モバイルペイメントシステム導入に関する小売事業者の心的要素の研究

Investigating the Effects of Shop Owners' Mental Factors on Their Introduction of Mobile Payment Systems

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy of Engineering
of
Muroran Institute of Technology

Course of Advanced Information and Electronic
Engineering, Division of Engineering

March 2022

Declaration

I hereby declare that this thesis is my own work and effort and that it has not been submitted anywhere for any award. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

Muroran, March 2022 Zijie Zhang

Acknowledgements

With the guidance of my advisor and committee members, help from friends, and support from my family, I am able to finish my dissertation.

Firstly, I would like to express my sincere gratitude to my supervisor **Dr. Hidetsugu Suto** and co-supervisors **Dr. Shinya Watanabe** and **Dr. Mianxiong Dong** for the continuous support for my Ph.D. study, for their patience, encouragement and inspiring suggestions. I am blessed to have them as my supervisors and mentors during my Ph.D. study. Their advice on my research as well as my career have been invaluable.

Besides my supervisors, I would like to thank **Dr. Yoshifumi Okada** for his insightful comments which encouraged me to explore new methods in my research. I also would like to thank **Dr. Madoka Takahara** for her helpful advice on our work.

I would like to say thanks to the members of **System Design Laboratory**, especially to Dr. Tanapun Srichanthamit and Mr. Kosei Furukawa for their amazing help when I met troubles. Also, I thank to Ms. Xue Song and Ms. Ponnapa Musikapun for their support on conducting survey for data collection.

Furthermore, I wish to express my gratitude to my parents for their understanding and support for my career and life decisions.

Muroran, March 2022 Zijie Zhang

Abstract

This paper summarizes a conceptual design of a supporting system for finding effective strategies for promoting the introduction of mobile payment systems. For finding the strategies, a method for finding important rules from results of association analysis is proposed. The effectiveness of the method is validated by conducting an experiment and the usefulness of the system is demonstrated by showing an example of using scenario. The paper consists of six chapters.

In Chapter 1, the scope and the goal of this study are described. Mobile payment services are convenient payment methods for shopping behaviors in digitalized society. Though governments have been promoting the usages of mobile payment services, there are gaps in usage rates among different countries despite the efforts. Effective strategies are required for improving the introduction rates in shopping facilities, especially in small-sized shops which are used frequently in people's daily lives. Thus, shop owners' mental factors for introducing mobile payment systems should be considered by marketing planners when conducting the promotions. However, it is difficult to make effective promotion strategies because the planners do not know about mental gaps between shop owners who introduce the systems and those who do not. To solve the problem, a supporting system is designed for helping marketing planners find effective strategies. For finding such strategies, a method is proposed for finding important rules from results of association analysis.

In Chapter 2, literature review and theoretical background are shown. By showing the literature review, previous studies on investigating mental factors for using mobile payment systems were compared with this study. As theoretical background of this study, the unified theory of acceptance and use of technology (UTAUT) and association analysis are described. In the experiment of this study, data of shop owners' attitudes towards mobile payment systems and their introduction of the systems were collected by conducting questionnaire surveys. Question items of the questionnaire were designed by referring to other questionnaires made by previous works using UTAUT. After collecting the data, association analysis was used for investigating the relationship between shop owners' attitudes and the decision of introducing mobile

payment systems.

In Chapter 3, a method for finding important rules from results of association analysis is described. In order to find the rules, the concept of 'key rule' is defined. Based on the definition, algorithms for extracting key rules and obtaining hints for converting rules (false rules) with consequent itemsets as 'FALSE' into rules (true rules) with consequent itemsets as 'TRUE' are designed. Evaluation criteria are designed for evaluating key rules. The criteria are cost, expectation and coverage. By calculating the evaluation values according to the criteria, important rules are found. Such rules represent important hints for converting consequent itemsets by changing antecedent itemsets.

In Chapter 4, an experiment for showing the effectiveness of the proposed method is shown. Data about shop owners' attitudes towards mobile payment systems and the decisions of system introduction were used. For preparing the data, questionnaire surveys were conducted in four areas: Japan, China, Thailand and Taiwan. By using the proposed method, key rules were found and evaluated. Then, important rules with the highest evaluation values that represent the effects of antecedent itemsets on different consequent itemsets were discussed. As a result, the proposed method is proved to be effective for identifying important information from the results of association analysis.

In Chapter 5, a conceptual design of a supporting system for finding effective promotion strategies for mobile payment systems is described. Target users of the system are marketing planners who want to encourage shop owners to introduce mobile payment systems. There are three mechanisms: (1) conducting association analysis, (2) finding key rules, and (3) finding the key rules with the selected itemset. In the system, the proposed method for finding important rules from results of association analysis is applied. For showing the usefulness of the supporting system, an example of using scenario was demonstrated by using the data collected from Japan. By using the system, important rules with the selected itemsets were obtained and promotion strategy is discussed. The strategy indicates that if shop owners think that introducing mobile payment systems can improve their work performance by saving the time of managing cash, it is effective to conduct promotions for changing their attitudes towards the required equipment for introducing the systems.

In Chapter 6, conclusion and future works are shown. The study summarized in this paper contributes to providing a solution for discovering effective promotion strategies by applying a method for finding important rules from results of association analysis from the perspective of shop owners' mental factors on their decisions of introducing mobile payment systems.

概要

本稿は，マーケティングプランナーがモバイルペイメントシステム導入の効果的な普及戦略の作成を支援するシステムの概念設計をまとめたものである．効果的な戦略を作成するために，アソシエーション分析の結果から重要ルールを抽出する手法を提案した．実験結果を示すことによって提案手法の有効性を証明した．そして，システムを使用する例を示すことによって支援システムの有用性を明らかにした．本稿は6つの章で構成される．

1章に，本研究の着目する問題点と目的を示す．デジタル化社会での消費行動において，便利な支払い手段の一つとしてモバイルペイメントサービスがある．各国がサービスの普及を推進しているが，国別で普及率の差がある．この状況において，商業施設のモバイルペイメントシステムの導入率を促進するための効率的な戦略が重要である．特にそれらの施設の中に，人の日常の消費行動に関わる小売事業者のシステム導入率を改善する必要がある．そのため，マーケティングプランナーが宣伝を行うとき，小売事業者のシステム導入有無に関係する心的要素に着目すべきである．しかし，システムを導入している事業者と導入していない事業者の心的要素の違いを把握できていないため，効果的な宣伝を行うのが難しい．そこで本研究では，効果的な普及戦略を作成する支援システムを設計する．それらの戦略を作成するために，アソシエーション分析の結果から重要ルールを抽出する手法を提案する．

2章に，本研究の関連研究と背景理論を紹介する．関連研究を紹介することによって，モバイル決済システムを使うことに影響する心的要素を調べた先行研究と本研究の比較を行った．本研究の背景理論として，Unified Theory of Acceptance and Use of Technology (UTAUT)とアソシエーション分析が挙げられる．本研究の実験では，小売事業者のモバイルペイメントシステムに対する考え方とシステム導入の決断についてのデータ取得のために，UTAUTを用いた先行研究のアンケートを参考にして設問項目を作った．収集したデータで事業者の考え方とシステム導入の意思決定との関係を調べるために，アソシエーション分析を用いた．

3章に，アソシエーション分析の結果から重要ルールを抽出する提案手法を示す．重要ルールを見つけるために，‘key rule’の概念を定義した．その定義によって，それらのルールの抽出と異なる結果部を持つルール間の変換を行うアルゴリズムが設計された．抽出するルールを評価するために，3つの評価指標

（cost，expectation，coverage）を用いた．用いた評価指標によってルールの評価値が計算される．ルールの評価値によって，重要ルールを見つけることができる．重要ルールを用いて，ルールの結果部を変えるために条件部の調整の仕方についてのヒントが観察できる．

４章に，提案手法の有効性を示すための実験を示す．小売事業者のモバイルペイメントシステムに対する考え方とシステム導入の意思決定を示したデータを用いた．日本，中国，タイ，台湾，４つのエリアの小売事業者を対象として，アンケート調査を行った．提案手法を用いることで，'key rule'が抽出されて評価された．そして，評価値の最も高い重要ルールを見つけた．重要ルールを観察することによって，条件部の違いが結果部に対する影響がわかった．アソシエーション分析の結果から重要な情報を見つけたことによって，提案手法の有効性を証明した．

５章に，モバイルペイメントシステムの効果的な普及戦略の作成を支援するシステムの概念設計を記述する．ターゲットユーザは小売事業者のシステム導入を促進したいマーケティングプランナーである．システムは３つのメカニズムがある：(１)アソシエーション分析の実行，(２)'key rule'の抽出と(３)選択されたアイテム集合を持つルールの抽出．設計されたシステムでは，アソシエーション分析の結果から重要ルールを抽出する提案手法が応用される．システムの有用性を明らかにするために，日本で収集したデータを用いてシステムの使用例を示した．システムを使うことによって，選択されたアイテム集合を持つ重要ルールが見つけられた．見つけたルールを観察することで，効果的な戦略が得られた．得られた戦略によると，事業者がもしシステム導入で金銭を管理する時間の節約によって仕事のパフォーマンスが向上すると思ったら，システム導入に必要な設備に対する考え方を変えるのが有効である．

６章に，本研究の結論と今後の展望をまとめる．本稿はモバイルペイメントシステム導入に関する小売事業者の心的要素の観点から，アソシエーション分析の結果から重要ルールを抽出することによって，効果的な普及戦略を発見するソリューションの提供に貢献するものである．

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1 Introduction

This chapter provides an introduction to the research described in this paper. First, background of the study is briefly shown. Second, the main goal and sub-goals of this study are shown. Then, the contributions of this study are described from both theoretical and practical perspectives. Finally, the structure of this paper is shown.

