

**ACCEPTANCE OF VEIN AUTHENTICATION TECHNOLOGY IN
AUTOMOTIVE ON THAI CONSUMERS**



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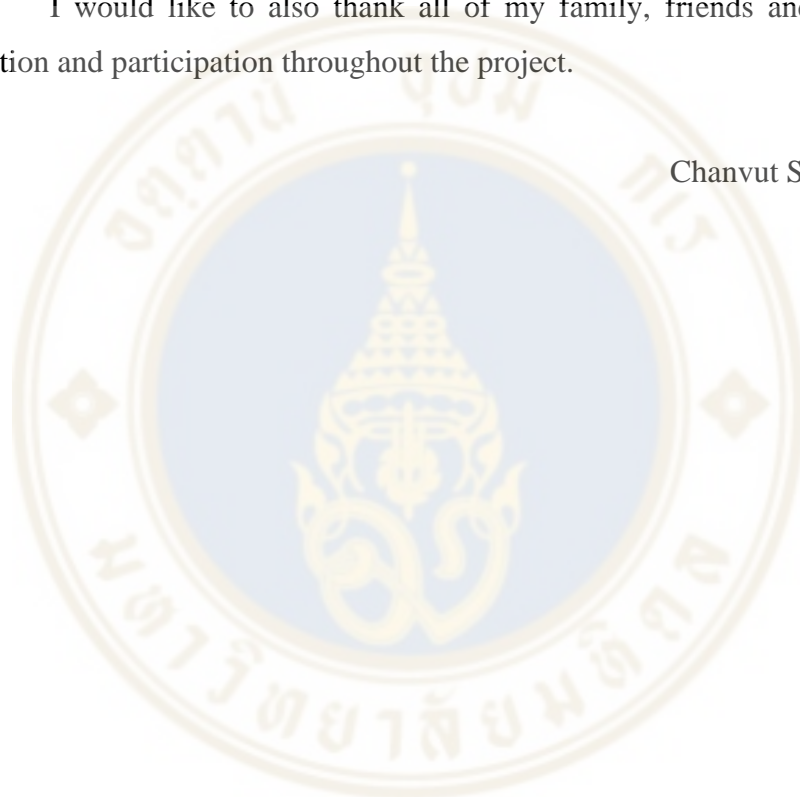
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Chanvut Siribunjongchoke



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CHANVUT SIRIBUNJONGCHOKE 6149023

M.M. (GENERAL MANAGEMENT)

THEMATIC PAPER ADVISORY COMMITTEE: NISIT MANOTUNGVORAPUN,
Ph.D., ASSOC. PROF. NATHASIT GERDSRI, Ph.D., TRIN THANANUSAK, Ph.D.

ABSTRACT

Vein authentication technology has been on the technologies' trend that become widely adopted for identification purpose. This study appears to be the first study to explore the acceptance of vein authentication technology in automotive on Thai consumers and explain the attitude towards this technology. This study applied quantitative approach by using online questionnaire of 400 respondents in Thailand. The findings explain positive relationship between original TAM and another external factor which is perceived cost. While privacy is the factor that does not have significant impact on acceptance level of Thai consumers.

KEY WORDS: Vein Authentication/ Technology Acceptance Model/ TAM/
Automotive Access System/ Biometric Acceptance/ Thailand

40 pages

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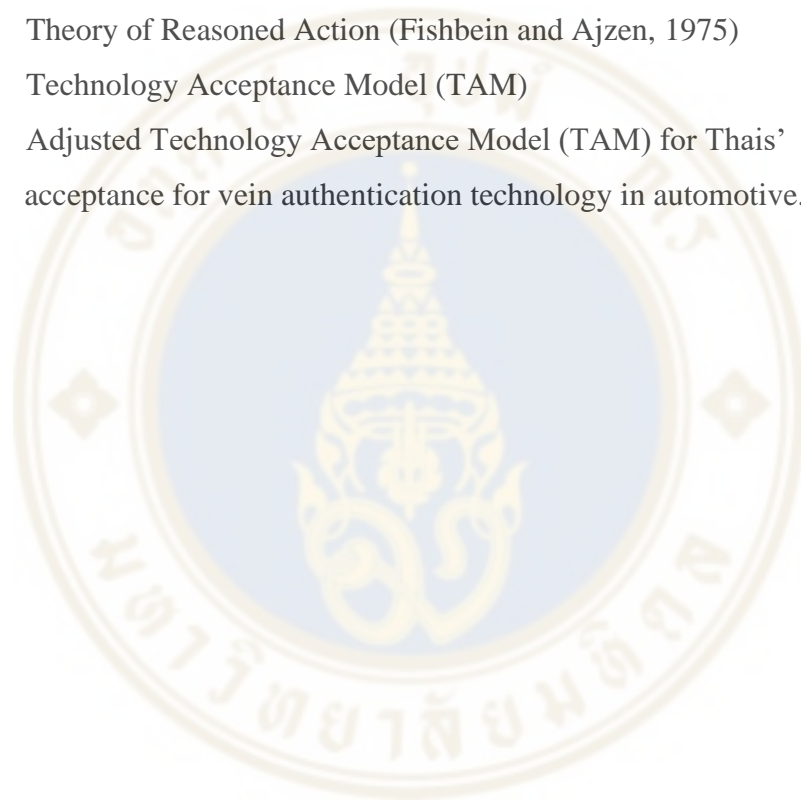
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CHAPTER I

INTRODUCTION

Biometric technology is considered as one of the technologies that attracts high level of attention and is widely adopted across industries to be used for authentication and identification purpose (Bilgihan et al, 2013). It also appears that the use of biometric technology has been growing rapidly and replacing the traditional authentication method such as personal identification number (PIN) due to strong advantages in terms of security, ease of use and shopper friendly (Giarimi & Magnusson, 2002).

