

EVALUATION OF WILLINGNESS TO BUY A LOW-POLLUTION CAR IN JAPAN

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Abstract: In recent years, Japan has recognized a need to actively take measures to reduce CO₂ emissions that will bring about the green house effects. Thus, the Japanese central and local governments are rapidly promoting prevalence of low-pollution private cars. This study clarifies awareness of people toward purchase of a low-pollution car to propose measures to improve introduction of low-pollution cars. We made surveys in Tokyo and Sapporo to identify the status of people's willingness to buy a low-pollution car. Citizens of Sapporo are concerned about the environment; however, it does not actually lead to purchase of low-pollution cars. Next, we evaluated low-pollution car prices by applying Kishi's Logit PSM (KLP). KLP that is developed from Price Sensitivity Measurement (PSM) enables the analysis to clarify affordable low-pollution car prices for purchasers. The analysis results have found that there are few hybrid cars that people think their prices are reasonable.

Key Words: a low-pollution car, willingness to buy, Kishi's Logit PSM

1. INTRODUCTION

In recent years, global warming caused by green house gases has been a serious problem all over the world. Japan has recognized a need to actively take measures to reduce CO₂ emissions that will bring about the green house effects. 20% of CO₂ emissions in Japan is relevant to transportation, about 90% of which is resulting from motor vehicles. Thus, the Japanese central and local governments are making efforts aiming at rapid prevalence of low-pollution private cars. However, compared with other prefectures, the penetration rate of low-pollution cars is significantly low in Hokkaido. Therefore measures to promote use of low-pollution cars are required to be sought.

In the analysis of consumers' willingness to buy an electric private car, Tanaka *et al.* clarified the purchase price would influence the willingness to buy (Tanaka *et al.*, 1996). But the analysis result has not specifically clarified the appropriate degree of price down that would motivate them to buy a car. Ikeda *et al.* analyzed the relation between purchasers' environmental awareness and vehicle choice but it has not identified how purchasers' environmental awareness change would affect their vehicle choice (Ikeda *et al.*, 2000).

This study quantitatively identifies that higher environmental awareness is led to higher willingness to buy a low-pollution car. It also clarifies that even people whose environmental awareness is low, they are highly likely to buy low-pollution models when the purchase price comes down.

This study aims at analyzing people’s evaluations on low-pollution car purchase prices to identify a suitable price range. Questionnaire surveys on how consumers evaluate low-pollution car prices were conducted in Tokyo and Sapporo. Kishi’s Logit PSM (KLP) is applied to the low-pollution car price evaluation analysis.

2. ENVIRONMENTAL AWARENESS CONCERNING LOW-POLLUTION CAR PURCHASE

2.1 Outline of the questionnaire surveys

In this study, the questionnaire survey on low-pollution car purchase was conducted in Tokyo and Sapporo. Sapporo was selected as one of the survey locations because it is the capital city of Hokkaido prefecture where the low-pollution cars penetration rate is significantly low. We compare the survey results in Sapporo with those in Tokyo, the capital of Japan. In Tokyo that is facing serious environmental problems, the penetration rate of low-pollution cars is high. The outline of the questionnaire survey is shown in Table 1.

Table 1. Outline of the Questionnaire Surveys

	In Tokyo	In Sapporo
Date	Feb. 1-14, 2003	Dec. 4, 2002
Method	On site distribution/collection of the questionnaire sheets	
Number of the subjects	308 (Male 235, Female 73)	182 (Male 166, Female 16)

The questionnaire asked the status of car ownership, private car trip frequency, environmental awareness and willingness to pay for purchase of a private car. KLP was applied to analyze the survey results.

More male subjects than female subjects responded but responses were obtained evenly from every age group in both cities.

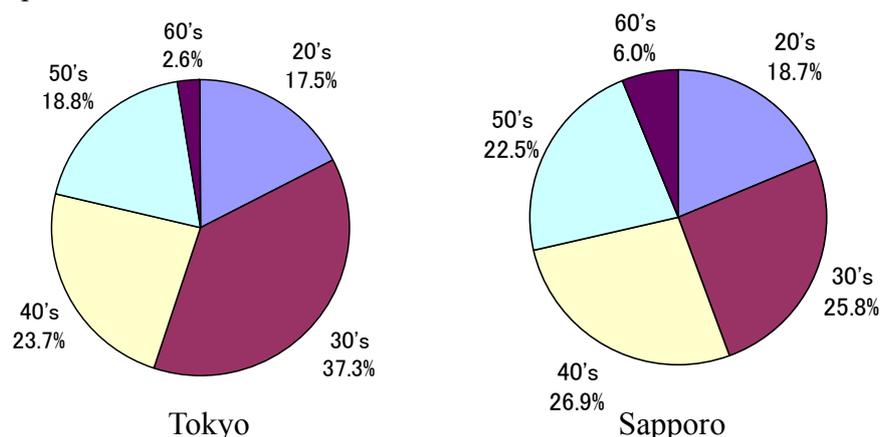


Figure 1. Subjects Age Group Ratio

Private car ownership and trip frequencies are indicated in Figure 2 and 3. More people own and use private cars in Sapporo than in Tokyo. In Sapporo, 88% of the subjects own private cars and 37% use their cars almost every day. On the other hand, in Tokyo, 75% subjects own private cars and the percentage of those who use their cars almost every day is 17%.

