Software Product Satisfaction Prediction

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***Abstract*- The objective of this research was to find out the software satisfaction prediction model. The software development companies should concern about customer satisfaction their software production. Two dependent attributes "software product quality" and "on time delivery" are used to represent the customer satisfaction on their order software. The cross validation technique, MMRE, showed that the mean magnitude of relative error of software quality was about 15.00 percent. In other words, the correction of prediction was about 85.00 percent while the correction of prediction in on time delivery was about 89.00 percent.**

Keyword: **software satisfaction, factor analysis, structural equation modelling.**

I. INTRODUCTION

Software development company business is widely spread in many kinds of work. There are software application development, system software, computer network, and security setting. Each work type software development requires difference human resources, software-hardware-network infrastructure, and project management. This research mainly emphasis the business software application development task. Therefore, the literature review about independent and dependent variables was related to software satisfaction prediction. A certain amount of statistic methods could be used to develop the prediction model. The factor analysis and structural equation modeling were used under this study. Factor analysis was used to detect the attributes characteristic if they were related together. They were grouped together to form up the new latent variable (factor). All factors were detected their relation to endogenous factor and other factors by structural equation modeling method. Therefore, the customer satisfaction prediction equations were defined from confirmatory model. These models were tested their accuracy in prediction by MMRE. The low value of MMRE showed that the model was good in prediction.

II. LITERATURE REVIEWS

A. Factor Analysis

One of the outstanding and useful methods to identify latent from question-level survey observed data is Factor Analysis. This method was quite useful in the survey analysis when the interests are quite complicated and cannot be measured directly by a single question. From this problem, the most appropriate method should be factor which can be obviously evaluated. It is intended used for assessing the related theoretical frameworks or hypotheses. In terms of my preference, it could be in the form of these questions: whenever possible, test results via reproducibility via confirmatory factor analysis (CFA). Nevertheless, CFA can be used for some models and some data sets, it is still useful and effective [1].

B. Structural Equation Modeling

SEM, one of the powerful techniques, combine the delicate path models with the latent variables. Confirmatory factor analysis models, regression models, and complex path models are specified by the researchers.

The basic element of a structural equation model was presented with the introduction of the estimation technique, Maximum Likelihood (ML), and a discussion about the problems of assessment and improvement of the model fit and model extensions to multi-group problems, and factor mean as well. SEM is widely employed in the field of behavior sciences as a mixture of factor analysis and regression or path analysis. SEM is normally presented by the latent factors. Regression or path coefficients between the factors are used for displaying the relationship between the theoretical constructs [2].

C. Customer satisfaction

This study examined the relationship between the image attributes and consumers' satisfaction who visited the supermarkets by focusing on the variables that making up the image attributes and classified them into factors. In addition, this stressed on the assessment of the impact of image attributes on customers' satisfaction. In this study, a quantitative approach was

employed with 400 participants from Campo Grande, MS, southwest Brazil. They are in charge of buying goods in the supermarket. The data analysis were Exploratory Factor Analysis (EFA) and Structural Equation Modeling were used. The findings showed that the attributed were categorized into five factors. Among the five factors, personnel, product, and price are mostly affected on customers' satisfaction [3].

D. Programmer Competency

The software developer competencies (SDC) consists of five competency streams of software developer: a) the quality concern, b) problem resolution, 3) teamwork, 4) customer service, and 5) future orientation. There was a survey that was conducted in Indian software industry in order to develop, validate, and form the SDC instrument. In addition, LISREL eight software are used to create the face, convergent, discriminant, predictive, and concurrent validity of SDC instrument. The findings showed that SDC is significant and helps establish its validity. In addition, SDC can be used for measuring the staff's success and beneficial for the companies because it is unique in the field of software. It also empowers the assessment of mostly high achievers into the objective aspect. The predictive validity of each SDC dimension was assessed by its relationship with the skills inventory – satisfying both reliability (ρC = 0.9032) and convergent validity criteria. Table 1 displayed the findings of the correlation tests which relates each SDC dimension to the skills. The positive correlation coefficients for all the dimensions provide evidence for predictive validity [4].

E. Software Requirement Engineering

A software requirement must be met by the customers' requirement based on imposed documentations. Considering the software requirement a variety of aspects, not only system, performance, and reliability, but also Modern SRS Package. Modern SRS Package consists of a) Introduction, b) Use Case Model Survey, c) Actor Survey, d) Requirements (Functional Requirements and Non-Functional Requirements), e) User Documentation and Help System Requirements, f) Design Constraints, g) Purchased Components, h) Interfaces, i) Licensing and Security Requirements, j) Legal, Copyright, and Other Notices, and k) Applicable Standards [5].

