

Analyzing the Adoption of Online Payment using System Dynamics

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시스템 다이내믹스를 이용한 온라인 지불결제 서비스 수용에 관한 분석

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요약 온라인 소매업은 인터넷 기반 회사들에게 전 세계의 온라인 고객들과 연결될 수 있는 기회를 제공했다. 그러나 많은 고객들은 온라인 지불결제 서비스의 위험성이나 사용의 어려움으로 인해 원하는 상품을 선택하고도 온라인에서 거래를 완료하지 못하는 경우가 종종 있다. 그동안 많은 연구자들이 온라인 지불결제에 영향을 미치는 요인들을 조사했지만 온라인 시장 환경이 급격하게 변화되면서 향후 5년 또는 10년 후의 전개될 상황을 예측하기란 매우 어렵다. 본 연구의 목적은 온라인 지불결제에 영향을 미치는 요인들을 검토하고 제3자 결제 회사 및 온라인 서비스 제공 업체에게 장기적인 동태적 의사 결정 모형을 제공하는데 있다. 이를 위해 본 연구는 온라인 지불결제 서비스 수용 모형을 개발하고 향후 10년 동안 전개될 상황을 시뮬레이션하기 위해 시스템 다이내믹스 기법을 사용하였다. 분석결과 온라인 지불결제 고객은 10년 안에 지속적으로 증가할 것이며 핵심 영향 요인으로는 서비스 품질, 시스템 품질 및 예상 소요 시간인 것으로 나타났다.

키워드 : 시스템 다이내믹스, 서비스 품질, 시스템 품질, 노력기대, 온라인 구전효과

Abstract Online retail business has provided internet-based companies with the opportunities to be connected with online customers from all over the world. However, many online customers do not complete their transactions online even if they have already choose what they want because they perceive online payment service is risky or perceive difficulty of paying online. A large body of researchers have examined the important variables that influence online payment, however, these studies can hardly predict the future development tendency after five or ten years since the environment of online market changes so fast more than ever. Therefore, the purpose of this study is to examine the importance of factors affecting online payment and to provide long term dynamic decision making model for third-party payment companies and online service providers. To serve the purpose, this study used system dynamics approach to develop a model of online payment adoption and to simulate various development paths for ten years. The analysis results show that the number of online payment customers increase continuously in ten years, and service quality, system quality, and effort expectancy are key factors for customers to pay online.

Key Words : System Dynamics, Service Quality, System Quality, Effort Expectancy, e-WOM

1. Introduction

The development of e-commerce in the past two decades has changed the way of conducting retail

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business significantly. E-commerce operators can develop their retail businesses in the virtual world economic cost through the latest e-business technologies. Some big online shopping mall, such as Amazon, TaoBao, 11th, do not even have any physical stores. This online retail business provides internet-based companies with the opportunities to be connected with online customers from all over the world. However, many online customers do not complete their transactions online even if they have already choose what they want because they perceive online payment service is risky or perceived the difficulty of paying online. Therefore, a large body of researchers have examined the important variables that influence online payment in order to provide useful indications to online shopping mall based on existing customer data or questionnaires. For example, [1] reported that perceived ease of use of a system has more significant impact on user's adoption than other factors. According to [2], perceived risk is a vital factor affecting online consumer behavior. [3] found that perceived enjoyment positively influence the intention to use mobile payment. [4] indicated that familiarity can reduce uncertainty when uncertainty cannot be reduced through rules and customs. These researches do provide useful indications to Internet-based companies and help to make effective decision makings for managers or online shoppers. However, these studies can hardly predict the future development tendency after five or ten years since the environment of Internet market changes so fast more than ever, and there are still a lot of customers hesitate or discard to pay online. In addition, few studies examined online payment context using a system dynamics approaches. Therefore, having these as the background in our study, the structure and the influencing factors of online payment were analyzed using a new perspective of system dynamics approach. We developed a system dynamics model of online

payment platform, and used the model to simulate various development paths by varying different factors that affect customers' intention to adopt online payment. Our simulation results will not only show the important factors influencing online payment but also provide long term decision makings by predicting the development tendency in ten years. By doing so, a general business model of online shopping mall was developed.