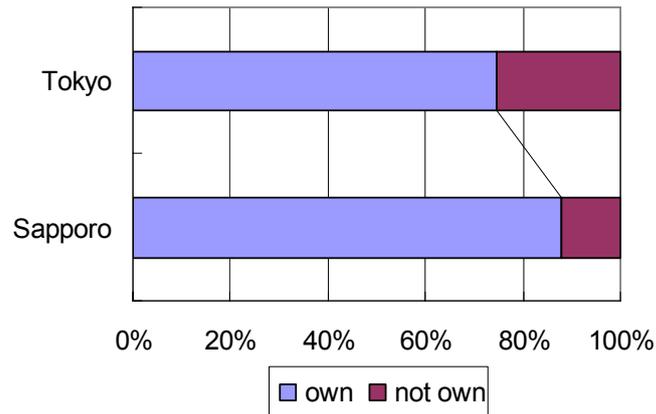


Figure 2. Private Car Ownership

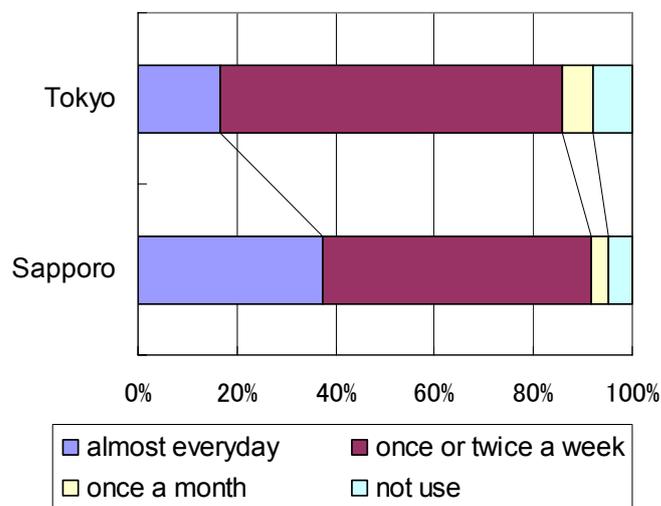


Figure 3. Frequency of Private Car Trip

2.2 Environmental Awareness in Tokyo and Sapporo

Next, whether the subjects would know Japanese Government's green tax program that reduces automobile tax for low-pollution cars was asked. The percentage of those who knew it was over 50% both in Tokyo and Sapporo, and the rate in Sapporo was higher than in Tokyo (Figure 4). For the question "Are you trying to stop unnecessary idling when you

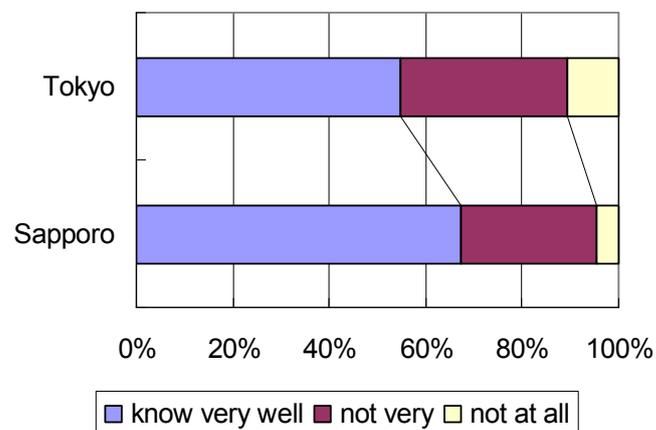


Figure 4. Recognition level of the green taxation program

drive, or to use public transportation for the environment?”, people who answered “I am always trying” or “I am trying to” occupied 43% in Tokyo and 54% in Sapporo as Figure 5. To the question “Do you think you have a high level of environmental awareness?”, more people answered “Yes” in Sapporo than in Tokyo as Figure 6. This survey indicates that people in Sapporo are more environmentally conscious than those in Tokyo.

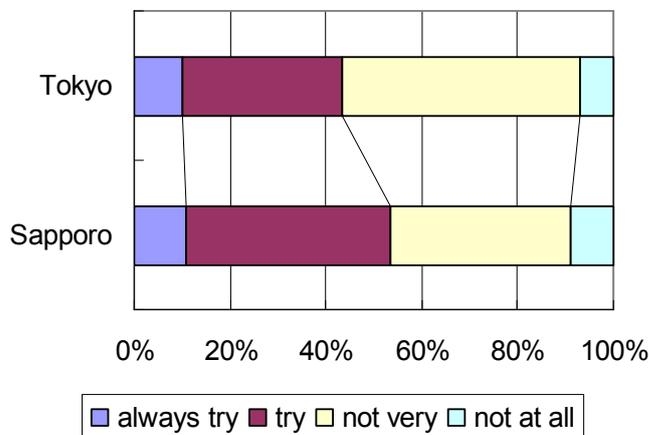


Figure 5. “Are you trying to stop idling when you drive, or to use public transportation for the environment?”

