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Research Article

Significant Attributes from Multiple Regression and Marginal Effects on Multinomial Logit Model for Chemical Servitization

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Abstract

Chemical industry traditionally produces and sells tangible goods. Recently, firms in chemical industry provide additional services to their customers. Several manufacturers change from tangible product suppliers to both product and service providers. This movement is called servitization (Vandermerwe & Rada, 1988). Chemical servitization levels can be classified into 4 categories which are product only, service added to the product, service differential the product and service is the product (Thoben, Eschenbacher, & Jagdev, 2001). The objectives of this paper are to construct servitization framework for chemical suppliers to shift to product service integration and to examine factors affecting chemical service levels to provide guidance to chemical suppliers to implement product service system (Kortman, Theodori, Ewijk, Verspeek, & Uitzinger, 2006). The first part of the framework is to develop servitization levels for chemical industry in Thailand. The second part is to define servitization levels for suppliers to offer to their customers. Questionnaire surveys were distributed to chemical dealers, sub-dealers, and end-users, and the sample size was 200. To accomplish the research objective, descriptive statistics, Analytical Hierarchy Process (AHP), Multiple Regression Analysis, and Multinomial Logit Model (MNL) used in this research. The finding includes seven significant factors which were identified in order to analyze the service level of customer needs. Implications and suggestions for suppliers who want to change their business model to providing chemical solution should offer chemical blending, chemical storage, chemical documentation, and environmental and safety program as bundle services with chemical products.

Keywords: Chemical Servitization, Servitization Levels, Product Service System, Extended Product, Multinomial Logit Model, Multiple Regression Analysis

Introduction

Servitization concepts have been introduced to explain the idea that manufacturers or producers turn out to be service providers (Buschak & Lay, 2014; Goedkoop, 1999; Tukker, 2004; Vandermerwe & Rada, 1988). This concept has been applied in many industries including chemical industry. Chemical servitization is a new trend for companies in chemical industry to change their focus to gain competitive advantages and leave out cost competition to win against competitors (Kortman, Theodori, Ewijk, Verspeek, & Uitzinger, 2006; Robinson, Clarke-Hill, & Clarkson, 2002). Chemical is one of the most important industry that its products are wildly used in our daily lives. Consumers are influenced by chemicals in many ways such that we consume food, housekeeping, painting pharmaceuticals agriculture, construction, adhesive, and textile products. As the range of chemical product chain is too wide to concentrate, this study will focus only on commodity chemicals products in B2B business type in a perception that chemicals are used as raw materials for manufactures to produce finished goods.

The organizational changes in traditional manufacturers to new trend of servitization have been developed since the last two decades. "Power by hour" is a shift in offering from aero engines selling to providing a total care package developed by Rolls-Royce Aerospace to its customers such as Boeing

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and Airbus. The new business model combines tangible products with intangible services of maintenances. Revenue generates from charging customers based on hours of engine used. Another organizational change is the example of SEFCHEM, Dow Chemical's subsidiary company which provides solvent service solutions. SEFCHEM cooperated with Pero AG established a new company to offer cleaning services. The new cleaning full-service company provides cleaning services, uses cleaning machines from Pero AG, and attains chemical supplies from SEFCHEM (Buschak & Lay, 2014).

Chemical products are defined as commodity products which are used as raw materials for manufactures and can be transformed to intermediate and specialty chemicals. They are also sold by volume with standardized quality with few variants. The commodities are in high market competition because price is the key buying criteria for buyers. Thus, any suppliers who offer lower prices will be more attractive to customers than the suppliers who charge higher prices .When a chemical firm cannot charge customers in high prices, the firm is in a struggle situation namely "commodity trap". Robinson et al. (2002) studied servitization model which is a strategy that helps companies to drip out the commodity trap, achieve competitive advantages and seek for differentiation instead .The servitization strategy is an approach for companies changing from traditionally cost oriented to service and relationship management .Servitization is also one element of logistics 4.0 trends for sustainable business model to transform enterprises from tangible product to service-oriented that can increase the value proposition by integrating services and manufacturing processes in their offers (Strandhagen et al., 2017).

Major problems of Thai chemical providers are high competitiveness markets, price sensitivity, volume based selling with low margin, limited services with low value, and tangible goods business model. Under the uncertainty economic condition, Thai chemical providers are also facing the same problems as others in other parts of the world. These companies need to change their focus of their business as well.

The objectives of this research are to construct servitization framework for chemical suppliers and to investigate determinant affecting chemical service levels to provide a guidance to companies in chemical industry to implement product service system.

Materials and methods

Chemical Servitization

Servitization is popularly adopted for innovative business model development in chemical industry to help customers avoid chemical waste. It is used as a link between physical offers and additional services provided to customers (Buschak & Lay, 2014). The innovative business models for chemicals industry can be described as chemical product services (CPS) where business models shift from selling chemical products by volume to combining with some basic services to fulfil customers and suppliers' requirements (Kortman et al., 2006); chemical management services (CMS) where business models create a long-term collaboration between customers and chemical service providers to supply and manage chemical related services (Stoughton & Votta, 2003); and chemical leasing where chemical companies supply special services and substances but hold the ownership of chemicals. The traditional business models for chemical industry was focusing on selling chemical products by volume. This leads to conflicts between customers and suppliers because the customers want to decrease chemical volume and cost while the suppliers want to maximize sales volume (Kortman et al., 2006; Reiskin, White, Johnson, & Votta, 2000; Toffel, 2008).

Chemical product service (CPS) business model aligns the interests of customers and chemical suppliers that both of them receive benefit from reducing chemical sales volume and cost. The suppliers are no longer focusing on selling chemical product by volume (Kortman et al., 2006), see Figure 1.

