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A STUDY USING FUZZY LINGUISTICS ON THE CORRELATION BETWEEN FUNCTION OF WOOD FURNITURE PRODUCT DESIGN AND TAIWAN CONSUMER SATISFACTION

The study adopted fuzzy linguistics to discuss the correlation between function of wood furniture product design and Taiwanese consumers satisfaction. The result indicates that the function of wood furniture product design and the fuzzy linguistics of consumer satisfaction are significantly correlated while fuzzy linguistics calculated by fuzzy membership function $\mu(x)$ lie in between "more agree" and "strongly agree". The multiple regression equation was used, based on independent variables such as actual performance, ergonomic design, and form design, to remarkably predict the fuzzy linguistic value of consumer satisfaction. The conclusion of this study could be a reference to design of wood furniture product for designers or companies, in order to develop wood furniture product meeting consumer demand and great satisfaction which might enhance business performance and the company competitiveness.

Keywords: fuzzy linguistics; function of wood furniture product design; consumer satisfaction; fuzzy membership function.

Ан Шенг Лі

КОРЕЛЯЦІЯ МІЖ ФУНКЦІОНАЛОМ ДИЗАЙНУ ДЕРЕВ'ЯНИХ МЕБЛІВ ТА МІРОЮ ЗАДОВОЛЕНОСТІ ПОКУПЦІВ: ДОСЛІДЖЕННЯ ЗА ДАНИМИ ТАЙВАНЮ ЗА ДОПОМОГОЮ ЛІНГВІСТИЧНИХ ЗМІННИХ

У статті за допомогою методів нечітких множин та лінгвістичних змінних досліджено кореляцію між функціоналом дизайну дерев'яних меблів та мірою задоволеності покупців за даними Тайваню. Результати аналізу вказують на високу кореляцію в цілому, розташовану між оцінками "скоріше згоден" та "категорично згоден". У регресійному аналізі незалежними змінними обрано функціональність, ергономіку та дизайн форми. Висновки дослідження можуть стати корисними для дизайнерів та виробників меблів при дослідженні потреб клієнтів, що у подальшому може вплинути на бізнес-показники меблевих підприємств.

Ключові слова: лінгвістичні змінні; функціонал дизайну дерев'яних меблів; задоволеність клієнтів; функція приналежності у нечітких множинах.

Табл. 5. Рис. 4. Форм. 4. Літ. 24.

Ан Шенг Лі

КОРЕЛЯЦИИ МЕЖДУ ФУНКЦИОНАЛОМ ДИЗАЙНА ДЕРЕВЯННОЙ МЕБЕЛИ И МЕРОЙ УДОВЛЕТВОРЁННОСТИ ПОКУПАТЕЛЕЙ: ИССЛЕДОВАНИЕ ПО ДАННЫМ ТАЙВАНЯ ПРИ ПОМОЩИ ЛИНГВИСТИЧЕСКИХ ПЕРЕМЕННЫХ

В статье при помощи методов нечётких множеств и лингвистических переменных исследована корреляция между функционалом дизайна деревянной мебели и мерой удовлетворённости покупателей по данным Тайваня. Результаты анализа указывают на высокую степень корреляции в целом, расположенную между оценками "скорее согласен" и "категорически согласен". В регрессионном анализе независимыми переменными выбраны функциональность, эргономика и дизайн формы. Выводы исследования могут быть полезны для дизайнеров и производителей мебели при исследовании потребностей клиентов, что в дальнейшем может повлиять на бизнес-показатели мебельных предприятий.

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Ключевые слова: лингвистические переменные; функционал дизайна деревянной мебели; удовлетворённость клиентов; функция принадлежности в нечётких множествах.

1. Introduction

As time changes, companies face more challenges. Consumers selecting commodities will no longer emphasize the basic value a product offers; instead, they attach importance to product. Lee (2009) mentioned that to satisfy consumer demand, enterprise should achieve product differentiation by innovative product design function and even understand customer requirement for product to successfully design a favorable and satisfying product.

Chang and Hsu (2005) posed that consumers making much of different product design functions influence their preference for buying furniture. Especially furniture's form, ergonomic and functional design are evidently correlated with consumers' preference for buying furniture, which enhances consumer satisfaction. Lee (2009) said designers could conduct market research before furniture design to understand the consumer demand for furniture product function and further improve consumer satisfaction.