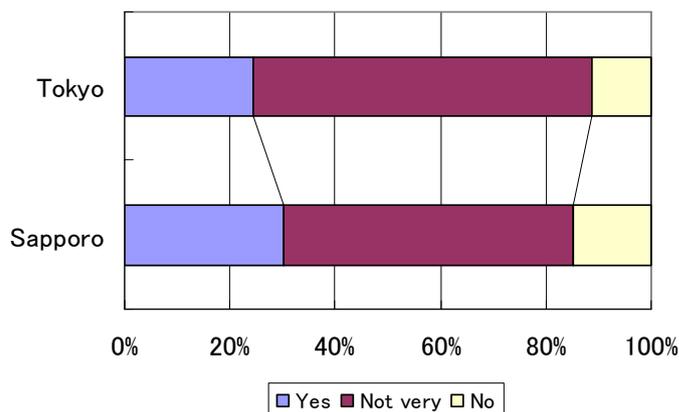


Figure 6. “Do you think you have a high level of environmental awareness?”

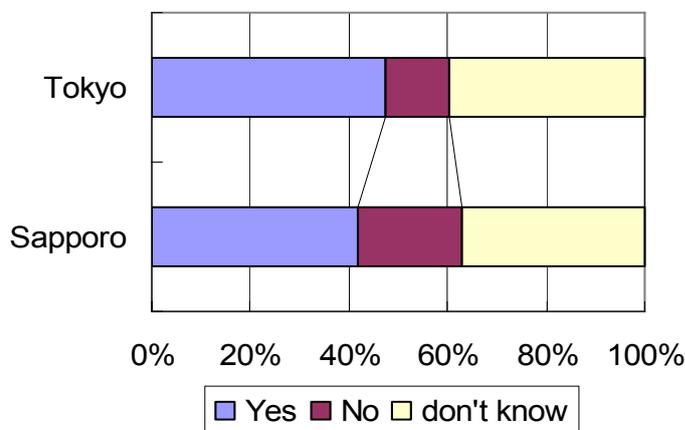


Figure 7. “Do you want to buy a low-pollution car?”

On the other hand, the percentage of people who were willing to buy a low-pollution car was

higher in Tokyo than in Sapporo as shown in Figure 7. That is supposedly because the people in Tokyo feel more keenly than people in Sapporo the environment aggravation due to Tokyo's overwhelmingly greater population and traffic volume compared with those in Sapporo so that people in Tokyo are more sensitive about environmental quality improvement than people in Sapporo. Although people in Sapporo are more concerned about the environment than people in Tokyo, their concerns do not lead to low-pollution car purchase.

3. OUTLINE OF KISHI'S LOGIT PSM

3.1 Price Sensitivity Measurement (PSM)

Price Sensitivity Measurement (PSM) is a method to measure consumers' perceptions of a price of a product or a brand. The Consumers' perceptive responses to a product price are epitomized as "reasonable", "expensive", "too expensive to buy" and "too cheap to buy". Prices are generally determined by factors such as, supply and demand; cost prices, and price competitiveness. PSM has been developed as a method to find solutions through psychological approach to pricing issues concerning consumers' price sensitivity and acceptability.

3.2 Four Prices in PSM

In the PSM method, consumers are asked to suppose product prices at four different levels: "reasonable," "expensive," "too expensive to be willing to buy," and "too cheap to be willing to buy." (Table 2)

Table 2. Four Prices and the Questions

(1) Reasonable "What price do you think would be reasonable for the product?"
(2) Expensive "What price do you think would be too expensive for the product?"
(3) Too expensive to be willing to buy "What price do you think would be too expensive to be willing to buy the product?"
(4) Too cheap to be willing to buy "What price do you think would be too cheap to be willing to buy the product, because of doubts about its quality?"

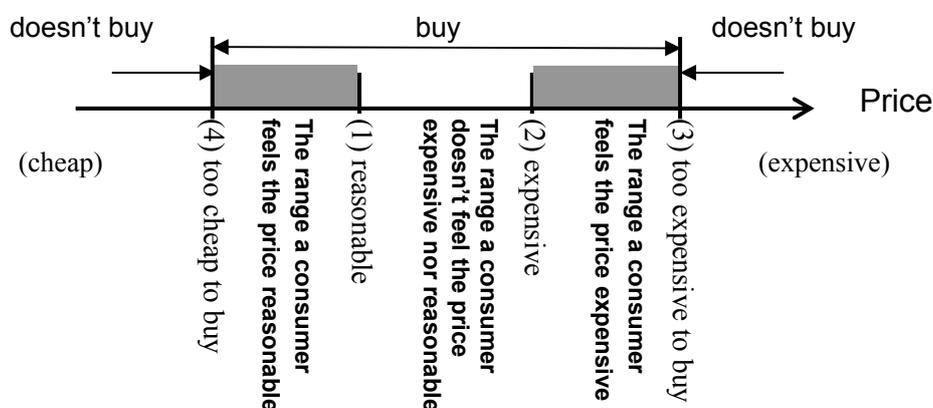


Figure 8. Consumers' Price Sensitivity and Willingness to Buy

The four prices are supposed to correlate as described in equation (1) and Figure 8

$$(4) < (1) \leq (2) < (3) \tag{1}$$

Based on the collected pricing data, frequency distributions were analyzed and relative cumulative frequencies were established as Figure 9. The prices given by the subjects as “Reasonable” and “Too cheap to be willing to buy” are depicted as decreasing curves, and “Expensive” and “Too expensive to be willing to buy” prices show increasing curves.