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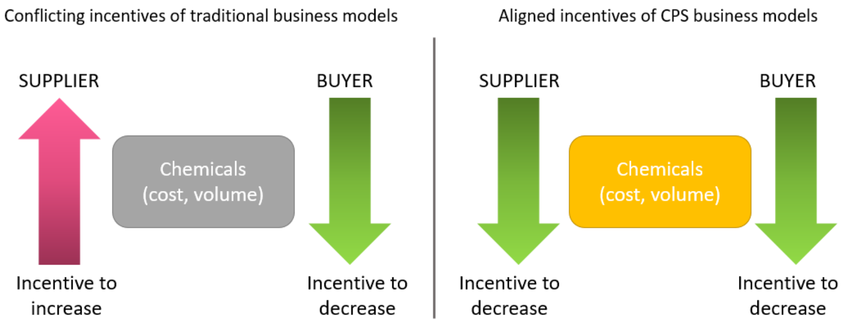

Figure 1 Traditional and CPS Business Models (Kortman et al., 2006)

Business models for CPS are variety by adding some more extra services, and they can be related to the several stages in the chemical life cycle. Kortman et al. (2006) recommended some extra chemical services; for example, chemical packaging, chemical management, chemical inventory and storage, chemical advice on process tuning, chemical transportation, chemical recycling and waste treatment, chemical health concern, environmental and safety programs, and worker's training. Kortman et al. (2006) classified CPS into two different types as CPS-I and CPS-II as the transition from traditional business models to CPS models (See Figure 2). CPS-I is a business model that chemical producers or suppliers are still selling chemical products by volume. To increase value of the chemical product, some related services are added to the products. CPS-II is a business model chemical suppliers provide product service integrated solutions regarding to customer requirements instead of offering products by volume. The ownership of chemical product is fully transferred from suppliers to customers.

Chemical management service (CMS) is a business model for chemical products that both suppliers and customers collaborate each other to improve and develop chemical product services (Stoughton & Votta, 2003) in term of partnership (Reiskin et al., 2000). Example of CMS are chemical supply, chemical quality monitoring, chemical adjustment, removal of applied chemical, chemical recycling, and chemical solution network. The benefits of CMS mentioned by Kortman et al. (2006) are liability reduction, storage space decreasing, chemical labor reduction, and heal and environmental saving.

Chemical leasing is a business model that the ownership of chemical product is still on the suppliers, not customers. This means the main concentration is not on selling chemical product by volume but on the integrated services offered with the products. Thus, profit is not directly from selling chemical product in large volume, but it comes from bundled services instead (Kortman et al., 2006).

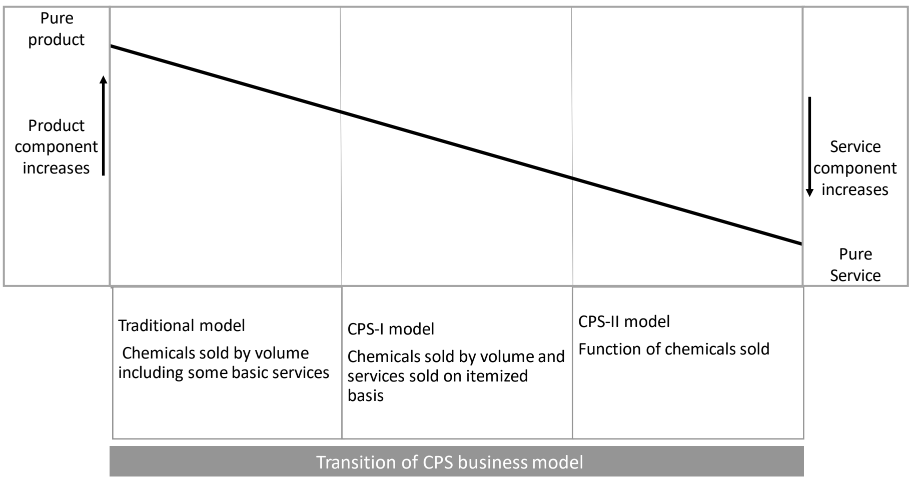

Figure 2 Transition from the traditional business models to the CPS models (Kortman et al., 2006)

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Many literatures also talk about the same concepts but in different terms. Product Service System (PSS) (Tukker, 2004), Product Transition (Oliva & Kallenberg, 2003), and Extended Product (Thoben, Eschenbacher, & Jagdev, 2001) are phrases commonly used when the manufacturing firms apply the servitization concepts. The below section is related theory applied for the servitization used in this study.

Extended Product Theory

To have advantages in competitive market, manufacturers and suppliers have to integrate their core products with additional services to make their products more valuable and attractive. This concept is defined as Extended Product (Thoben, Eschenbacher, & Jagdev, 2001), which consists of three layers, the kernel as an illustration of the core and functionalities of product (tangible), the middle layer describing the product shell including packaging of the core product (packaging), and the outer layer representing all the intangible assets of the offer (services), see Figure 3.

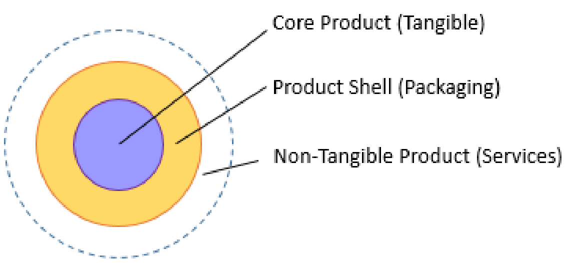

Figure 3 Extended Product Theory (Thoben et al., 2001).

A combination of core product and the product shell is called narrow sense which tangible products are offered to the market, whereas a blending between product shell and non-tangible product is named a broader sense as a product solution that both tangible and intangible products are integrated together (Thoben et al., 2001). Figure 4 illustrates dimension of migration process based on the expanded product concept transforming from tangible product to intangible services and finally service as product (Chen & Gusmeroli, 2015).

Servitization levels are also mentioned in chemical industry in similar ways as in other manufacturing industries. The starting point is the pure manufacturer traditionally provide chemical product in large volume. The next level is chemical supplier offers some product related services such as transportation and worker training. Chemical supplier may also provide other different services not directly related to chemical product such as product monitoring system. Lastly, in the highest level, chemical suppliers focus on providing intangible services with the add on tangible products (Buschak & Lay, 2014; Chen & Gusmeroli, 2015; Kortman et al., 2006). Example of product as a service is chemical trend that SAFECOM cooperates with Pero AG company to provide cleaning services to their customers rather than selling tangible chemical products (Buschak & Lay, 2014).