Tsai et al. (2003) indicated enterprises taking customer demand and user's satisfaction into consideration in design and development of new product save development cost and prolong product lifecycle. It is a new stream to know consumers' preference and demand for wood furniture product design in addition to customer demand-oriented product development. With customer's cognition of a product, consumer satisfaction may be increased. The study expected to be a reference to design of new wood furniture product for designers or companies which betters business performance and competitiveness of company.

2. Research purpose

The study aims to investigate the correlation between the function of wood furniture product design and Taiwan consumer satisfaction by applying fuzzy linguistics.

3. Research limitation

The limitation in the study was its investigation on Taiwan consumer satisfaction at the function of wood furniture product design on the basis of consumer's opinion after experiencing the function of wood furniture product. The participants were randomly selected from the hypermarkets in Taiwan.

4. Literature review

4.1. Function of wood furniture product design. Nussbaum (1988) explained the meaning and the nature of design from the functional, aesthetic and ergonomic perspectives related to product design. McDonagh et al. (2002) classified the functions of design including product performance, ergonomics and aesthetics of form. Veryzer (1995) posed that consumers are often affected by the components of product design such as color, texture, size and form. The study probed the correlation between the function of wood furniture product design and fuzzy linguistics of consumer satisfaction. As mentioned above and according to McDonagh et al. (2002) on the function of design containing actual performance, ergonomics and aesthetics of form, the study generalized a conclusion of using actual performance, ergonomic design and form design as the dimensions to be studied, the definition of which were added to the items in the survey conducted. Definitions and measurement for the questionnaire

are as follows: 1. Actual performance: the function of a product is practical, simple in structure and able to solve problems occurred in the use for consumers. 2. Ergonomic design: easy-to-use and comfortable product for consumers that increases efficiency and safety. 3. Form design: designs which attract consumers including texture, shape, size and color. Thus, actual performance, ergonomic design and form design were used as the dimensions to research the function of wood furniture product design.

4.2. Consumer satisfaction. In recent years, consumer awareness has been emerging and growing. Hence, customer orientation is emphasized to understand the potential customer demand and successfully promote a product at a market. Oliver (1999) said satisfaction is a kind of joyful content indicating a judgment and cognition for the level of delight deriving from a product experienced by a consumer after a purchase. Oliver (1993) investigated consumer satisfaction as the value obtained from a particular product or a service used. Woodside and Daly (1989) and Churchill and Surprenant (1982) mentioned consumer satisfaction is the formation of consumption behavior which reflects the degrees of like and dislike after use. Oliver (1993) indicated satisfaction is an evaluation of comparative cognition in obtainment and expectation of a product used by a consumer.

4.3. Function of wood furniture product design and satisfaction. The study is focused on whether cognitive difference in consumer satisfaction with product design could be known in advance while minimizing the difference and enhancing consumer satisfaction. Chang and Hsu (2005) presented the functions of product design divided into 3 categories such as functional design, ergonomic design and form design. The research result demonstrated a positive interaction between product design and consumer satisfaction. Nussbaum (1988) discovered product design bridges the interaction between human and objects that directly impacts consumer satisfaction. The study concluded the correlation between the function of wood furniture product design containing actual performance, ergonomic design and form design and fuzzy linguistics of consumer satisfaction.

5. Research method and framework

The study chiefly investigated mutual prediction and correlation between "function of wood furniture product design" and "fuzzy linguistics of consumer satisfaction" with the framework shown in Figure 1.

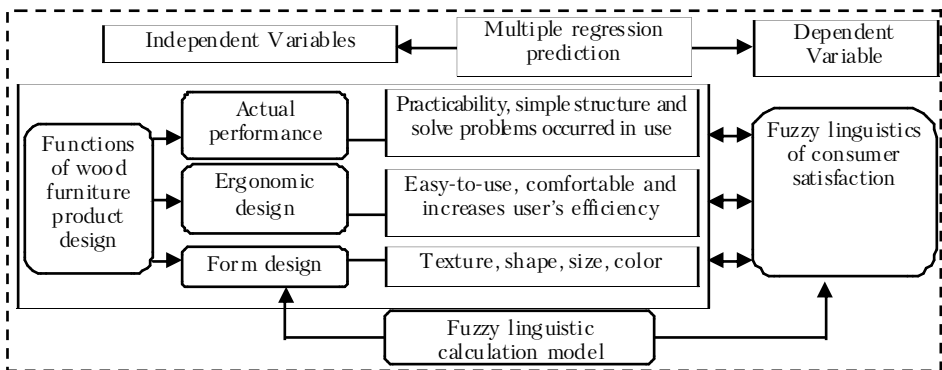


Figure 1. Framework for the correlation between function of wood furniture product design and fuzzy linguistics of consumer satisfaction, author's design