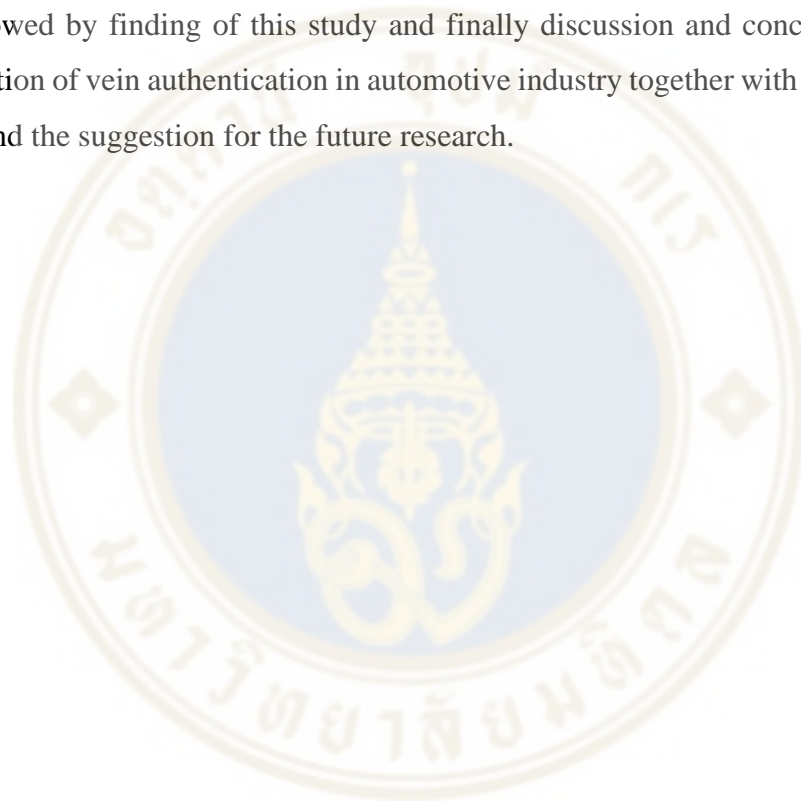
The biometric technology can be described as the involvement of the automatic authentication of individual regarding his or her characteristics (Bolle, Connell, Pankanti, Ratha and Senior, 2004). It includes both personal physical and behavioural characteristics that can be measured, quantified, recorded and store in digital system (Falaleeva and Wafa, 2005). There are several types of biometric methods used in the market; for example, finger scan, signature verification, hand geometry, iris or retina scan, face recognition, voice biometric and vein authentication (Giarimi & Magnusson, 2002). While vein authentication seems to be one of the best technologies in terms of accuracy, security and cost (Lula et al, 2012). However, the commonality among different methods is the comparison between the original trait registered in the system and user's characteristic to determine authentication (Giarimi & Magnusson, 2002). Despite all advantages of the biometric technologies, there seems to be the limitation from users regarding information privacy and acceptance level resulting in adoption level of biometric technology (Falaleeva and Wafa, 2005).

There are several discussions in previous researches that the biometric technology has been used in several industries such as financial, healthcare, government sectors, law enforcement and transportation (Falaleeva and Wafa, 2005). Moreover, the automotive industry can be seen as one of many industries that tries to adapt multi biometric technology to provide additional benefits to users especially the security

purpose (Lupu, 2007). However, there are still limited number of researches that discuss on the users' acceptance of this technology in automotive industry.

Therefore, this study aims to explain to what extend that Thai consumers accept the use of biometric technology in automotive by focusing on only vein authentication method and how it influences the automotive purchase. The methodology of this study is adopting the quantitative approach by using TAM.

This study will begin with studying relevant framework and concepts from previous studies following by research framework and methodology. After that it will be followed by finding of this study and finally discussion and conclusion regarding implication of vein authentication in automotive industry together with limitation of this study and the suggestion for the future research.



CHAPTER II

LITERATURE REVIEW

This part will capture the relevant concepts and information regarding acceptance of the use of vein authentication method in automotive from previous literatures. It will show the important information related to the research question as follows. There are three main parts, the first one is the overview of biometric technology following by the biometric technology acceptability and biometric technology in automotive industry.

2.1 Overview of Biometric technology

Biometric technology can be described as automatic technology used to define a person identity based on physiological and behavioral characteristics (Weaver, 2006). There are several types of Biometric technology that are being used in the present and each type has its own strengths and weaknesses. The common behavioral methods can be seen as voice recognition, signature recognition, and key stroke analysis, etc. While physiological techniques include fingerprint, hand geometry, retina scan, iris patterns, face recognition and vein patterns, etc. The physiological techniques appear to be widely used recently due to its universality, permanence, performance, uniqueness, acceptance, collectability and circumvention (Luo, Hao., et al, 2010). Therefore, this section will discuss only on matured physiological methods to give background of each physiological technology together with pros and cons.

2.1.1 Fingerprint Technology

The fingerprint technology is a technology that used a pattern on fingertip to identify person's identity (Liu & Silverman, 2001). The fingerprint can be seen as one of the oldest technologies which was used for criminal identification case or payment process before (Giarimi & Magnusson, 2002). The key advantage of

fingerprint is its uniqueness which cannot be two identical ridge patterns even the twins will have fully different ridge patterns (Pol, 1997). Another advantage of the fingerprint technology is that it can be cheap and small which is applicable to install in a small device with limited space (Giarimi & Magnusson, 2002). On the other hand, the fingerprint cannot only be accepted if the finger is damaged or injured but also some people tend to have a weak ridge patterns leading to unidentified identity (R.J., 2001)

2.1.2 Hand Geometry

Hand Geometry is a method that evaluates characteristic of hands and fingers of a user by matching the shape of hand from the sample and the recorded template (Giarimi & Magnusson, 2002). This method is usually used for time attendance and building access control (Liu & Silverman, 2001). This is due to it's key strength of user friendly and high accuracy (Giarimi & Magnusson, 2002). However, the drawback of this technology is the size as it requires at least the size of the hand which will be difficult for a small device. And the accuracy will be affected by the damaged hand as well (Giarimi & Magnusson, 2002).

2.1.3 Retina Scan

Retina Scan is a technology that analyses the blood vessels from the back of the eye (Liu & Silverman, 2001). This method requires low light intensity source to scan the pattern of retina by reading through pupil and evaluate the compliance between sample and recorded retina pattern (Liu & Silverman, 2001). The retina scan can be considered as old biometric technology but provides high accuracy solution (Giarimi & Magnusson, 2002). It can be said that the retina scan has two key advantages which are high accuracy as it is highly focuses on user's unique retina and the retina is less likely to change overtime. Another advantage can be high security as the retina pattern cannot be shared or easily recorded as the voice scan (Giarimi & Magnusson, 2002).

However, the disadvantage of retina scan method can be seen as its high price leading to commercial implementation difficulty. The retina scan method also requires users to stand and keep the eyes still in front of the device during the enrolment process to be able to measure the retina pattern which might not provide high compliance for the users. Moreover, there seems to be concern from the users on the

impact of the light that may derange on their eyes and the close distance between users and device (Giarimi & Magnusson, 2002). This method seems not to be a user-friendly process for the users who wear glasses either (Liu & Silverman, 2001).

2.1.4 Iris

The iris is the internal organ which is a colored part of the eye locates in front of the lens but behind the eyelids (Ganorkar and Ghatol, 2007). The iris method evaluates the matching of the visibility of rings, furrows, corona and the freckles which is converted by the recognition technology and compared with the stored pattern (Giarimi & Magnusson, 2002). The iris is considered as one of the most reliable biometric method due to its stability as it is less likely to change during lifetime leading to higher accuracy (Anderson, 2001). There are several strong benefits of this method which are its high matching performance, ease of use, greater analysis speed (Ganorkar and Ghatol, 2007). Moreover, the iris method appears to be more friendly to users with glasses which can be considered as one of a few methods that works well with glasses (Liu & Silverman, 2001).