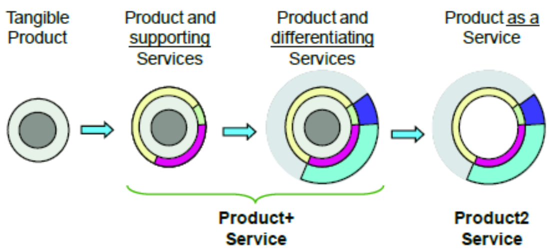

Figure 4 Extended Product Elements (Chen & Gusmeroli, 2015)

Servitization Frameworks

Ryu, Rhim, Park, and Kim (2012) proposed servitization framework adapted from Meyer and Arthur (1999). This framework composed of three components which are markets, product-service-knowledge system (PSK) (see Table 1), and competencies in the supply chain. Chen and Gusmeroli (2015), Oliva and Kallenberg (2003) proposed a framework for manufacturing servitization which combined three dimensions; 1) the x-axis represents servitization process; 2) the y-axis represents stages of product extension; 3) the z-axis is illustrated service innovation. However, none of these papers proposed guidance or solutions on servitization process. Thus, this research closes the gap by constructing the servitization framework for chemical suppliers observing factors affecting chemical service levels to provide guidance to chemical suppliers to implement product service system.

This study proposed new servitization framework adapted from the previous studies and illustrated as Figure 5. The first part of the framework begins with Chen and Gusmeroli (2015) framework, and ends with Ryu et al. (2012) in the second part. The three dimensions are changed to; 1) the x-axis represents customer segment which classified by 3 different company sizes and 5 types of industry; 2) y-axis represents 4 different types of servitization levels, namely product only, service added to the product, service differential the product, and service is the product; 3) z-axis represents PSK system. PSK is classified to three service types dealing with product, service, and knowledge. The second part was adopted from (Kanignant et al., 2018).

Research Methodology

Scope of the Study

The chemical products mentioned in this research are chemical products which are considered as commodity products. Size of chemical companies are defined as number of employees based on OSMEP (2000) which can be classified into three groups of small (less than 50 employees), medium (50-200 employees), and large (more than 200 employees). Respondents in this research are separated by types of industry which can be divided into five groups of: Industrials including adhesive, ink, packaging, paint, petrochemicals, resin, thinner, tire (wheel); Consumer Product including cosmetics, food, pharmaceutical; Resources for example mining; Technology for example electronics; and Others.

The study focuses in chemical industry only in Thailand and approaches one B2B business company of tier-3 who is a chemical importer or distributor traditionally provides tangible chemical products for their customers in large volume and have high competitive market. Chemical product in this study is defined as commodity product that has similar property. It is also price sensitive and is often sold in bulky amount. The company's customers are: tier-2 firms who provide chemical products as wholesalers, tier-1companies who perform as sub dealers supplying chemical products to manufacturers, and the end-users who are manufacturers using chemical products as raw materials in production to make products. The study studies servitization strategies for this distributer company to generate product transition for customers.

Respondents in this research are separated by position of companies in chemical supply chain, see Figure 6, which can be divided into three groups as 1) end-users or manufacturers, 2) tier-1: sub dealers or suppliers, and 3) tier-2: dealers or wholesalers. This research does not include respondents who are upstream producers or oversea and local makers, tier-3 companies who are importers or distributors, and consumers. Figure 6 illustrates chemical product supply chain for an easier point of view of targeted respondents.

Table 1 Product-Service-Knowledge System

Product	Service	Knowledge
Chemical product only	Chemical document and license	Chemical health risk assessment
Chemical blending	Chemical inventory	Environmental and safety programs
Chemical packaging	Chemical waste treatment	Worker's training
Chemical storage		
Chemical recycling		
Transportation		

