which are rich in various types: from the largest hotel having about 3,600 rooms to the highest class Japanese inn with a few rooms. Their types and capacities also depend on a district. This availability of the hotel bookings may indicate the future demand of tourists and supply of hotel managers. If it contains availability of all the rooms of hotels, we may detect demand-supply situations in each region from comprehensive data.

According to the study of tourism management [3], there are push and pull factors, so that tourism motivation is determined by the situation of the travelers (push) and the situation of the destination (pull). The idea behind this two-dimensional approach is that people travel because they are pushed by their own internal forces and pulled by the external forces of the destination attributes [4]. The pull factors originate from the destination properties (supply). More recently, Tkaczynski et al. applied the stake-holder theory, a management theory proposed by Freeman (1984) [5], to a destination in tourism [6]. The existence of hotel accommodations implies that pull factors are present in the district where they are located. In the context of economics, this means that the demand-supply situation is generated by both consumers and suppliers. Namely, they can be dependent on the area and the season [7].

Moreover, a problem for estimating demand from censored booking data has been recognized for many years in the hotel industry. Liu et al. developed parametric regression models that consider not only the demand distribution, but also the conditions under which the data were collected [8]. Sato investigated regional patterns of Japanese travel behavior by using the EM algorithm for finite mixtures of Poisson distributions [9].

Deep and wide knowledge on econophysics developed in the last decade [10,11,12,13,14,15] will also help us to understand price mechanism. As well as financial markets, we can assume that balance between demand and supply in the hotel industry reflects both the social and economic situations. In the present article, I propose a method to detect available opportunity types of demand-supply situations from data on room opportunities collected from internet hotel booking site. The hotel industry is highly inhomogeneous. The quality, stuff, and services are very unique, but there are no rooms with the completely same properties. The anormality of the relationships between demand-supply and the market price seems to be recognized. This is the motivation of this study. As

we show as the main result, the averaged market prices of some districts do not follow the normal relationship between excess supply and the market price.

This paper is organized as follows. In Sec. 2, the data description will be shown. In Sec. 3, the overview of Japanese hotel industry will be briefly explained. In Sec. 4 the empirical analysis will be conducted. Sec. 5 is devoted to concluding remarks.

2   Data Description

The data are sampled from the Jalan net web site (*http://www.jalan.net*) every day. This data set contains plans for two adults to stay at the hotel per night. Each plan also contains the sample date when the data were sampled, the target date when the stay at the hotel is consumed, the regional sequential number, the hotel identification number, the hotel name, the postal address, the URL of the hotel web page, the geographical position, the plan name, and the room rate. The data period is from 1 January 2010 to 15 May 2011. The data is missing from 19 to 29 March 2011 due to the Great East Earthquake.

In the dataset, there exist about 100,000 opportunity types in about 14,000 hotels every day. Table 1 gives an example of the contents included in the data set. Since the data contain regional information, it is possible for us to analyze regional dependencies of hotel rates.

We define two kinds of dates (a target date and a sample date). Let us denote D as the difference between the target and sample dates. It is inferred that as D decreases the remaining number of opportunity types decreases. Furthermore the regional dependence of the remaining number of opportunity types on D may be related to the supply-demand situation in each district.

Figure 1 (top) shows an example of the regional distribution and representative rates on 15 April 2010 ($D = 6$). The data to draw the map is sampled on 9 April 2010. Green dots represent hotel plans cost 50,000 JPY per night. Black dots represent hotel plans cost 1,000 JPY per night. Red dots represent hotel plans cost over 50,000 JPY per night. As one can see, there is a strong regional concentration. Table 2 shows the total number of rooms of accommodations located in each prefecture. Tokyo (JP-13) has the largest number of rooms (116,542 rooms). Hokkaido (JP-01) has the second largest (72,327 rooms). Osaka (JP-27) has the third largest (57,082 rooms).