2.1.5 Face Scan

Face scan technology is the method that recognizes facial characteristics through picture taken from digital camera and relies on the comparison of different parts of the face (Giarimi & Magnusson, 2002). This method appears to be widely accepted and attracts considerable interest (Liu & Silverman, 2001). The advantage of the face scan method can be seen as user friendly and cost effective as there are several developed programs provided for free trails and download in the market. This method also requires only digital camera installed in the device which seems to be affordable and easy to use for users. The only disadvantage of this method seems to be the requirement of frequent updating as the ongoing changing of users' faces overtime (Giarimi & Magnusson, 2002).

2.1.6 Vein Recognition

Vein recognition is the method that analyses the vein patterns underneath the skin (Lula et al, 2012) which is considered as the most recent biometric recognition

technology that becomes more widely used (Luo et al, 2010). It has been said that vein recognition has more advantages over normal fingerprints technology due to the uniqueness of vascular patterns as the patterns are different in each person. Moreover, the vein patterns are less likely to change over time leading to high stability of the method. The vein is also hidden under the skin and not visible to human's eye which will create additional benefit on difficulty to copy or forge as well. Therefore, the vein recognition technology can provide high level of security and reliability for personal identification (Lula et al, 2012). Another strong benefit of vein is the non-requirement of contact between user and sensor resulting in removing hygiene concern from users (Luo et al, 2010).

The principle of vein recognition can be described as the comparison between the stored and captured template. Figure 2.1 presents the process of vein recognition starts with capturing the vein underneath the skin through infrared sensitive camera or an array of Light Emitting diode (Wu and Ye, 2009). Then analyses the similarity with the registered template from data base to identify the user's identification and provide judgement output (Luo et al, 2010).

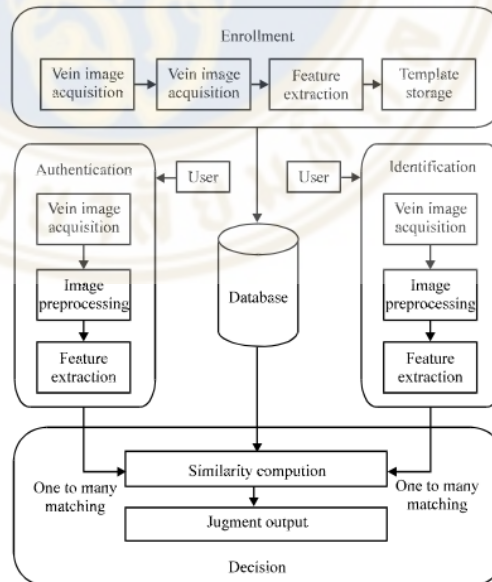


Figure 2.1 A general framework of vein recognition (Luo et al, 2010)

The vein recognition can be used by several characteristics such as finger or palm. Regarding the device size and application, it can be seen that a vein device only requires around 35x35x27 mm. for palm vein to install sensor device which can be considered as relatively small comparing to other biometric methods (Watanabe, 2008). The advantage of the small size together with other strong benefits allow the vein recognition to be broadly adopted in several industries such as banking ATM system, portable computer or driver identification (Zeng et al, 2010).



Figure 2.2 A contactless vein authentication sensor (Watanabe, 2008)

It can be seen that the use of vein authentication has been developed and available for many years but less likely to see the implication in market comparing to face or finger recognition (Uhl et al., 2020). However, the use of vein authentication appears to be widely applied in financial industry i.e. ATM rolls out in several countries such as Japan, Poland, Turkey and Hong Kong (Uhl et al., 2020). The vein authentication is not limited to financial industry but also adopted in technology device industry such as laptops and tablets for access identification system (Uhl et al., 2020).

2.2 Acceptability of Biometric Technology

Regarding the widely used and adopted of several biometric technologies recently to identify person's authentication and identity, there are several studies that

attempt to explain how the biometric technology is perceived in order to reflect the level of users' acceptance (Riley et al, 2009). However, there is a key theory that is used to describe users' perception and acceptability which is technology acceptance model (TAM) and a concern in accepting the technology which is a information privacy (Falaleeva and Wafa, 2005).

2.2.1 Information Privacy

It can be described that information privacy is explaining how users are able to control the subsequences of information about themselves (Stone and Stone, 1990). There are several dimensions that individual concerns information privacy such as the amount of data collection, the secondary purpose of collected data which might be varied from the original collection, the data access of improper or unauthorized organization and the error on data collection and the effect of that error on individual's life (Smith, Milberg and Burke, 1996).

2.2.2 Technology Acceptance Model (TAM)

TAM is the model used to explain the determinants of computer acceptance which has been adjusted and widely used by several researchers and scholars. It appears that TAM applies Theory of Reason Action (TRA) as a theoretical basis because TRA is the model used to explain the determinants of intended behavior which is very general (Davis et al, 1989). According to TRA, attitude of a person (A) and social norm (SN) will determine the behavior intention of a person (BI) and it will lead to a specific actual behavior (Fishbein and Ajzen, 1975).

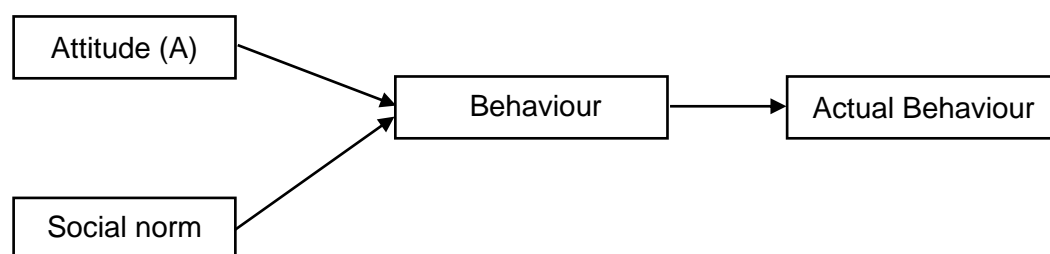


Figure 2.3 Theory of Reasoned Action (Fishbein and Ajzen, 1975)

It can be said that the purpose of TAM is not only to predict the behavior but also explain the use behavior towards information system. Therefore, TAM has

shown two main factors that primarily relate to computer acceptance behavior of users; Perceived usefulness and Perceived ease of use. The first one, Perceived usefulness (PU) is the perception of users towards technology that in which degree they feel this specific technology will be helpful or in which degree it can enhance their job performance. Secondly, Perceived ease of use (PEOU) is the perception of users that how easy they feel when using the specific technology (Falaleeva and Wafa, 2005). As TAM is theoretically based on TRA, there is similarity in that BI will be determined by A; however, TAM proposes that BI is not only determined by A as in TRA but also PU.