F. Software Project Management

Research Project Management Process can be defined as the tools or devices supported for the effectiveness when working. In this study, a new software for project management and a new approach were described, and Ten-Step methodology was illustrated. Ten-Step is so useful for managing timetables, changes, quality control, and risk and budget for any projects. Ten-Step comprises four sequential phases namely, prepare, plan, execute, and harvest. The following steps are shown in Ten-Step: 1) Define the Work, 2) Build the Schedule and Budget, 3) Manage the Schedule and Budget, 4) Manage Issues, 5) Manage Changes, 60 Manage Communication, 7) Manage Risk, 8) Manage Human Resources, 9) Manage Quality, and 10) Manage Metrics [6].

G. Predicting the Perceived Worth of Software Product Requirements with Customer Satisfaction

This paper was the investigation in order to confirm that the customers' satisfaction affected the perceived requirement worth. It is crucial to make a prediction for the requirement worth of proposed software products. This is because it can be useful for product managers to understand the customers' perceive worth of product requirements or features and help them plan and develop their products for the customers. Customers' satisfaction was the input which based on their feeling whether their requirement or features of the proposed software products are met or unmet. The findings showed that customers' satisfaction significantly affected on perceived requirement worth (95%) whereas the others remained stable. According to the two models under this study, it showed the same results and revealed that one unit goes up in customers' satisfaction leads to a three (3) units increase in the perceived worth of requirements. This can be implied that the perceived worth of software requirements were predicted by the customers' satisfaction. As the further studies should be emphasis on the effect of customers' satisfaction on perceived requirements worth [7].

H. Customer Satisfaction and Customer Loyalty

This study was about the customers' satisfaction and their loyalty. The service was provided by Trivsel. It seemed that from the Trivsel's service, it can gain a large amount of customer loyalty. When considering the data obtained from the questionnaire, it showed that the customers' satisfaction was the fundamental for customers' loyalty. Moreover, after analyzing the collected data from the questionnaire it is clear that

customer satisfaction is the basis of the customer loyalty. It showed that customers' satisfaction has a great influence on customers' loyalty. In order to assess the customers' satisfaction, a variety of methods were used for this assessment. Before purchasing, during purchasing, and after purchasing, customers estimate the product in terms of prices. This indicated that the customers' satisfaction could be varied. As a result, satisfaction and loyalty could be the core element for many businesses in terms of setting business reputation in a market and increasing customers' demand [8].

III. METHODOLOGY

A. Research hypothesis

The research conceptual model was shown in Figure 1. This research conceptual model was constructed/created on the basis of related research. This study consisted of four hypothesis with two main factors. They were as follows:

H1: factor programmer competency had direct effect on software product.

H2: factor requirement engineering had direct effect on software product.

H3: factor software project management had direct effect on software product.

H4: factor software support had direct effect on software product.

The four independent factors were programmer competency, requirement engineering, software project management, and software support, and the dependent was software satisfaction.

B. Conceptual model

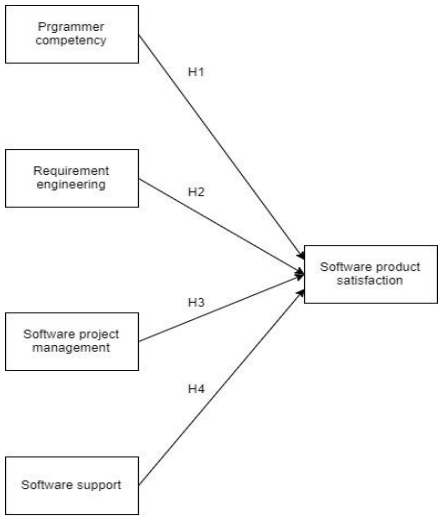

Figure 1. Research Conceptual Model

C. Research Work Flow

The research was conducted in sequence shown in Figure 2.