1.1 Background of the study

The introduction rates of mobile payment systems are still low in a few countries despite the efforts of the governments [1]. There are many reasons which cause low rates of usages, e.g. quality of service (QoS) of mobile networks, user-friendliness of mobile payment applications, etc. Undoubtedly, the availability of mobile payment services in shopping facilities directly affects customers' usages of cashless payment. In order to improve the usage rate of cashless payment without consuming many resources, it is necessary to effectivily promote the introduction of mobile payment systems in shopping facilities. Therefore, effective strategies for encouraging shop owners to introduce the systems are required.

In order to conduct effective promotions for introducing mobile payment systems, it is necessary to make plans focusing on shop owners' mental factors for introducing the systems. However, it is difficult for promotion planners to decide on promotion strategies, because they lack information about the relationship between shop owners' mental factors and their introduction of the systems.

To solve the problem, a supporting system for finding effective strategies for promoting mobile payment systems is designed. In order to find effective strategies, a method for finding important rules from results of association analysis is proposed. By observing such rules, hints about converting the consequent itemsets of the rules can be found.

1.2 Purposes of the study

This study aims to provide a solution for helping marketing planners find and decide effective strategies for promoting mobile payment systems. The following objectives are decided for achieving the goal of this study.

(1) Define the concept that represent the difference between rules with different consequent itemsets.

(2) Design an algorithm for extracting the rules based on the concept.

(3) Design evaluation criteria for evaluating the extracted rules.

(4) Propose a method for finding important rules by using the algorithm and evaluation criteria.

(5) Conduct an experiment for validating the effectiveness of the method.

(6) Design a supporting system for finding effective promotion strategies by applying the proposed method.

(7) Show an example for demonstrating the usefulness of the system.

1.3 Research contributions

The study summarized in this paper contributes to providing a solution for discovering helpful information by using association analysis from the perspective of shop owners' mental factors on their decisions of introducing mobile payment systems. The theoretical and practical contributions of this paper are shown as follows.

Theoretical contribution In this study, a method is proposed for finding important rules from results of association analysis. First, the concept 'key rule' is defined. Key rules are pairs of rules with different consequent itemsets that are found by intersecting the set of variables of the rules. Such rules represent the difference of antecedent itemset when the consequent itemsets are different. Then, evaluation criteria, cost, expectation and coverage, are used for evaluating the key rules by calculating evaluation values. By comparing the values, important rules can be found from the key rules. According the important rules, hints about converting consequent itemsets of the rules can be observed. The effectiveness of the method is proved by conducting an experiment.

Practical contribution A supporting system for finding effective strategies for promoting mobile payment systems is designed. In the system, the proposed method for finding important rules from results of association analysis is applied. By using the system, information that helps the planners make effective promotion strategies can be obtained. The usefulness of the system is demonstrated by

showing an example of using scenario.

1.4 Structure of thesis

This paper is organized as four main parts which are divided into six chapters. The first part covers the introduction and backgrounds through literature review (Chapter 1-2). The second part describes a method for finding important rules from results of association analysis (Chapter 3). The third part shows an experiment for validating the effectiveness of the proposed method (Chapter 4). The fourth part presents a conceptual design of a supporting system for finding effective strategies for promoting the introduction of mobile payment systems (Chapter 5). Finally, conclusions and future works (Chapter 6) are shown.

Brief descriptions of each chapter are presented below.
Chapter 1: **Introduction**
In Chapter 1, the scope and the goal of this study are described.
Chapter 2: **Backgrounds**
In Chapter 2, literature review and theoretical background are shown.
Chapter 3: **A method for finding important rules**
In Chapter 3, a method for finding important rules from results of association analysis is shown.
Chapter 4: **Experiment**
In Chapter 4, an experiment for showing the effectiveness of the proposed method is described and results of the experiment are discussed.
Chapter 5: **A supporting system for finding effective promotion strategies**
In Chapter 5, a conceptual design of a supporting system for finding effective strategies for promoting the introduction of mobile payment systems is described.
Chapter 6: **Conclusions and future works**
In Chapter 6, conclusions of this work and applications of the proposal are shown.

2 Backgrounds

2.1 Introduction

This chapter describes the backgrounds of the study summarized in this paper. In this chapter, the definition of mobile payment and current situation of promoting mobile payment services are shown as the background of this study. Then, previous works are described for showing the perspective of this study and the contrast of the approach that is used in this study compared with other works. Finally, the unified theory of acceptance and use of technology (UTAUT) and association analysis are explained as the theoretical background of this study.

2.2 Background of the study

2.2.1 Mobile payment

From the point of view of technology, mobile payment is commonly considered as a technology used to conduct a transaction. It has been defined [2] as "... the process of two parties exchanging financial values using a mobile device in return for goods or services." The definition implies that two major types of stakeholders, customers and merchants, are involved. Mobile payment is a complex system and other stakeholders are also involved for supporting or managing the exchange, such as financial institutions and mobile network operators [3]. Therefore, an inclusive way of thinking would consider mobile payment as a transaction enabling mobile data service resulting from the interactions of the mobile service supply chain stakeholders [4]. As focusing on the introduction of mobile payment systems by the small retailers, this study considers mobile payment from the perspective of a shop owner - customer interaction: a mobile phone based technology that enables payment in the purchase process.

There are many benefits if a shop owner introduce mobile payment systems, e.g. avoiding forfeit money, reducing physical contacts and easily managing transaction records.

Due to the benefits, the governments in many countries have been promoting the usage of mobile payment systems [1]. According to a report [1], the introduction rates are still low in many countries despite the efforts of the governments. There are many reasons which cause low rates of usages, e.g. quality of service (QoS) of mobile networks, user-friendliness of mobile payment applications, etc. Undoubtedly, the availability of mobile payment services in shopping facilities directly affects customers' usages of cashless payment. In order to improve the usage rate of cashless payment without consuming many resources, it is necessary to efficiently promote the introduction of mobile payment systems in shopping facilities.

2.2.2 Promotions of mobile payment services

There are many benefits of using mobile payment services, e.g. the convenience of money settlement, checking transfer records and etc. However, there are also concerns about using the services, e.g. leakage of personal information, unstable internet connection, and etc. Promotions for encouraging people to use mobile payment services are conducted by showing the benefits of using them. Such promotions have effects on people's mentalities towards the services. Moreover, the mentalities affect the decisions of using the services or not. For example, Owner A owns a shop in which mobile payment systems are not introduced and Owner B owns a shop in which mobile payment systems are introduced. In Owner A's mind, he/she thinks that (1) his/her friends recommends to use the systems, (2) money settlement is fast by using the systems, and (3) it takes time to learn to use the systems. In Owner B's mind, he/she thinks that (1) his/her friends recommends to use the systems, (2) no need for cash by using the systems, and (3) it is easy to learn to use the systems. In such a case, (3) of Owner A becomes the reason for him/her deciding not to introduce the systems. By focusing on such information about mentalities of shop owners, effective promotion plans can be expected.

In order to conduct effective promotions against shopping facilities, it is necessary to make plans focusing on shop owners' mental factors for introducing mobile payment systems. Therefore, insights about mental factors of shop owners to decide system introduction are required.

2.2.3 Digital tools for supporting marketing decisions

There are many digital tools used for supporting people making decisions on marketing. Alexouda [5] developed a supporting system for helping marketing managers decide optimal plans of product line design through analyzing different scenarios by using evolutionary algorithms. By using the system, the decision making process can be facilitated and the quality of the decision can be improved. Kukar et. al [6] proposed a system for providing decision support to farmers for simulated scenarios related to agricultural marketing. By using the system with users' own data, insights of the data can be provided as system outputs.

As we can see, digitalized decision supporting tools have been useful in helping people make marketing decisions. Thus, this study also focuses on designing a system for supporting marketing planners promote the introduction of mobile payment systems by analyzing data and obtaining insights.

2.3 Previous works

2.3.1 Investigating consumers' mentalities for using mobile payment systems

In order to promote the usage of mobile payment systems, the relationship between consumers' mental factors and their intentions or behaviors of using the systems has been investigated.

Zhou [7] conducted an analysis for finding the factors which affect consumer's continuous usage of mobile payment systems by using structural equation modeling (SEM) [8]. The analysis found that consumers continue to use the systems if they think the services are provided with quality.

Humbani and Wiese [9] investigated on the factors which affect consumers' adoption of mobile payment systems by conducting regression analysis. The results show that consumers' mental images on convenience and compatibility have positive effects on the adoption of the systems. Perceived factors such as risk, cost and insecurity were found to be inhibitors for adopting the systems.

