# The Validity Of "*TDS-DTM*": A Strategic Methodology Of Merchandise Development Of *New JIT*-Key To The Excellence Design "*LEXUS*"

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**ABSTRACT**

*Recently, the author has touched on the development of the principle of "New JIT" and its validity. In this paper, the author presents "TDS-DTM" (Toyota Development System-Design Technical Methods) as a methodology of New JIT, which contributes to strategic product development. The excellence profile design of "LEXUS" has achieved by TDS-DTM.*

**Keywords:** New JIT, TDS-DTM, Customer Science, Profile Design, Psychographics, LEXUS,

## 1. Introduction

Recently, the author has touched on the development of the principle of "*New JIT*" and its validity as a new management technology for 21st century manufacturing. *New JIT* innovates the business process of each division, which encompasses sales, development and production. *New JIT* includes hardware and software systems developed according to new principles to link all activities throughout a company. The hardware system comprises three core elements: "TMS" (Toyota Marketing System), "TDS" (Toyota Development System) and "TPS" (Toyota Production System). The software system is the deployment of "TQM-S", which is a new principle for quality management by utilization of "*Science SQC*".

In this paper, the author discusses the importance of "Customer Science" and presents "*TDS-DTM*" (Toyota Development System-Design Technical Methods), which contributes to strategic product development. *New JIT* has achieved a given objective by pursuing studies on applying the above methodology to the excellence profile design of vehicles. Concretely, the application of the process to the product development of "*LEXUS*" will be described in the sequence of steps 1, 2 and 3 as the follows: step 1 is the studies on the customers' sense of values using collages, step 2 is the studies on the customer's design preferences for vehicle appearance and step 3 is the studies on the psychographics of the *LEXUS* profile design. The market reputation of the *LEXUS* in Japan and overseas has demonstrated the validity of *TDS-DTM*, a strategic methodology of product development as the key to *New JIT*.

## 2. *New JIT*, A New Management Technology Principle

The mission of enterprises is to provide customers (consumers) with products that delight them, and fulfilling that mission is the key to the continuation of a corporation. In the new century that requires product development on the basis of global marketing management, it is becoming more and more necessary to develop products that enhance customer value with the understanding of their life stage and style. To realize this, we believe that it is important to implement "*Customer Science*" [1], in which images of the customer's voice (implicit knowledge) are correctly conceptualized (developed into a language) and converted into (turned into explicit knowledge of) engineering language (drawings) as shown in Fig. 1.

To do this, it is important to develop a new methodology to enable us to conduct strategic product development so as to supply customers with what they want before they know it, and verify the effectiveness of this methodology, *Customer Science*. In this connection, the authors [2-7] proposed the *New JIT* shown in Fig. 2 as a new methodology for promoting corporate quality management by grasping *Customer Science* from a scientific viewpoint.

This is configured with the hardware system having the three core elements of TMS, TDS and TPS for establishing new management technology principles for business planning, sales, R&D, design, engineering, and production, among others in the figure. The author quotes *Science TQM* so called TQM-S (Total Quality Management by utilizing new quality control principle *Science SQC*) with software system, which the authors proposed as a corroborative science methodology to apply these systems to quality management [8, 9]. It has demonstrated enhanced effectiveness in respective divisions of engineering design, production and business-sales and others).

## 3. New Expectation for TDS, Key to *New JIT*

In the area of product technology, the validity of TDS shown in Fig. 3 was demonstrated in studies on the improved reliability of the automotive transaxle [10-11]. TDS contributes to enhancing reliability and creating technologies of business process for research and development, design and prototype, and test evaluation.

As stated earlier, the task today is to establish a strategic product development method to lead the current generation by exploring customer needs in depth with the purpose of developing and supplying customer-oriented, attractive products. To do this, it is important to strengthen design on the basis of information (a) in Fig. 3, and the innovation of the business process for the product development and design becomes ever more important in Fig. 4 [12].

In particular, the process required for product development is as follows: (1) at the strategic product concept stage, "wants" are created; (2) at the development designing stage, the concept is made into more concrete form; and (3) at the product designing stage, the development of high quality drawings is required. The new expectation for and role required of TDS is the establishment of a new methodology to support the designing of strategic products from customer information in stages (1) and (2).

