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Abstract
This paper presents an empirical study on the use of a smartcard namely Octopus for micro e-payments in Hong Kong. The Octopus was initially designed to enable several public transport service providers such as subways, railways, buses and ferries to share a common platform for fare collection and settlement. Recently, it has been used to facilitate micro e-payments in selected service sectors. Individual customers can conveniently use a computerized smartcard for purchasing selected goods and services. A customer-oriented investigation suggests that perceived convenience of use, automatic add-value services, security, reliability, perceived ease of use, perceived usefulness and merchant support significantly influence continued use of the Octopus smartcard. Our empirical work provides useful information for developing sustainable smartcards for e-payments in different business environments.

INTRODUCTION

The Octopus smartcard system was initially designed to enable several service providers in the public transport industry to share an integrated platform for fare collection and settlement in Hong Kong. The payment process can be instantly completed when the card is placed on a card reader/writer - an electronic device with an optical sensor. Because the system can be customized in the light of different particular business environments, it has been recently extended to support e-payments in selected retail sectors involving limited value of transactions. This paper examines the sustainability of the Octopus smartcard from a customer perspective by measuring possible concerns associated with its adoption. It begins with hypotheses, followed by the illustration of our research methods for evaluating the impacts of several variables on customers' willingness to continuously use the smartcard. Subsequently, it presents our empirical results and discusses the actual use of the smartcard for micro e-payments in selected service sectors.

HYPOTHESES

The adoption of information technology and information systems has been examined in different business environments. In particular, Technology Acceptance Model (TAM) (Davis 1989) has been extensively used to evaluate the acceptance of computer-based information systems. Being a useful tool to study the usage of new technologies, the TAM has also been extended to evaluate the acceptance of different IT applications. Numerous empirical studies prove that the TAM is capable of explaining user behavior across a broad range of end-user systems (e.g. Szajna 1996; Karahanna and Straub 1999; Anandarajan, Igbaria and Anakwe 2000). TAM can consistently interpret a substantial proportion of the variance in usage intention and behavior and compares favorably with alternative models such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) (Venkatesh 1999; Venkatesh and Davis 2000). Its basic constructs include perceived usefulness and perceived ease of use (Davis, Bagozzi and Warshaw 1989). However, user acceptance may be affected by many factors in different environments in addition to these two dimensions. It is vital to cope with a specific circumstance when evaluating a particular application (Igbaria, Guimaraes and Davis 1995). It might be meaningful to explore whether the flowing aspects affect customers' willingness to continuously use the Octopus smartcard for micro e-payments.

A smartcard should be relatively compact and allow a user to carry it around (Davis and Mitchell 1996). Similar to the size of a credit card, it would be desirable if an Octopus card has a compact design together with a pleasurable outlook. Hence, compact design might be one of the features related to customers' willingness to use the smartcard.

Hypothesis 1   *Compact design will have a positive effect on customers' willingness to use.*

It would be an advantage if a system enables a convenience of use in different commercial environments (Baty and Lee 1995; Torkzadeh and Dhillon 2002). The Octopus network has been recently customized to facilitate e-payment in various environments. A number of merchants have installed Octopus devices for e-payment in various retail sectors. For instance, instead of using coins, a customer can use the card to buy a soft drink from a vending machine. Payment can be immediately completed when a card is placed on top of an Octopus device installed at the vending machine. Similarly, the card can be used to pay a parking fee. It seems that the card can enable one to conveniently settle small amount of transactions. Therefore, we would examine the following:

Hypothesis 2   *Perceived convenience of use for different purposes will have a positive effect on customers'*
                willingness to use.
Hypothesis 3   *The ability to replace other payments will have a positive effect on customers' willingness to*
                use.

The stored value of an Octopus card can be reloaded via the add-value services. When the remaining value of the card bellows a particular value, one can easily use cash to top up the card value at customer service centres and ticketing offices of public transport service providers, 7-Eleven convenience stores and some retail outlets. In addition, one can add value onto a card through Add-Value machines installed in different stations and terminals.