Table 1. Structure of our dataset

| Variable Name	Meaning	Example Content
Sample date	Date of collection	from 2009-12-24
Target date	Date of Stay	Up to 6 days before
Hotelid	Hotel identification number	300000
Hotelname	Hotel name	Hotel ABC
Postcode	Postal code	066-8520
Hoteladdress	Address	Honmachi, Chitose City
Hoteldetailurl	URL	http://www.jalan...
X	Latitude	509943536
Y	Longtitude	154132695
Planname	Opportunity name	Wonderful travels!
Meal	Meal availability	no meal
Sample rate	the latest best rate	3500 (JPY)
Rate	Rate per night	7000 (JPY)
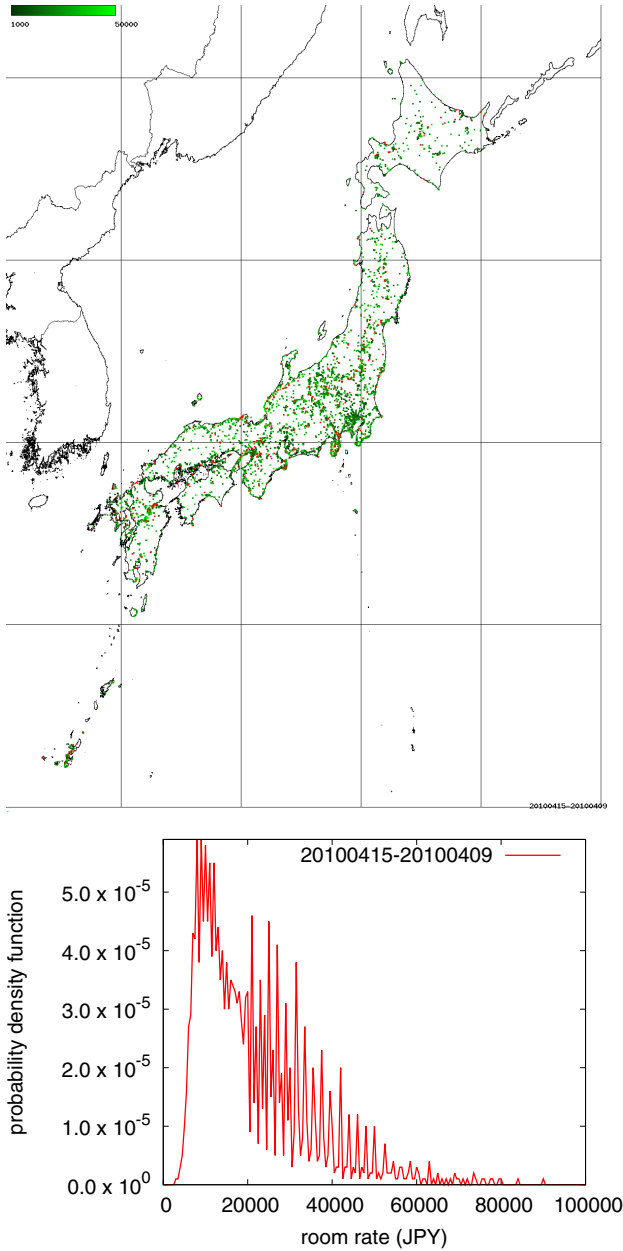
Fig. 1. (top) Example of the regional distribution of opportunity types over Japan on 15th April 2010 ($D = 6$). Color dots correspond to the room rates per night. The green dots represent room opportunities with 50,000 JPY. Black dots represent room opportunities with 1,000 JPY. The red dots represent room opportunities with prices more than 50,000 JPY. (bottom) The probability density function.
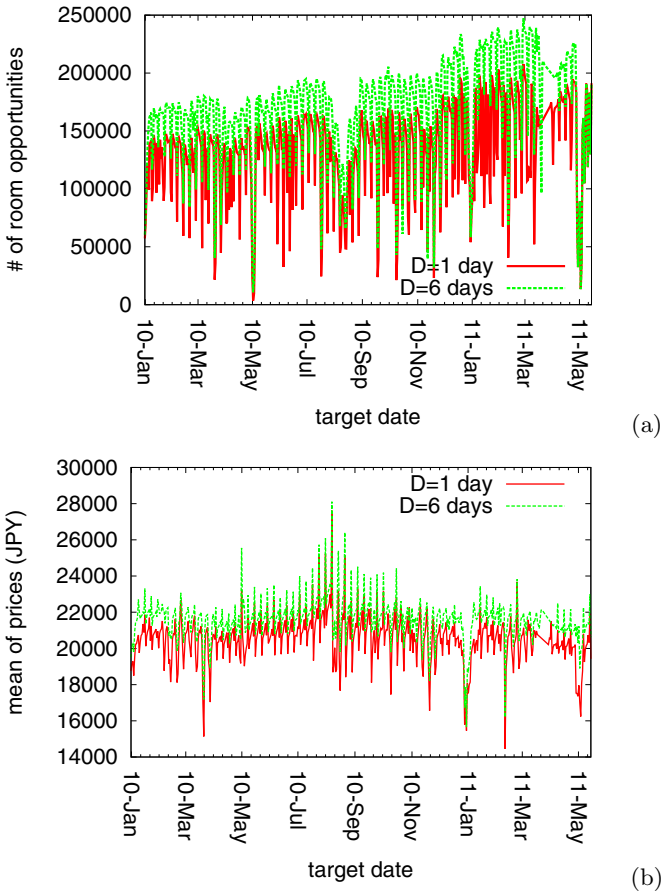
(a)