5.1. Fuzzy linguistics. Chen and Hwang (1992) pointed out 8 common fuzzy linguistic variables in current researches that considerably facilitate the subsequent studies. Costs et al. (1994) and Hesketh et al. (1988) figured out fuzzy scale as a basis for behavioral measurement while creating applicable measuring tools. Voxman (2001) mentioned two canonical representations of discrete fuzzy number and proposed calculating them separately. Matarazzo and Munda (2001) offered that conventional researches of linguistic strategy were limited to triangular fuzzy number, so they suggested integrating the calculation of fuzzy numbers.

Fuzzy numbers commonly used in the studies include: triangular fuzzy number, trapezoidal fuzzy number and normal fuzzy number. Therefore, the study used triangular fuzzy number as the index weight based on Likert 5-point fuzzy linguistic scale. The fuzzy linguistic scale was designed from the view of fuzzy linguistics, and meanwhile evaluation of fuzzy linguistics was used for knowing the feel of participants.

5.2 Triangular fuzzy number. Zadeh (1965) presented the application of fuzzy theory for expressing the respondents' fuzzy linguistics of product. Commonly used are the function and the chart shown in Figure 2:

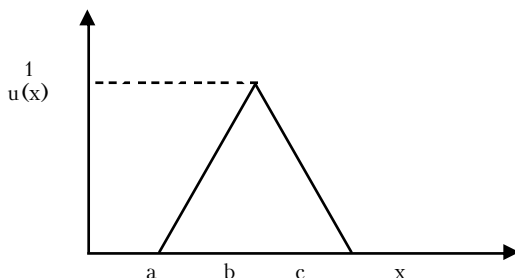


Figure 2. **Triangular fuzzy number and the chart of membership function,** designed by the author

$$u(x) = \begin{cases} 0 & , x \in [0, a] \\ x - a & , x \in (a, b) \\ 1 & , x = b \\ c - x & , x \in (b, c) \\ 0 & , x \in [c, \infty) \end{cases} \quad (1)$$

6. Research hypothesis and question

Lee et al. (2008) investigated and discovered a positive correlation between product design and consumer purchase intention. Hsiao and Chen (2010) proposed product design delights people who express positive preference and evaluation. The study posed the following hypothesis and question for research:

Research hypothesis: H1: Wood furniture product design is significantly correlated with the fuzzy linguistics of consumer satisfaction.

Research question: Multiple regression equation is used for such independent variable as the function of wood furniture product design to predict the dependent variable – the fuzzy linguistics of consumer satisfaction.

6.1. Operational definition of the studied variables and statistical handling of the questionnaire data related to fuzzy linguistics. The study adopted fuzzy linguistics for valid questionnaires which were then analyzed. According to the data handling of

fuzzy rule base is suggested by scholars including Chien and Tsai, (2000) and Wu et al. (2004). It offers 5 linguistic terms – "Strongly agree", "More agree", "Agree", "Disagree" and "Strongly disagree" about such linguistic variable as the expected satisfaction with respective triangular fuzzy numbers. a , b and c stand for the coordination numbers for the expected triangular fuzzy linguistics while $X = (0, 0, 1)$, $(0, 1, 2)$, $(1, 2, 3)$, $(2, 3, 4)$ and $(3, 4, 5)$ were hypothesized as the 5 linguistic terms. As to data output of fuzzy inference and defuzzification (Klir and Yuan, 1995), defuzzification was applied to the fuzzy statistics posterior to fuzzy arithmetic of satisfaction to get a crisp value for analysis in later researches. Defuzzification was conducted based on the Center of Area used in the study by Kaufmann and Gupta (1991), Chien and Tsai (2000) as well as Hsu and Lin (2005). Below are the triangular fuzzy numbers calculated in this study (Figure 3).