Liébana-Cabanillas et al. [10] analyzed the relationship between consumer's background (gender, age and experience level) and their attitudes of using mobile payment systems on the social network. From the analysis, the external influences of social image and subjective rules were found to be the most important factors.

Karimi and Liu [11] focused on the effect of consumer's 'mood' on the decision of using mobile payment systems. Their results suggest that consumers are willing to use mobile payment systems as new services when they have positive mood got from their satisfaction by shopping activities.

Park et al. [12] investigated factors determining consumers' adoption of mobile payment services. A questionnaire survey was conducted in the U.S. by using question items based on Unified Theory of Acceptance and Use of Technology (UTAUT) [13], and then they conducted SEM to find the relations between consumers' mental factors and their intentions of adopting mobile payment services. They found that the benefits of convenience, economy and enjoyment positively affect consumers' attitudes towards mobile payment services; social influence positively affects the awareness of the benefits and technology anxiety negatively affects the awareness of the benefits.

Al-Saedi et al. [14] proposed a model for investigating the adoption of mobile payment

services by identifying frequent factors for adopting the services. A questionnaire survey was conducted in Oman by using question items based on their extended-UTAUT model and then they conducted SEM to find the relations among the constructs. Then, the identified relations were used for comparing with the results of 25 previous studies. They summarized that the most frequent factors were determined as perceived risk, perceived trust, perceived cost, and self-efficacy. The most influential factor was found to be performance expectancy.

These previous studies discussed important mental factors affecting the decision of using mobile payment systems from the perspective of consumers' mentalities.

2.3.2 Investigating the mentalities of shop owners or retailers for introducing mobile payment systems

There are other works that focused on analyzing the mentalities of retailers or shop owners for the decision of introducing mobile payment systems.

Petrova and Wang [15] analyzed the data collected by interviewing New Zealand retailers for investigating the factors which have positive and negative effects on adopting mobile payment systems. They conducted content analysis on the collected conversations by using a descriptive coding method. As a result, they found that retailer's intention of adopting the systems is (1) positively affected by perceived customer expectations for convenient payment and perceived efficiency of the systems and (2) negatively affected by the conflict with existing point-of-sale payment systems and uncertainty about its advantages due to lack of information.

In order to investigate the effect of shop owners' mental models for introducing mobile payment systems, Song et al. [16] conducted a questionnaire survey in Japan with question items designed based on their proposed model which was extended from UTAUT [13]. Then the collected data were analyzed by using SEM [8] and the relationships between the constructs were found. The results show that social influences have both the positive and negative effects on shop owners' intentions of introducing mobile payment systems.

To support service providers promote mobile payment systems, Khan and Ali [17] categorized and ranked the factors for retailers to introduce the systems. Their data was collected from retails stores in China and SEM was applied to identify the significant factors for retailers to adopt mobile payment systems. Then the identified significant factors for system introduction were used as input to the neural network for ranking the factors by importance. External pressure from retailers' customers and relative advantages of mobile payment systems were the most important factors for retailers to adopt the systems.

Similar with these studies, the study summarized in this paper also discusses the effect

of shop owners' mentalities on the decision of introducing mobile payment systems.

2.3.3 Comparing the approaches with previous works

As we can see, many previous works adopted the methods that they collected data by conducting questionnaire surveys and then analyzed the data by SEM. Compared with them, this study also used questionnaire survey designed based on UTAUT model for collecting data about shop owners' attitudes towards mobile payment systems. Different from their works, this study analyzed the data by using association analysis for obtaining rules representing the association between shop owners' attitudes and different decisions of system introduction. Then, a method for finding important rules from the results of the analysis is proposed. By applying the proposed method, a practical solution for finding effective promotion strategies is designed.

2.4 Theoretical backgrounds

2.4.1 Unified Theory of Acceptance and Use of Technology

UTAUT [13] is a model for describing users' intentions and behaviors of using systems. In the questionnaire survey described in the section 4.2.1, the following constructs of UTAUT were adopted for designing question items: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC) PE stands for the degree to which a person believes that using the systems can help them to improve his/her work performances. EE stands for the degree to which a person thinks that using the system is easy. SI stands for the degree to which a person believes that the dominant others think he/she should use the systems. In the original UTAUT model, positive effect of SI on the attitudes of accepting the systems is considered. However, in the context of shop owners' introduction of mobile payment systems, their attitudes are affected by others' negative opinions, e.g. the risks of insecurity of personal information and instability of system operation. Such facts were also discussed by Song et al. [16]. Thus, both positive and negative effects of SI were considered by using Positive Social Influence (PSI) and Negative Social Influence (NSI) instead of SI. PSI stands for the similar degree to the original SI. NSI stands for the degree to which a person thinks that the system is not reliable according to the information obtained from others. FC stands for the degree to which a person believes that there are some support frameworks to use the systems.

Many previous works [18][19][20] designed questionnaire based on the descriptions of these constructs. By reviewing the question items designed in those previous works, question items for asking shop owners' attitudes on mobile payment systems and the decision of introducing the systems were designed. Then, in the experiment of this study, data were collected by conducting questionnaire surveys and datasets were prepared.

2.4.2 Association analysis

Association analysis is a method of investigating relations between variables in a dataset. By conducting the analysis, rules indicating the relations are obtained. A rule consists of an antecedent itemset and a consequent itemset. Support, confidence and lift [21] are used as measurements for examining the rules obtained from association analysis. Support indicates the frequency of the items appeared in a dataset. Confident indicates the number of times that the rule is found to be true. Lift indicates the ratio of the confidence of the rule and the expected confidence of the rule. We assume that M stands for a dataset, X stands for an antecedent itemset of a rule, and Y stands for a consequent itemset of the rule. Support is calculated by $\mathrm{supp}(\mathrm{X}) = \sigma(\mathrm{X})/\sigma(\mathrm{M})$. Confidence is calculated by $\mathrm{conf}(\mathrm{X} \Rightarrow \mathrm{Y}) = \mathrm{supp}(\mathrm{X} \Rightarrow \mathrm{Y})/\mathrm{supp}(\mathrm{X})$. Lift is calculated by $\mathrm{lift}(\mathrm{X} \Rightarrow \mathrm{Y}) = \mathrm{conf}(\mathrm{X} \Rightarrow \mathrm{Y})/\mathrm{supp}(\mathrm{Y})$.

When conducting the analysis, the measurements are used as thresholds for obtaining association rules. However, the number of rules obtained from a dataset is too large to observe, e.g. datasets prepared by conducting questionnaire surveys, datasets of people's shopping records. In the experiment of this study, association analysis was conducted for identifying the relationship between the mental factors of shop owners and their decisions of introducing mobile payment systems by using the measurements. More than 220,000 rules were obtained from a prepared dataset and it is difficult to observe and find important rules. Thus, it is necessary to have a method for finding important rules from results of association analysis.

2.4.3 Previous works applied association analysis

There are many studies that applied association analysis. Jiao and Zhang [22] proposed a domain independent inference system for supporting product portfolio identification by applying association rules mining technique to map from customer needs to functional requirements. By mining and evaluating rules obtained from results of clustering, requirement information that are represented by the rules can be provided. Altuntas and Selim [23] proposed weighted association rule-based data mining algorithms for supporting decision making on facility layout plans from the perspectives of demand, part handling factor and efficiency of material handling equipment. Shi et al. [24] applied association rule mining and rough sets for helping designers and enterprisers decide features of product design according to customers' demands by finding the relationship between product features and adjectives that represent 'KANSEI'.

2.5 Conclusion

In this chapter, the background of the study, previous works and theoretical backgrounds are shown. As background of the study, the definition of mobile payment and the current situation of promoting mobile payment services are described. Then, many previous works are shown and they are compared with the study summarized in this paper. Compared with the previous works, this study provides a practical solution for

finding effective strategies for promoting mobile payment systems. In this study, the constructs of UTAUT were adopted for designing question items in the questionnaire used for collecting data. Besides, association analysis is used as the technique for obtaining rules representing the relationship between shop owners' mentalities and their decisions of introducing or not introducing mobile payment systems. Because of the large number of rules, a method for finding important rules from results of association analysis is proposed. The proposed method is applied in the supporting system for promoting mobile payment systems.

3 A method for finding important rules

3.1 Introduction

In order to find causal relations between variables in a large dataset, e.g. datasets prepared by conducting questionnaire surveys, datasets of people's shopping records, association analysis is widely used. By conducting the analysis, association rules that describe the associations between antecedent itemsets and consequent itemsets are obtained. Among the obtained rules, rules that have different consequent itemsets can be obtained when consequent items are decided. By comparing rules with different consequent itemsets, important information about the effects of antecedent itemsets on different consequent itemsets can be found. However, it is difficult to identify the rules that represent such information because the number of rules is too large, even though support, confidence and lift are used as thresholds for obtaining results. Thus, it is necessary to have a solution for identifying important rules among obtained rules.