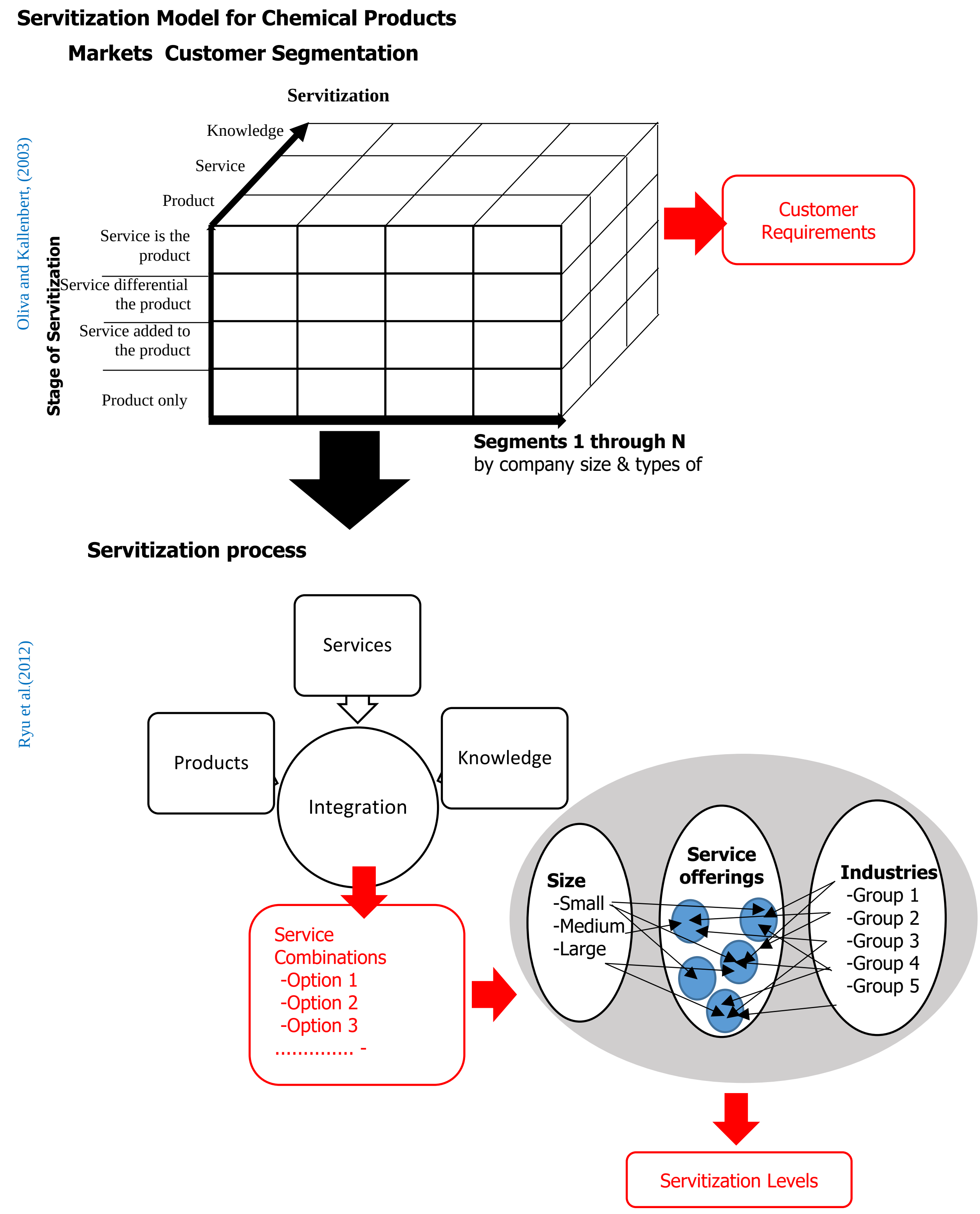

Figure 5 Servitization Model for Chemical Product

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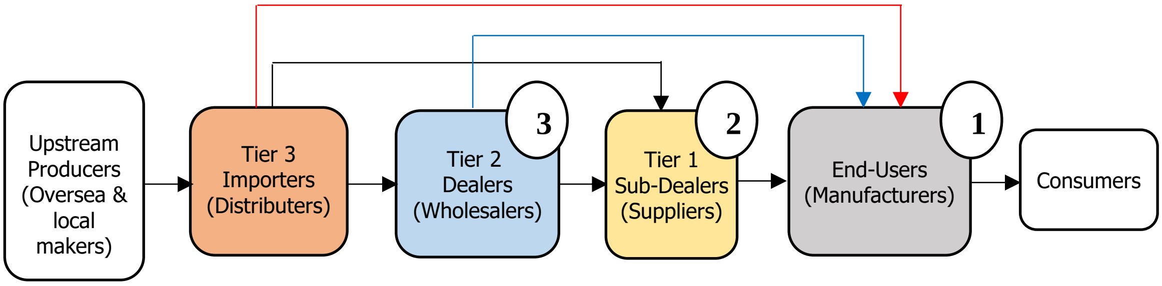

Figure 6 Chemical Supply Chain

Data Collection
Research Tools and Design

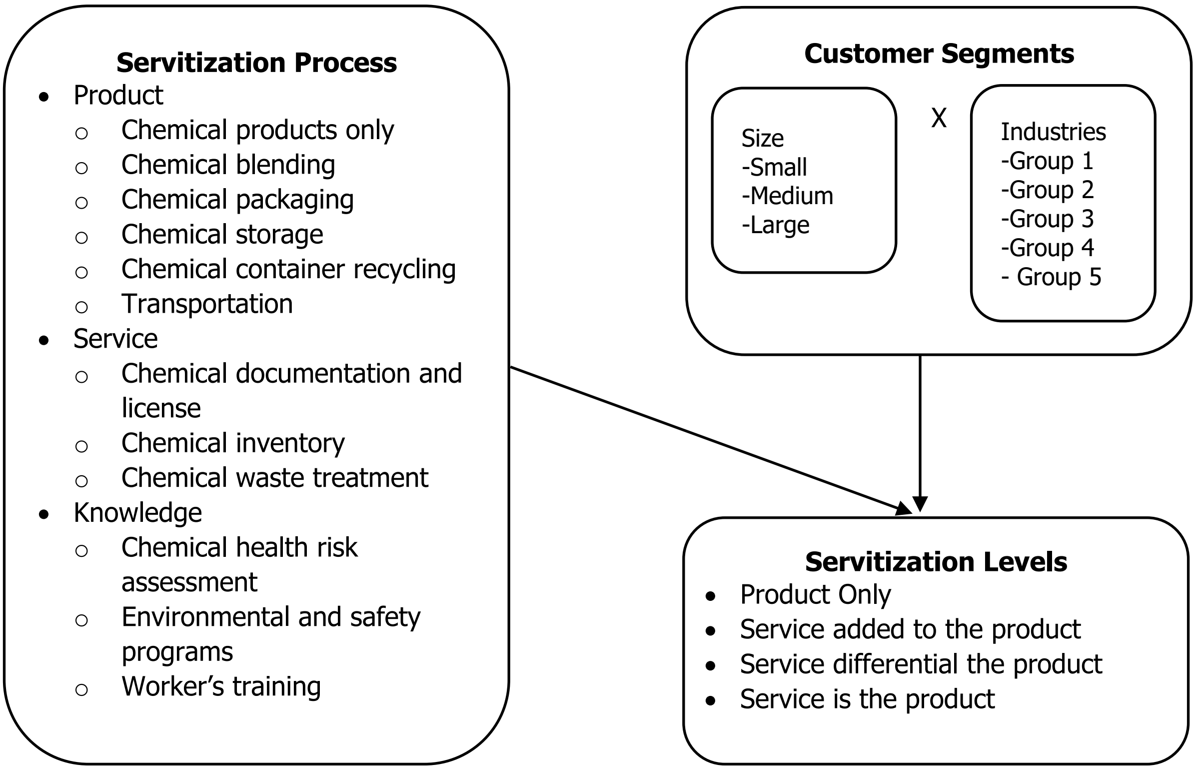

Figure 7 Relationship between Independent and Dependent Variables

The research tools for this study is questionnaire survey distributed to respondents via face to face or an interview. The questionnaire composed of 3 sections; 1) company background, 2) attitude towards product or service needed driven by 10-point Likert Scale ranging from 0 to 10 to employ the questions and scale responses in the survey, and 3) comparison attitude towards servitization levels constructed by Analytical Hierarchy Process (AHP) using the pairwise comparison between 4 service levels. In the questionnaire design process, required data for composing questionnaire is assemble from literature reviews and discussion with the staff of chemical distributor.

Index of Item-Objective Congruence (IOC) was used to analyze the content validity. The questionnaire was reviewed by five experts including two chemical management officers, and three academic experts. The reliability of the questionnaire was examined in order to confirm that the collected responses were reliable and consistent. The researcher distributed 30 pilot questionnaires to staff of the chemical distributor company to ask their customers excluded from the sample group. For the pilot data reliability test, Cronbach's Alpha score of each question was greater than 0.9. This can be assumed that the questionnaire was highly reliable. The chemical distributor company has almost 250 customers in

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Thailand in various locations, and the sample size for this study is 200. The survey was started from May to September 2020 through phone interview only according to COVID-19 situation until the sample size was achieved. The collected data is sufficient enough to do the data analysis and estimate parameters of this study.