Thus, the purpose of this study is: (1) to examine the importance of factors affecting online payment using system thinking approach: (2) to provide long term decision makings for third-party payment companies and online service providers by developing a system dynamics model of online payment platform, and use the model to simulate various development paths by varying different factors.

2. Literature Review

Consumers' behavioral pattern of Internet shopping can be classified as three different steps of "pre-purchase interaction, purchase consummation, and post-purchase interaction". In our study, since the purpose of this study is to examine consumers' online payment adoption, we classified the pattern as two steps of "pre-purchase stage and purchase/online payment stage".

2.1 Pre-purchase Stage: Bass Model

Pre-purchase search is information seeking and processing activities in which consumers engage to make their purchase decisions. In this stage, potential consumers read, or observe product related information through various media or word-of-mouth (WOM) presented by previous customers to produce a well-considered purchase decision. According to the characteristics of pre-purchase stage, it is the most suitable to explain the stage by the Bass model [5]. The Bass model consists of a simple

differential equation that describes the process of how new products get adopted in a population. The model presents a rational of how current customers and potential customers of a new product interact. It has been widely used in forecasting, especially products' sales forecasting and technology forecasting. Diffusion according to Bass can be described with the following equation:

$$dN(t)/dt = p[m - N(t)] + (q/m)N(t)[m - N(t)].$$

Where: $N(t)$ is the cumulative number of purchasers at time t ;

m is the size of potential purchasers;

p is the coefficient of innovation;

q is the coefficient of imitation.

This equation predicts that diffusion of innovations may occur under the effect of advertising, media reports, or word-of-mouth. Many researches have adopted the Bass model to examine consumers' motivation in pre-purchase stage. [6] emphasized the importance of online social network advertising effects on consumers' motivation in pre-purchase stage. Early in the 1996, [7] putted forward the vital influencing factor of advertising in market. And the influencing lasts long till nowadays. In addition, considering the feature of untouchability of online shopping, many potential customers take online payment action after reading other consumers' electronic word-of-mouth (e-WOM) information[8]. Through the e-WOM that previous consumers provided, they are able to understand the quality of the product/service. Therefore, in pre-purchase stage, we adopt two main influencing factors, advertising and e-WOM, to influence the potential customers' intention to visit the Web Site.

2.2 Purchase Stage

In the purchase stage in our study, we mainly examine variables influencing consumers' online payment adoption intention, since potential customers still hesitate to pay online due to factors such as perceived risk, complicate process to pay, limited

payment options etc. Understanding potential customers' acceptance and use of technology is one of the most mature stream of information systems research[9]. There have been several theoretical models developed from theories in psychology and sociology[10]. Among those, unified theory of acceptance and use of technology 2 (UTAUT2) [11] and updated information system success model (IS success model) [12] can be viewed as powerful theories to explain individual behavior intention and acceptance of technology. UTAUT2, IS success model have been widely used in the context of e-commerce, organizational level, and user adoption of various information systems etc., and have improved to have significant effects on behavior intention and technology use. UTAUT2 including interaction terms explained 74% of the variance in behavioral intention which represent significant jumps in variance explained compared to the original UTAUT[11]. Among the factors in UTAUT2, effort expectancy has been widely proved to have significant influence on user's intention to use Internet technologies. For IS success model, many researchers employed it to predict user intention to conduct online shopping, mobile user behavior, electronic government success, mobile banking adoption behavior. For example, [13] have pointed out that customers tend to regard system security as one of the most important factors relevant to online shopping. [14] suggested that service quality of the online shopper is another main factor to predict purchase intention or online payment intention of the online shopping services. Thus, in the purchase stage, we employed three main factors-effort expectancy, service quality, and system quality to influence the online payment behavior of customers.