## 4. Proposal of *TDS-DTM*, the Validity of a Strategic Methodology of Merchandise

### 4.1 Necessity of a Strategic Design Support Method

In the process of product development designing (hereinafter referred to as designing), proposing a strategic product (work) is based on the conception. It is important to study methodology "a Strategic Design Support Method" to scientifically support the process of conception. That is, it must be determined what sort of conception should be created for presenting an advanced concept ahead of others. It is important that the designing of strategic products should not be an analysis teleologism for obtaining general solutions as design engineering. Instead, it should create a live particular solution to grasp the next generation.

To enable to forecast what sort of product will sell in the future, the author thinks it will become more important in terms of design strategy to grasp the customers' sense of values objectively and incorporate it into the design process for embodiment [13-15].

### 4.2 Proposal of *TDS-DTM*, a strategic Methodology of Merchandise

The authors [12] think that the analysis process itself that turns implicit knowledge named designing into explicit knowledge constitutes the secret to the conception. In this connection, the author propose "*TDS-DTM*" (Toyota Development System-Design Technical Methods), the conception support method for developing strategic product quoting the "SQC Technical Method," which is a core method of the "Scientific SQC" in Fig. 5. This

diagram signifies implementing *Customer Science* for turning the design process into an explicit knowledge as more creative activities from the implicit knowledge of designing. We will attempt to carry on the "bridging" portion in the course of realization of strategic product designing from the mainly research-oriented analysis as the event analysis according to the business process (Step 1 to Step 2 to Step 3 in the diagram) shown in Fig. 4.

This methodology is intended to establish a new methodology for supporting conception, which will ascertain the field covered by conception adapted to the times and contribute to enhancing the proposal capability of designers. In the following, we will expressly show the utilization process of the "Design Technical Methods" proposed and demonstrate its validity through cases of application studies.

## 5. Application of *TDS-DTM* to the *LEXUS* Design Profile

This section discusses studies on the "Design Profile" to which Toyota first applied the "Design Technical Methods". In the following, the application process of *TDS-DTM* for the product development of a new model of "Aristo/Celsior (U.S. name: *LEXUS* GS400/LS430)" be described in the sequence of Step 1, Step 2 and Step 3 of Fig. 5. In these connections, the authors [12, 16-18] confirm the development of *New JIT*, the key to the excellence design *LEXUS.*

### 5.1 Studies on Customers' Sense of Values Using Collages (Step 1.)

A collage is something created by gluing various materials on a picture surface. It is a design process for creating images as represented by Picasso [21] with his work (Still Life with Chair Caning, 1912); such a work is called a collage panel. Upon designing a global strategic vehicle *LEXUS*, the matter of primary concern for the designer is how to catch the target customers' heart. For the present time, we use collages created by the designer and search for coincidence with the designer's images by investigating the customers' sense of values scientifically using the following methods:

#### 5.1.1 Creation of collage panels for researching design images

Types: (An image by the designer)

We prepared for six kinds of the following as an example of Fig.6.
A: Ethnic (Soft), B: British (Traditional), C: German (Artificial), D: French (Natural), E: Japanese (Ceremonial), F: Italian (Casual)

Composition:

Decorative accessories, Watches, Rooms,
Interior decor, Gadgets, Clothing

#### 5.1.2 Questionnaire with customers for image survey by generation

Example: 372 Japanese subjects selected with an assumption of domestic sales

Generation: The name of the generation, the age, the number samples and the origin of the name are as follows:

(a) "Cinema generation" (19 people aged 56 to 65);
When they were in the bloom of youth, the movie industry was also in the golden period and in the center of the youth cult.
(b) "Baby-boomers" (30 people aged 50 to 55);
Their generation presents the maximum population in the post-war period.
(c) "DC-baptized generation" (53 people aged 43 to 49);
This generation is characterized by zeal for by wearing fashionable DC (designer and character) branded

clothes.
(d) "New humans" (so called "Shinjinrui") (52 people aged 37 to 42);
When they were young, they were thought "eccentric" by an adult.
(e) "Bananas" (90 people aged 31 to 36);
This generation tends be sensible and prefer moderate personality. Sensuous characters in the work of the Japanese novelist, Banana Yoshimoto are typical of this generation.
(f) "Baby-boomer juniors" (128 people aged 25 to 30);
This generation is the children of baby boomers.