(b)

Fig. 2. (a) Temporal development of the number of hotel rooms where two adults would be able to stay one night during the period from 1 January 2010 to 15 May 2011. D represents the duration between target date and sample date (in days). $D = 1$ means 1 day before room use, and $D = 6$ 6 days before use. (b) Time series of the average rates of opportunity types on stay dates. The mean value of rates is calculated from all the available opportunity types which are observed on each stay date.

Table 2. The total number of rooms located in each prefecture of Japan. 961,974 rooms in 16,650 accommodations are included in the data. This data was collected on 20 January 2012.

| ISO-3166:JP	prefecture	# hotels	# rooms
JP-01	Hokkaido	987	72,327
JP-02	Aomori	178	12,632
JP-03	Iwate	222	12,128
JP-04	Miyagi	227	18,547
JP-05	Akita	138	8,375
JP-06	Yamagata	266	10,830
JP-07	Fukushima	363	17,034
JP-08	Ibaraki	510	18,587
JP-09	Tochigi	562	17,878
JP-10	Gunma	205	11,774
JP-11	Saitama	146	9,466
JP-12	Chiba	458	32,102
JP-13	Tokyo	798	116,542
JP-14	Kanagawa	559	35,283
JP-15	Niigata	449	12,158
JP-16	Toyama	1,425	37,559
JP-17	Ishikawa	555	23,993
JP-18	Fukui	140	9,170
JP-19	Yamanashi	261	14,740
JP-20	Nagano	225	7,366
JP-21	Gifu	1,267	41,689
JP-22	Shizuoka	389	13,650
JP-23	Aichi	407	35,814
JP-24	Mie	397	17,385
JP-25	Siga	148	8,716
JP-26	Kyoto	479	24,114
JP-27	Osaka	351	57,082
JP-28	Hyogo	551	25,511
JP-29	Nara	118	4,254
JP-30	Wakayama	247	9,843
JP-31	Tottori	169	7,389
JP-32	Shimane	167	7,400
JP-33	Okayama	193	12,327
JP-34	Hiroshima	213	17,063
JP-35	Yamaguchi	160	10,733
JP-36	Tokushima	89	4,392
JP-37	Kagawa	136	8,901
JP-38	Ehime	155	9,734
JP-39	Kochi	124	6,991
JP-40	Fukuoka	285	36,330
JP-41	Saga	122	5,622
JP-42	Nagasaki	198	13,128
JP-43	Kumamoto	404	16,949
JP-44	Oita	441	14,034
JP-45	Miyazaki	106	9,640
JP-46	Kagoshima	231	15,027
JP-47	Okinawa	444	29,765
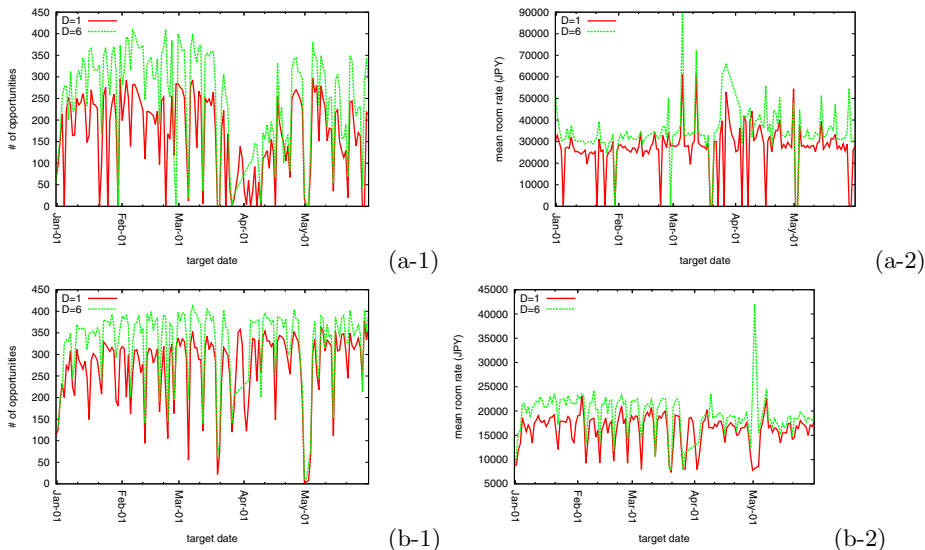
Fig. 3. The number of available room opportunity types for (a-1) Higashiyama and Gion in Kyoto for the period from 1 January to June 1 2010 and (b-1) Yuda and Oufu in Yamaguchi. The average room rates for (a-1) Higashiyama and Gion in Kyoto for the period from 1 January to June 1 2010 and (b-2) Yuda and Oufu in Yamaguchi. D represents the difference between the sample date and target date.

Figure 1 (bottom) shows a probability density of room rates on 15 April 2010 ($D = 6$). The highest density is found at 9,000 JPY. Several peaks exist for more than 20,000 JPY. These peaks are related to rounding effect of room pricing. This shows that hotel managers prefer some specific prices when they determine room prices. Throughout the investigation we regard the number of available opportunity types as a proxy variable of the remaining opportunities of rooms.

3   Overview of Data

The total number of opportunity types at which two adults have possibility to stay was counted up from the data throughout the whole sample period. Figure 2 (a) shows the total number of opportunity types per day. There exists weekly seasonality for the total number of opportunity types. In the case of Japan, Saturday nights are the highest demanded date in a week. The total number of opportunity types is low on Saturday. There is a strong dependence of the remaining number of rooms on the Japanese calendar. Namely, holidays influence reservation activities of costumers. For example, during the golden week holidays (from 1st to 5th May) and public holidays in the spring season (around 20th March) the total number of the remaining rooms shows a rapid drop. The summer vacation season (from the end of July to the beginning of September) the total number of opportunity types decrease. As D decreases, the

remaining number of rooms decreases. Specifically, two days before the target date, a drastic decrease of the number of hotels is observed.