2.3 Advertising

When it comes to the purpose of attracting potential customers to the web site, Internet

advertisements and event promotions, which stimulate the demand in the Internet shopping mall, are always regarded as a cost-effective and efficient than traditional media method. Usually, e-vendors provide information about their products or service on the Internet shopping mall to attract potential customers and eventually deriving purchase intentions through online communication. In addition, e-vendors will also introduce new products or promote purchase by providing customized information to existing customers through e-mails, or by contacting the customers continuously[7]. Thus, we hypothesis that Internet shopping mall advertisements can attract more potential customers.

2.4 e-WOM

e-WOM is defined as any positive or negative statement made by potential, actual, or former customers about a product or service company, which can influence a multitude of people to make purchase decisions via the Internet[15]. It has transformed the ways in which marketing communication has traditionally operated as one-way communication from companies to consumers through mass communication channels. With the development of Internet, consumers no longer rely on advertisements to get acquaint with brand information and make a purchase decision. Consumers generate contents about the products or service, or online conversations, between companies and consumers can all influence consumers' online payment behavior. Especially in the pre-purchase stage, potential consumers trust on other consumers' opinions posted online[16]. And according to[8], more than two thirds of potential consumers take online payment action after reading other consumers' e-WOM messages, which showing its social influence that impacts consumer trust and behavior. However, e-WOM include positive e-WOM and negative e-WOM. Positive e-WOM can enhance expected quality and brand attitude, and leads

potential consumers to purchase the product[17]. Whereas negative e-WOM elicits product denigration, rumor, private complaining, and finally diminishes purchase intentions and sales[18]. Therefore, we hypothesis that positive e-WOM can attract more potential customers.

2.5 Effort Expectancy

Effort expectancy is defined as the degree of ease associated with the use of the system. Actually, there is substantial similarity among the construct definitions and measurement scales with perceived ease of use, complexity, and ease of use. The similarities among these constructs have been noted in prior research[19]. According to [10], effort expectancy are proved to have influential on behavioral intention to use a technology. Many other research also found that effort expectancy has a significant impact on intention to adopt new technology. For example, [20] found that effort expectancy has a significant influence on the students' intentions for using e-mailing system, [21] indicated that effort expectancy positively influence the clinical decision support system (CDSS). [22] proved that effort expectancy influence a user's intention to use Internet technologies, which supports the existing literature that the use of a system is dependent on how easy it is. Thus, the process or the degree of effort of the online payment, as well as various payment options will significantly influence consumer's payment action. Thus, we hypothesis that effort expectancy will significantly effect online payment adoption.

2.6 Service Quality

Service quality is defined as the degree to which the service is delivered to best address customer needs in terms of the support of the entity managing the system[12]. In every service encounter, customers or users expect and acceptable and comfortable level of service quality[23]. Thus

service quality has been widely adopted to strengthen the significant relationship with behavior intention. For example, [24] indicated that the first need for Greek e-government is to provide higher service quality to make taxation information system successful. [25] found that service quality has a significant positive effect on intention to use e-learning systems. [14] also suggested that service quality of the online shopper is the main factor to predict purchase intention of online shopping services. Service quality contains important elements such as assurance, empathy, and responsiveness. The responsive speed of the service provider or online shopper is important to influence customers' payment intention. Therefore, we hypothesis that satisfied service quality at the purchase stage could significantly influence online payment adoption.