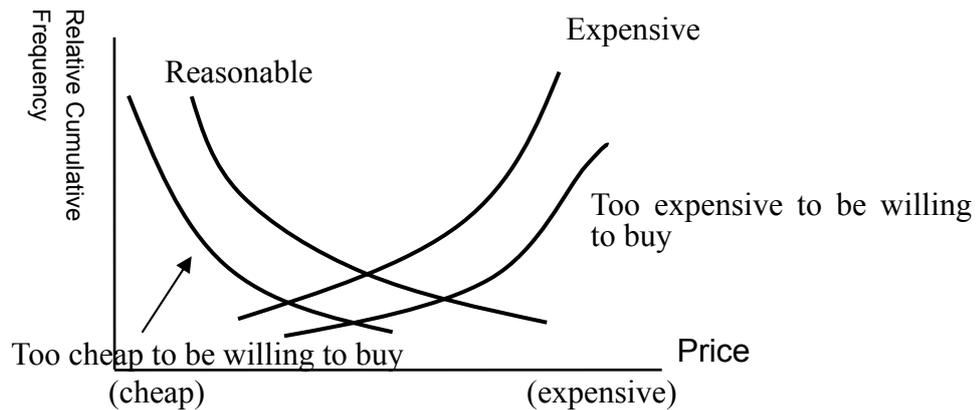


Figure 9. Relative Cumulative Frequencies of Four Prices

Complementary events of “Reasonable” and “Expensive” prices are established, and then the intersections in the graph are used as reference price indicators of PSM. The complementary event of the “Reasonable” price is “Should be less expensive” (Figure 10), and that of the “Expensive” price is “Should be more expensive” (Figure 11).

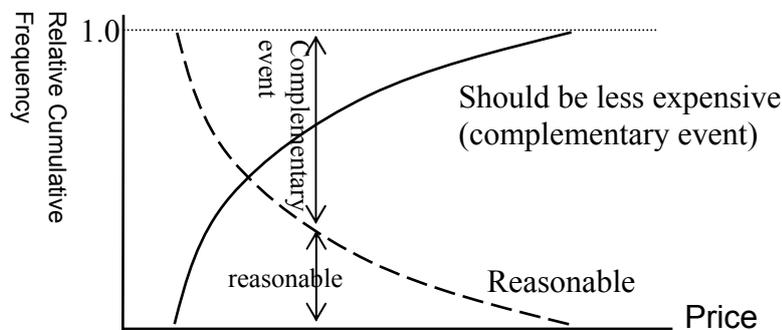


Figure 10. Complementary Event of the “Reasonable” price

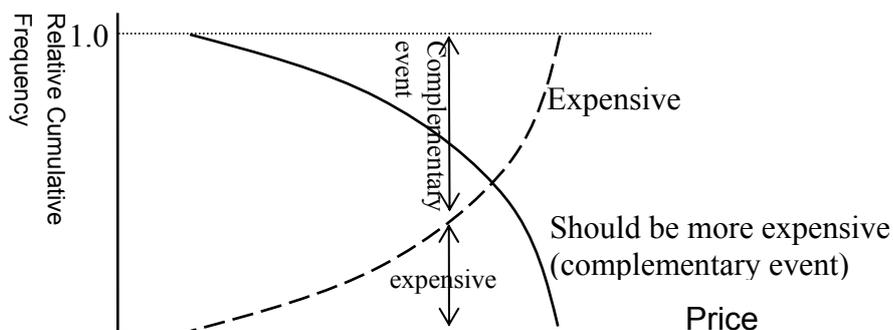


Figure 11. Complementary Event of the “Expensive” price

3.3 Kishi's Logit PSM (KLP)

In the PSM analysis, relative cumulative frequencies of “Should be less expensive”, “Should be more expensive”, “Too expensive to be willing to buy” and “Too cheap to be willing to buy” are established and the intersections in the graph are used as reference price indicators of PSM.

However, we can't make detailed evaluations in PSM on the price range that is not included in the subjects' responses. Kishi's Logit PSM (KLP) has improved PSM applying four relative cumulative frequencies that are regressed by using the logit model as indicated by equation (2) and equation (3) (Kishi *et al.*, 1999, 2002, 2003). The resulting curves are shown in Figure 12. When a dependent variable lies between 0 and 1, it is equal to the relative cumulative frequency. As the logit model is a continuous function, KLP can circumstantially analyze consumers' evaluation on any prices.

$$T = \frac{1}{1 + \exp F(x)} \quad (2)$$

$$F(x) = ax + b \quad (3)$$

where

- T : relative cumulative frequency
- x : price
- T_1, F_1 : should be less expensive
- T_2, F_2 : should be more expensive
- T_3, F_3 : too expensive to be willing to buy
- T_4, F_4 : too cheap to be willing to buy