Furthermore, I show the dependence of average rates all over Japan on calendar dates in Figure 2 (b). During the holidays in March 2010, it is observed that the mean rates rapidly decrease, while during the spring holidays in the beginning of May 2010, the mean rates rapidly increase. Average room rates tell us customers' consumption strength. The remaining room rates are higher (lower) than booked room rates, then the average room rates goes up (down). This difference seems to come from the difference of the consumption structure and the different preference price levels between these holiday seasons. In the case of Japan, Saturdays in holidays or Saturdays in summer vacation season are more demanded days than other days. Therefore, the remaining room rates on Saturdays in summer vacation season show higher price than other days. On the other hand, the expensive rooms sometimes preferred. For example, the average room rates took lower than normal price levels on Saturday in the end of March.
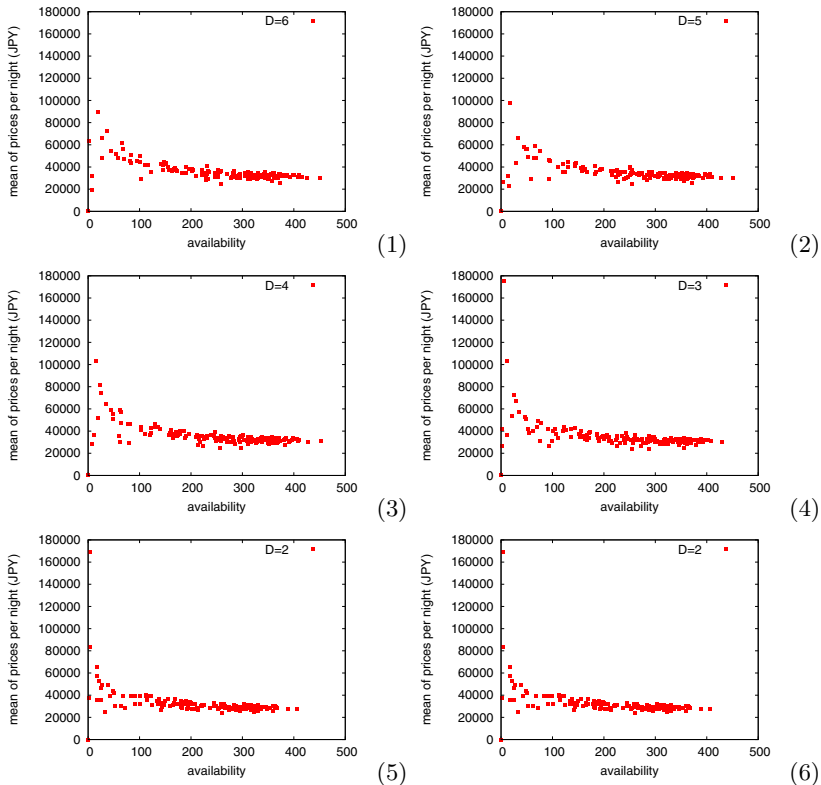