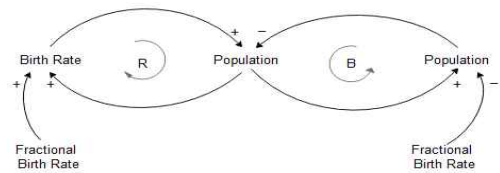
2.7 System Quality

System quality refers to the level of user satisfaction with the technical and functional aspects of an Internet shopping website[26]. According to[12], system quality include various factors such as usability, availability, reliability, adaptability of the system. While in the online shopping environment, system quality must support the customer's purchasing activity by providing security. If security is not guaranteed, customers are likely to switch or discard from the online payment process. According to[27], the dimension of system quality include security, which means appropriate restrictions to maintain security. Researchers also have pointed out that customers tend to regard system security as one of the most important factors relevant to online shopping[13]. Previous studies indicated that security strongly influence customer enthusiasm and website utilization[28], which will increase the adoption rate to conduct online payment behavior. Therefore, if

the online payment process is believed to have system security, customers will more likely to adopt the online payment system.

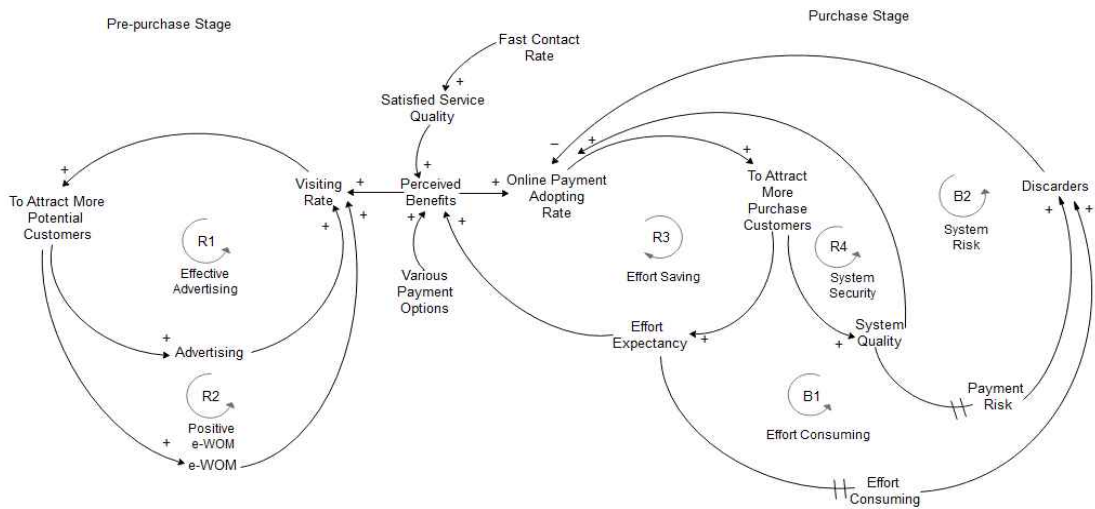
3. Simulation Model

Causal loop diagrams (CLDs) are a qualitative diagramming language for representing the feedback structure of systems. A CLDs consists of variables connected by arrows denoting causal influences among the variables. The important feedback loops are also identified in the diagram. In CLDs, variables are related by causal links, shown by arrows. Each causal link is assigned a polarity, positive (+) or negative (-) to indicate how the dependent variable changes when the independent variable changes. The important loops are emphasized by a loop identifier which shows whether the loop is a positive (reinforcing) or negative (balancing) feedback.



[Fig. 1] Causal Loop Diagram Example

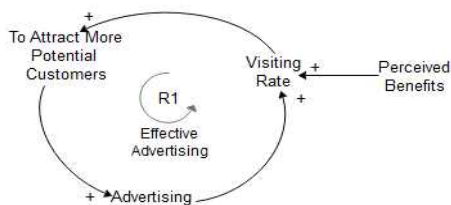
([Fig. 1]) showed an example of CLDs, and in the example, the birth rate is influenced by population and the fractional birth rate. In our study, the system dynamics model encompasses key feedback loops related to the two stages of online payment. It includes pre-purchase stage and purchase/online payment stage. We presented the main feedback loops of the model based on literature review that are illustrated in ([Fig. 2]) and are explained as follows:



[Fig. 2] Causal Loop Diagram

3.1 Hypothesis 1 (Reinforcing Feedback Loop R1)

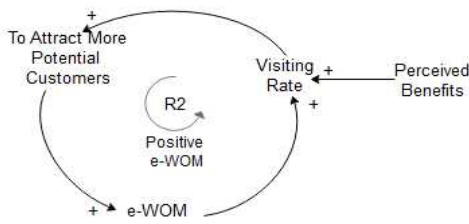
Advertising is an audio or visual form of marketing communication that employs an openly sponsored, nonpersonal message to promote or sell a product, service or idea[29]. In order to attract more potential customers, e-vendors usually intend to carry out some attractive advertisements or promotions such as discount coupons, attractive discount price, to introduce their products or services. According to[30], effective advertisements and promotional activities can attract customers in the process that potential customers visit the web site. Thus, as ([Fig. 3]) showed, we hypothesis that effective advertisements will increase visiting rate so as to attract more potential customers.



[Fig. 3] Reinforcing Feedback Loop (R1)

3.2 Hypothesis 2 (Reinforcing Feedback Loop R2)

To attract more potential customers, another effective and significant factor is the word-of-mouth activities, e-WOM communication can be classified into two levels: market-level analysis and individual-level analysis[30]. In this study, we mainly focus on individual-level analysis and it is defined as the process of personal influence in which communication between an e-WOM sender and a receiver can change the receiver's attitude and purchasing decision. Regarding the literature review about e-WOM, the customers with previous purchase experience tend to provide comments or advices to other potential customers online. Satisfied customers will spread positive words, while unsatisfied customers will spread negative comments. Potential customers will inflow under positive e-WOM effects and outflow the website due to negative e-WOM[31]. Therefore, as ([Fig. 4]) showed, we hypothesis that positive e-WOM will increase visiting rate and eventually increase more potential customers.



[Fig. 4] Reinforcing Feedback Loop (R2)

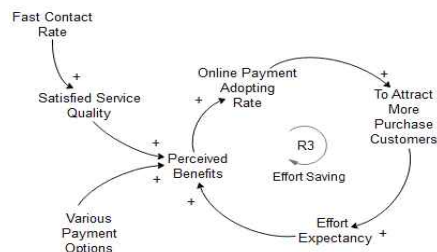
3.3 Hypothesis 3 (Reinforcing Feedback Loop R3)

In the purchase stage, the main purpose is to increase the online payment adoption rate. According to the IS success model[12], perceived benefit of customers can significantly influence purchase/payment intentions. There are two main types of perceived benefits, which are direct and indirect advantages. In our study, since we mainly examine service quality and effort expectancy on online payments, benefits of customers that perceived belongs to indirect advantages. Indirect advantages are those benefits that are less tangible and difficult to measure.

Effort expectancy, in our study, it mainly refers to the ease associated with consumers' online payment adoption. Based on literature review, effort expectancy are proved to have positive effect on behavioral intention. For example, [10] proved that effort expectancy have influence on behavioral intention to use a technology. Effort expectancy has something in common with perceived ease of use. [32, 33] all proved that perceived ease of use has a significant influence on intention to use in the perspective of e-commerce. Empirical studies by[34] indicated the significant influence of perceived ease of use on intention behavior. Customers will perceive indirect benefits such as time saving if the online payment adoption is easy to use. Thus, as ([Fig. 5]) showed, we hypothesis that the easier of the online payment online payment, such as various payment options that online shopping mall's

managers or third-party payment companies make, the higher adoption rate of the online payment.