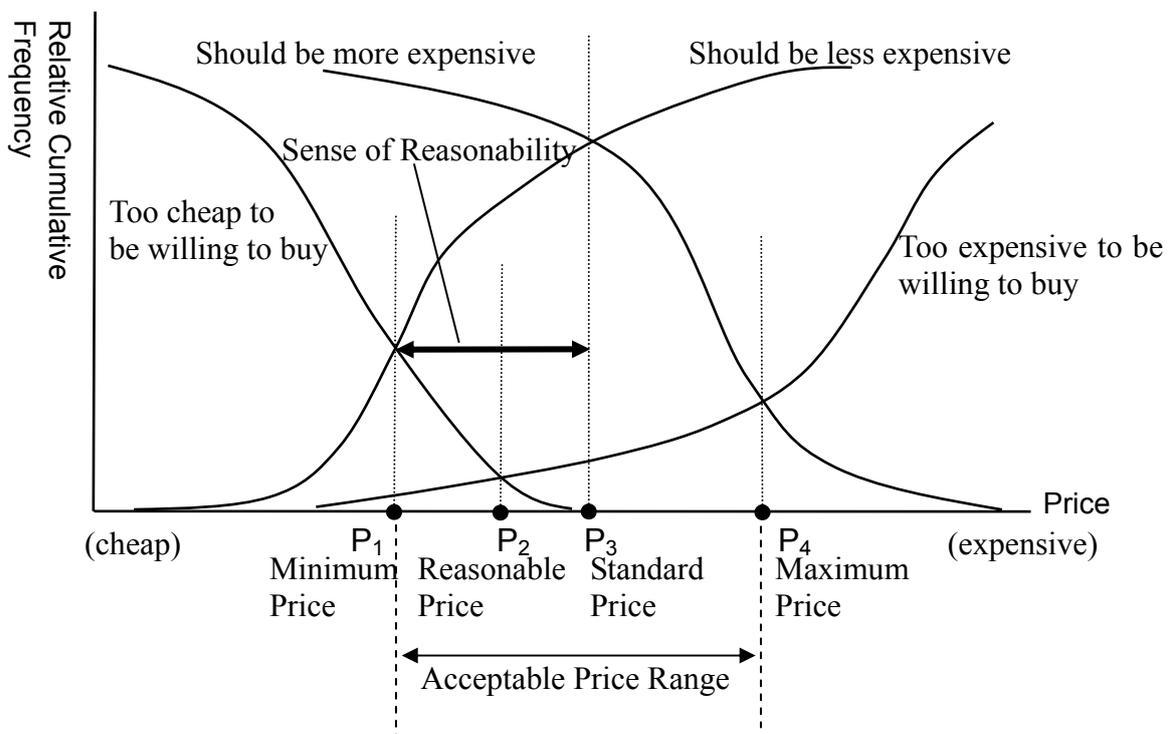


Figure 12. KLP Reference Price Indicators

From Figure 12, the following reference price indicators can be obtained:

a) P_1 (Minimum Price)

The two curves of “Should be less expensive” and “Too cheap to be willing to buy” are focused. The price should be discounted in order to decrease consumers who feel it should be less expensive, but the more price is discounted, the more consumers feel it is too cheap to be willing to buy, thus the product isn’t accepted. When the price is below P_1 in Figure 12, more consumers think it is too cheap to be willing to buy. It is supposed to be the minimum price for the entire consumer population.

The reason why consumers think it is too cheap to be willing to buy is that they doubt the product quality. And “Should be less expensive” means that consumers are buying the product in spite of the expensive price, because they think the product quality is more important than the price. It indicates that the minimum price is the amount which consumers think it should not be lower to ensure the product quality.

b) P_4 (Maximum Price)

The intersection of the two curves, “Should be more expensive” and “Too expensive to be willing to buy” represents the maximum price. For prices higher than this price, more consumers think that they are too expensive to be willing to buy the product. As the both curves represent consumers’ priority on price rather than quality, the maximum price is determined on the basis of their price conscious considerations.

c) P_3 (Standard Price)

The intersection of the curves of prices “Should be less expensive” and “Should be more expensive” indicates that the number of consumers who are affirmative to either opinion is the same. That is to say, the same number of consumers think the price reasonable or expensive from the viewpoint of the complementary event. In other words, the entire consumer population is regarded to think the price neither expensive nor cheap, because the price is reasonable.

The Standard Price represents the point where the product quality and the price well balance.

d) P_2 (Reasonable Price)

The intersection of the curves of “Too expensive to be willing to buy” and “Too cheap to be willing to buy” is focused. When a price is higher than the amount indicated by the intersection, more consumers think it is too expensive to be willing to buy than those who think it is too cheap. In the same way, when a price is lower than the price, more consumers think it is too cheap to be willing to buy than those who think it is “too expensive to be willing to buy”. The price represents the border to differ customers’ motivational factor for “not to be willing to buy a product” from “doubts about the quality” to “too expensive price”. Accordingly, Reasonable Price indicated by the intersection can be defined as a price which consumers perceive reasonable considering the quality.

e) P_1 to P_4 (Acceptable Price Range)

Acceptable Price ranges between Maximum Price and Minimum Price. Distributors should set a price within the range that is acceptable for the entire consumer population.

f) Sense of Reasonability

Within the Acceptable Price Range, the entire consumer population feels a price more reasonable when it is placed between Standard Price and Minimum Price.

3.4 Usability of KLP

(1) Identifying price setting standards

When consumers purchase a product, they weigh its quality and benefit against the price. If a product’s price is felt too expensive for consumers, they will not purchase the product. Or when the price is felt too cheap, they suspect if the product’s quality would be low.