Implementation of questionnaire: (subjects selected at random)

Out of the image-expressing design terminologies, the designer extracts 24 "image words" (such as "1.Elegant", "2.Cute", "3.Approachable", "4.Delicate","5.Tasteful", "6.Fine Sense", "7.Refined", "8.Calm", "9.Intellectual", "10.Traditional", "11.Adult", "12.Orthodox", "13.Simple", "14.Urban", "15.Advanced", "16.Bold", "17.Powerful", "18.Energy", "19. Light", "20.Sporty", "21.Future", "22.Luxurious", "23.Youthful", and "24.Individuality") popularly used by designers and easily understood by people in general.

The subjects (I) select image words (multiple answer) they associate with the panel presented, and (II) rank the panels in the order of their preference (1st place: 6 points, 2nd place: 5 points, 3rd place: 4 points, 4th place: 3Points, 5th place: 2 points and 6th place: 1 point).

### 5.1.3 Analytical example of the "images of preferences by generation"

As an analytical example of investigating customers' sense of values, Fig. 7 shows the result of analysis of the principal component analysis of the questionnaire (order of image word preference by generation). From the figure, the primary component axis is interpreted as modern/formal, the secondary axis as soft/sharp. A: ethnic, D: Italian, and F: French are positioned in the first quadrant, B: British in the second quadrant, E: Japanese in the third quadrant and C: German in the fourth quadrant. In addition, according to the data given in the same diagram, the mean value of each group implys the general characteristics of each group as follows: the "bananas" and "new humans" tend to like panels A, B, D and F, the "baby-boomers" and "DC-baptized generation" tend to like B and E, the "cinema generation" like E, and "baby-boomer juniors"
like C.

However, the above results were affected by the difference in the customers' lifestyle elements, and the preferences of a panel are widely spread among subjects of the same generation as shown in the example of the Fig. 8.

The inside of the figure shows the dispersion of the taste with six collage panels of the baby-boomer generation and the image words. Similarly, we have found that the panel images of the designer coincide with the preferences of the consumers of the generation the designer belongs to but do not necessary coincide fully with those of other generations.

From these analytical results, (although not shown in the diagram) it is possible to surmise that the idea for developing strategic products can be born in two ways, namely, by the royal road to designing by using a designer of the same generation as that of the target customers, or by using a designer of a different generation from the target to create an appealing design from a new point of view. Based on these analyses, we study customer preferences for designing vehicle appearance as step 2.

### 5.2 Studies on the customer's design preferences for vehicle appearance (Step 2.)

It is a well-known fact that the design of vehicle appearance has considerable weight in the customer's decision to make a purchase. To which part of vehicle appearance design do customers, domestic and overseas (regardless of age and sex), pay attention? Professional automotive profile designers have a theory (rule of thumb)

that in general, Japanese customers tend to focus on the front design while North American customers look at the overall design of front, side and rear. Our challenge here is to give an objective analysis on the theory.

To the authors' knowledge, no report has been made for objective verification of the theory by research and analysis in the academic world. Therefore, quantitative evaluation on the sections of vehicle appearance customers are interested in will advance a customer-in design strategy. For designing the new *LEXUS* GS400/LS430 for model change, 157 customers (young and old, and male and female panels) of various personality are asked to evaluate the appearance of the four major, mutually-competing models (BMW 850i/1990 model, Benz 300-24/1989 model, Legend coupe/1991 model and Soarer 4.0GT/1991 model) and priority of the three appearance factors: front, side and rear views. In analysis I, we will verify the correlation between the evaluation and priority by multi-regression analysis.