Fig. 4. The relationship between averaged rates and the number of available opportunity types at Higashiyama and Gion in Kyoto for the period from 1 January to 1 June 2010. (1) $D = 6$, (2) $D = 5$, (3) $D = 4$, (4) $D = 3$, (5) $D = 2$, and (6) $D = 1$. D represents the difference between the sample date and target date.
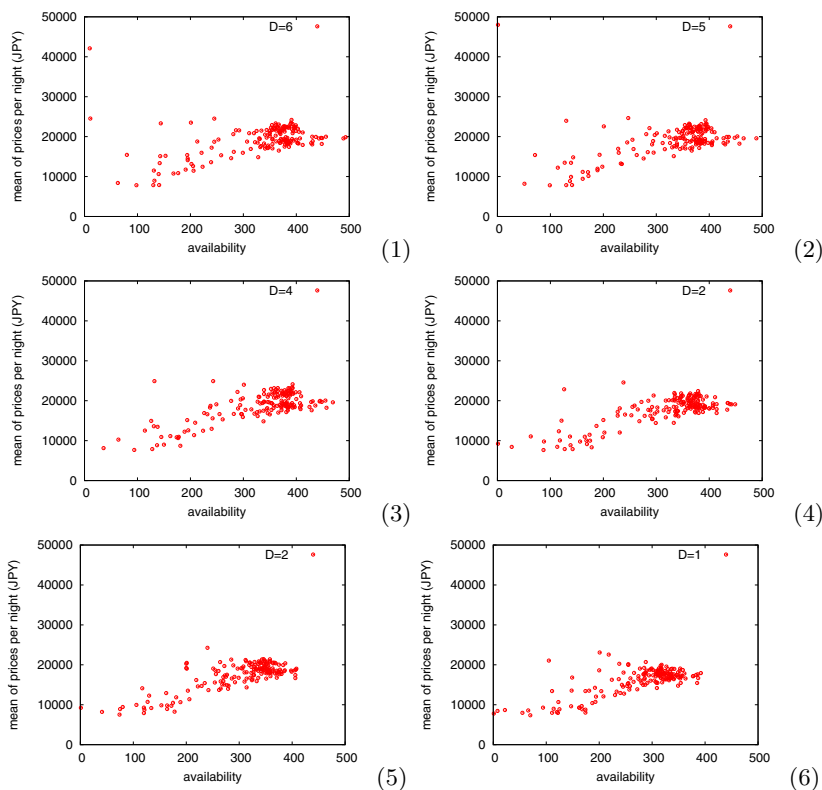
Fig. 5. The relationship between averaged rates and the number of available opportunity types at Yuda and Oufu in Yamaguchi for the period from 1 January to 1 June 2010. (1) $D = 6$, (2) $D = 5$, (3) $D = 4$, (4) $D = 3$, (5) $D = 2$, and (6) $D = 1$. D represents the difference between the sample date and target date.

4   Empirical Analysis

In this section, I show the result of an empirical analysis of the demand-supply situation. First of all, we study the number of available opportunity types for different regions. Figure 3 shows the number of available room opportunity types for two regions (Higashiyama and Gion in Kyoto and Yuda and Oufu in Yamaguchi) for the period from 1st January to 1st June 2010. It is found that