As mentioned, parameters in the model are defined by the 3-axis as follows:

- X-axis is the independent parameter represents customer segments.
- Y-axis is the dependent parameter contains 4 different types of servitization levels.
- Z-axis is the independent parameter of PSK.

From these three dimensions, the relationship between independent and dependent variables can be illustrated as Figure 7.

Multinomial Logit Model (MNL)

MNL was utilized in this research rather than Multinomial Logistic Regression (MLR) as the sample size was limited. Peduzzi, Concato, Kemper, Holford, and Feinstein (1996) suggested that MLR was a good technique for large sample sets. The discrete choice model or multinomial logit model was developed by McFadden (1973) and applied in the study of travel mode choices, for example; the choice between bus, car, train, or airplane. The objective is to estimate probability of choosing each of the four modes and to calculate the odds ratios for choice of different modes. The simple MNL can be written as:

$$U_{nj} = \beta x_{nj} + \varepsilon_{nj.} \qquad (1)$$

Where

U_{nj}	= the utility of alternate j to individual n,	ε_{nj}	= an error
x_{nj}	= J-vector of observed attributes of alternative j	n	=1, …, N
β	= a vector of utility weights	j	=1, …, J

The probability that person n chooses alternative j is given by:

$$\Pr(j \mid x_n) = \frac{e^{\beta x_{nj}}}{\sum_{k=1}^{J} e^{\beta x_{nk}}} = \frac{e^{g_j(x)}}{\sum_{k=1}^{J} e^{g_k(x)}}. \qquad (2)$$

In this research study, the dependent variables are categories of servitization level: 1 = product only, 2 = services added to the product, 3 = service differential the product, and 4 = service is the product. For each choice of dependent variable, assume that p covariates and has a constant term, denoted by the vector x, of length $p+1, where\ x_0 = 1$, the multinomial logit model with the value of dependent variable Y = 1 as a reference outcome can be expressed as:

$$g_1(x) = ln\left[\frac{\Pr(Y=2|x)}{\Pr(Y=1|x)}\right] = \beta_{10} + \beta_{11}\chi_1 + \beta_{12}\chi_2 + \cdots + \beta_{1p}\chi_p = x'\beta_1. \qquad (3)$$

$$g_2(x) = ln\left[\frac{\Pr(Y=3|x)}{\Pr(Y=1|x)}\right] = \beta_{20} + \beta_{21}\chi_1 + \beta_{22}\chi_2 + \cdots + \beta_{2p}\chi_p = x'\beta_2. \qquad (4)$$

$$g_3(x) = ln\left[\frac{\Pr(Y=4|x)}{\Pr(Y=1|x)}\right] = \beta_{30} + \beta_{31}\chi_1 + \beta_{32}\chi_2 + \cdots + \beta_{3p}\chi_p = x'\beta_3. \qquad (5)$$

Then the conditional probabilities of each outcome category are:

$$\Pr(Y=1|x) = \frac{1}{1+e^{g_1(x)}+e^{g_2(x)}+e^{g_3(x)}}. \qquad (6)$$

$$\Pr(Y=2|x) = \frac{e^{g_1(x)}}{1+e^{g_1(x)}+e^{g_2(x)}+e^{g_3(x)}}. \qquad (7)$$

$$\Pr(Y=3|x) = \frac{e^{g_2(x)}}{1+e^{g_1(x)}+e^{g_2(x)}+e^{g_3(x)}}. \qquad (8)$$

$$\Pr(Y=4|x) = \frac{e^{g_3(x)}}{1+e^{g_1(x)}+e^{g_2(x)}+e^{g_3(x)}}. \qquad (9)$$

By taking the log and applying the fact that $\sum \Pr(j|x_n) = 1$, all these four equations are associated by consuming the same denominator and by:

$$\Pr(Y=1|x) + \Pr(Y=2|x) + \Pr(Y=3|x) + \Pr(Y=4|x) = 1. \qquad (10)$$

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Thus

$$\frac{\partial \Pr(Y=1|x)}{\partial x} + \frac{\partial \Pr(Y=2|x)}{\partial x} + \frac{\partial \Pr(Y=3|x)}{\partial x} + \frac{\partial \Pr(Y=4|x)}{\partial x} = 0. \qquad (11)$$

In this study, the outcome of Y = 1, product only, is the reference outcome. Marginal effect describes the average effect of changes in independent variables on the changes in the probability of dependent variables in multinomial logit model.

$$\frac{\partial \Pr(Y=2|x)}{\partial x} = \Pr(Y=2|x)\,(1-\Pr(Y=2|x))\beta_1 - \Pr(Y=2|x)\Pr(Y=3|x)\,\beta_2 - \Pr(Y=2|x)\Pr(Y=4|x)\,\beta_3. \qquad (12)$$

$$\frac{\partial \Pr(Y=3|x)}{\partial x} = \Pr(Y=2|x)\,(Y=3|x)\beta_1 - \Pr(1-\Pr(Y=3|x))\Pr(Y=3|x)\,\beta_2 - \Pr(Y=3|x)\Pr(Y=4|x)\,\beta_3. \qquad (13)$$

$$\frac{\partial \Pr(Y=4|x)}{\partial x} = \Pr(Y=2|x)\,(Y=4|x)\beta_1 - \Pr(Y=3|x)(Y=4|x)\,\beta_2 - \Pr(1-\Pr(Y=4|x))\Pr(Y=4|x)\,\beta_3. \qquad (14)$$

$$\frac{\partial \Pr(Y=1|x)}{\partial x} = -\left(\frac{\partial \Pr(Y=2|x)}{\partial x} + \frac{\partial \Pr(Y=3|x)}{\partial x} + \frac{\partial \Pr(Y=4|x)}{\partial x}\right). \qquad (15)$$

Data Analysis

To accomplish the research objectives, few data analysis techniques are applied including descriptive statistics used to explain respondent demographic information; Analytical Hierarchy Process (AHP) used at the process of customer parwise-comparison on 4 servitization levels; Multiple Regression Analysis adopted for exploring significant factors; and Multinomial Logit Model (MNL) used to find the Marginal Effect of each significant factors in this research. The dependent variables are unordered choices of 4 servitization levels which will be compared by the customers. Research variables are acquired from literature review and can be defined as shown in Table 2.