In this chapter, a proposed method for finding important rules from the results of association analysis is described. First, the definition of 'key rule' is shown. Second, the procedure of the method is described according to the definition. Then, the way of obtaining hints about converting a false rule into a true rule is also described.

3.2 A method for finding 'key rule'

3.2.1 Definition of 'key rule'

In this study, a target consequent item is labelled as 'true' and a non-target consequent item is labelled as 'false'. A rule that has a consequent item as true is called a 'true rule' and a rule that has a consequent item as false is called a 'false rule'. An antecedent item consists of a pair of a variable and an attribute of the variable. By comparing antecedent items between a true rule and a false rule, if there is a common variable in the antecedent itemsets of both rules, then hints for effectively converting from a

false rule to a true rule are shown. Such rules are called 'key rule', which is defined as a pair of true rule and false rule that has common variables between their antecedent itemsets.

3.2.2 Mathematical definitions

The mathematical definitions used for describing the method are shown below.

- $\mathbb{K}$: a set of key rules.
- $\mathbb{T}$: a set of true rules.
- $\mathbb{F}$: a set of false rules.
- R_a: a rule a, $\mathrm{R}_a \in \mathbb{T} \cup \mathbb{F}$.
- e_a^i: an antecedent item i of rule a, $\mathrm{e}_a^i = (\mathrm{p}_a^i, \mathrm{q}_a^i)$, $\mathrm{e}_a^i \in \mathrm{R}_a$.
- p_a^i: a variable of item i of rule a, $\mathrm{p}_a^i \in \mathrm{T} \cup \mathrm{F}$.
- q_a^i: an attribute of item i of rule a.
- T_a: a set of variables of rule a, $\mathrm{T}_a \in \mathbb{T}$.
- F_a: a set of variables of rule a, $\mathrm{F}_a \in \mathbb{F}$.

According to the definition of 'key rule', key rules are found by: if $\exists \mathrm{p}_1^i = \mathrm{p}_2^i$, $(\mathrm{R}_1, \mathrm{R}_2) \in \mathbb{K}$.

3.2.3 Procedure of the method

Figure 3.1 shows an image of the proposed method.

The procedure of the method is shown below. We assume that there are a true rule R_1 and a false rule R_2. $\mathrm{R}_1 = \{(\mathrm{x}_1, \mathrm{c}), (\mathrm{x}_2, \mathrm{c}), (\mathrm{x}_3, \mathrm{c}), \mathrm{TRUE}\}$, and $\mathrm{R}_2 = \{(\mathrm{x}_1, \mathrm{c}), (\mathrm{x}_2, \mathrm{a}), (\mathrm{x}_4, \mathrm{a}), \mathrm{FALSE}\}$.

(1) Generate an empty set. In this step, $\mathbb{K}$ is generated for keeping key rules.

(2) Find variables of a true rule. In this step, T_a is found. $\mathrm{T}_1 = \{\mathrm{x}_1, \mathrm{x}_2, \mathrm{x}_3\}$.

(3) Find variables of a false rule. In this step, F_a is found. $\mathrm{F}_2 = \{\mathrm{x}_1, \mathrm{x}_2, \mathrm{x}_4\}$.

(4) Compare the variables. In this step, T_a is compared with F_a. The variables of T_1 is compared with the variables of T_2.

(5) Keep a pair of rules. In this step, if $\exists \mathrm{p}_i \in \mathrm{T}_1 \cap \mathrm{F}_2$, then $(\mathrm{R}_1, \mathrm{R}_2)$ is stored in $\mathbb{K}$. $\mathrm{T}_1 \cap \mathrm{F}_2$ by $\{\{\mathrm{x}_1, \mathrm{x}_2\}$, so $(\mathrm{R}_1, \mathrm{R}_2)$ is found as key rules.

The pseudocode of the procedure is shown as Algorithm 1.

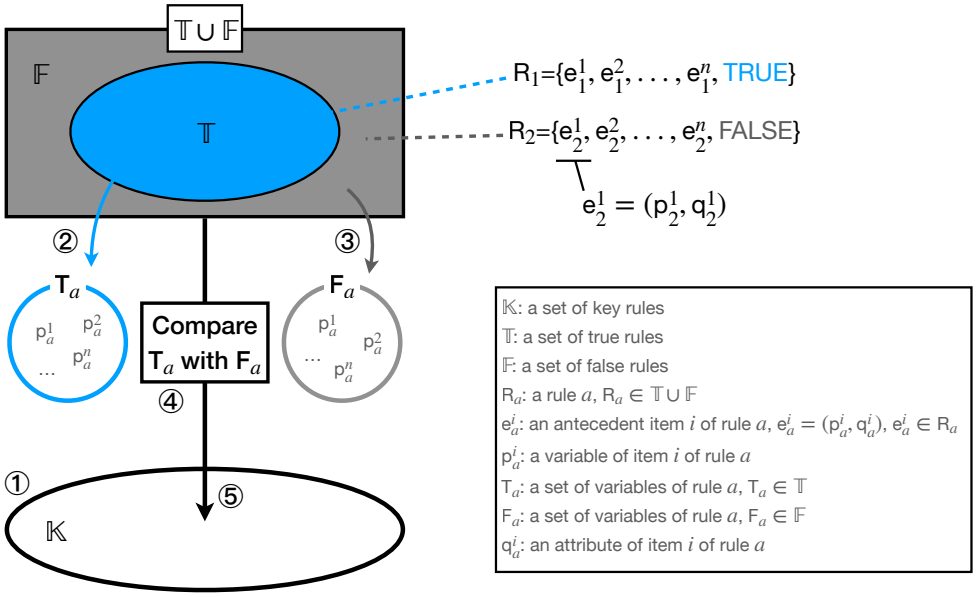

Figure 3.1 – An image of the proposed method for finding key rules

The description of Algorithm 1 is shown below.

line 1: An empty set is created for keeping key rules.

line 2-3: An antecedent item of a true rule is chosen.

line 4-5: An antecedent item of a false rule is chosen.

line 6-7: If the chosen items are the same, the pair of true rule and false rule is put into the created set.

Algorithm 1 A method for finding key rules.

1: Create $\mathbb{K} = \varnothing$
2: **for each** $R_i \in \mathbb{T}$ **do**
3: **for each** $e_i^m = (p_m, q_m) \in T_i$ **do**
4: **for each** $R_j \in \mathbb{F}$ **do**
5: **for each** $e_j^n = (p_n, q_n) \in F_j$ **do**
6: **if** $p_m = p_n \in T_i \cap F_j$ **then**
7: $\mathbb{K} \leftarrow (R_i, R_j)$
8: **else**
9: **Goto** line 4
10: **end if**
11: **end for**
12: **end for**
13: **end for**
14: **end for**

line 8-9: If there are no same items, next false rule is chosen.

3.2.4 obtaining hints for converting a false rule

After finding key rules from the results of association analysis, hints about converting a false rule into a true rule can be obtained. We assume that there are a true rule R_1 and a false rule R_2 which are found as key rules. The way of obtaining hints for converting R_2 to R_1 is shown by Algorithm 2.

Algorithm 2 Obtaining hints for converting a false rule to a true rule.

```
1: if R1 ⊊ R2, p1^n ≠ p2^n then
2:     (p2^n, q2^n) → (p2^n, ¬q2^n)
3: else
4:     if R1 ⊄ R2, p1^n ≠ p2^n then
5:         R2 ← (p1^n, q1^n)
6:     else
7:         if p1^n = p2^n ∧ q1^n ≠ q2^n then
8:             q2^n → q1^n
9:         end if
10:    end if
11: end if
```

The description of Algorithm 2 is shown.

line 1-2: When a true rule is included in a false rule, if a variable of the false rule cannot be found in the true rule, then the attribute of the variable of the false rule needs to be changed into something else.

line 3-5: When a true rule is not included in a false rule, if a variable of the true rule cannot be found in the false rule, then the pair of the variable and the attribute needs to be added to the false rule.

line 6-8: If different attributes of the same variable is found, then the attribute of the variable of the false rule is changed into the one of the true rule.

We assume that there is a pair of true rule R_1 and false rule R_2that are found to be key rules. In this example, the case that $R_1 \subsetneq R_2$ is considered. $R_1 = \{(x_1, c), (x_2, c), \text{TRUE}\}$, and $R_2 = \{(x_1, c), (x_2, c), (x_3, a), \text{FALSE}\}$. In this case, line 1-2 is conducted for obtaining the hints for converting R_2. Thus, (x_3, a) needs to be changed to $(x_3, \neg a)$.

In this example, the case that $R_1 \not\subseteq R_2$ is considered. $R_1 = \{(x_1, c), (x_2, c), (x_3, c), \text{TRUE}\}$, and $R_2 = \{(x_1, c), (x_2, a), (x_4, a), \text{FALSE}\}$. In this case, line 3-8 is conducted for obtaining the hints for converting R_2. Thus, (x_3, c) needs to be added to R_2 and (x_2, a) needs to be changed to (x_2, c).