there are regional dependencies of the temporal development. In the case of Gion in Kyoto, in the spring season there is high demand. In the case of Yuda and Oufu in Yamaguchi, there is higher demand in the summer season than in the spring season.

A demand-supply situation determines the price direction. Namely, the excess demand (supply) increases (decreases) prices of goods or services. In order to understand such effects on room prices, we computed relationship between the number of available room opportunity types and averaged prices for each region.

Figures 4 and 5 show the relationship between availability and the average rates for two sub areas. On the one hand, Figure 4 shows that even in the case
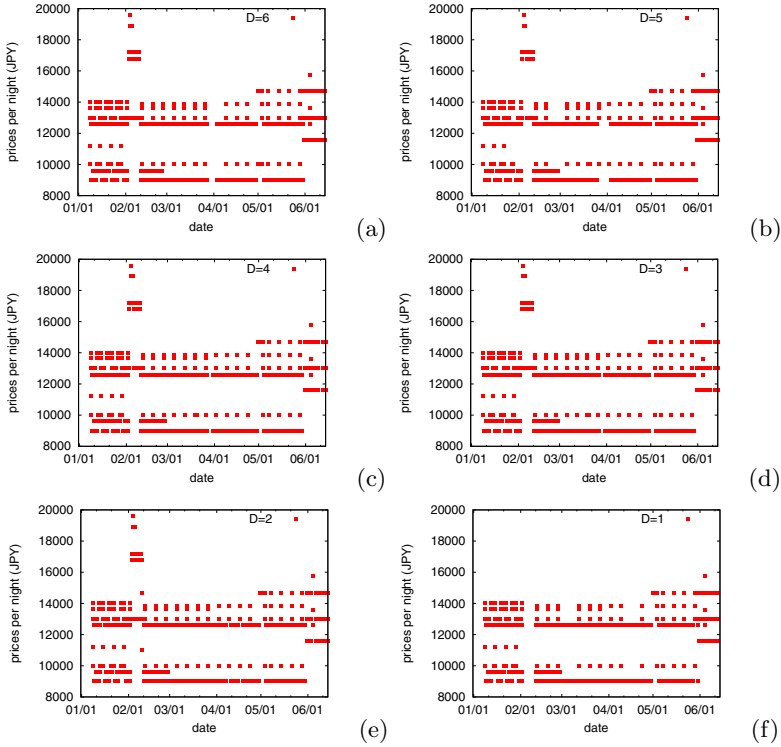
Fig. 6. The temporal dependence of prices per night for a hotel which serves a few kinds of rooms (a) 6 days before the stay, (b) 5 days before, (c) 4 days before, (d) 3 days before, (e) 2 days before, and (f) 1 day before. The x-axis represents target date, and the y-axis a room prices. These graphs depict temporal development of room prices.