The three appearance factors are further divided into the design balance (profile) and detailed elements (4, 9, and 5 sections respectively) for a similar study on their causal relationships as analysis II. A preliminary cluster analysis shows that the customers can be stratified in terms of the overall liking of the vehicle appearance into a group lower in age and annual income and a group higher in age and annual income in their personalities for all four models. Fig. 9 shows an example of analytical results on a vehicle model specified to the group lower in age and annual income. In analysis I, the contributory factor adjusted for the degree of freedom ($R^{*2}$) representing the degree of influence to the overall evaluation of vehicle appearance (X1) is 0.74, indicating a high causal relationship.

The breakdown is as follows: The influence of front view (X2) is fairly high at Bfv = 0.46 while those of the side and rear views (X7 and X17) are at Bsv = 0.30 and Brv = 0.29, showing their positive influences. In analysis II, the head lamp and grille (X3) have a high degree of influence on the front view (X2) while the overall side view and design (X16) and tail lamp (X20) and rear bumper design (X21) exert much influences on the side view (X7) and rear view (X17) respectively. In the group higher in age and annual income, though not illustrated, the influence of the front view is even higher at Bfv = 0.59 while the influence of the side and rear views (X7 and X17) are relatively low at Bsv = 0.18 and Brv = 0.17 in analysis I. In analysis II, the analytical results are similar to those for the group with lower age and annual income but the influence of bonnet (X4) is high on the front view (X2).

It is verified that the vehicle appearance is evaluated in a wider range; for example, the influence of the line (X19) from the rear to the trunk and the design balance (X22) of the rear as a whole are high on the side view (X7). This analytical trend also applies to other three models. A similar survey and analysis are conducted in North American market. While the front view is generally high priority in Japan, it is known that the front, side and rear views are equally valued in North America.

Other noticeable input is that Japanese customers are likely to provide individual evaluation for each front, side and rear view at a dealer, while North American customers evaluate the front view while looking at a moving car on the opposite lane, evaluate the side view while looking at a car driving pass, evaluate the rear view similarly on the street. We confirmed that as they evaluate the three appearance factors, their focus is the total balance of the design. Through this analytical study approach, designers have understood the need for the customer-in design strategy that gives consideration to the characteristics of each country. These findings are the result of verification of the designer's theory (rule of thumb), which greatly contributed to the designing of the global strategic vehicle, *LEXUS* GS400/LS430.

### 5.3 Studies on the psychographics of the "LEXUS" profile design (Step 3.)

In the product development stage, a process of modifying the appearance profile (proportion: ratio) to a scientifically legitimate profile that matches the preferences of customers based on the relationship of the contour and psychological factors is called "profile design psychographics". The significance of the present study does not lie in the trendy research of the "newness" of mere passing fad that places importance to the form and surfaces (round, square). It is the development of explicit knowledge of "evolutional newness" demanded as a matter of

course. It is most typically expressed with proportion.

A principal component analysis was conducted on 62 domestic and overseas vehicle models. Their model years (year of introduction), classes (selling price) and proportions (hood ratio, luggage compartment ratio, cabin ratio, roof ratio, front and rear overhang ratios, wheel base ratio, overall height ratio, overall breadth ratio, and the roof/cabin ratio in relation to overall length were obtained autographically and their principal components were analyzed respectively by vehicle class (from class 5 for high class to class 1 for low class) and the year of introduction (three categories: before ’86, ’87 to ’91, and ’92 and onward).

When the scatter diagrams on these two principal components are overlapped as shown in Fig. 10-1 and Fig. 10-2, old, high class vehicles with a coach-type cabin (with long hood and luggage compartment length) such as the famous Rolls Royce, Benz W123, BMW518, Jaguar X16, etc., are laid in the second quadrant. In the opposite fourth quadrant, late-model vehicles with a long cabin and shorter hood and luggage compartment are positioned. From the results of these analyses, it has been quantitatively clarified that seemingly “highest class” and “latest” are mutually contradictory elements.

The authors then identified the general rule (that was not the intentional but the natural consequence of designers’ works) of the common proportional ratio (highest class) that is inherited in the world’s prestigious vehicles and insusceptible to change over five or ten years. In addition to applying the general rule to the *LEXUS* design profile, the authors manifested advanced form and surface to realize the combination of “highest class” and “latest” for *LEXUS* design development. With this study, we explicitly established the roles of the profile, form and surface. We also realized and embodied the combination of a profile of a reputable vehicle, advanced form and surface through the development of the *LEXUS* GS400/LS430.