3.2.5 Evaluating the key rules

Three criteria are adopted for evaluating key rules, which are cost, expectation and coverage. Cost stands for the potential cost of converting a false rule into a true rule, which is calculated by $1/N$, where N represents the number of antecedent items that need to be converted. Expectation stands for the expected level of confidence if a false rule is converted into a true rule, which is calculated as the confidence of a true rule. Coverage stands for the percentage of matched targets among all targets, which is calculated by $\mathrm{supp}(\mathrm{X} \Rightarrow \mathrm{FALSE})/\mathrm{supp}(\mathrm{FALSE})$, where X represents an antecedent itemset of a rule. According to the criteria, evaluation values (EV) of each key rule are calculated by:

$$\mathrm{EV} = \alpha \times \mathrm{Cost} + \beta \times \mathrm{Expectation} + \gamma \times \mathrm{Coverage} \tag{3.1}$$

The perspectives of reviewing the rules are adopted by adjusting the weights ($\alpha+\beta+\gamma = 1.00$).

3.3 Conclusion

In this chapter, a proposed method for finding important rules from the results of association analysis is summarized. First, the concept of 'key rule' is defined by introducing the concepts of 'true rule' and 'false rule'. Second, the procedure of the method is described according to the definition by showing the mathematical definitions and the conceptual image. Third, the way of obtaining hints about converting a false rule into a true rule is also described and examples are given. Then, criteria for calculating evaluation values of key rules are shown.

In the next chapter, an experiment for showing the effectiveness of the proposed method is described. In the experiment, first, association analysis was conducted by using the data collected by conducting questionnaire surveys. After conducting association analysis, a large amount of rules were obtained. Thus, the effectiveness of the proposed method was tested for finding key rules from the obtained rules of the analysis.

4 Experiment

4.1 Introduction

In this chapter, an experiment for showing the effectiveness of the proposed method for finding important rules is described. In order to validate the effectiveness of the proposed method, an experiment was conducted by the following steps. First, the authors' team conducted survey of shop owners' attitudes towards mobile payment systems and their decisions of introducing the systems in four areas: Japan, China, Thailand, and Taiwan. Second, the collected data were preprocessed by generating itemsets for conducting association analysis. Third, association analyses were conducted by using the prepared datasets for obtaining rules that have different consequent itemsets. Then, the proposed method was applied for finding key rules from the obtained rules.

4.2 An experiment for showing the effectiveness of the proposed method

4.2.1 Questionnaire surveys on shop owners' attitudes and their decisions

A questionnaire survey was conducted for collecting data about shop owners' attitudes on mobile payment systems and the decision of introducing the systems. Table 4.1 shows the question items of the questionnaire. There are twenty-four question items in the questionnaire survey. Question items No. 1 to No. 21 belong to categories that correspond to constructs of the UTAUT. Question items No. 22 and No. 23 belong to the category of cost. For these question items, a five-point Likert scale [25] is adopted (from 1-Strongly disagree to 5-Strongly agree). Question item No. 24 asks shop owners' decisions about introducing mobile payment systems in their shops. The answer to this question is yes or no.

The shop owners in four areas (Japan, China, Thailand and Taiwan) participated the survey. Private business of retailers and food shops which are managed by less than

ten people were chosen as target shops of the survey. Table 4.2 shows the number of available data from each area by different methods. After data cleansing, the number of data without missing values are 838. The numbers of data collected from Japan, China, Thailand and Taiwan are 269, 117, 273 and 179 respectively. Table 4.3 shows the demographic information of the samples.

Table 4.1 – Categories and Question items of the questionnaire.

Category	No.	Description
Performance expectancy (PE)	1	(PE1) I think the introduction of mobile payment systems in the shop will make work more convenient.
	2	(PE2) I think the introduction of mobile payment systems will help to finish the job quickly.
	3	(PE3) Introducing mobile payment systems can save the time of changing cash.
	4	(PE4) Introducing mobile payment systems can reduce my tasks.
	5	(PE5) With using mobile payment systems, I don't need to lose time for taking cash.
	6	(PE6) Introducing mobile payment systems can save the problem of preparing coins or cash.
	7	(PE7) Introducing mobile payment systems saves me the trouble to do daily settlements every day.
	8	(PE8) Introducing mobile payment systems can enhance service efficiency.
Effort expectancy (EE)	9	(EE1) It is easy for me to become skilful at using mobile payment systems.
	10	(EE2) Learning to operate mobile payment systems is easy for me.
Positive social influence (PSI)	11	(PSI1) People who influence my behavior recommend that I should use mobile payment systems.
	12	(PSI2) I want to be a leader in introducing mobile payment systems.
	13	(PSI3) The community of my business has advocated using mobile payment systems.
	14	(PSI4) I will use mobile payment systems if my competitors use them.
Facilitating condition (FC)	15	(FC1) I have the necessary equipment to introduce mobile payment systems.
	16	(FC2) I have the necessary knowledge to introduce mobile payment systems.
	17	(FC3) I have taken guidance to start providing services by using mobile payment systems.
	18	(FC4) I have someone who can help me when I have problems with using mobile payment systems.
	19	(FC5) Mobile payment systems can be used in combination with other payment systems.
Negative social influence (NSI)	20	(NSI1) Providing personal information to mobile payment systems is risky.
	21	(NSI2) Mobile payment systems are likely to have many problems.
Cost (CO)	22	(CO1) The cost of introducing mobile payment systems is high.
	23	(CO2) The cost of operating mobile payment systems is high.
Decision of introduction	24	Are there any mobile payment systems introduced in my shop?

Table 4.2 – The number of collected data from each area.

	The number of collected data after cleansing			
Area	Visit	Online	Mail	Facsimile
Japan	202	14	51	2
China	0	117	0	0
Thailand	273	0	0	0
Taiwan	5	174	0	0

Table 4.3 – The number of collected data from each area.

	Japan (n=269)		China (n=117)		Thailand (n=273)		Taiwan (n=179)		Total
	Count	(%)	Count	%	Count	%	Count	%	
Gender									
Male	165	(61.34)	40	(34.19)	119	(43.59)	76	(42.46)	400
Female	104	(38.66)	77	(65.81)	154	(56.41)	103	(57.54)	438
Generation									
Post-war cohort (75-94 years old)	13	(4.83)	0	(0.00)	0	(0.00)	1	(0.56)	14
Baby boomers (56-74 years old)	109	(40.52)	4	(3.42)	8	(2.93)	22	(12.29)	143
Generation X (44-55 years old)	79	(29.37)	43	(36.75)	28	(10.26)	62	(34.64)	212
Generation Y (26-43 years old)	65	(24.16)	65	(55.56)	217	(79.49)	87	(48.60)	434
Age below 26	3	(1.12)	5	(4.27)	20	(7.33)	7	(3.91)	35
Mobile payment systems introduction									
Introduced	130	(48.33)	106	(90.60)	215	(78.75)	127	(70.95)	578
Did not introduce	139	(51.67)	11	(9.40)	58	(21.25)	52	(29.05)	260

4.2.2 Preprocessing data

The collected data were pre-processed by generating itemsets for conducting association analysis. Participants' answers to question items No. 1 to No. 23 were labelled for reducing response bias [26]. If an answer is '1-Strongly disagree' or '2-Disagree', the answer is labelled as 'disagree'. If an answer is '3-Neither disagree nor agree', the answer is labelled as 'neutral'. If an answer is '4-Agree' or '5-Strongly agree', the answer is labelled as 'agree'. For the answer to question item No. 24, 'yes' is labelled as 'TRUE' and 'no' is labelled as 'FALSE'. According to the correspondence, itemsets of each sample were generated. Five datasets that are the datasets of all areas, Japan, China, Thailand and Taiwan were prepared.

4.2.3 Conducting association analysis

Association analyses were conducted by using the prepared datasets. Two target consequent items were set for conducting the analyses: (1) the item which indicates the decision of introducing mobile payment systems and (2) the item indicates the decision of not introducing the systems. Minimum support, minimum confidence and

minimum lift were decided as parameters for conducting the analyses. Table 4.4 shows the patterns of minimum support and minimum confidence. In the table, n stands for the number of appearance of a consequent item in a dataset. A pattern of minimum support was combined with each minimum confidence. Thus, association analyses were conducted with twenty-five patterns of conditions for each prepared dataset. For each rule obtained from the analysis, lift was examined to be greater than or equal to 1.00.

Table 4.4 – Conditions of the experiment.

Condition ID	Minimum support	Minimum Confidence
S1C1	$0.50 \times n$	0.75
S1C2		0.80
S1C3		0.85
S1C4		0.90
S1C5		0.95
S2C1	$0.60 \times n$	0.75
S2C2		0.80
S2C3		0.85
S2C4		0.90
S2C5		0.95
S3C1	$0.70 \times n$	0.75
S3C2		0.80
S3C3		0.85
S3C4		0.90
S3C5		0.95
S4C1	$0.80 \times n$	0.75
S4C2		0.80
S4C3		0.85
S4C4		0.90
S4C5		0.95
S5C1	$0.90 \times n$	0.75
S5C2		0.80
S5C3		0.85
S5C4		0.90
S5C5		0.95

Linear time Closed itemset Miner (LCM) version 5.3, which is proposed by Uno et al. [27], was used as the tool for conducting association analysis. They developed the algorithms [28] [29] based on backtracking algorithms [30]. By using the tool for conducting the analysis, closed frequent itemsets were found from the datasets.