Hypothesis 4   *Add-value services will have a positive effect on customers' willingness to use.*

Previous studies indicate that security is a critical factor to electronic transactions (e.g. Edwards 1996; Lunt 1996; Segev, Porra and Roldan 1998). Perceived security refers to the extent to which one believes that a system is secure for transmitting sensitive information (Salisbury, Pearson, Pearson and Miller 2001). One with a high level of perceived security should have an impact on one's attitude towards a service (Dutta and McCrohan 2002). Particularly, individual customers might perceive a risk when involving private data and expect a stringent security procedure (Rotenberg 1993; Stewart and Segars 2002). In case of the Octopus, a personalized card can be issued to an individual. A personalized card can also be used as an identity card. One can also add value onto the personalized card by authorizing the issuer to debit a particular amount of money from a designated credit card account or a bank account. Hence, customers might be concerned about the personalization of the card and the add-value service.

Hypothesis 5   *Securing personalized data will have a positive effect on customers' willingness to use.*

Being fundamental to service quality, reliability refers to the ability to perform a service dependably and accurately (Parasuraman, Zeithaml and Berry 1988). Usually, users would have greater confidence in a system if it could be reliably operated (Liao and Cheung 2002). Similar to other technology-based services, the use of a smartcard for e-payment should have a considerable risk because it involves financial transactions. In case of the Octopus, it is desirable that no error occurs when the fund is deducted from the card. It is also desirable that the system can operate smoothly without delay or disruption during a payment process.

Hypothesis 6   *Reliability will have a positive effect on customer willingness to use.*

From the supplier's point of view, extra benefits associated with the use of the Octopus may help promote the use of the smartcard. The public transport service providers usually offer a little discount on fare if the Octopus card is used. Many merchants in the service sectors also provide customers with limited incentives if they would use the card for e-payments. It is suspected that the provision of additional incentives can effectively encourage customers to use the smartcard in a more frequent manner.

Hypothesis 7   *Additional incentives will have a positive effect on customer willingness to use.*

The perceived usefulness refers to whether a user believes that the use of a system would be functional and beneficial (Davis 1989). A system with a high degree of perceived usefulness is likely to be used frequently, even though attributes vary depending on individual characteristics associated with the system (Igbaria, Guimaraes and Davis 1995). The use of the Octopus card by individual customers should be explored because it

might fall into behavioral patterns with which individual customers are comfortable.

Hypothesis 8   *Perceived usefulness will have a positive effect on customers' willingness to use.*

Perceived ease of use refers to the degree to which a user believes that the use of a system requires little effort (Davis 1989). It is generally regarded as an attribute associated with computer-based services. It has been empirically proven that perceived ease of use is a major consideration in terms of the acceptance of a new system. For instance, Cooper (1997) finds that ease of adoption as an important characteristic for adoption of innovative service from customer perspective. Daniel (1999) also suggests that the perceived ease of use as one of the factors for customer acceptance in a study of electronic business. In terms of technology-based services, customers might worry about the effort required to carry out a particular operation and the complexity of the process of service delivery (Dabholkar 1996). Hence, user friendliness becomes not only a quality attribute in technology-based services, but also contributes towards user behaviour. System usage is affected by perception of usefulness, which is, in turn, affected by perceived ease of use (Karahanna and Straub 1999). In case of the smartcard, it might directly influence the willingness of customers to use the Octopus. Hence, we would examine the following hypothesis.

Hypothesis 9   *Perceive ease of use will have a positive effect on customers' willingness to use.*

A system would not be effectively adopted if the users had little confidence on the system. In the context of an electronic payment system, customers might wish to use the card if service providers with established reputations had implemented the system to facilitate their services. The implementation of the Octopus system by popular service providers and reputable merchants might encourage customers to use the Octopus card. Therefore, we would explore whether the implementation of the Octopus by popular merchants has an impact on customers' willingness to use.