Distributors could set a price as it will be acceptable for their target consumers by applying KLP. KLP enables them to develop future marketing strategies by comparing set prices with those resulting from KLP analysis.

(2) Estimation of market size

The figure of KLP reference price indicators looked from a different viewpoint can show a segmentalized market to which a product belongs, which makes it possible to analyze how the product is evaluated in the segmentalized market.

As shown in Figure 13, a market is segmentalized to Discount Market and Premium Market, and indicators to measure the size of the both markets are developed.

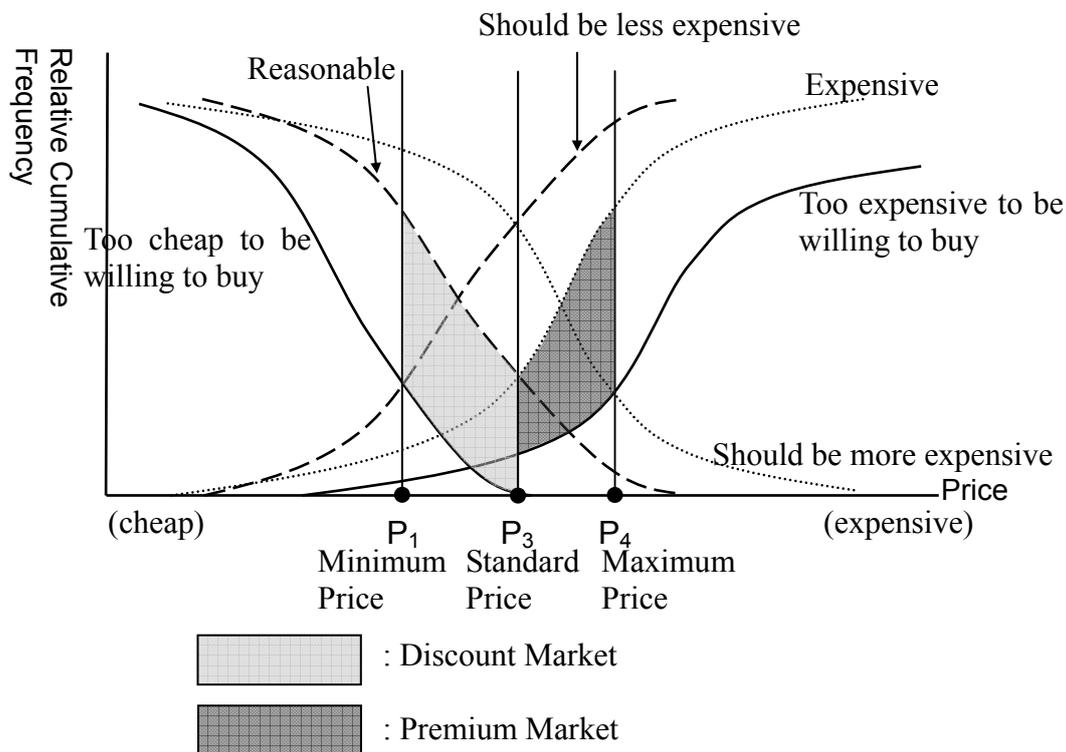


Figure 13. Estimation of Market Size by KLP

a) **Discount market**

When consumers who feel a product price within the range between Standard Price and Minimum Price is too cheap to buy are removed from those who feel it is reasonable, the remained group of people can be defined as Discount Market. It is the group of potential consumers who will buy the product when they feel its price reasonable. Multiplying the price by the number of potential purchasers relevant to the rate of Discount Market gives potential sales volume.

b) **Premium market**

When consumers who feel a product price within the range between Standard Price and Maximum Price is too expensive to buy are removed from those who feel it is expensive, the remained group of people can be defined as Premium Market.

It is the group of potential purchasers who will buy the product despite feeling it is expensive and they are typically seen in the market such as brand-name goods?. Multiplying the price by the number of potential purchasers relevant to the rate of Premium Market gives potential sales volume in that market.

4. APPLICATION OF KLP TO ANALYSIS OF LOW-POLLUTION CAR PRICE EVALUATIONS

4.1 KLP Analysis to Find an Acceptable Price for a Low-Pollution Car

This study applied KLP to low-pollution car price evaluations, targeting a hybrid car.

In the questionnaire survey, we asked the subjects in Tokyo and Sapporo four prices of KLP in the event of buying a new gas-powered car and a new hybrid car. Here, the analysis results of responses in Tokyo for hybrid car purchase are taken for instance. Logit models of relative cumulative frequencies of four prices are derived from equation (4) to (8), which are graphed as Figure 14. The intersections in the graph are used as reference price indicators of KLP. In the same way, we analyze the responses for gas-powered car purchase in Tokyo and those for both types of cars in Sapporo. Table 3 shows the results of the KLP analysis.