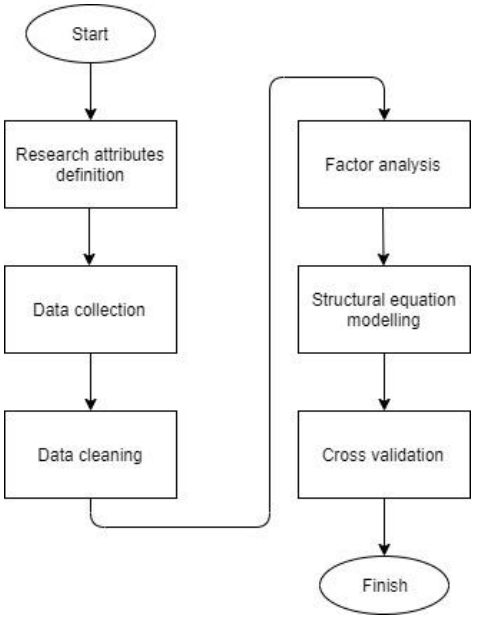

Figure 2. Sequence of research activities

Activity research attribute, all independent and dependent attributes were considerably chosen from related research and software engineering theory. In terms of data collection, a questionnaire was created in relations to the objective of customer satisfaction on their finished software product. All attributes were rechecked about its congruence (Index of Item-objective: IOC10) by five software satisfaction experts. After that, the defined questionnaire were sent to five software development companies. In the aspect of data cleaning, collected observation was rechecked for skewness, outlier, and missing data to clean the incorrect or incomplete appearance. Next, Factor Analysis, this step was performed to create the new variables from the interest group of some aspect attributes. Some attributes might be deleted because they were not significant related to other attributes. Factor Analysis could overcome the multicollinearity problem between the related attributes. Structural equation modeling, SEM was used to test four research's hypotheses if there were significant relationship. Nevertheless, the coefficient could present the level of importance of each independent factor to dependent factor. Cross validation, the SEM model must be measured for its accuracy of prediction.

MMRE was used to measure the percentage of error in prediction.

D. Research Attributes

According to related research, four factors were chosen to be studied under this research. There are 15 attributes which were grouped into four factors based on the following aspects: attribute name, label, type, range, and meaning, as shown in Table I.

TABLE I. RESEARCH ATTRIBUTES DESCRIPTION

Factor	Attribute	Data type	Data range	Meaning
Programmer competency-FP	Programming competency-p1	Order	1-5	5=highest competency
	Experience on allocated application-p2	Order	1-5	5=highest experience
	Assign the right job-p3	Order	1-5	5=highest right job assign
	Suitable work load –p4	Order	1-5	5=highest available time
Requirement engineering-FR	Feasibility study(FS)-r1	Order	1-5	5=Highest activity in FS
	Configuration management (CM)-r2	Order	1-5	5=perform every activities of CM
	Software prototyping –r3	Order	1-5	5=extremely use of software prototyping
Project management-FPM	Pert-CPM:Pert-pj1	Order	1-5	5=perform every activities of Pert
	Project estimation-pj2	Order	1-5	5=extremely use of software cost estimation
Project management-FPM	Project risk management-pj3	Order	1-5	5=perform every activities of risk management
	Project communication-pj4	Order	1-5	5-very good in staff and customer communication
Software support-FS	Manual-s1	Order	1-5	5=good software manual
	Software documentation-s2	Order	1-5	5=good software manual
	Training-s3	Order	1-5	5=adequate training
	Help desk-s4	Order	1-5	5=good customer relation management
Software product satisfactory-FPD	Software product Quality-sw_q	Order	1-5	5=software product has highest quality
	On time delivery-d_t	Order	1-5	5=software product has highest quality

The proposed independent factor and its member were presented in Figure 2, 3, 4, and 5