of a small number of room opportunity types there still exist opportunity types to book expensive rooms. In this case, we may assume that consumers prefer to book cheaper rooms with available room opportunity types in a sub area. On the other hand, Figure 5 shows that opportunity types cheaper than the mean price for the large number of available opportunity types remain in the case of the small number of available opportunity types. In this case we may assume that consumers demand mainly distributes at the higher side than prices of which they serve.

Figures 6 and 7 show the temporal dependence of prices per night for two hotels during the period from January 1 to June 1, 2010. It is found that hotel managers offered prices depending on calendar dates. Specifically it is confirmed that relatively higher prices were offered on new year holidays and spring holidays. Furthermore in these cases, rates on the spring season are higher than ones on the winter season.

The hotel shown in Figure 6 provides different kinds of room opportunity types. The prices ranged from 9,000 JPY to 20,000 JPY. The price suddenly
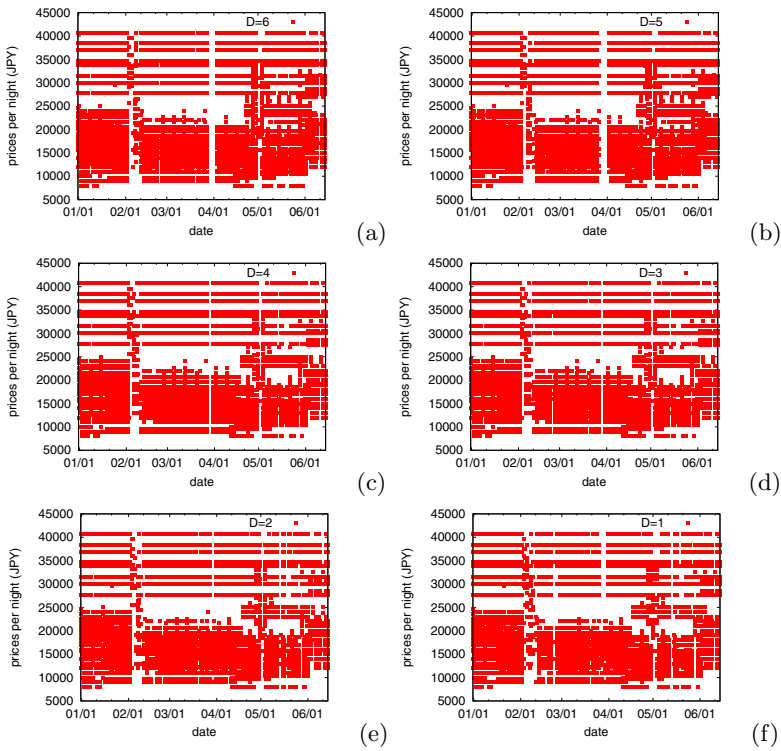
Fig. 7. Temporal dependence of prices per night for a hotel which provides various kinds of rooms for the period from 1 January to June 1 2010. (a) 6 days before the stay, (b) 5 days before, (c) 4 days before, (d) 3 days before, (e) 2 days before, and (f) 1 day before. The x-axis represents target date, and the y-axis a room prices. These graphs depict the temporal development of room prices.

jumped up to a range from 12,000 JPY to 20,000 JPY from 3 to 10 February 2010. After June 2010 the price range shifted up. The Figures (a) to (f) confirm that room opportunity types were eventually booked. The cheap opportunity types ranging from 8,000 JPY to 12,000 JPY were booked 6 days before the stay. The expensive opportunity types ranging from 12,000 JPY to 20,000 JPY were booked from 6 days before in the case of the beginning of February.