$$T = \frac{1}{1 + \exp F(x)} \tag{4}$$

$$T_1; F_1 = -0.018x + 3.853 \quad (R^2 = 0.83) \tag{5}$$

$$T_2; F_2 = 0.016x - 4.549 \quad (R^2 = 0.89) \tag{6}$$

$$T_3; F_3 = -0.011x + 4.270 \quad (R^2 = 0.86) \tag{7}$$

$$T_4; F_4 = 0.040x - 4.793 \quad (R^2 = 0.92) \tag{8}$$

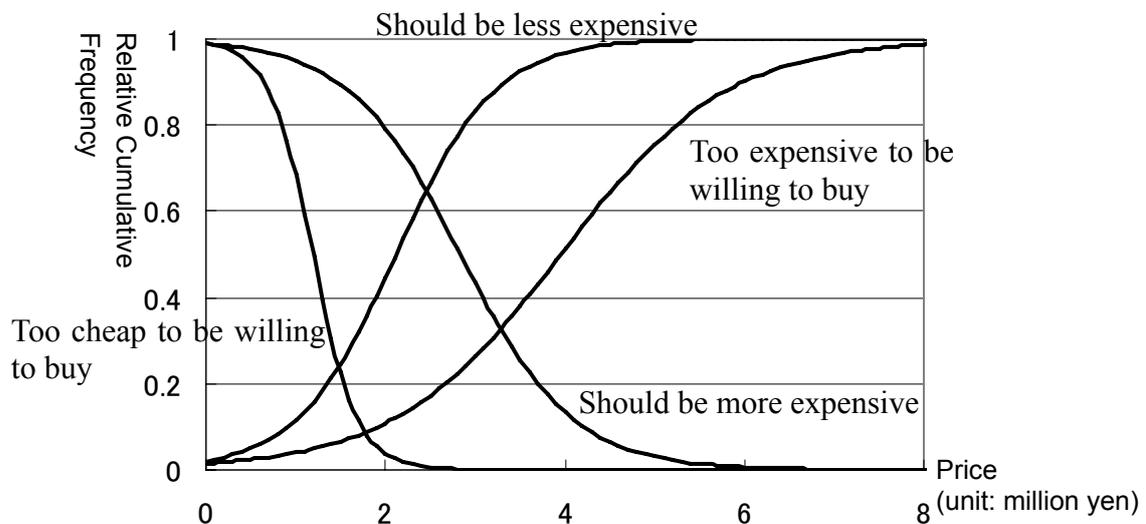


Figure 14. KLP Analysis of Hybrid Car Prices Evaluations in Tokyo

Table 3. KLP Analysis Results of Acceptable Prices For Gas-Powered Car and Hybrid Car (unit: million yen)

	Tokyo		Sapporo	
	Gas-Powered Car	Hybrid Car	Gas-Powered Car	Hybrid Car
Minimum Price	1.540	1.482	1.565	1.669
Maximum Price	3.348	3.286	3.130	2.983
Standard Price	2.490	2.456	2.364	2.344
Reasonable Price	1.844	1.778	1.883	2.053

Compared with Sapporo, both Standard Price and Maximum Price are higher in Tokyo. Standard Price for a gas-powered car and a hybrid car is higher about 130,000 yen and 110,000 yen, respectively, in Tokyo than in Sapporo. Maximum Price for a gas-powered car and a hybrid car also is higher about 200,000 yen and 300,000 yen, respectively, in Tokyo than in Sapporo.

However, the acceptable price for a hybrid car is lower than that of a gas-powered car, both in Tokyo and Sapporo.

Next, responses of people who answered, “I have a high level of environmental awareness.” are focused and analyzed (Table 4).

Table 4. KLP Analysis Results of the Acceptable Price for a Gas-Powered car and a Hybrid Car (High Environmental Awareness Group)

(unit: million yen)

	Tokyo		Sapporo	
	Gas-Powered Car	Hybrid Car	Gas-Powered Car	Hybrid Car
Minimum Price	1.358	1.592	1.476	1.784
Maximum Price	3.038	3.049	2.921	3.164
Standard Price	2.260	2.392	2.321	2.605
Reasonable Price	1.461	1.740	1.728	2.238

In both cities, the acceptable price for a hybrid car is higher than that of a gas-powered car. And it is higher in Sapporo than in Tokyo. Standard Price for a hybrid car in Sapporo is about 200,000 yen higher than in Tokyo.

The respondents as a whole value a gas-powered car over a hybrid car. It will be difficult for a hybrid car to be accepted by consumers unless its price is lowered. On the other hand, people with high environmental awareness put great value on a hybrid car and accept it even if it is more expensive than a gas-powered car. Furthermore the tendency is more apparent in Sapporo than in Tokyo.

4.2 Discount Market and Premium Market for a Hybrid Car

We analyze Discount market and Premium market for a hybrid car. The responses in Tokyo for a hybrid car are taken as samples to create a diagram showing Discount Market and Premium Market. (Figure 15) It was created by adding logit models of “Reasonable” and “Expensive” prices to Figure 14.