The market reputation of the *LEXUS* [20-22] in Japan and overseas has demonstrated the validity of *TDS-DTM*.

## 6. Conclusion

This study discussed the effectiveness of TDS as the key to *New JIT* and proposed the innovation of business process in developing and designing attractive product by *TDS-DTM* as the method to develop idea for strategic product development. *TDS-DTM* was applied to the study of *LEXUS* profile design to enable the analysis of customers’ value regardless of the nationality from the “Customer Science” point of view. This study played the key role to develop “*LEXSUS* GS400/LS430” of which design profiles receive global popularity.

## Acknowledgements

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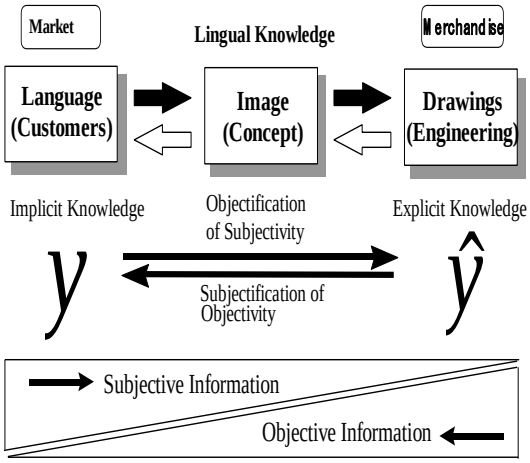