The social norm proposed in TRA had been removed in TAM since this factor is difficult to identify the effect on BI and normally computer has been voluntarily used by professional or managers. Therefore, TAM proposes that actual behavior will be determined by BI and BI will be determined by A and PU. TAM also proposes that PU will not only determine BI but also influence BI through A and A will also be determined by not only PU but PEOU. PEOU will also influence PU and both PU and PEOU will be influenced by external variables.

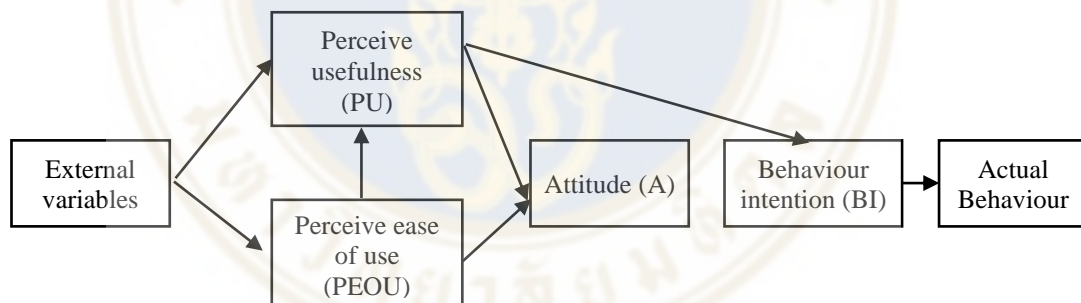


Figure 2.4 Technology Acceptance Model (TAM)

TAM has been proven that it can be used not only in computer program but also others field as there were several researches studied about TAM in various of field and industry as showed in Table 2.1.

Table 2.1 Adoption of TAM

Research topic	Variables	Context	Source
Factors influencing the attitudes and behavioural intentions to use just walk out technology among Bangkok consumers	Perceived usefulness, Perceived Ease of use, Perceived Entertainment, Trust, Technology anxiety	Payment	(Chuawatcharin and Gedsri, 2019)
Exploring Students' Acceptance of E-learning through the Development of a Comprehensive Technology Acceptance Model	Perceived usefulness, Perceived Ease of use, System Characteristics, Individual Factors	Education	(Salloum et al, 2019)
Mobile Game Adoption in China: the Role of TAM and Perceived Entertainment, Cost, Similarity and Brand Trust	Perceived usefulness, Perceived Ease of use, Perceived Entertainment, The Economic Cost, Brand Trust, Similarity, Subjective Norm	Mobile Game	(Jiang et al, 2015)
Customers' Perception of E-banking Adoption in Cameroon: An Empirical Assessment of an Extended TAM	Perceived usefulness, Perceived Ease of use, Perceived Trust, Perceived Security, Perceived Reliability, Perceived Accessibility, Perceived Service Cost, Perceived Awareness	E-Banking	(Fonchamnyo, 2012)

Table 2.1 Adoption of TAM (cont.)

Research topic	Variables	Context	Source
Investigating acceptance of telemedicine services through an extended technology acceptance model (TAM)	Perceived usefulness, Perceived Ease of use, Trust, Social Influence, Facilitating Conditions, Technology Anxiety, Resistance to Use, Perceived Risk, Privacy	Healthcare	(Kamal et al, 2020)
Customer Acceptance Analysis of Customer Relationship Management (CRM) Systems in Automotive Company using Technology Acceptance Model (TAM) 2	Perceived usefulness, Perceived Ease of use, Perceived Enjoyment, Subjective Norm, Output Quality	Automotive	(Ngangi and Santoso, 2019)

2.3 Biometric Technology in automotive industry

As discussed previously on types of biometric technology together with advantages and disadvantages of each technology. And also the acceptability model which helps explain how individual concerns or accepts the application of biometric technology. Moreover, it can be seen that the biometric technology can be applied in various industries such as mobile, computer, banking, hospitality or even automotive business to identify driver authentication (Lupu, 2010).

The great example of the use of biometric technology can be seen in hospitality industry as it can offer a number of benefits to hotel operation and also experiences of guest (Bilgihan et al, 2013). The biometric technology is used in hotel includes in room safes, face recognition and iris scan for staff to enter specific area (Adams, 2002). Moreover, it can be used for VIP guests' verification for automatic hotel

entrance which can increase customer experiences and hotel's image (Murphy & Rottet, 2009).

However, there seems to be a discussion on biometric technology application in automotive industry as well yet still limited. It is recommended that this technology can be used as access control for intelligent car through the combination of several biometric technology characteristics (Lupu, 2007). For example, finger or palm vein scan can be used to access the car then a person can be verified through other tests such as iris scan or voice scan (Lupu, 2007). If a person can pass all verification processes, he or she can start the engine. On the other hand, if the person fails the tests, the scanned data can be sent to owner of the vehicle to alert on the attempted access which the mismatched data is already collected resulting in easier process for the police to track (Lupu, 2007). It can also be said that this biometric technology can help adding incremental value to the vehicle and increase security level for the user (Lupu, 2007).

2.4 Summary of literature review

The concept of biometric technology has been defined as an authentication method to verify and identify a person. It has also described that vein authentication method has become one of the most popular and accurate comparing to other types of biometric technology. Several literatures also address the acceptability as well as the consumers' concern on information privacy.

Moreover, the literature review has explained the use of biometric technology in businesses such as hospitality and mobile industry. However, there are no empirical researches that explain the acceptability of vein authentication of automotive product on Thai consumers. Therefore, this study aims to explore three research questions to fill research gap as mentioned.

1. To what extent Thai consumers accept vein authentication installation in automotive product?
2. What are the important factors that influence Thai consumer's attitude towards vein authentication in automotive product?

What are the relationships between Perceived usefulness, Perceived ease of use, Perceived cost, Perceived risk and consumer's attitude to use vein authentication in automotive product?



CHAPTER III

METHODOLOGY

This part will highlight the research methodology which will be used in this study. Firstly, it will explain the reason why the specific research method is selected then follow by data collection strategy. Lastly, it will cover the research framework and hypotheses of the study.

3.1 Research method

The quantitative method was adopted in this study by conducting the online survey. This method can provide the result in numerical data which could measure and describe the acceptability of vein authentication impact on Thai people (Neuman, 2011; Wisker, 2014). This method also allows researchers to be able to evaluate the information from large number of respondents which will be useful to explore the acceptability of vein authentication method on Thai people effectively. Moreover, the quantitative method could also elaborate the difference of characteristics among the large group of people such as people who have positive perception of vein authentication and negative perception leading to less likely to accept this method in automotive product (Bryman, 2008).