The logit model of “Reasonable” price is derived from:

$$T_1' = \frac{1}{1 + \exp(0.018x - 3.853)} \tag{9}$$

The logit model for the price “Too cheap to be willing to buy” given by equation (4) and equation (8) is:

$$T_4 = \frac{1}{1 + \exp(0.040x - 4.793)} \tag{10}$$

Discount market (L) is expressed by equation (11) as:

$$L = T_1' - T_4 \quad (P_1 \leq x \leq P_3) \tag{11}$$

where

P_1 ; Minimum Price and P_3 ; Standard Price

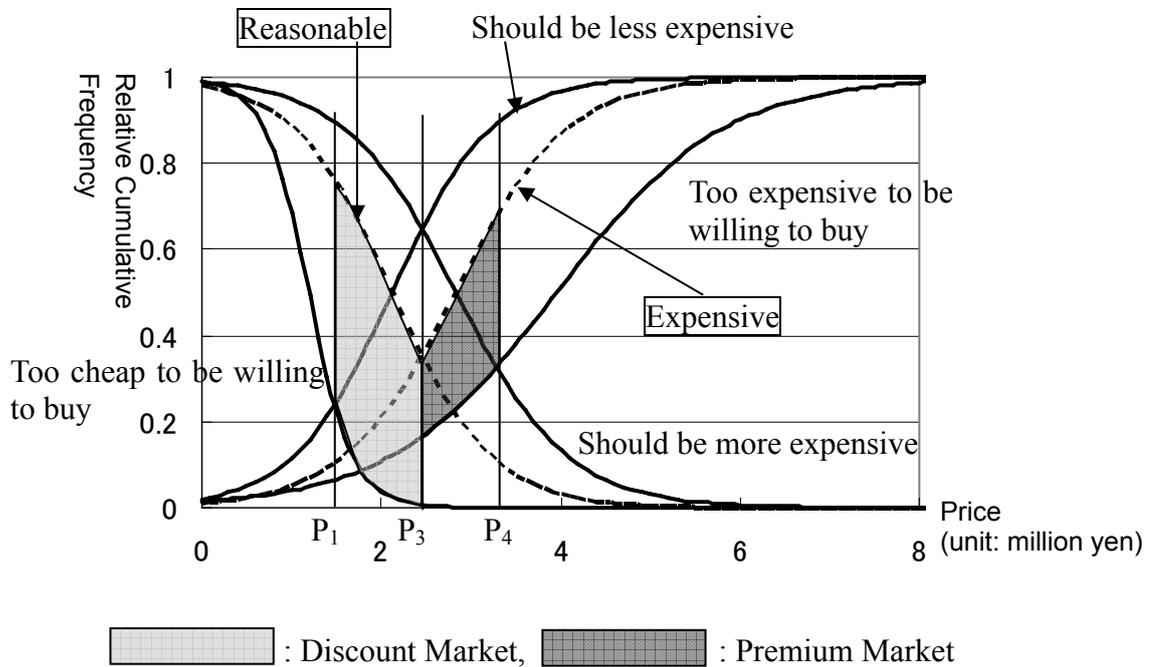


Figure 15. Discount Market and Premium Market for a Hybrid Car in Tokyo

When $x = 1.711$ million, $L_{\max} = 0.566$.; most people will buy hybrid cars perceiving the price of 1.711 million yen as reasonable.

The logit model of “Expensive” price is derived from:

$$T_2' = \frac{1}{1 + \exp(-0.016x + 4.549)} \tag{12}$$

The logit model of the price “Too expensive to be willing to buy” is given by equation (4) and equation (7):

$$T_3 = \frac{1}{1 + \exp(-0.011x + 4.270)} \tag{13}$$

Discount Market (U) is expressed by equation (14):

$$U = T_2' - T_3 \quad (P_3 \leq x \leq P_4) \tag{14}$$

where

P_3 ; Standard Price and P_4 ; Maximum Price

When $x = 3.286$ million, $U_{\max} = 0.346$.; most people will buy hybrid cars in spite of perceiving the price of 3.286 million yen as expensive.

Analysis results of responses in Tokyo and in Sapporo are shown in Table 5.

Table 5. Discount Market and Premium Market of a Hybrid Car (unit: million yen)

		Tokyo	Sapporo
Discount market	L_{\max}	1.711 (56.6%)	1.716 (47.9%)
Premium market	U_{\max}	3.286 (34.6%)	2.983 (31.6%)

The prices for the largest Discount Market are almost the same in Tokyo and Sapporo, but the market scale of Tokyo is larger than that of Sapporo.

Although people in Sapporo are concerned about the environment, their concerns do not lead to low-pollution car purchase. A purchase price is an important factor when people buy a low-pollution car (Hashimoto *et al.*, 2003). From the results of KLP analysis, price of hybrid car accepted by people in Sapporo is lower than in Tokyo. That is the reason why they have a weak purchase consciousness.

5. CONCLUSION

Hybrid car prices vary depending on vehicle type. For example, in Japan, the price of Toyota Prius is about 2.2 million yen and it is almost the same with Standard Price. On the other hand, the price of Toyota Crown or Estima Hybrid is over 3.3 million yen and it is even higher than Maximum Price although it is the case of the high environmental awareness group. Although there are people who will buy a hybrid car which is more expensive than a gas-powered car, there are few hybrid cars with prices acceptable for the potential purchasers.

Now gas-powered cars are mainstream vehicles in Japan and it is necessary to prevail low-pollution cars to minimize vehicle oriented environmental problems. Toward the future, lowering low-pollution car price and diversifying the vehicle type are as important as raising the environmental awareness of people. Subsidy systems for low-pollution car purchase including the green tax program should also be sought.

In the questionnaire survey, respondents' income has not been asked to respect their privacy. Since the average income per household in Tokyo is higher than that in Sapporo, there may be any relation between people's income and willingness to buy a low-pollution car, but it could not be clarified in this paper. It will be investigated in our future study.

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