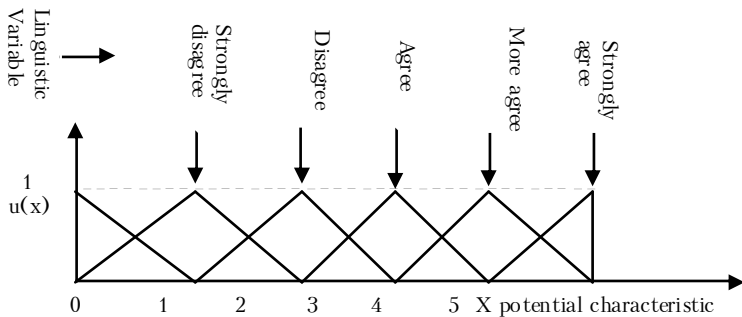


Figure 3. The chart for membership function of five-point fuzzy linguistic variable, designed by the author

$a_1 b_1 c_1 - X = (a_1, b_1, c_1)$ – arithmetic of fuzzy linguistics for the first part of the questionnaire.

$a_2 b_2 c_2 - X = (a_2, b_2, c_2)$ – arithmetic of fuzzy linguistics for the second part of the questionnaire.

X – the equation for linguistic defuzzification of satisfaction as below: suppose $X = (a, b, c)$, $V_X = (a+2b+c)/4$.

Equation for descriptive statistics for fuzzy linguistics of the second part in the questionnaire was inferred as (1): $X=(a_1, b_1, c_1)$, $V_X = (a_1+2b_1+c_1)/4$, which was transformed to

$$\text{Fuzzy Linguistic Mean} = \left[\sum_1^n (a_1 + 2b_1 + c_1) \right] / 4N, \tag{2}$$

$N = 595$ (the number of respondent).

Equation for descriptive statistics for fuzzy linguistics of the third part in questionnaire was inferred as (2): $X=(a_2, b_2, c_2)$, $V_X = (a_2+2b_2+c_2)/4$, which was transformed to

$$\text{Fuzzy Linguistic Mean} = \left[\sum_1^n (a_2 + 2b_2 + c_2) \right] / 4N, \tag{3}$$

$N = 595$ (the number of respondent).

According to the equations (2) and (3), fuzzy linguistic value of the questionnaire was statistically analyzed.

7. Questionnaire Design

The questionnaire designed in this study attempted to discuss the function of wood furniture product design against the fuzzy linguistics of Taiwan consumer satisfaction; the degree included strongly agree, more agree, agree, disagree and strongly disagree. The first part – basic information – contained gender, age, educational attainment and monthly salary. The second part: according to participants' view and evaluation of function of wood furniture product design composed of actual performance, ergonomic design and form design, 1 indicated "strongly disagree", 2 – "disagree", 3 – "agree", 4 – more "agree" and 5 – "strongly agree" in terms of fuzzy linguistic values. The third part: satisfaction with wood furniture product was subjectively evaluated by participants after use. Fuzzy linguistic value was explained the same as that in the second part.

7.1. Questionnaire survey, reliability and validity. Validity of the questionnaire was confirmed by the expert panel through interview. 78 pilot studies were conducted for proper amendment and adjustment. According to the criteria suggested by Nunnally (1978), questionnaire has good reliability when Cronbach's α is greater than 0.7. Concerning the participants' view and the evaluation of function of wood furniture product design composed of actual performance, ergonomic design and form design in the second part of questionnaire, Cronbach's α of 0.937 was obtained in the pilot study which is greater than the standard 0.7. For participants' satisfaction with purchasing and using wood furniture product was subjectively evaluated by in the third part of the questionnaire, Cronbach's α of 0.928 in the pilot study was greater than 0.7. The pilot studies of the two parts in the questionnaire showed extremely high reliability.

8. Analysis of Descriptive Statistics on the Questionnaire

595 participants throughout Taiwan were selected for the sample of this study. Regarding gender distribution, male accounted for 53.6% while female accounted for 46.4%. As to age, the group of 30–39 years old is the largest, accounting for 32.6%; the group of 60 years old is the smallest, accounting for only 2.9%. In terms of education, college accounts for 43.4% which is the highest value while junior high and below accounts for 7.7% which is the lowest value. In the case of salary, the level of USD 1,000–1,500 is the largest group accounting for 36% while USD 2,000 and above has the lowest value of 8.1%.

8.1. Descriptive statistics of the fuzzy linguistic questionnaire. The study, based on the function of wood furniture product design including actual performance, ergonomic design and form design against fuzzy linguistics of consumer satisfaction in the second and third part of the questionnaire (as shown in Table 1), found consumers value most the ergonomic design in the function of wood furniture product design showing the average value of 4.0790 for fuzzy linguistics. Consumers place less importance on actual performance of function of wood furniture product design showing the average value of 3.9709 for fuzzy linguistics.