3.2 Data Collection

The data was collected by using online survey through google form platform due to no geographical coverage limitation resulting in high penetration of target sample. In addition, the online survey is very cost-effective survey method compared to the traditional paper-based survey. This is because the paper-based survey requires cost of printing and distributing the questionnaire. Importantly, the online questionnaire is flexible to adjust according to the need. It can be designed to have filter questions so the

participants will be asked only relevant questions and respondents who are not the target group can be screened out. The data collected from questionnaire can be interpreted as numerical data which allowed the researcher to effectively analyze and understand the impact of vein authentication acceptance on Thai consumers. On the other hand, the online survey has some limitations such as low response rate or and restricted to only online population.

The questionnaire was developed in Thai language because it would be more suitable for Thai people who answer this questionnaire to fully understand the instructions and questions. Moreover, participants could give an accurate answer and complete the questionnaire without misunderstanding.

The questionnaire will start with the explanation of vein authentication characteristic and mechanism of the system in order that respondents are able to grasp the idea and concept of the system. Following by the sample video clip of using the vein authentication technology embedded in the car access system. Then respondents will be asked some questions about their demographic information. Questions are consisting of only basic information like age, gender, occupation, income without asking about specific answers such as name or address. The sample size of this study was 400 respondents in order to achieve 95% confidence (Yamane, 1967).

3.3 Research framework

This research adopted TAM theory as a research framework which focuses on the impact of Perceived usefulness and Perceived ease of use on attitude (Davis et al, 1989). This is because TAM was widely applied in recent researches such as the study of impact of Perceived risks on the social commerce adoption which reveals significant impact on the Perceived usefulness of social commerce (Biucky et al, 2017). Apart from applying TAM theory, this study also considers cost and privacy as additional factors that impact users' acceptance of biometric technology because cost seems to be one of important factors leading attitude and behavior (Jiang et al, 2015). There are also empirical researches that used cost as key factor that impacts on Perceived usefulness such as the study of factors that impact mobile game adoption in China (Jiang et al, 2015). The result of such study shows that cost appears to be one of the factors that

significantly impact Perceived usefulness besides social norm and Perceived entertainment (Jiang et al, 2015). While privacy impact was also studied and shown significant influence users' adoption on E-banking (Fonchamnyo, 2012).

Therefore, these two factors were also integrated in the questionnaire in order to allow the researcher to fully understand the impact on PU, PEOU, C and P on attitude towards biometric technology acceptance.

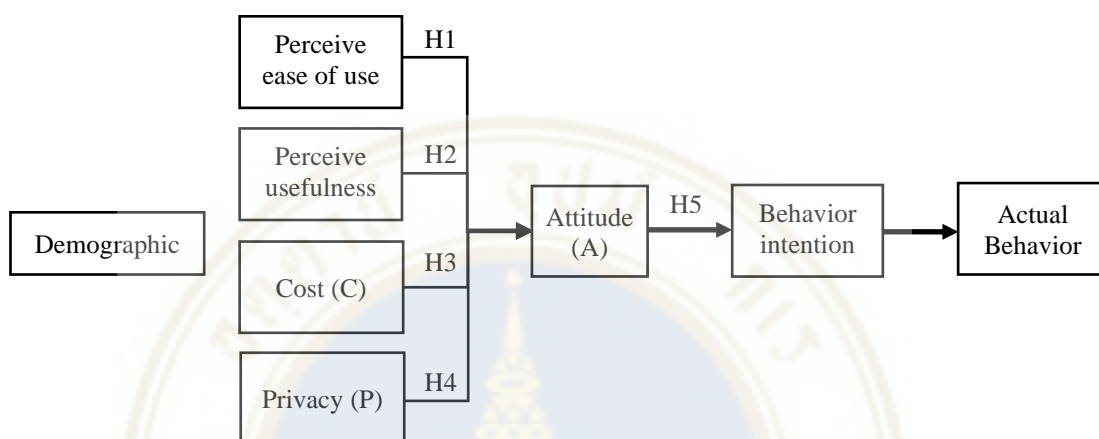


Figure 3.1 Adjusted Technology Acceptance Model (TAM) for Thais' acceptance for vein authentication technology in automotive.

Based on the TAM theory and consideration of cost and privacy, the following section are hypotheses in this research.

H1: PEOU of vein authentication will have positive relation with A towards using vein authentication in automotive in Thailand.

H2: PU of vein authentication will have a positive relation with A towards using vein authentication in automotive in Thailand.

H3: Cost of vein authentication will have a negative relation with A towards using vein authentication in automotive in Thailand.

H4: Privacy of vein authentication will have a negative relation on A towards using vein authentication in automotive in Thailand.

H5: A will have a positive effect on BI towards using vein authentication in automotive in Thailand.

The demographic information was an external factor which set as an independent factor.

CHAPTER IV

RESULT AND DISCUSSION

This chapter will describe the results from the questionnaire and provide some analysis from that information. The data obtained from the study was analysed by using SPSS program and applied descriptive statistics to describe the features of the research. The chapter will first summarize profile of sample and then illustrate the results. The ending part of this chapter will discuss answers to research questions, implications, and limitations of the study.

4.1 Demographic characteristic

According to the number of respondents of the online questionnaire of the acceptance of vein authentication in automotive of Thai consumers, there were 400 participants in total and 156 (39.0%) participants are male while 244 (61%) women responded the questionnaire. The age group of participants was covered between 18 - 65 years old while the biggest group was comprised of age range between 20 - 40 years old which is 84% of total participants. A majority of respondents (90%) have higher level of education with Bachelor's degree or upper level; on the other hand, only 10% of participants have education lower than Bachelor's degree. Over 50% of respondents are employees following by university student at 21% and 58% of respondents have income lower than 45,000 THB. while 42% has income higher than 45,000 THB. per month.

4.2 Research hypothesis test and finding

In this research, multiple regression was used to analyze the relation between PU, PEOU, Cost, Privacy and A. While Logistic regression was used as a tool to analyze the relationship between A and BI. The result is shown in Table 4.1 which

illustrates the coefficient value between PU and A; Beta = 0.417, $p = 0.00$, meaning PU significantly affect A at 95% confidence ($P < 0.05$) and it can be said that if PU value increase by 1 A value will increase by 0.417 which supports the hypothesis H1 that PU has a positive relation with A towards using vein authentication in automotive in Thailand. Coefficient value between PEOU and A; Beta = 0.246 and $p = 0.00$, also supports H2 which means PEOU has a positive relation with A towards using vein authentication in automotive in Thailand at 95% confidence ($P < 0.05$) and if the PEOU value increase by 1, A value will increase by 0.246. From both relationship of PU and PEOU towards A meaning that the higher the level of usefulness and ease of use respondents Perceived, the better attitude on the vein authentication acceptance. For coefficient value between C and A; Beta = 0.375 and $p = 0.01$, also shows that C value has significantly affect A at 95% confidence ($P < 0.05$) and if C value increase by 1 A value will increase by 0.375. Therefore, the hypothesis H3, Cost of vein authentication will have a negative relation with A towards using vein authentication in automotive in Thailand, is also supported. However, the coefficient value between P and A; Beta = -0.037, $p = 0.396$, does not support H4 which can be said that privacy may not influence attitude towards vein authentication acceptance in Thailand.