Under Chinese online shopping context, customers tend to acquire useful information and advice from e-vendors. Customers will switch to another e-vendor if the response or contact rate is slow or perceived communication barriers. Thus, service quality plays an important role in customers' purchasing-decisions. Service quality refers to overall customer evaluations and judgments regarding the excellence and quality of e-service delivery in the virtual marketplace. Service quality has several dimensions and variables. Customers will perceived indirect benefits like reduced search costs, time savings through high rate of contact from e-vendors so that make further purchase decisions. Therefore, as ([Fig. 5]) showed, we hypothesis that contact rate from e-vendors can increase service quality, and satisfied service quality will help increase customers' perceived benefits, and eventually increase online payment adoption rate.

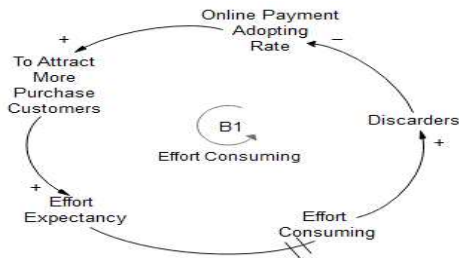


[Fig. 5] Reinforcing Feedback Loop (R3)

3.4 Hypothesis 4 (Balancing Feedback Loop B1)

Delays are critical in creating dynamics. Delays give systems inertia, can create oscillations, and are often responsible for trade-offs between the short- and long-run effects of policies. Effort expectancy may still exist effort consuming condition with time delays. Since effort expectancy will positively influence online payment adoption only after significant delays while systems are built and settled

to be easy to use and accepted by customers. Thus, as ([Fig. 6]) showed, we hypothesis that effort expectancy may exist effort consuming with time delay and effort consuming will increase the number of discarders, and finally will decrease online payment adoption rate.

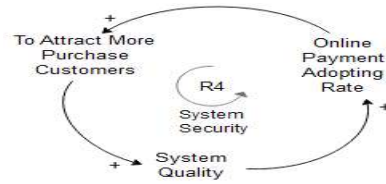


[Fig. 6] Balancing Feedback Loop (B1)

3.5 Hypothesis 5 (Reinforcing Feedback Loop R4)

System quality refers to the level of user satisfaction with the technical and functional aspects of an Internet shopping website. System quality has dimensions such as navigation, usability, availability, adaptability, interactivity, and security[12]. Since users cannot interact with each other face-to-face and both of the e-vendors and customers are strangers in online payment, many of the customers are concerned about their personal information and the directions of the transactions. It is crucial for online payment to protect individual users' privacy and make users feel safe when making a transaction. Therefore, security is an important system quality dimension in online payment context[35]. Researchers also have pointed out that customers tend to regard system security as one of the most important factors relevant to online shopping[13]. Previous studies indicated that security strongly influence customer enthusiasm and website utilization[28], which will increase the adoption rate to conduct online payment behavior. Thus, as ([Fig.

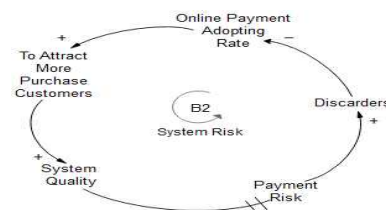
7]) showed, system security of the online payment will increase online payment adopting rate.



[Fig. 7] Reinforcing Feedback Loop (R4)

3.6 Hypothesis 6 (Balancing Feedback Loop B2)

It acquires long term to achieve a security system. With time delays, there may still exist payment risk for online payment customers. Perceived risk refers the uncertainty with the possibility of facing the negative consequences of a product or service, or online payment. According to[36], perceived risk comprises of various components like security risk, financial risk, social risk, time risk and performance risk. In our study, the risk is mainly refers to the security risk. Previous studies examined the barrier of security risk on online payment. [37] have studied perceived risk and behavioral intention of mobile commerce user and found the negative effect between them. Therefore, as ([Fig. 8]) showed, we hypothesis that with time delays, security risk may exist and that will increase the number of discarders, and eventually decrease online payment adoption rate.