4.2.4 Applying the proposed method

When applying the method, true rules and false rules were compared by $\mathrm{T}_a \cap \mathrm{F}_a$ (T_a represents a set of variables of a true rule a and F_a represents a set of variables of a false rule a). In order to validate the effectiveness of the method in strict conditions, the following sub-cases were chosen for extracting key rules: $\mathrm{T}_a \supset \mathrm{F}_a$, $\mathrm{T}_a = \mathrm{F}_a$ and

$T_a \subset F_a$. Three criteria, cost, expectation and coverage, were used for calculating evaluation values (EVs) of the key rules, which are described in the section 3.2.5. In the experiment, four patterns of the weights were considered. Table 4.5 shows the way of arranging the weights. As shown in the table, for calculating the EV from a neutral perspective (EV1), the weights were distributed equally; for calculating the EVs from the perspective of each criterion (EV2, EV3 and EV4), the weights were distributed for emphasizing each criterion respectively.

Table 4.5 – The combinations of weights from different perspectives for calculating EVs.

Perspective	α	β	γ
(EV1) Overall	1/3	1/3	1/3
(EV2) Cost-focused	0.80	0.10	0.10
(EV3) Expectation-focused	0.10	0.80	0.10
(EV4) Coverage-focused	0.10	0.10	0.80

4.3 Results and discussion

By conducting association analysis and applying the proposed method, true rules, false rules and key rules were obtained. Table 4.6, 4.7, 4.8, 4.9 and 4.10 show the number of rules obtained by each condition with the data of all areas.

Table 4.6 – The number of rules obtained by minimum support $0.5 \times n$ with the dataset of all area.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S1C1	222532	1	108419
S1C2	222190	0	0
S1C3	164305	0	0
S1C4	0	0	0
S1C5	0	0	0

Table 4.7 – The number of rules obtained by minimum support $0.6 \times n$ with the dataset of all area.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S2C1	21366	1	6639
S2C2	21293	0	0
S2C3	18159	0	0
S2C4	0	0	0
S2C5	0	0	0

By using the dataset of all areas, key rules were found with the following conditions: minimum support as $0.5 \times n$ (S1) and minimum confidence as 0.75 (C1); minimum support as $0.6 \times n$ (S2) and minimum confidence as 0.75 (C1).

Table 4.8 – The number of rules obtained by minimum support $0.7 \times n$ with the dataset of all area.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S3C1	902	0	0
S3C2	842	0	0
S3C3	500	0	0
S3C4	0	0	0
S3C5	0	0	0

Table 4.9 – The number of rules obtained by minimum support $0.8 \times n$ with the dataset of all area.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S4C1	113	0	0
S4C2	88	0	0
S4C3	23	0	0
S4C4	0	0	0
S4C5	0	0	0

Table 4.11, 4.12, 4.13, 4.14 and 4.15 show the number of rules obtained by each condition respectively with the dataset of Japan.

By using the dataset of Japan, key rules were found by the following conditions: minimum support as $0.5 \times n$ (S1) and minimum confidence as 0.75 (C1), 0.80 (C2) and 0.85 (C3); minimum support $0.6 \times n$ (S2) and minimum confidence as 0.75 (C1), 0.80 (C2) and 0.85 (C3); minimum support $0.7 \times n$ (S3) and minimum confidence as 0.75 (C1) and 0.80 (C2).

Table 4.16, 4.17, 4.18, 4.19 and 4.20 show the number of rules obtained by each condition respectively with the dataset of China.

By using the dataset of China, key rules were found by the following conditions: minimum support $0.5 \times n$ (S1) and minimum confidence as 0.75 (C1), 0.80 (C2) and 0.85 (C3); minimum support $0.6 \times n$ (S2) and minimum confidence as 0.75 (C1), 0.80 (C2)

Table 4.10 – The number of rules obtained by minimum support $0.9 \times n$ with the dataset of all area.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S5C1	19	0	0
S5C2	9	0	0
S5C3	2	0	0
S5C4	0	0	0
S5C5	0	0	0

Table 4.11 – The number of rules obtained by minimum support $0.5 \times n$ with the dataset of Japan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S1C1	11	43	47
S1C2	10	29	27
S1C3	3	12	5
S1C4	0	2	0
S1C5	0	0	0

Table 4.12 – The number of rules obtained by minimum support $0.6 \times n$ with the dataset of Japan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S2C1	5	10	9
S2C2	4	4	6
S2C3	1	2	1
S2C4	0	0	0
S2C5	0	0	0

and 0.85 (C3); minimum support $0.7 \times n$ (S3) and minimum confidence as 0.75 (C1).

Table 4.21, 4.22, 4.23, 4.24 and 4.25 show the number of rules obtained by each condition respectively with the dataset of Thailand.

Table 4.26, 4.27, 4.28, 4.29 and 4.30 show the number of rules obtained by each condition respectively with the dataset of Taiwan.

When using the dataset of Thailand and the dataset of Taiwan, key rules cannot be found from the two datasets. It happened because the number of false rules is 0 in all conditions. No false rules were found because participants' backgrounds were not controlled when collecting data by questionnaire surveys. The proposed method requires true rules and false rules for finding the common variables. In the actual applications, the datasets need to be checked that both true rules and false rules can

Table 4.13 – The number of rules obtained by minimum support $0.7 \times n$ with the dataset of Japan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S3C1	1	6	2
S3C2	1	2	2
S3C3	0	2	0
S3C4	0	0	0
S3C5	0	0	0

Table 4.14 – The number of rules obtained by minimum support $0.8 \times n$ with the dataset of Japan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S4C1	1	1	0
S4C2	1	0	0
S4C3	0	0	0
S4C4	0	0	0
S4C5	0	0	0

Table 4.15 – The number of rules obtained by minimum support $0.9 \times n$ with the dataset of Japan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S5C1	0	0	0
S5C2	0	0	0
S5C3	0	0	0
S5C4	0	0	0
S5C5	0	0	0

be obtained for applying the proposed method.

From the experiment, key rules with the highest EVs were obtained from the datasets of all areas, Japan and China. Table 4.31 shows the key rules with the EVs. The same key rules were obtained from the datasets of all areas and Japan. By observing the key rules extracted from the datasets of all areas and Japan, we can see different attributes corresponding to the variable FC1 by comparing the pair of true rule and false rule. The rules imply that it is effective to change the consequents from false into true by changing the attributes of FC1 from 'disagree' to 'agree'. Moreover, higher EVs were calculated in the case of Japan, which means that the key rules are more effective in the dataset of Japan than in the dataset of all areas. By observing the key rules extracted from the dataset of China, we can see different attributes corresponding to the variable PE1 by comparing the pair of true rule and false rule. The rules imply that it is effective to change the consequents from false into true by changing the attributes of PE1 from

Table 4.16 – The number of rules obtained by minimum support $0.5 \times n$ with the dataset of China.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S1C1	31102	13	13559
S1C2	31102	12	13554
S1C3	31102	2	2113
S1C4	31102	0	0
S1C5	29082	0	0

Table 4.17 – The number of rules obtained by minimum support $0.6 \times n$ with the dataset of China.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S2C1	27219	3	1916
S2C2	27219	2	1911
S2C3	27219	2	1911
S2C4	27219	0	0
S2C5	25341	0	0

Table 4.18 – The number of rules obtained by minimum support $0.7 \times n$ with the dataset of China.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S3C1	9160	1	5
S3C2	9160	0	0
S3C3	9160	0	0
S3C4	9160	0	0
S3C5	8070	0	0

'neutral' to 'agree'.

As shown in Table 4.31, all key rules show the highest EVs in all combinations of weights for calculating the EVs from different perspectives. It happened because the weights were not optimized according to the value ranges of cost, expectation and coverage. Therefore, a mechanism for optimizing the weights is required for finding important rules.

4.4 Conclusion

In this chapter, in order to verify the effectiveness of the proposed method that is described in Section 3, an experiment is summarized. In the experiment, a scenario of promoting mobile payment systems was adopted and data about shop owners' attitudes towards the systems and the decisions of system introduction were used. For preparing the data, questionnaire surveys were conducted in four areas: Japan,

Table 4.19 – The number of rules obtained by minimum support $0.8 \times n$ with the dataset of China.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S4C1	1048	0	0
S4C2	1048	0	0
S4C3	1048	0	0
S4C4	1048	0	0
S4C5	776	0	0

Table 4.20 – The number of rules obtained by minimum support $0.9 \times n$ with the dataset of China.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S5C1	55	0	0
S5C2	55	0	0
S5C3	55	0	0
S5C4	55	0	0
S5C5	9	0	0

Table 4.21 – The number of rules obtained by minimum support $0.5 \times n$ with the dataset of Thailand.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S1C1	58	0	0
S1C2	29	0	0
S1C3	0	0	0
S1C4	0	0	0
S1C5	0	0	0

China, Thailand and Taiwan. By using the proposed method, key rules were found and evaluated. Then, important rules with the highest evaluation values that represent the effects of antecedent itemsets on different consequent itemsets were discussed. As a result, the proposed method is proved to be effective for identifying important information from the results of association analysis.