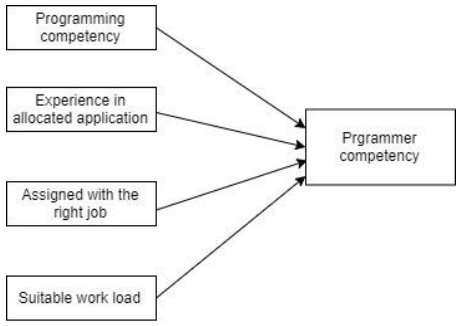

Figure 2. Factor Programmer Competency and Its Members

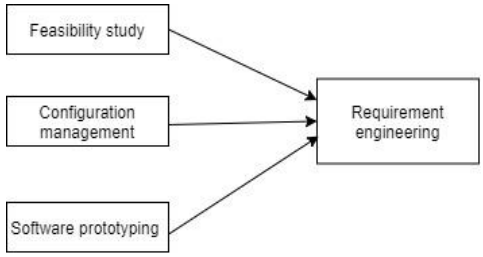

Figure 3. Factor Requirement Engineering and Its Members

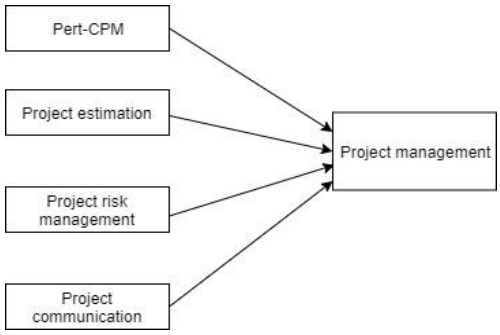

Figure 4. Factor Project Management and Its Member

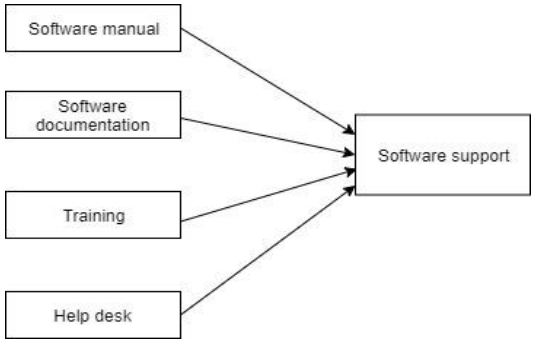

Figure 5. Factor Software Support and Its Member

E. Dependent Variable

The proposed dependent factor (software product satisfaction) and its member were shown in Figure 6.

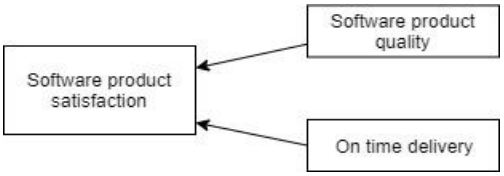

Figure 6. Factor software product satisfaction and its member

F. Index of Item-Objective Congruence: IOC

All attributes were examined by five experts in the aspect of IOC. The result of expert's opinions showed that all attributes were closely related to the dependent variable in Table II.

TABLE II. RESULT OF IOC TEST

	Expert opinion							
Attribute	expert #1	expert#2	expert #3	expert #4	expert #5	total	IOC	result
Programming competency	+1	'+1	'+1	'+1	+1	5	1	pass
Experience on allocated application	'+1	'+1	'+1	'+1	'+1	5	1	pass
Assign the right job	'+1	'+1	'+1	'+1	'+1	5	1	pass
Suitable work load	'+1	0	'+1	'+1	'+1	4	0.8	pass
Feasibility study-FS	0	'+1	'+1	'+1	'+1	4	0.8	pass
Configuration management-CM	'+1	+1	'+1	'+1	'+1	5	1	pass
Software prototyping	'+1	'+1	0	'+1	'+1	4	0.8	pass
Pert-CPM:Pert	'+1	'+1	'+1	'+1	'+1	5	1	pass
Project estimation	'+1	'+1	'+1	'+1	0	4	0.8	pass
Project risk management	'+1	'+1	'+1	'+1	'+1	5	1	pass
Project communication	'+1	'+1	'+1	'+1	'+1	5	1	pass
Manual	'+1	'+1	0	'+1	'+1	4	0.8	pass
Software documentation	'+1	'+1	'+1	'+1	'+1	5	1	pass
Training	'+1	'+1	'+1	'+1	'+1	5	1	pass
Help desk	'+1	'+1	0	'+1	'+1	4	0.8	pass

G. Data Gathering

There were 260 past complete developed software projects collected from five software development companies, from 2018 to 2020. The source of customers' organization were small to medium business firms in Bangkok, Thailand.

H. Data Cleaning

The gathered data were detected for their skewness, outlier, and missing data.

I. Factor Analysis

Factor analysis was performed in order to explore whether its members were significantl related. This activity was proceeded with four independent factors and one dependent factor.

J. Structural Equation Modelling

Structural Equation Modelling is used to confirm whether the research conceptual model hypothesis or proposed model were accepted or rejected.