**Fig. 1 Schematic drawing of "Customer Science"**

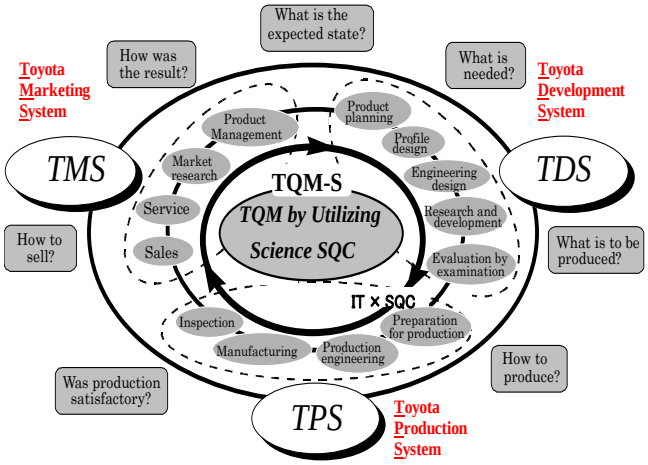


**Fig. 2 Schematic drawing of "New JIT"**

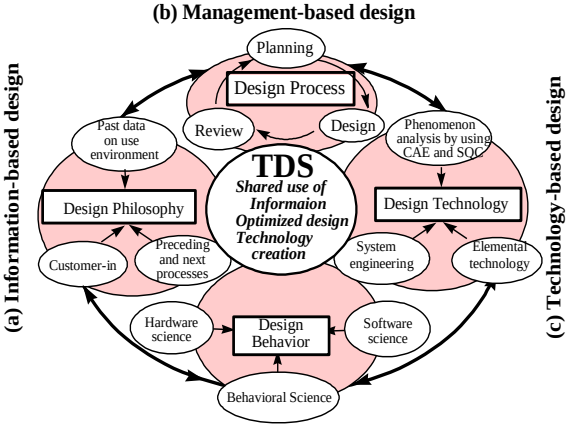


**Fig. 3 Schematic drawing of "TDS"**

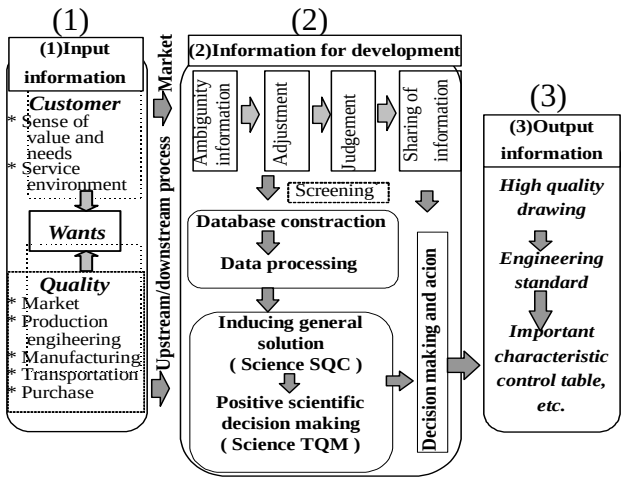


**Fig. 4 Business process of development design**

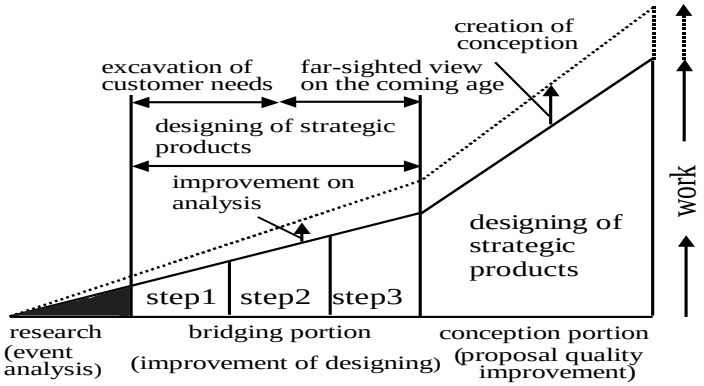


**Fig. 5 "*TDS-DTM*", the conception support methods for developing strategic product**


**Fig.6 Image example of the designer to a collage panel - type B (British) and type E (Japanese) -**

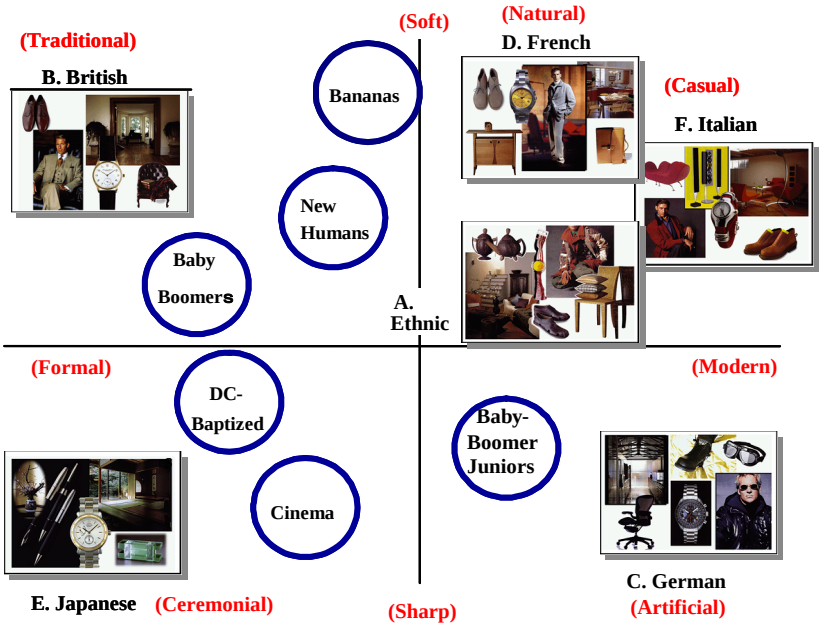


**Fig.7 Collage panel image analysis by generation**
**(Principal component analysis/correlation method: scatter diagram of the principal ratings)**