The hotel shown in Figure 7 provides many different kinds of room opportunity types. The prices ranged from 9,000 JPY to 40,000 JPY. The price suddenly jumped up to a range from 20,000 JPY to 40,000 JPY from 3 to 10 February 2010. After June 2010 the price range also shifted up. The Figures (a) to (f) also confirm that room opportunity types were eventually booked. The expensive opportunity types were booked 6 days before the stay. The cheaper opportunity types ranging from 12,000 JPY to 20,000 JPY were booked from 6 days before in the case of the Golden week (the beginning of May).

Figure 8 shows the average values of available room rates on two types of hotels. It is found that the average room rates on Saturday is higher than weekdays.
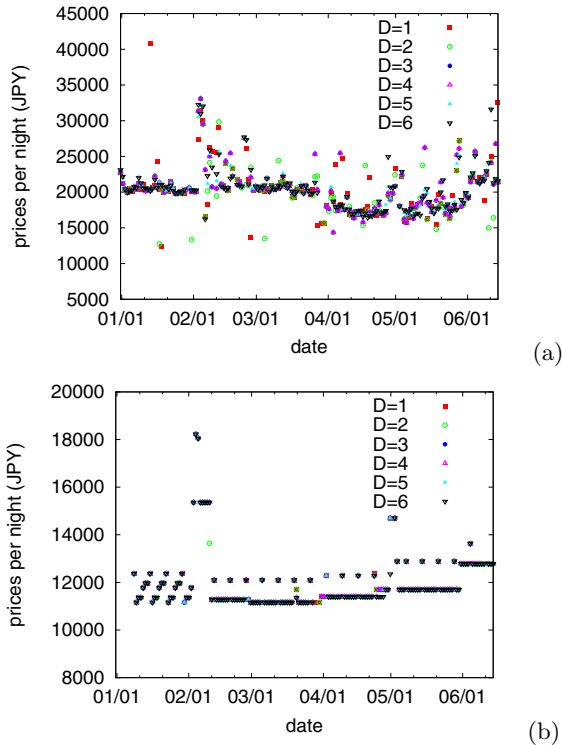
Fig. 8. The average values of available room rates on (a) medium and (b) large hotels for the period from 1 January to 1 June 2010

The average room rates during the high demand days (4-6 February, 1-4 May) are higher than ordinary days. The hotel managers adjust room rates according to expected demand in advance.

This is a kind of regime switching of hotel prices. The hotel managers have to catch up demand and supply balance of rooms. The balance normally changes in time. The room rate distribution is a kind of finger print of the demand and supply balance.

5 Conclusion

We analyzed data of a Japanese hotel booking site. There is a strong dependence of the number of available opportunity types on the calendar date.

We investigated the relationship between the mean room price and the excess supply at each target date. The relationship between average room price and the number of available opportunity types is often a decreasing function in terms of the availability of rooms. However, at several districts, the number of available rooms shows an increasing function in terms of the availability. The difference seems to come from the imbalance between the quality of rooms and demand of customers. In such districts it is often observed that customers preferred to book

expensive rooms than cheaper rooms during high demand season. Consequently, the average room fair sometimes increases in terms of availability of rooms.

The hotel booking data is sensitive to macroeconomic conditions significantly since this reflects temporal migration for both the business and tourism purposes. It is found that this large-scale data on hotel opportunity types provides us with insights into properties of human activities related to travels and tourism in Japan.

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