In the next chapter, a supporting system for helping marketing planners to promote mobile payment systems is shown. The method for finding important rules is applied in the system for providing hints about promotion strategies.

Table 4.22 – The number of rules obtained by minimum support $0.6 \times n$ with the dataset of Thailand.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S2C1	55	0	0
S2C2	29	0	0
S2C3	0	0	0
S2C4	0	0	0
S2C5	0	0	0

Table 4.23 – The number of rules obtained by minimum support $0.7 \times n$ with the dataset of Thailand.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S3C1	25	0	0
S3C2	23	0	0
S3C3	0	0	0
S3C4	0	0	0
S3C5	0	0	0

Table 4.24 – The number of rules obtained by minimum support $0.8 \times n$ with the dataset of Thailand.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S4C1	25	0	0
S4C2	23	0	0
S4C3	0	0	0
S4C4	0	0	0
S4C5	0	0	0

Table 4.25 – The number of rules obtained by minimum support $0.9 \times n$ with the dataset of Thailand.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S5C1	25	0	0
S5C2	23	0	0
S5C3	0	0	0
S5C4	0	0	0
S5C5	0	0	0

Table 4.26 – The number of rules obtained by minimum support $0.5 \times n$ with the dataset of Taiwan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S1C1	1411	0	0
S1C2	1389	0	0
S1C3	1307	0	0
S1C4	930	0	0
S1C5	83	0	0

Table 4.27 – The number of rules obtained by minimum support $0.6 \times n$ with the dataset of Taiwan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S2C1	311	0	0
S2C2	300	0	0
S2C3	266	0	0
S2C4	137	0	0
S2C5	0	0	0

Table 4.28 – The number of rules obtained by minimum support $0.7 \times n$ with the dataset of Taiwan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S3C1	84	0	0
S3C2	78	0	0
S3C3	54	0	0
S3C4	15	0	0
S3C5	0	0	0

Table 4.29 – The number of rules obtained by minimum support $0.8 \times n$ with the dataset of Taiwan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S4C1	21	0	0
S4C2	17	0	0
S4C3	6	0	0
S4C4	0	0	0
S4C5	0	0	0

Table 4.30 – The number of rules obtained by minimum support $0.9 \times n$ with the dataset of Taiwan.

Condition ID	No. of true rules	No. of false rules	No. of key rules
S1C1	8	0	0
S1C2	5	0	0
S1C3	1	0	0
S1C4	0	0	0
S1C5	0	0	0

Table 4.31 – Key rules with the highest EVs.

Data samples	Rule type	Antecedent itemset	EV1	EV2	EV3	EV4
All areas	True	(FC1, agree)	0.78	0.93	0.83	0.57
	False	(FC1, disagree)				
Japan	True	(FC1, agree)	0.83	0.95	0.84	0.71
	False	(FC1, disagree)				
China	True	(PE1, agree)	0.85	0.95	0.95	0.64
	False	(PE1, neutral), (PE2, agree), (FC5, agree)				

5 A supporting system for finding effective promotion strategies

5.1 Introduction

In this chapter, a supporting system for finding effective strategies for encouraging shop owners to introduce mobile payment systems is described.

Despite the governments are promoting the usage of mobile payment services [1], there are gaps in the usage rates of the services among different countries. In order to improve the usage rates, it is necessary to encourage shopping facilities to provide mobile payment services. Owners of shopping facilities decide to introduce mobile payment systems or not according to their attitudes towards the systems. Differences in the owners' mentalities lead to different decisions about system introduction. If marketing planners want to promote the introduction of mobile payment systems in shopping facilities, it is necessary to understand the differences. However, it is difficult to have enough information about shop owners' mentalities.

In this study, a supporting system for helping marketing planners find and decide strategies for promoting mobile payment systems is designed. First, the mechanisms of the system are described. In order to provide information for deciding the strategies, a mechanism for finding important information from results of association analysis is applied. Second, the structure and the flow of the system is shown. Then, the usefulness of the system is demonstrated by showing an example. In the example, data collected by questionnaire surveys about shop owners' attitudes towards mobile payment systems and the decisions of system introduction were used. According to the results, effective promotion strategies are discussed.

5.2 The design of the system

5.2.1 System mechanisms

There are three main mechanisms in the system: (1) Association analysis, (2) Rule extraction and (3) Rule selection. In the mechanism of association analysis, by conducting association analysis using the prepared datasets, true rules and false rules are obtained. When conducting association analysis, minimum support, minimum confidence and minimum lift are used as thresholds for obtaining rules. Table 5.1 shows the patterns of minimum support and minimum confidence. In the table, n stands for the number of appearances of a consequent item. Each minimum support is combined with each minimum confidence as a condition for conducting association analysis. As we can see, the combination of S5 and C5 stands for the strictest condition and the combination of S1 and C1 stands for the loosest condition. Minimum lift is set as 1.00. The analysis is conducted with all conditions for preparing sets of rules.

Table 5.1 – Patterns of parameters for conducting association analysis.

Minimum support	Minimum confidence
(S1) 0.5×n	(C1) 0.75
(S2) 0.6×n	(C2) 0.80
(S3) 0.7×n	(C3) 0.85
(S4) 0.8×n	(C4) 0.90
(S5) 0.9×n	(C5) 0.95

The mechanism of rule extraction extracts important rules which shows hints for conducting promotions. Such information can be represented by a pair of true rule and false rule. The pair of rules is called a 'key rule'. In this case, a true rule stands for a rule with the consequent itemset that represents shop owners' decision of introducing mobile payment systems; a false rule stands for a rule with the consequent itemset that represents shop owners' decision of not introducing the systems. In this mechanism, key rules are found from the results of association analysis by applying the method that is described in the section 3.

Each key rule is evaluated by three evaluation criteria: cost, expectation and coverage. Cost stands for the potential cost of converting a false rule into a true rule, which is calculated by $1/\mathrm{N}$, where N represents the number of antecedent items that need to be converted. Expectation stands for the expected level of confidence if a false rule is converted into a true rule, which is calculated as the confidence of a true rule. Coverage stands for the percentage of matched targets among all targets, which is calculated by $\mathrm{supp}(\mathrm{X} \Rightarrow \mathrm{FALSE})/\mathrm{supp}(\mathrm{FALSE})$, where X represents an antecedent itemset of a rule. According to the criteria, evaluation values (EV) of each key rule were calculated:

$$\mathrm{EV} = \alpha \times \mathrm{Cost} + \beta \times \mathrm{Expectation} + \gamma \times \mathrm{Coverage} \tag{5.1}$$

The summation of the weights (α, β and γ) is 1.00. The default setting of each weight is

1/3.

The mechanism of rule selection enables a user to find hints for deciding promotion strategies for shop owners who have a persistent attitude. In this mechanism, the user needs to select an itemset which represents a persistent attitude. Each item consists of a pair of question item and an attitude of the question item. For obtaining key rules which have the itemset selected by the user, antecedent items of key rules are checked. If the itemset exists in the antecedent items of key rules, then the key rules will be obtained and presented to the user.

5.2.2 System structure

The system consists of four modules and a database: (A) association analysis module, (B) rule extraction module, (C) rule selection module, (D) user interface module and (E) database of prepared data of itemsets. In the database, data about shop owners' attitudes towards MP systems and their decisions about system introduction are prepared. The questionnaire used for collecting the data is described in the section 4.2.1. The way of preprocessing the data is described in the section 4.2.2.

Figure 5.1 shows the structure of the system. The flow of the system is described as follows:

(1) A user selects a set of item(s) which represents the persistent attitudes of target shop owners. I stands for an itemset that consists of the items selected by the user.

(2) Module D sends a request of conducting analysis to Module A and sends the itemset I to Module C.

(3) Module A sends a request to Database E and obtains data of itemsets. Then, association analysis is conducted by using the data.

(4) Module B obtains the results of the analysis from Module A. In the results, there are true rules and false rules. Then, key rules are extracted and EVs are calculated.

(5) Module C obtains the key rules from Module B. Then, the key rules which have the itemset I in the antecedent itemsets are found.

(6) Module C sends the located key rules to Module D.

(7) Module D presents the key rules to the user by referring to the descriptions of question items.