Table 2 Variable Coding

No.	Variables	Variable Type	Measurement	Definition
1	LnY2Y1	Dependent	Ratio Scale	Natural logarithm of the probability of Y = 2 compared to Y = 1
2	LnY3Y1	Dependent	Ratio Scale	Natural logarithm of the probability of Y = 3 compared to Y = 1
3	LnY4Y1	Dependent	Ratio Scale	Natural logarithm of the probability of Y = 4 compared to Y = 1
4	Y1	Dependent	Ratio Scale	Probability of an event Y = 1, Product Only
1	Y2	Dependent	Ratio Scale	Probability of an event Y = 2, Service added to the product
2	Y3	Dependent	Ratio Scale	Probability of an event Y = 3, Service differential the product
3	Y4	Dependent	Ratio Scale	Probability of an event Y = 4, Service is the product
4	MeanPCP	Independent	Ratio Scale	Average score of chemical product only
5	MeanPCB	Independent	Ratio Scale	Average score of chemical blending
6	MeanPCK	Independent	Ratio Scale	Average score of chemical packaging
7	MeanPCS	Independent	Ratio Scale	Average score of chemical storage
8	MeanPCC	Independent	Ratio Scale	Average score of chemical container recycling
9	MeanPCT	Independent	Ratio Scale	Average score of chemical transportation
10	MeanSCD	Independent	Ratio Scale	Average score of chemical documentation
11	MeanSCI	Independent	Ratio Scale	Average score of chemical inventory
12	MeanSCW	Independent	Ratio Scale	Average score of chemical waste treatment

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No.	Variables	Variable Type	Measurement	Definition
13	MeanKCH	Independent	Ratio Scale	Average score of chemical health risk assessment
14	MeanKES	Independent	Ratio Scale	Average score of environmental and safety program
15	MeanKWT	Independent	Ratio Scale	Average score of worker's training
16	Seg	Independent	Nominal	Segment type
17	Type	Independent	Nominal	Company type
18	Size	Independent	Nominal	Company size

Results

Demographic information of respondents was described by frequency and percentage. Table 3 below shows respondent demographic information.

Demographic Information

The majority of customer segment in the chemical supplier company was in industrial (68.5%) followed by consumer segment (24%), technology (6.5%), and resource (1%) varies in several types of company; for example, thinner (13%), food (13%), adhesive (11%), color (9.5%), petrochemical (9%), respectively. The size of customers was almost the same proportion between large (39.5%) and medium (36.5%) companies and the rest is small size (24%). Most of the customers' companies were located in Bangkok and perimeter (77%), and the rest is located in the East (15%), Central (5%), and others (3%) region of Thailand.

Table 3 Respondent Demographic Information

Category	Frequency	Percent (%)
Industry Segment		
Industrial	137	68.5
Consumer	48	24
Resource	2	1
Technology	13	6.5
Others	0	0
Total	**200**	**100**
Company Type		
Adhesive	22	11
Ink	8	4
Packaging	15	7.5
Color	19	9.5
Petrochemical	18	9
Resin	6	3
Thinner	26	13
Tyre (Wheel)	8	4
Others (Industrial)	16	8
Cosmetic	16	8
Food	26	13
Medicine	3	1.5

Category	Frequency	Percent (%)
Company Size		
Small (<50)	48	24
Medium (50-200)	73	36.5
Large (>200)	79	39.5
Total	**200**	**100**
Year		
0-5 Years	20	10
6-10 Years	30	15
10-15 Years	35	17.5
> 15 Years	115	57.5
Total	**200**	**100**
Location		
Bangkok and Perimeter	154	77
Central	10	5
East	30	15
North	4	2
West	2	1

Others (Consumer)	3	1.5
Mining	0	0
Others (Resource)	1	0.5
Electronic	11	5.5
Others (Electronic)	2	1
Other Industry	0	0
Total	**200**	**100**

South	0	0
Total	**200**	**100**

Table 4 explains customer companies by segment and size. It shows that the largest customer segment is the industrial segment dominated by large size companies (66 of 137 or 48%) followed by medium size companies (46 of 137 or 34%) and small size companies (25 of 137 or 18%).

Table 4 Respondent Demographic Information by Segment and Size

Segment / Size	Size			Total
	Small	Medium	Large	
Industrial	25	46	66	137
Consumer	21	19	8	48
Resource	0	1	1	2
Technology	2	7	7	13
Others	0	0	0	0
Total	**48**	**73**	**79**	**200**

After using AHP technique, probability of each choice of service level is calculated by pairwise comparison from the respondents. 0.1 consistency ratio is the requirement of the qualification of data from each respondent. The independent variables are selected by adopting multiple linear regression between independent variables and log odd value of each service level compared with the base of service level. In this study, product only is performed as the base of service level comparison. For example, the variable LnY2Y1 is natural logarithm of the probability of Y = 2 (service added to the product) compared to Y = 1 (product only). Multiple linear regression models of each log odd comparison were used to measure the significant level of the influence of independent variables. Only independent variables that meet the criteria of significant level will be carried further to calculate marginal effect in multinomial logit model in order to see the changes caused by these variables. As we have 3 groups of independent and dependent variables, 9 multiple regression models were run for the result. Independent variables from product, service and knowledge categories were plugged-in the model with dependent variables of natural logarithm of the probability of service added to the product compared to product only level (LnY2Y1), natural logarithm of the probability of service differential the product compared to product only level (LnY3Y1), and natural logarithm of the probability of service is the product compared to product only level (LnY4Y1) separately one at a time. Table 5 shows the results of 9 multiple regression models. As the result, independent variables that have significant level less than .05 or .1 will be selected and carried further in multinomial logistic models to find the marginal effects of independent variables toward those four dependent variables.