Table 4.1 Multiple regression result

Hypothesis	Relation	P value	Beta value	Result
H1	PU – A	0.00	0.417	support
H2	PEOU – A	0.00	0.246	support
H3	C – A	0.01	0.375	support
H4	P – A	0.396	-0.037	Not support

Lastly, the Table 4.2 shows the relationship between A and BI from logistic regression. Logistic regression is used to analyse the influence of independent variables to binary answer of dependent variable. The Exp (B) value shows the probability of success case. If the independent variable is categorical variable (multiple answers), the results show the probability of success case of each answer compared with the reference answer. For example, participants who answered agree in A are less likely to say “Yes”

on BI than participants who answered Strongly agree at $(1-0.356)*100\%$. From the table 4.2, attitude significantly influences BI. In addition, it could be claimed that ones who have positive attitude on biometric authentication are more likely to have higher level of intention to use the biometric authentication.

Table 4.2 The relationship between A and BI from logistic regression

Attitude	P value	Exp (B)
Strongly disagree	0.088	0.040
Disagree	0.003	0.054
Neutral	0.001	0.142
Agree	0.045	0.356
Strongly agree	0.007	

4.3 Data validity

From the questionnaire, there are Likert's scale question format. several questions representing each factor so the Cronbach's alpha coefficient value is used to validate the reliability of questions in the questionnaire. Regarding the Cronbach's alpha, the question used are reliable if the alpha value is 0.7 or above (Saunders et al, 2016). In this study, it can be summarized that the questions in questionnaire are reliable as The Cronbach's alpha of PU is 0.711 and PEOU is 0.759. While the Cronbach's alpha was not applied in question in C due to this section has only one question with binary answer.

CHAPTER V

DISCUSSION AND IMPLICATION

In order to explain the acceptance of vein authentication in automotive in Thailand, we use multiple regression analysis together with the logistic regression to find out the relation between various factors in proposed TAM; PU, PEOU, C, P, A and BI.

The results show that three hypothesized adopted from the original TAM (H1, H2 and H5) are proven in this research findings similar to previous studies. To illustrate, the PU and PEOU from original TAM shows the positive relation to A while A also has a positive relation with BI (Davis et al, 1989). As mentioned earlier that this study included another two dimensions to explain external factors impacting A which were cost and privacy. The result shows that cost seems to have negative effect on A. This result is aligned with previous study that also reveals that cost has significant impact on attitude besides social norm and Perceived entertainment (Guoyin Jiang et al, 2015). Therefore, it can be concluded that within the acceptable range of price the technology tends to be accepted by Thai consumer and vice versa.

Regarding the research question on to what extent Thai consumers accept vein authentication in automotive, this study shows that the acceptance rate is relatively high as the result illustrates that 68% of participants intend to use vein authentication in automotive. This can be implied that there is an opportunity for automotive industry to adopt this technology to the product resulting in improving both brand's image, convenience and safety (Lupu, 2007).

Secondly, the study aims to understand key factors that influence acceptance level of vein authentication in automotive. The finding reveals that Perceived usefulness, Perceived ease of use and cost have impact on acceptance level. However, each factor shows different level of impact as Perceived usefulness has highest impact on acceptance level following by cost and Perceived ease of use. This can be said that the level of impact of each factor is varied by product or industry. For example, this

study explores the acceptance level in automotive which Perceived usefulness appears to be the most important factor rather than cost and Perceived ease of use. This might mean that Thai consumers value usefulness of this vein authentication installed in their automotive as this can provide additional benefit to the use of automotive product. In this part, the manufacturer may find it helpful to prioritize or allocate the resource when developing or launching this product in the market.

As we have already known that the usefulness is the factor that give the highest level of impact on consumer attitude towards using the vein authentication technology in automotive. If there is a limited resource, manufacturers should focus on creating a useful system. According to the questionnaire, there is a question asking about the usefulness of vein authentication to make them concern less in forgetting the key. More than half of respondents answered strongly agree, so it can be implied that many Thai people are likely to forget car key or at least concerning about this issue and they think vein authentication will be able to help them solve this issue. In addition, we asked respondents “to what extent do you agree that if using vein authentication in car access system, you will not have to carry the car key with you”. More than 70% of respondents either agree or strongly agree with that statement, so it means that they would like to remove the car key from their personal belonging. For questions regarding usefulness we also asked them about security and unlocking time whether vein authentication is better than the key. Most of them are likely to agree with those benefits but the level is not as high as the benefit regarding the car key as mentioned earlier. Therefore, among the usefulness of vein authentication technology in car access system, the highest concern for Thai people is the about the key.

Regarding to cost, we compare the cost of vein authentication technology to a cost of tire and ask respondents that whether they are able to accept. Most of respondents are able to accept, so it shows that there is no fixed limit of cost they are willing to pay. The limit is dependent on which car will be installed because normally the higher the car price is the higher the tire price will be. Therefore, developers who are interested in developing this technology may need to consider which car you would like to install before investing. The questionnaire also has several questions regarding ease of use. Questions mainly focus on finding out how they perceive about complexity

in using vein authentication technology. Thai people think that this technology can be used without study and can be used by everyone regardless of age and gender.

The final research question aims to explain relation between variable factors such as Perceived usefulness, Perceived ease of use, cost and consumer's attitude to use vein authentication in automotive product. This study confirms that all above variable factors have positive relation with consumers' attitude towards the use of vein authentication in automotive product except cost which has a negative relation. This can be implied that the more business can create and build benefits and ease of use within the acceptable cost of vein authentication in automotive, the more consumers are likely to accept and adopt product with this technology.

Regarding to the research result, privacy concern appears to be not related factor of Thais consumer on vein authentication technology. This can be explained by cultural value aspect as Thai culture are more likely to be based on collectivistic (Kitiyadisai, 2005). The collectivism is the culture that values communalism or social bonds and cohesion of group commitment (Burholt,2018). Thai tradition tends to be shared family and do activities with a whole family such as cooking, eating, sleeping resulting less concern for privacy in Thai culture (Kitiyadisai, 2005). Unlike westerners which culture is bases on individualistic leading to higher concern of privacy in most of activities (Kitiyadisai, 2005). This can be summarized that cultural values appears to have influence or impact on privacy concern level (Bellman et al., 2004). However, there seems to be other factors apart from cultural values that may impact on privacy concern such as government regulation or privacy protection law and level of internet or technology experience (Bellman et al., 2004)

5.1 Limitation and future research

There are three limitation in this study that we need to discuss so that it can be improved in the future study.