K. Model Accuracy

The SEM model had to be checked for its prediction accuracy. MMRE (mean magnitude of relative error) technique was used to calculate for the fitted SEM model's percentage error of prediction.

$$MMRE = \frac{1}{n}\sum_{i=1}^{n}\frac{|actual_i - estimated_i|}{actual_i} \quad (1)$$

$$Percentage\ Correct = 100.(1\text{-}MMRE) \quad (2)$$

IV. RESEARCH RESULT

A. Data Cleaning

Gathered observations were calculated for descriptive statistics, as shown in Table 3. The result of data cleaning show that there were no outlier observation cases. All attributes had a normal distribution. There are no any attribute data with a large scale of skewness.

TABLE III. DATA DESCRIPTION

Attribute	n	Variable name	Mean	SD	Skewness*	Outlier	Missing
Programming competency	260	p1	2.35	0.84	0.139	none	none
Experience on allocated application	260	p2	2.25	0.79	0.354	none	none
Assign the right job	260	p3	2.25	0.98	0.571	none	none

Suitable work load	260	p4	2.25	0.95	0.209	none	none
Feasibility study-FS	260	r1	2.26	1	0.771	none	none
Configuration management-CM	260	r2	2.33	0.98	0.151	none	none

TABLE III. *(continued).*

Attribute	n	Variable name	Mean	SD	Skewness*	Outlier	Missing
Software prototyping	260	r3	2.31	0.85	0.85	none	none
Pert-CPM:Pert	260	pj1	2.28	1	0.69	none	none
Project estimation	260	pj2	2.31	1	0.37	none	none
Project risk management	260	pj3	2.28	0.95	0.82	none	none
Project communication	260	pj4	2.18	0.99	0.49	none	none
Manual	260	s1	2.36	1	0.599	none	none
Software documentation	260	s2	2.43	1	0.617	none	none
Training	260	s3	2.26	1.1	0.465	none	none
Help desk	260	s4	2.28	0.89	0.77	none	none
Software product Quality	260	sw_q	2.14	1.01	0.66	none	none
Ontime delivery	260	d_t	2.14	1.02	0.51	none	none

Note normal skewness (-1< range <1)

B. Factor Analysis

Factor FP, all proposed attributes (p1, p2, p3, and p4) were dimensionality reduced by factor analysis. The result of Factor Analysis was shown in Table IV. All attributes had significant relationship to form up factor FP.

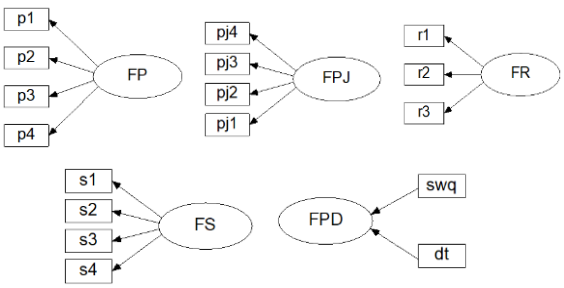

Figure 7. Proposed factor and their attributes
In the same way, FR, FPJ, FS, FP, and FPD were presented the result in the same direction.

TABLE IV. SUMMARY OF FACTOR ANALYSIS RESULT OF ALL PROPOSED FACTORS

Factor	Variable name	KMO	Bartlett	Cumulative variance %	Load
FP	p1	0.799	0.00	72.8	0.81
	p2				0.85
	p3				0.85
	p4				0.86
FR	r1	0.71	0.00	73.52	0.83
	r2				0.86
	r3				0.88
FPJ	pj1	0.79	0.00	75.48	0.87
	pj2				0.86
	pj3				0.84
	pj4				0.89
FS	s1	0.81	0.00	76.6	0.86
	s2				0.87
	s3				0.88
	s4				0.89
FPD	sw_q	0.61	0.00	89.64	0.947
	d_t				0.947

The result of factor analysis informs us that all attributes of all proposed factor were significant relationship. The KMO statistics was all greater than "0.60". All Bartlett's tests were significant (p=0.00). The factor could explain the variance of all members with the cumulative percentage above 89.64 percent. All attributes had its loading to their factors with high value which were greater than 0.30.

C. Structural equation modeling

According to research conceptual model (3.A) and Factor analysis (4.B), the proposed SEM model was presented in Figure 8. This proposed SEM was confirmatory check for the best fitting. The result of best fitting SEM Model was shown in Figure 9.