Table 5 Results of 9 Multiple Regression Models

Model	LnY2Y1		LnY3Y1		LnY4Y1	
	B	Std. Error	B	Std. Error	B	Std. Error
(Constant)	-.379	.620	-.334	.727	-.602	.769
MeanPCP	-.203**	.078	-.329**	.092	-.219**	.097
MeanPCB	-.013	.034	.030	.040	.099**	.043
MeanPCK	.095	.107	.092	.125	-.047	.133
MeanPCS	.020	.046	.049	.055	.162**	.058
MeanPCC	.042	.054	-.002	.063	-.141**	.067
MeanPCT	.164*	.100	.267*	.117	.312**	.124
	*R^2 = .238, Adjusted R^2 = .057, Sig. = .077**		*R^2 = .275, Adjusted R^2 = .076, Sig. = .018***		*R^2 = .284 , Adjusted R^2 = .081 , Sig. = .012***	

Model	LnY2Y1		LnY3Y1		LnY4Y1	
	B	Std. Error	B	Std. Error	B	Std. Error
(Constant)	-.671	.551	-1.068	.647	-1.600	.684
MeanSCD	.178**	.066	.246**	.078	.240**	.082
MeanSCI	-.005	.056	-.071	.066	.015	.070
MeanSCW	-.026	.053	.021	.062	.022	.065
	*R^2 = .190 , Adjusted R^2 = .036 , Sig. = .066**		*R^2 = .230 , Adjusted R^2 = .053 , Sig. = .014***		*R^2 = .242 , Adjusted R^2 = .059 , Sig. = .008***	

Model	LnY2Y1		LnY3Y1		LnY4Y1	
	B	Std. Error	B	Std. Error	B	Std. Error
(Constant)	.244	.497	.242	.588	-.633	.618
MeanKCH	-.055	.083	-.036	.098	.021	.103
MeanKES	.122*	.084	.151*	.100	.150*	.105
MeanKWT	-.016	.076	-.056	.090	.000	.094
	R^2 = .115 , Adjusted R^2 = .013 , Sig. = .456		*R^2 = .116 , Adjusted R^2 = .014 , Sig. = .444*		*R^2 = .181 , Adjusted R^2 = .033 , Sig. = .088**	

From the 1st to the 3rd multiple regression models, the independent variables that are considered statistically significant are MeanPCP and MeanPCT and have beta value of -.203 and .164 respectively in the first model, -.329 and .267 in the second model, and MeanPCP, MeanPCB, MeanPCS, MeanPCC, and MeanPCT have beta value of -.219, .099, .162, -.141, and .312 respectively in the third model. The adjusted R^2 value for the first to the third model was .057, .076, and .081 respectively meaning that less than 10% of the probability of service added to the product was explained by six predictors under product category. The 1st to the 3rd multiple regression models are:

$$\hat{Y}_1 = -.379 - .203PCP - .013PCB + .095PCK + .020PCS + .042PCC + .164PCT. \quad (16)$$

$$\hat{Y}_2 = -.334 - .329PCP + .030PCB + .092PCK + .049PCS - .002PCC + .267PCT. \quad (17)$$

$$\hat{Y}_3 = -.602 - .219PCP + .099PCB - .047PCK + .162PCS - .141PCC + .312PCT. \quad (18)$$

In the 4th to the 6th multiple regression models, the independent variable that is considered statistically significant is MeanSCD and has beta value of .178, .246, and .240 in the fourth, fifth, and sixth model, respectively. The adjusted R^2 value for the first to the third model was .036, .053, and .059 respectively meaning that less than 10% of the probability of service differential the product was explained by three predictors under service category. The 4th to the 6th multiple regression models are:

$$\hat{Y}_4 = -.671 + .178SCD - .005SCI - .026SCW. \quad (19)$$

$$\hat{Y}_5 = -1.068 + .246SCD - .071SCI - .021SCW. \quad (20)$$

$$\hat{Y}_6 = -1.600 + .240SCD - .015SCI - .022SCW. \quad (21)$$

While the 7th to the 9th multiple regression models, the independent variable that is considered statistically significant is MeanKES and has beta value of .122, .151, and .150 in the seventh, eighth, and ninth model, respectively. The adjusted R^2 value for the first to the third model was .013, .014, and .033 respectively meaning that less than 10% of the probability of service differential the product was explained by three predictors under knowledge category. The 7th to 9th multiple regression models are:

$$\hat{Y}_7 = .244 - .055KCH + .122KES - .016KWT. \quad (22)$$

$$\hat{Y}_8 = .242 - .036KCH + .151KES - .056KWT. \quad (23)$$

$$\hat{Y}_9 = -.633 + .021KCH + .150KES + .000KWT. \quad (24)$$

Based on the result of nine multiple regression models, 7 significant factors of the 4-category service levels are MeanPCP, MeanPCB, MeanPCS, MeanPCC, MeanPCT, MeanSCD, and MeanKES. These variables were used for finding the average marginal effects. The Average Marginal Effects (AMEs) was combined and convenient way to compute marginal effect of each dependent variable at every observed value of independent variable and average through the estimation of resulting effects (Leeper, 2017). Findings based upon the estimated equation (11) to (14) can be generated that 7 attributes were significant as presented in Table 6. This data indicates and distinguishes the 4-category service levels.

Data shown in Table 6 is the result of the average marginal effect of 7 significant factors calculated from equation (11) to (14). The 7 significant variables from 4-category service levels illustrated in Table 5

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were chemical product only, chemical blending, chemical storage, chemical container recycling, transportation, chemical document, and environmental and safety programs.

Table 6 Logit Average Marginal Effects of Significant Factors of Four Categories Service Levels

No.	Significant Attributes	Logit average marginal effects			
		Product Only	**Service Added to the Product**	**Service Differential the Product**	**Service is the Product**
1	MeanPCP: Chemical Product Only	0.054	0.0003	-0.015	-0.039
2	MeanPCB: Chemical Blending	-0.008	-0.006	-0.006	0.020
3	MeanPCS: Chemical Storage	-0.013	-0.010	-0.009	0.033
4	MeanPCC: Chemical Container Recycling	0.012	0.009	0.008	-0.029
5	MeanPCT: Transportation	0.115	-0.008	-0.069	-0.069
6	MeanSCD: Chemical Documentation	-.066	-.008	.039	.035
7	MeanKES: Chemical Environmental and Safety Programs	-.005	-.024	.015	.014

The marginal effect of the first variable, chemical product only, toward 4-category service levels shows that product only level is the service level that customers who focus on purchasing chemical product only should basically be concentrated compared to the others 3 service levels of service added to the product, service differential the product, and service is the product level. The marginal effect of 0.054 indicates that if there is an increase in the demand of chemical product only by one unit, the service of product only will be more likely to be selected at 5.4%. This research finding was consistent with the study of Eder, Delgado, Kortman, and Studies (2006). In terms of chemical product, traditional business models are focusing on selling chemical product by volume. Chemical suppliers do not have incentive to provide additional services, but they earn money by selling more amount of chemicals.