[Fig. 8] Balancing Feedback Loop (B2)

<Table 1> Operational Definition of the Main Variables

Main Variables	Operational Definition	References
Advertising	Advertising is an audio or visual form of marketing communication that employs an openly sponsored, nonpersonal message to promote or sell a product, service or idea.	[29]
e-WOM	E-WOM is a process of personal influence in which communication between an e-WOM sender and a receiver can change the receiver's attitude and purchasing decision.	[30]
Perceived Benefit	A consumer's belief about the extent to which he/she will become better off from the online purchase with a certain Website.	[37]
Effort Expectancy	Effort expectancy is the degree of ease associated with consumers' use of technology.	[10]
Service Quality	Refers to overall customer evaluations and judgments regarding the excellence and quality of e-service delivery in the virtual marketplace	[38]
System Quality	System quality is one of the quality dimension, which represents how users evaluate their interaction with IT features of the system	[27]

<Table 1> gave the operational definitions of the main variables and references.

4. Methodology

The study mainly adopted system dynamics simulation method to examine factors influencing online payment adoption problems.

4.1 System Dynamics

System dynamics a computer-aided approach for analysing and solving complex problems with a focus on policy analysis and design. System dynamics mainly to understand the dynamic behaviour of complex physical, biological, and social systems using a perspective of information feedback and delays, which is the essential viewpoint to cause the behaviour of systems in system dynamics. System dynamics simulation is a methodology that examines how feedback loops, accumulations, and time delays between various factors influence the behavior of a complex system over time. Researchers have started to conceptualize platforms as dynamic systems and examine how they develop through time. For instance, [39] have used system dynamics modelling to examine the historical emergence of

mobile telecommunications markets, as well as platform strategies that result in two-sided platform success or failure. [39] also develop a simulation model to examine how platform quality, indirect network effects, and consumer expectations influence entry into platform-based markets. In this study, after the causal loop diagrams was constructed based on various theories and previous literature regarding the online payment or purchase decision in the internet shopping mall, then we will develop a stock and flow diagrams, since causal loop diagrams emphasize the feedback structure of a system, while stock and flow diagrams emphasize their underlying physical structure.

4.2 Simulation Analysis

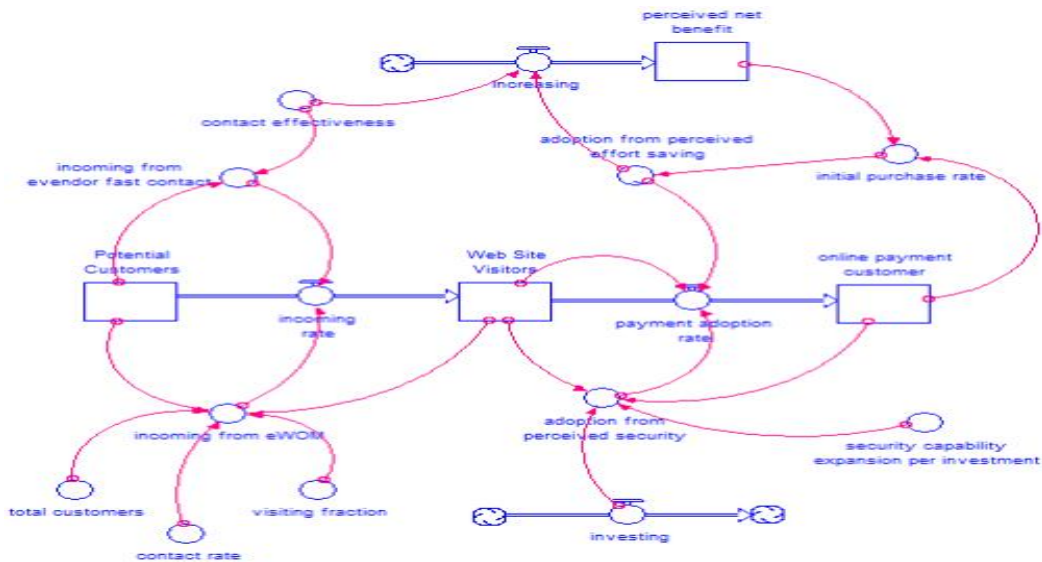
Simulation is the imitation of the operation of a real-world process or system over time. It first requires that a model be developed, which can represents the key characteristics, behaviors and functions of the selected system or process. The model represents they system itself, whereas the simulation represents the operation of the system over time. In our study, when analyzing the online payment adoption rate, the simulation is conducted for 10 years with the unit of analysis in a year,