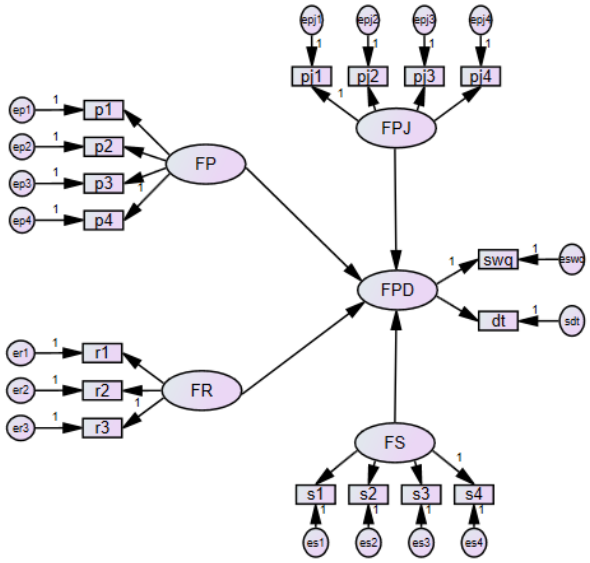

Figure 8. Proposed SEM Model

The fitting statistics are presented in Table V.

TABLE V. BEST FITTED SEM MODEL CRITERIA STATISTICS

Measure	Cut-off	result	pass/fail
Model Chi-square	p>0.05	0.051	pass
Goodness of fit: GFI	GFI>0.95	0.97	pass
Root Mean Square Error of Approximation: RMSEA	RMSEA<0.08	0.066	pass

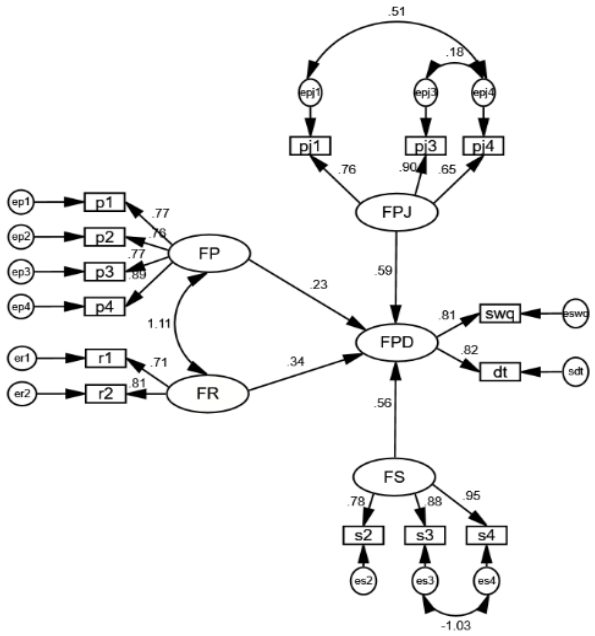

Figure 9. Fitted SEM Model (standardized)

D. Model cross validation

The best fitted SEM model in 4.3 had only one endogenous latent factor: FPD. Factor FPD had two dependent variables: SW_Q and D_T.

SW_Q equation, standardized form, was presented in details shown in (3). In the same word, D_T equation was presented by (4).

$$Sw\_q = 0.81FPD + eswq \quad (3)$$

$$d\_t = 0.82FPD + edt \quad (4)$$

$$FPD = 0.34FR + 0.23FP + 0.59FPJ + 0.56FS$$

Where FR, FP, FPJ and PS are exogenous factor, eswq = 0.213, and edt = 0.245.

In case of model evaluation, SEM Model experiment observations are simple random sampling on 20 percent of 260 cases. Therefore there were 52 observations be used in cross validation. These validation activities were performed 10 rounds. The results of cross validation were calculated for average and standard deviation as shown in Table VI.

TABLE VI. MMRE-CROSS VALIDATION RESULT TESTED 10 ROUNDS

Item	Average MMRE	MMRE-Standard deviation	Correct prediction percentage
SW_Q	0.15	0.022	85.00
D_T	0.11	0.03	89.00

V. CONCLUSION

The results of SEM model show that, among the four factors, “project management” was rated as the most important factor (0.59), followed by “support” (0.56), “requirement” (0.34), and “programmer competency” (0.23). Nevertheless, the two factors “programmer competency” and “requirement” had the interactive effect, shown on figure 9, which could be predicted by “software product satisfaction: FPD” in total standardized coefficient at 0.57, (0.23+0.34). However, software development companies should concern on “project management” and “support” because these two factors could predict customer satisfaction approximately 66.86%, ((0.59+0.56)/ (0.59+0.56+0.23+0.34))*100.

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