Secondly, for the chemical blending, service is the product was the preferable service customers want. The marginal effect of 0.02 can be explained that if there is an increase in the demand of chemical blending by one unit, the service level of service is the product will be more likely to be chosen by 2%. On the contrary, the marginal effect of the service level of product only is -0.008, this means the service level of product only will be less likely to be chosen by 0.8% if the demand of chemical blending increases by one unit. Moreover, the service level of service added to the product and service differential the product is also less likely to be selected by 6% if the level of chemical blending demand is increased by one unit because the marginal effect is -0.06. The good evident to support this finding is that chemical suppliers in developed countries, not only world leading companies for example Dow chemical but also local suppliers in North America, Europe, and Japan provide chemical blending service to their customer as bundle solution. They are concerning about safety and setting the highest priority when blending chemicals. With their highly equipped and experiences, this service is provided as custom solution to meet their customer requirement.

The third significant variable is chemical storage. The marginal effect shows that chemical supplier should provide service level of service as the product for customers who has requirement on chemical storage. The marginal effect of .033 indicates that when the demand of chemical storage increases by one unit, the service level of service is the product is more likely to be selected by 3.3%. This is opposite to the other three service levels that have negative marginal effects. From the result of marginal effect in table 6, it can be interpreted that when the demand of chemical storage increases by one unit, the service levels of chemical only, service added to the product, and service differential the product are less likely to be chosen by 1.3%, 1%, and 0.9%, respectively.

The next significant variable is chemical container recycling. The 0.012 marginal effect of product only level indicates that if the customer demand of chemical container recycling raises up one unit, the service level of product only is more likely to be selected at 1.2% of probability. Other two service levels are also having positive effects. Service added to the product and service differential the product are also more likely to be preferred at 0.8% and 0.9% respectively when the demand of chemical container recycling increases by one unit.

Transportation is another significant factor to be considered. The marginal effect of 0.115 can be explained that if the demand of transportation moves up one unit, the service level of product only is more likely to be chosen by 11.5%. While the other three service levels have negative marginal effect. Service added to the product, service differential the product, and service is the product are less likely to be select by 0.8%, 6.9% and 6.9%, respectively, when the demand of transportation from customer shifts up one unit.

The sixth significant factor is chemical documentation. The positive value of the marginal effect relates to a positive impact of this factor toward service level of service differential the product and service is the product. This means service differential the product and service is the product are more likely to be selected with the probability of 3.9% and 3.5% respectively. This can also be explained that the product only, and service added to the product service levels have negative impact by -6.6% and -0.8% of probability respectively when the demand of chemical documentation increases by one unit. Therefore, customers are more intended to require differential services and service solution when they have more demand of chemical documentation.

The last significance for 4-category service level is chemical environmental and safety programs. The marginal effect sign explains that both service differential the product and service is the product will respond the request of customer on chemical environmental and safety programs. With marginal effect of 0.15 and 0.14, this implies that service differential and service is the product are more likely to be selected with probability of 1.5% and 1.4% respectively if the customer demand of chemical environmental and safety programs rises up one unit.

Discussion and Conclusion

The objectives of this paper were achieved. Firstly, chemical servitization framework was developed and consisted of two parts. The first part of the framework was composed of the three dimensions of customer segments, servitization levels and PSK system, and the second part was the suggestions for Thai chemical suppliers. The research explored the relationship between 4-category service levels and chemical customer requirements. The four service levels were product only, service added to the product, service differential the product and service is the product (Thoben, Eschenbacher, & Jagdev, 2001), and each service level has its own attractiveness of services to be composed of. The questionnaire was distributed to gather data, and descriptive statistics, Analytical Hierarchy Process (AHP), Multiple Linear Regression, and Multinomial Logit Model (MNL) were adopted for data analysis. Secondly, seven substantial factors were identified in order to analyze the service level of customer needs. These significant attributes were chemical product only, chemical blending, chemical storage, chemical container recycling, transportation, chemical documentation, and environmental and safety programs. With different component of services, each service level proposes its own character to meet customer requirement. The marginal effects explain better view which determinant should be focus to improve supplier service offerings for customers.

The research findings highlight the significant attributes of chemical service levels. There will be several guidelines for chemical suppliers to propose service offerings to their customer from this research. For chemical suppliers who propose chemical product only should offer not only selling chemical product in large volume for discount price, but also providing chemical container recycling and transportation services in order to facilitate their customers. Suppliers who have a business model of service differential the product should offer chemical documentation and environmental and safety programs services because their customers want special services rather than just the chemical products only. Suppliers who desire to change their business model from selling tangible products to providing chemical solutions should offer chemical blending, chemical storage, chemical documentation, and environmental and safety programs as bundle services along with chemical products to their customers. However, the study didn’t have any suggestions for the suppliers who propose service with the product business model because the results did not show any chemical services that have enough impact to be included in this category. For the future study, researcher might examine some other attributes that have impacts on this service level. Future study may also investigate variables of these 4-category service levels in chemical industry in other industries in Thailand or the chemical industry in other countries. Substantial contributions for this paper are that this study is the first research proposing chemical servitization framework in Thailand and also providing guidance to chemical suppliers for different service level in order to meet their customers’ requirements.

Results of the multiple regression models in Table 5 show low values of R-square in every model. The researchers worried about this issue, and were afraid that the low value of R-square would not be acceptable because the models were not well-defined. However, we found a book from Neter, Wasserman, and Kutner (1985) explaining that R-square is not a measurement of fit, but it measures the explanatory of power. R-square could be low number because the researchers did not expect the model included all the relevant predictors to explain the dependent variables. Eventhough R-square is small, ranging from .012 to .081, but it is different from zero value. This can be indicated that the multiple regression models have statistically significant explanatory power with small effect size. In the social sciences where the models are difficult to specify, low R-square values are often expected.

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