Firstly, the sample is not well-contributed since 92% of the respondents have level of education higher than bachelor's degree. The questionnaire also contributed via online platform so the respondents need to have an access to internet and are familiar with technology. From these two points show that the respondents in this

study is cluster so in the future research if there is no time and budget constraints, the variety of respondents might give more accurate and clearer picture for Thai consumer.

Secondly, the model used to study in this study cover only four dimensions so there might be some others dimension that may affect the acceptance of vein authentication in automotive for Thai consumers such as Perceived entertainment, technology anxiety, social norm, etc. These additional dimensions can be considered in the future study.

Lastly, this research has studied about acceptance in new technology via video clip and short explanation about how the technology works, so basically the respondents in this research have no experience about the technology and may not be able to fully understand the mechanism and feeling in this technology. Vein authentication technology is not yet widely adopted in Thailand and also the biometric authentication in automotive. Therefore, if it is possible to create a mockup site for respondents to have a direct experience toward this technology, it will help them to fully understand and get more accurate result.

5.2 Conclusion

The biometric technology has been growing rapidly and replacing the traditional authentication method such as pin code due to its convenience, security and shopper friendly. Vein authentication appears to be one of the most widely adopted technology that analyses the vein pattern underneath the skin. This technology has been applied in several industry such as banking, computer or automotive. However, acceptability of vein authentication has been discussed widely in previous researches as this seems to be the key factor that impact the adoption of the technology.

This study conducted to understand the level of acceptance of vein authentication of Thai consumers to be able to identify how Thai consumers perceive this technology and factors that can influence their attitude. In order to explore the research question, TAM theory has been used to understand the impact of Perceived usefulness and Perceived ease of use on attitude and behaviour together with cost and privacy to see broader factors impacting on attitude.

The result shows that Thai consumers are more likely to accept vein authentication technology in automotive. This is based on the positive relation of Perceived usefulness and Perceived ease of use with attitude. While cost should be considered when applying this technology to automotive product as it has negative impact on attitude. This can also be explained that the higher cost that applied for additional technology of vein authentication, the less consumers consider adopting such technology in automotive.

Lastly, this study should be able to provide insightful findings that will be beneficial to both academic and automotive industry. As it can contribute to increase empirical study of TAM in this area and be source of consumers' information for automotive industry to adopt vein authentication in automotive.



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APPENDICES

Appendix A: Questions regarding TAM in questionnaire

- A: To what extent do you agree that vein authentication will create better image for your vehicle?
- PU1: To what extent do you agree that vein authentication is able to shorten the unlock time?
- PU2: To what extent do you agree that vein authentication is more safe than using normal key to access vehicle?
- PU3: To what extent do you agree that vein authentication will allow us to not carry a key?
- PU4: To what extent do you agree that vein authentication will make us less worry about forgetting the key?
- PEOU1: To what extent do you agree that vein authentication is not complex?
- PEOU2: To what extent do you agree that using vein authentication is easy to use without study?
- PEOU3: To what extent Do you agree that everyone can use vein authentication?
- PEOU4: To what extent do you agree that using vein authentication will change the way you access the vehicle?
- C: Will you accept that if the cost of vein authentication system equal to a cost of a tire?
- P: To what extent do you agree that your privacy information will leak to the manufacturer.

Appendix B: Full questionnaire

Acceptance of Vein authentication technology for automotive access applications (Thai consumers)

การสำรวจนี้เป็นส่วนหนึ่งของโครงการวิจัยที่จัดทำโดยนักศึกษาของวิทยาลัยการจัดการของมหาวิทยาลัยมหิดล มีวัตถุประสงค์เพื่อรวบรวมความคิดเห็นจากผู้บริโภคในประเทศไทย ที่มีต่อการนำระบบยืนยันตัวตนด้วยเส้นเลือดดำเข้ามาใช้ในรถยนต์ โดยคำตอบทั้งหมดที่ให้ไว้ในแบบสำรวจนี้จะถูกเก็บเป็นความลับและจะไม่มีการเปิดเผยข้อมูลที่ระบุตัวตนต่อสาธารณะ แบบสอบถามนี้จะใช้เวลาประมาณ 5 นาที ขอขอบคุณที่สละเวลาช่วยแสดงความคิดเห็นมา ณ ที่นี้ด้วยครับ

ก่อนเริ่มทำแบบสอบถาม กรุณาทำความเข้าใจกับข้อความด้านล่าง

การยืนยันตัวตนด้วยเส้นเลือด (Vein authentication) คือการยืนยันตัวตนโดยการสแกนผ่านชั้นผิวหนังลงไปเพื่อดูลักษณะเส้นเลือดของแต่ละบุคคล จุดเด่นและข้อได้เปรียบของการยืนยันตัวตนด้วยเส้นเลือด คือ การปลอมแปลงทำได้ยากมาก เพราะเส้นเลือดของแต่ละบุคคลมีความแตกต่างกัน นอกจากนี้การยืนยันตัวตนด้วยเส้นเลือด ผู้ใช้งานไม่มีความจำเป็นต้องสัมผัสกับตัวเซนเซอร์ จึงสามารถเพิ่มความมั่นใจในด้านความสะอาดของตัวอุปกรณ์ให้กับผู้ใช้งานได้

ดังนั้นการยืนยันตัวตนด้วยเส้นเลือดจึงเป็นหนึ่งในเทคโนโลยีที่ถูกนำมาใช้ยืนยันตัวตนอย่างแพร่หลายในปัจจุบัน เนื่องจากเป็นเทคโนโลยีที่ให้ความแม่นยำสูงที่สุดวิธีหนึ่งเมื่อเทียบกับวิธีการยืนยันตัวตนรูปแบบชีวมิติ (Biometric authentication) รูปแบบอื่น ๆ เช่น การสแกนใบหน้า หรือ การสแกนลายนิ้วมือ เป็นต้น ซึ่งในประเทศไทย ได้เริ่มมีการนำเทคโนโลยีนี้มาใช้ ตัวอย่างเช่น ธนาคาร SCB ใช้ในการยืนยันตัวตนเมื่อทำธุรกรรมทางการเงิน นอกจากนี้ไม่ว่าจะเป็นประเทศ เกาหลี หรือ ญี่ปุ่น ก็มีการนำเทคโนโลยีการยืนยันตัวตนด้วยเส้นเลือดมาใช้กันอย่างแพร่หลายเช่นกัน