considering the environment of internet market changing so fast more than ever. And in order to simulate the behavior change of online payment with time, we develop a stock and flow model (see [Fig. 9]) based on the CLDs that we constructed above. The stock represents the main quantity that is to be accumulated, such as population, money in a bank account, water in a bathtub, etc. A flow represents those actions or activities that cause the stock value to increase or decrease over time. We will conduct the simulation process using *iThink 9.1*. *iThink* is the definitive modeling tool to create professional simulations and presentations. It can seamlessly design, build, and publish models to share with anyone, anywhere, anytime.

4.3 Prediction Results

This study is still on the working. However, based on the Bass model, IS success model, and UTAUT2, we can predict the behavior trends of each variables related to online payment adoption. We predicted that potential customers in the pre-purchase stage will decrease and Website visitors

will increase, and the curve for both of the potential customers and Website visitors will present in the form of logistic curve and both of them are exactly on the contrary direction (see [Fig. 10]). Website visitors curve increase because they initially learn about the internet shopping mall or e-vendor's store through advertisements and e-WOM. While as time passing by, potential customers values are lower than the values of Website visitors, and less potential customers will "switch" to Website visitors. Thus, we assumed that the curve of potential customers will decrease slower and slower to the complete depletion. For online payment customers, we predicted that the curve will increase in the form of exponential growth, which means the stock value increases at a rate that is a percentage of the current amount. In addition, we will order the importance of the main factors of advertising, e-WOM, service quality, system quality, and effort expectancy by conducting scenario analysis, which means to analyze the main variables by considering alternative possible outcomes.



[Fig. 9] Stock-Flow Diagram



[Fig. 10] Prediction Result

5. Implications

Through the study, 5 variables related to the online payment adoption of an internet shopping mall were examined through a dynamic analysis. By connecting all the variables, the diagram for the cause and effect was systematically constructed. The results of this study provide both of the academical implications and practical implications which are described below.

First of all, from the perspective of academic, this study provided a new perspective from the system dynamics view based on the Bass model, IS success model, and UTAUT2. Although IS success model and UTAUT2 have been widely employed in research work, few studies have conducted online payment adoption using system dynamics approach. Second, the new perspective from system dynamics view have filled the gap in the e-commerce context, and provide a new trend for future researchers. While from the practical perspective, first of all, the results of this study can provide a more useful reference for consumers which allows them to shop under a more favorable environment. Second, at the same time the results of this study provide a more accurate strategy advice to Internet shopping mall managers, e-vendors, as well as online payment system managers to help them achieve the

objectives such as increasing customers' online payment adoption rate and continuous purchase growth. Finally, system dynamics possess the advantage of predicting the development tendency after five or ten years, thus the results of this study also can provide managers, e-vendors and online payment system managers with the development trend of their shopping mall or website so that they can make an appropriate strategy to fit for the trend.

Despite contributions of this study, there were a few limitations. There are many significant influential factors affecting online payment adoption in both pre-purchase stage and purchase stage, we only adopt 5 main variables. Future studies should conduct more variables. Besides, the causal loop diagrams were built on the perspective of Chinese, it may has different results in another country.

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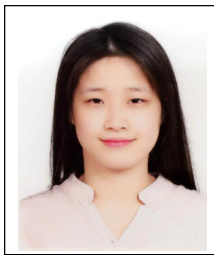
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