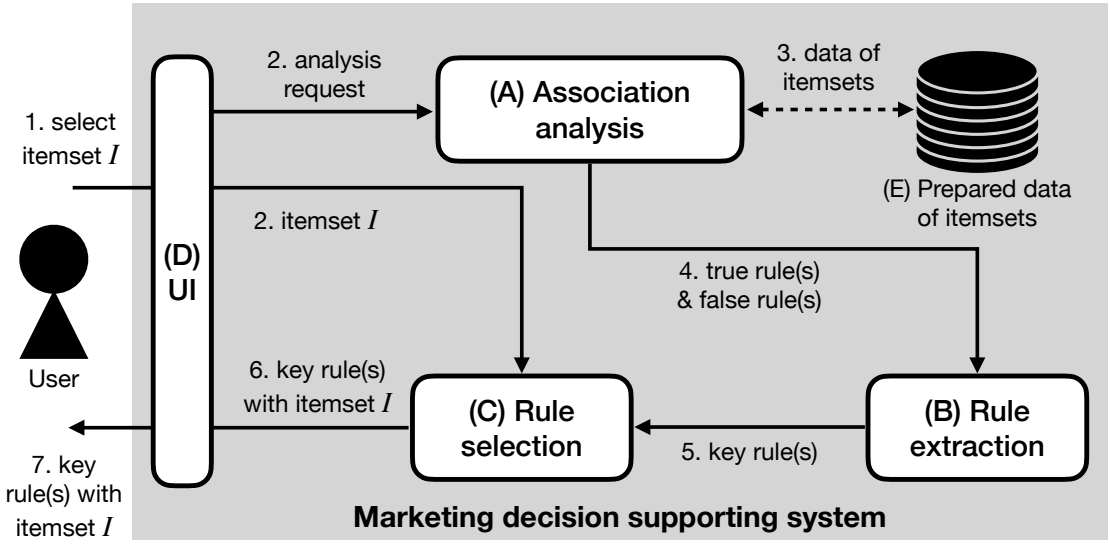

Figure 5.1 – An image of the structure of the supporting system

5.3 An example scenario of using the system

5.3.1 Overview of the scenario

In order to demonstrate the usefulness of the system, an example is shown. In the scenario, we assume that a marketing team wants to promote the introduction of mobile payment systems in Japan. The data collected from Japan is used by the team in the scenario. The number of available samples is 269 as shown in the section 4.2.1. The team wants to find out the promotion strategies targeting shop owners who think that using mobile payment systems can help them to improve their work performances. Planner A in the team focuses on the shop owners who agree that introducing mobile payment systems can save the time of changing cash (PE3). Planner B in the team focuses on the shop owners who agree that using mobile payment systems can save time for taking cash (PE5).

5.3.2 Procedure of using the system

According to the flow of the system, the procedure of using the system is described.

(1) Planner A selects an itemset {(PE3, agree)} and Planner B selects an itemset {(PE5, agree)}.

(2) Module D sends the two itemsets to Module C respectively and sends the request to Module A.

(3) Module A conducts association analysis by using the prepared data and true rules and false rules are obtained.

(4) Module B extracts key rules from the obtained rules and calculates the EVs.

Currently, in order to test the effectiveness of the mechanism, the following cases were chosen for extracting key rules: $T_a \supset F_a$, $T_a = F_a$ and $T_a \subset F_a$. Here, T_a represents a set of variable of a true rule a and F_a represents a set of variable of a false rule a. When calculating EVs of the key rules, the default weights were used.

(5) Module obtains the key rules from Module B and finds the key rules with the itemset {(PE3, agree)} and the itemset {(PE5, agree)} that have the highest EV respectively.

(6) Module C sends the located key rules which have the selected itemsets to Module D.

(7) The located key rules with the selected itemsets were presented respectively to each planner.

5.3.3 Results and discussion

Table 5.2 – Key rules with the highest EVs.

Fixed item	Rule type	Antecedent itemset	Cost	Expectation	Coverage	EV
(PE3, agree)	True	(PE3, agree), (FC1, agree)	1.00	0.86	0.45	0.77
	False	(PE3, agree), (FC1, disagree)				
(PE5, agree)	True	(PE5, agree), (FC1, agree)	1.00	0.83	0.42	0.75
	False	(PE5, agree), (FC1, disagree)				

As shown by the example scenario, key rules with the highest EVs which have the fixed antecedent items were obtained from the data. Table 5.2 shows the obtained key rules. The meaning of each key rule is described by referring to the descriptions of question items. The true rule of the key rule which has the selected itemset {(PE3, agree)} means that if shop owners think that introducing mobile payment systems can save the time of changing cash and they have the necessary equipment to introduce mobile payment systems, they will introduce the systems. The false rule means that if shop owners think that introducing mobile payment systems can save the time of changing cash and don't think that they have the necessary equipment to introduce mobile payment systems, they will not introduce the systems. By comparing the true rule and false rule, the difference implies that it is effective to conduct promotions for changing shop owners' attitudes towards the required equipment for introducing mobile payment systems when the target shop owners think that introducing the systems can save the time of changing cash.

The true rule of the key rule which has the selected itemset {(PE5, agree)} means that if shop owners think that using mobile payment systems can save time for taking cash and they have the necessary equipment to introduce mobile payment systems,

they will introduce the systems. The false rule means that if shop owners think that using mobile payment systems can save time for taking cash and don't think that they have the necessary equipment to introduce mobile payment systems, they will not introduce the systems. By comparing the true rule and false rule, the difference implies it is effective to conduct promotions for changing shop owners' attitudes towards the required equipment for introducing mobile payment systems when the target shop owners think that using the systems can save time for taking cash.

From the two key rules, a similar promotion strategy is obtained. The strategy indicates that if shop owners think that introducing mobile payment systems can improve their work performance by saving the time of managing cash, it is effective to conduct promotions for changing their attitudes towards the required equipment for introducing the systems. For example, the marketing team can conduct guidance meetings or distribute pamphlets to show that it requires only a smartphone and QR codes to start mobile payment services in their shops.

By using the system, important information for deciding promotion strategies were found according to target shop owners who have a persistent attitude chosen by marketing planners. Such information shows the difference in the shop owners' attitudes who make different decisions about introducing mobile payment systems. Therefore, the usefulness of the supporting system is shown.

5.4 Conclusion

In this chapter, the design of a supporting system for finding effective strategies for promoting mobile payment systems is summarized. The system helps marketing planners find the differences in shop owners' attitudes who make different decisions. First, the design of the system is shown by describing the mechanisms and the structure of the system. Then, an example scenario of using the system is shown for demonstrating the usefulness of the system. As a result, information about the differences in shop owners' attitudes who make different decisions was found. According to the differences, effective promotion strategies for promoting mobile payment systems in Japan are discussed.

6 Conclusions and future works

6.1 Conclusions

In this paper, a conceptual design of a system for supporting marketing planners promote shop owners' introduction of mobile payment systems is summarized. For marketing planners, it is difficult to conduct promotions effectively because they do not have enough information about the difference in mentality between shop owners who introduce mobile payment systems and those who do not. To solve the problem, a supporting system for helping the planners make effective promotion strategies is designed. The system has three mechanisms: (1) conducting association analysis, (2) finding important rules and (3) selecting the rules with selected itemset.

In order to realize the mechanisms, a method for finding important rules from the results of association analysis is proposed. By finding key rules that represents hints about converting false rules into true rules and evaluating the rules, important rules can be found. Three criteria were considered: cost, expectation and coverage.

For showing the effectiveness of the proposed method, an experiment was conducted by using the data about shop owners' attitudes towards mobile payment systems and their decisions of system introduction. The data were collected by conducting questionnaire surveys in Japan, China, Thailand and Taiwan. Five datasets were prepared in the experiment: the datasets of all area, Japan, China, Thailand and Taiwan. After conducting association analysis for obtaining true rules and false rules, the proposed method was applied. On one hand, from the datasets of all areas, Japan and China, key rules were found. On the other hand, from the datasets of Thailand and Taiwan, key rules were not found. The method is proved to be effective when there are enough numbers of true rules and false rules that are obtained from association analysis. By calculating evaluation values of key rules, the key rules with the highest evaluation values were found. Then, important hints about converting false rules into

true rules are discussed.

For showing the usefulness of the supporting system, a using scenario is shown as an example. The example demonstrates that marketing planners use the system for deciding promotion strategies of encouraging shop owners to introduce mobile payment systems. By using the system with the dataset of Japan, important rules were obtained and promotion strategies are discussed. The strategy indicates that if shop owners think that introducing mobile payment systems can improve their work performance by saving the time of managing cash, it is effective to conduct promotions for changing their attitudes towards the required equipment for introducing the systems. Because the effective strategy was found, the usefulness of the supporting system is shown.

6.2 Future works

6.2.1 Applications of the method

Principal component analysis (PCA) [31] and structural equation modeling (SEM) [8] are methods for analyzing a dataset for obtaining effective composite variables on different consequents from the dataset. However, it is difficult to find specific hints about effective actions for changing consequents. By using association analysis combined with the proposed method, important rules that represent the difference between rules with different consequents are found. Thus, specific hints about effective actions for converting false rules into true rules can be observed. In the case of marketing application, such hints can help marketing planners decide effective promotion strategies.

6.2.2 Application of the system

The conceptual design of the system provides a solution for discovering helpful information by using the proposed method from the perspective of shop owners' mental factors on their decisions of introducing mobile payment systems. The application of the system can be extended by modifying the question items in the questionnaire and the design of databases. In this study, the question items were designed for investigating shop owners' attitudes towards mobile payment systems according to the questionnaires of previous studies which adopted UTAUT. Thus, the collected data were used for finding out helpful information for promoting the introduction of mobile payment systems. We assume that a solution for supporting the promotion of health management systems is required. In such case, if we modify the question items to be asking about people's attitudes towards health management systems, the data can be collected and used as the input of the system. Certainly, the design of the database also needs to be adjusted according to the features of the collected data.

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