In the study, the average value for function of wood furniture product design against fuzzy linguistics of consumer satisfaction was higher than that for fuzzy linguistics of actual performance, ergonomic design and form design; the average value of fuzzy linguistics was 4.2, as shown in Table 1 and Figure 4. The fuzzy membership function $u(x) = 0.2$ derived from the equation $u(x) : 1 = (4.20 - 4.0) : (5 - 4)$ indi-

cating the fuzzy value of questionnaire numbers lied within 4 to 5 points equivalent to a degree between "strongly agree" and "more agree". This presented that consumer are quite satisfied with wood furniture product design.

Table 1. Descriptive statistics of the questionnaire for the fuzzy linguistics of satisfaction, designed by the author

Function of wood furniture product design	N	Fuzzy linguistic minimum	Fuzzy linguistic maximum	Fuzzy linguistic mean	Fuzzy linguistic Std. deviation
Fuzzy linguistic of actual performance	595	3.00	5.00	3.9709	.68541
Fuzzy linguistic of ergonomic design	595	3.00	5.00	4.0790	.63558
Fuzzy linguistic of form design	595	3.00	5.00	4.0139	.61709
Fuzzy linguistic of satisfaction	595	3.00	5.00	4.2039	.58069

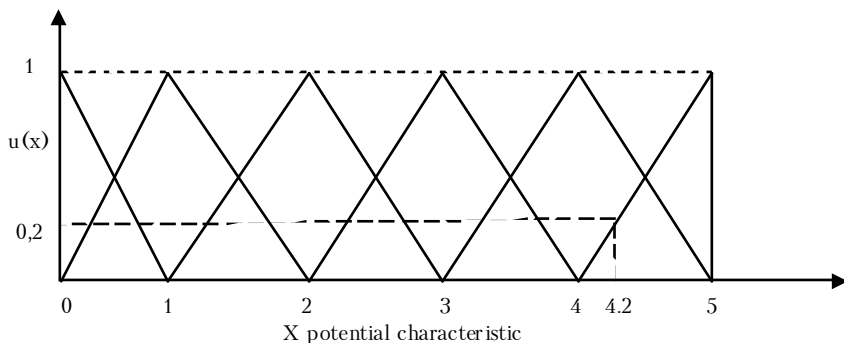


Figure 4. Membership function for linguistic variables of satisfaction, designed by the author

According to Table 2, the fuzzy linguistics of actual performance, ergonomic design and form design constituting function of wood furniture product design presented mutually significant correlation. Actual performance and ergonomic design were especially highly correlated, with $r(595) = .761, p < .00$. The fuzzy linguistics of actual performance and form design from function of wood furniture product design had the lowest correlation, with $r(595) = .476, p < .00$. In the meantime, consumer satisfaction remarkably correlated with the fuzzy linguistics of actual performance, ergonomic design and form design constituting function of wood furniture product design; in particular, actual performance was greatly correlated with satisfaction, with $r(595) = .605, p < .00$.

8.2. Multiple regressions for function of wood furniture product design against the fuzzy linguistics of consumer satisfaction. Multiple regression analysis was adopted to build function for the correlation between function of wood furniture product design and the fuzzy linguistics of consumer satisfaction, and with such function to predict dependent variable like satisfaction. t_1, t_2, t_3 were set as the independent variables of function of wood furniture product design (actual performance, ergonomic design and form design), and the fuzzy linguistics of consumer satisfaction (Y_i) as the

dependent variable to predict Y_i as time changed and induce the time-series regression equation as follows:

$$Y_i = a + b_1 t_{i1} + b_2 t_{i2} + b_3 t_{i3} \tag{4}$$

From the above, Y_i is equal to prediction for the fuzzy linguistics of consumer satisfaction, a is equal to additive constant, t_{i1} (actual performance), t_{i2} (ergonomic design), t_{i3} (form design) are equal to predictors, b_1, b_2, b_3 are equal to slope of a straight line. Multiple regression equation was adopted as the equation to predict consumer satisfaction which was transformed into *predicted satisfaction value* = $a + b_1 * \text{actual performance} + b_2 * \text{ergonomic design} + b_3 * \text{form design}$.