สามารถดูตัวอย่างการทำงานของระบบยืนยันตัวตนด้วยชีวมิติได้จากคลิปวิดีโอด้านล่าง (7 วินาที)

ทางผู้จัดทำแบบสำรวจจึงอยากขอความคิดเห็นจากมุมมองของผู้บริโภคในประเทศไทย ต่อการนำระบบยืนยันตัวตนด้วยเส้นเลือดดำนี้มาติดตั้งในระบบการล็อก/ปลดล็อกรถยนต์ส่วนบุคคล

ตัวอย่างการนำเอาระบบยืนยันตัวตนด้วยเส้นเลือดมาใช้กับระบบธนาคารโดยธนาคาร SCB ในประเทศไทย



ตัวอย่างการนำระบบยืนยันตัวตนด้วยเส้นเลือดมาใช้กับประตูกันทางเข้าสำนักงานในประเทศญี่ปุ่น



ตัวอย่างระบบยืนยันตัวตนด้วยชีวมิติในรถยนต์



โดยปกติคุณใช้รถยนต์ส่วนตัวหรือไม่ *

- ใช่
- ไม่ใช่

ลักษณะการใช้รถยนต์

คุณใช้รถบ่อยแค่ไหน *

- ทุกวัน
- 5 - 6 วัน/สัปดาห์
- 3 - 4 วัน/สัปดาห์
- 1 - 2 วัน/สัปดาห์

โดยปกติท่านใช้วิธีการใดในการปลดล็อครถของท่าน *

- กุญแจแบบธรรมดา
- กุญแจรีโมท
- ระบบสัมผัส (Keyless entry)
- Other...

การใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำจะช่วยลดเวลาในการปลดล็อกรถยนต์ *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

การใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ มีความปลอดภัยมากกว่าการใช้กุญแจรถยนต์ *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

การใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ ทำให้เราไม่จำเป็นต้องพกกุญแจรถยนต์ *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

การใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ ทำให้เราไม่กังวลว่าจะลืมกุญแจรถยนต์ *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

หลักการทำงานของระบบยืนยันตัวตนด้วยเส้นเลือดดำ ไม่ใช่เรื่องที่ซับซ้อน *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

ใครก็สามารถใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำได้ โดยไม่จำเป็นต้องศึกษา *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

ระบบยืนยันตัวตนด้วยเส้นเลือดดำ สามารถใช้ได้ทุกเพศ ทุกวัย *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

การใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำแทนการใช้กุญแจ ทำให้ขั้นตอนการเข้ารหัสเปลี่ยนไป *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

การใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ ทำให้ฉันกังวลว่าข้อมูลส่วนตัวจะหลุดไปยังผู้ผลิตรายใด *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

ฉันไม่มีความกังวลว่าข้อมูลส่วนตัวจะถูกคัดลอกเพื่อนำไปใช้ในจุดประสงค์อื่น เมื่อใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

ฉันรู้สึกมั่นใจในการใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ ถ้าหากมีหน่วยงาน หรือ องค์กรที่เข้ามารับผิดชอบในส่วนของความปลอดภัยของข้อมูลส่วนตัว *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

ฉันมั่นใจในการใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ ถ้าหากข้อมูลนั้นถูกบันทึกแบบออฟไลน์ในรถยนต์เท่านั้น *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

หากนำระบบยืนยันตัวตนด้วยเส้นเลือดดำมาติดตั้งในรถยนต์ จะทำให้ราคาของรถยนต์เพิ่มขึ้น *

	1	2	3	4	5	
ไม่เห็นด้วยอย่างยิ่ง	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	เห็นด้วยอย่างยิ่ง

ท่านรับได้หรือไม่ หากสามารถเลือกใช้ระบบยืนยันตัวตนด้วยหลอดเลือดแทนกุญแจ โดยจ่ายแพงขึ้นเท่ากับ *
ราคาข่างรถยนต์หนึ่งเส้น

1. รับได้
2. รับไม่ได้

การตัดสินใจในการใช้ระบบยืนยันตัวตนด้วย เส้นเลือดดำ

× ⋮

ถ้าหากในอนาคตมีรถยนต์ที่มีระบบยืนยันตัวตนด้วยเส้นเลือดดำ ท่านอยากที่ซื้อมาใช้หรือไม่ *

- อ ยาก
- ไม่อยาก

มีเหตุผลอะไรบ้างที่จะทำให้คุณอยากใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ แทนการใช้กุญแจรถยนต์ (ตอบได้ *
มากกว่า 1 ข้อ)

- เพิ่มความปลอดภัยในการโดนโจรกรรมรถ
- เพิ่มความสะดวกสบายเพราะไม่จำเป็นต้องพกกุญแจ
- ลดเวลาในการปลดล็อครถ
- ทำให้รถดูทันสมัย
- Other...

มีเหตุผลอะไรบ้างที่จะทำให้คุณ ไม่อยาก ใช้ระบบยืนยันตัวตนด้วยเส้นเลือดดำ แทนการใช้กุญแจรถยนต์ (ตอบ *
ได้มากกว่า 1 ข้อ)

- ถูกละเมิดความเป็นส่วนตัว
- ระบบอาจมีข้อผิดพลาด
- ราคาแพง
- ใช้งานยาก
- การดูแลรักษา
- Other...

ข้อมูลผู้ทำแบบสอบถาม



เพศ *

- ชาย
- หญิง
- Other...

อายุ *

Short answer text

อาชีพ *

- นักเรียน / นักศึกษา
- พนักงานบริษัท
- ธุรกิจส่วนตัว
- เกษียณ
- Other...

ประเภทของธุรกิจ *

- ธนาคาร / การเงิน
- อุตสาหกรรมยานยนต์
- เทคโนโลยี และ การสื่อสาร
- ธุรกิจเกี่ยวกับสุขภาพ
- หน่วยงานรัฐบาล
- การศึกษา
- สื่อ โฆษณา
- การบิน
- Other...

ระดับการศึกษาสูงสุด *

- มัธยมศึกษาตอนต้น
- มัธยมศึกษาตอนปลาย / ปวช
- อนุปริญญา / ปวส
- ปริญญาตรี
- ปริญญาโท
- ปริญญาเอก

รายได้โดยเฉลี่ยต่อเดือน (บาท) *

1. น้อยกว่า 15,000
2. 15,000 - 25,000
3. 25,001 - 35,000
4. 35,001 - 45,000
5. 45,001 - 55,000
6. 55,001 - 65,000
7. 65,001 - 75,000
8. 75,001 - 85,000
9. 85,001 - 95,000
10. มากกว่า 95,000

ระยะเวลาใช้รถยนต์เฉลี่ยต่อ 1 คันก่อนจะพิจารณาเปลี่ยนคันใหม่ (ปี) *

Short answer text