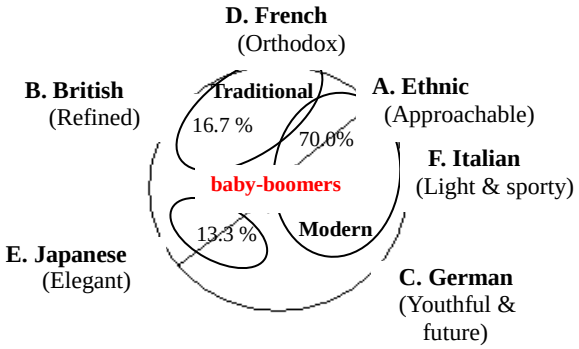


**Fig.8 The dispersion of the taste in baby-boomer Generation and the Image Words**

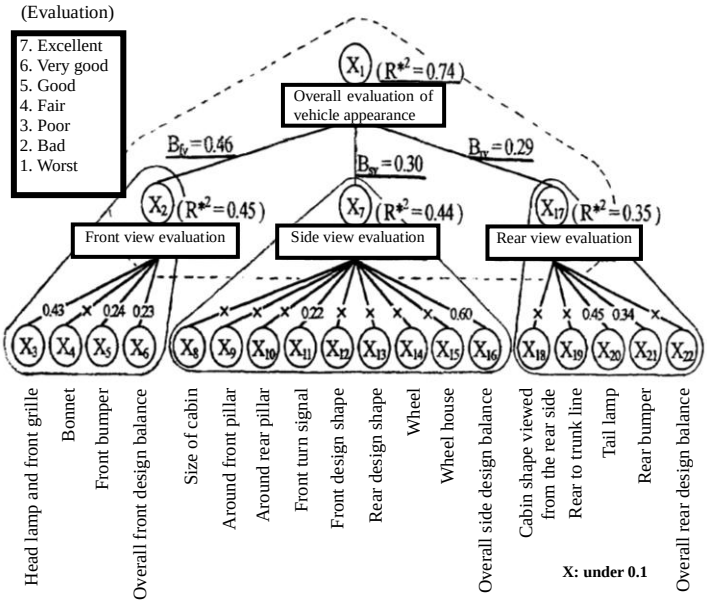


**Fig.9 Causal relationship between customer satisfaction assessment and vehicle appearance assessment factors by multiple regression analysis**

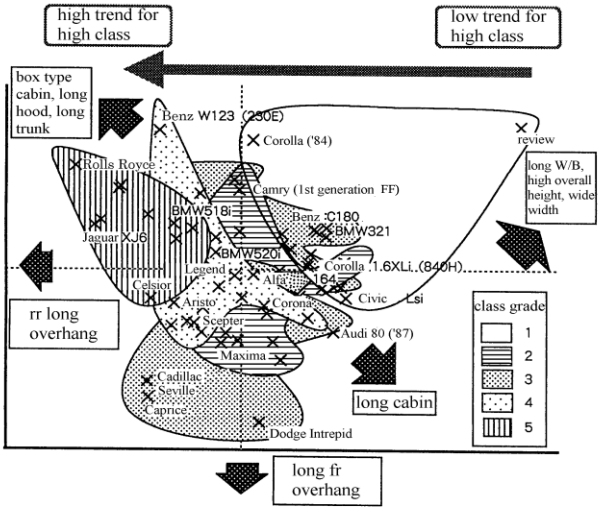


**Fig.10-1 Classification of vehicle model by the class degree**

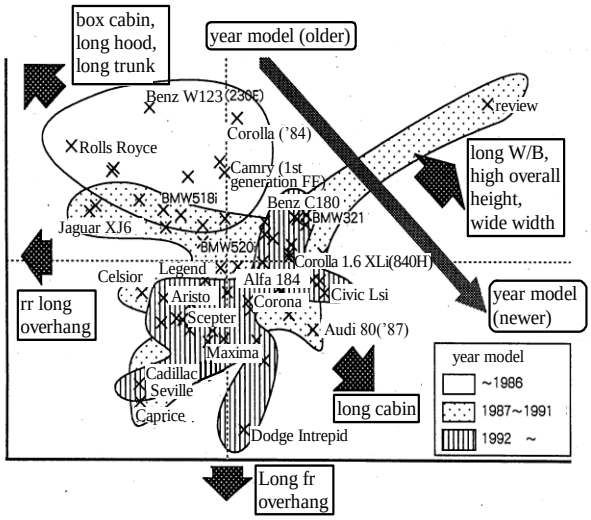


**Fig.10-2 Classification of vehicle model by the year model**

**NOTES**