Table 2. Correlation between actual performance, ergonomic design and form design constituting function of wood furniture product design and the fuzzy linguistics of satisfaction, designed by the author

Function of wood furniture product design	Pearson correlation Test	Fuzzy linguistic of actual performance	Fuzzy linguistic of ergonomic design	Fuzzy linguistic of form design	Fuzzy linguistic of satisfaction
Fuzzy linguistic of actual performance	Pearson correlation	1	.761(**)	.476(**)	.605(**)
	Sig. (2-tailed)	.	.000	.000	.000
	N	595	595	595	595
Fuzzy linguistic of ergonomic design	Pearson correlation	.761(**)	1	.567(**)	.438(**)
	Sig. (2-tailed)	.000	.	.000	.000
	N	595	595	595	595
Fuzzy linguistic of form design	Pearson correlation	.476(**)	.567(**)	1	.572(**)
	Sig. (2-tailed)	.000	.000	.	.000
	N	595	595	595	595
Fuzzy linguistic of satisfaction	Pearson correlation	.605(**)	.438(**)	.572(**)	1
	Sig. (2-tailed)	.000	.000	.000	.
	N	595	595	595	595

** Correlation is significant at the 0.01 level (2-tailed).

The study used multiple regression equation to predict the relation equation for the impact of function of wood furniture product design on the fuzzy linguistics of consumer satisfaction. According to Tables 3, 4 and 5, the multiple regression equation included 3 predictors such as actual performance, ergonomic design and form design which were significantly correlated with the fuzzy linguistics of consumer satisfaction indicating $R^2 = .496$, adjusted $R^2 = .494$, $F(3,591) = 194.064$, $p = .000$. The multiple regression analysis was conducted for the function of wood furniture product design to predict the fuzzy linguistics of consumer satisfaction, and the multiple regression equation induced the *predicted satisfaction value* = $1.527 + .508 \text{ actual performance} - .243 \text{ ergonomic design} + .412 \text{ form design}$.

Table 3. Model summary of multiple regression analysis, designed by the author

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate
1	.704(a)	.496	.494	.41319

a Predictors: (constant), form design, actual performance, ergonomic design.

Table 4. ANOVA of multiple regression analysis, designed by the author

Model	Multiple regression analysis	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	99.396	3	33.132	194.064	.000(a)
	Residual	100.899	591	.171		
	Total	200.295	594			

a Predictors: (constant), form design, actual performance, ergonomic design.

b Dependent variable: satisfaction value.

Table 5. Coefficients of multiple regression analysis, designed by the author

Model	Coefficient items of multiple regression analysis	Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.527	.126		12.087	.000
	Actual performance	.508	.038	.599	13.255	.000
	Ergonomic design	-.243	.044	-.266	-5.516	.000
	Form design	.412	.033	.438	12.307	.000

a Dependent variable: satisfaction average value.

9. Conclusions and suggestions

The study investigated the correlation between the function of wood furniture product design and the fuzzy linguistics of consumer satisfaction and had the following results: (1) consumers value most the ergonomic design in the function of wood furniture product design and place less importance on its actual performance. The fuzzy linguistics of actual performance, ergonomic design and form design presented mutually significant correlation. Especially actual performance and ergonomic design were highly correlated. The fuzzy linguistics of actual performance and form design had the lowest correlation. Moreover, consumer satisfaction remarkably correlated with the fuzzy linguistics of actual performance, ergonomic design and form design constituting function of wood furniture product design. (2) The average value for function of wood furniture product design against fuzzy linguistics of consumer satisfaction was higher than that for fuzzy linguistics of actual performance, ergonomic design and form design, which demonstrated that consumers are quite satisfied with wood furniture product design. (3) The study used multiple regression equation to predict the impact of function of wood furniture product design on the fuzzy linguistics of consumer satisfaction. The multiple regression equation included 3 predictors such as actual performance, ergonomic design and form design which were significantly correlated with the fuzzy linguistics of consumer satisfaction.

The multiple regression equation induced in this study was established to predict the impact of function of wood furniture product design on the fuzzy linguistics of consumer satisfaction. The conclusion of this study can be a reference for designers as for wood furniture products by considering such factors as actual performance, ergonomic design and form design as agreed by consumers. It might also be a basis for designers or companies developing wood furniture products in the hope of meeting consumer demands and increasing their satisfaction, thus enhancing business performance and therefore profit.

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Стаття надійшла до редакції 01.06.2013.