Hypothesis 10   *The implementation of the Octopus system by popular service providers will have a positive effect on customers' willingness to use.*

RESEARCH METHODS

Our research methods included questionnaire design, data collection and statistical analysis. A questionnaire was designed for collecting data in relation to individual perceptions on the Octopus in different retail and service environments. It also consisted of questions examining the characteristics that might be related to the actual use of Octopus smartcard. Individual respondents were requested to rate their perception based on a seven-point Likert-scale ranging from strongly disagree to strongly agree: 1 (strongly disagree), 2 (disagree), 3 (slightly disagree), 4 (neutral), 5 (slightly agree), 6 (agree), and 7 (strongly agree). Questionnaires were distributed using a simple random sampling technique (Cochran 1977; Hair 2000), which resulted in useful 202 useful responses from individual customers. Several statistical procedures were employed to test the data collected. In particular, multiple linear regression analysis was conducted to test the hypotheses proposed in the previous section. Diagnostic tests were then applied to check the validity of the regression model.

The following regression model is used to explore the impacts of the exogenous variables (x_1 to x_{10}) on the endogenous variable, i.e. customer willingness to continuously use the Octopus card (y).

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \ldots \ldots + \beta_{10} x_{10} + \mu$$

Where, x_1 (Compact design), x_2 (Convenience of use), x_3 (Substitution capacity), x_4 (Add-value services), x_5 (Secure personalized data), x_6 (Reliability), x_7 (Additional incentives), x_8 (Perceived usefulness), x_9 (Perceived ease of use), x_{10} (Merchant support, and μ (error term).

RESULTS

Table 1 shows the results of the regression analysis. Firstly, Model (a) results in ($F = 17.55$, *d.f.* $= 10$, 191, $p < 0.001$, Adjusted $R^2 = 45.16\%$). It suggests that perceived convenience of use, add-value services, secure personalized data, perceived reliability, perceived ease of use, perceived usefulness and merchant support significantly explain the customers' willingness to use the Octopus card. However, such exogenous variables as compact design, substitution and additional incentives cannot significantly explain customers' willingness to use the smartcard. It only has a modest multicolinearity, because the highest value of the variance inflation factor is 2.0150 for one of the exogenous variable - perceived usefulness.

Secondly, we use the same sets of the above-mentioned selection criteria and discover that Model (b) ($F = 25.02$, $d.f. = 7, 194$, $p < 0.001$, Adjusted $R^2 = 45.55\%$) effectively fits the endogenous variable. As shown in Table 1, the value of White Test for Model (a) is 97.69, which is not significant at the 10% level. This result indicates no heteroskedasticity in Model (a). In addition, the value of White Test (White 1980) for Model (b) is 32.77, which is not significant at the 10% level. Moreover, the Durbin-Watson statistic [1.9521 for Model (a) and 1.9544 for Model (b)] and the Breusch-Godfrey statistic (Breusch and Godfrey 1978) [3.0676 for Model (a) and 3.0334 for Model (b)] are not significant at the 10% level, which indicates no serial correlation for both Model (a) and Model (b). Hence, the diagnostic check for residuals suggests that both Model (a) and Model (b) can be used in the explanation of the endogenous variable - customers' willingness to continuously use the Octopus card.

Table 1   Results of Regression Analysis

Exogenous Variable	Model (a)		Model (b)		Findings
	Parameter Estimate	Variance Inflation	Parameter Estimate	Variance Inflation	
(Constant)	1.1337***		1.2183***		
H1: Compact design	0.0299	1.3696			*Not support*
H2: Convenience of use	0.0900*	1.3279	0.0893**	1.3228	Support
H3: Substitution	-0.0119	1.4708			*Not support*
H4: Add-value service	0.0913*	1.4300	0.0861*	1.4147	Support
H5: Secure personalized data	0.0825**	1.4383	0.0903**	1.3329	Support
H6: Perceived reliability	0.1166***	1.1652	0.1115***	1.1401	Support
H7: Additional incentives	0.0179	1.0891			*Not support*
H8: Perceived usefulness	0.1661**	2.0150	0.1757**	1.9619	Support
H9: Perceived ease of use	0.1345**	1.7828	0.1326**	1.6545	Support
H10: Merchant support	0.1814***	1.4203	0.1860***	1.2707	Support
Adjusted R^2	0.4516		0.4555		
Root MSE	0.5210		0.5191		
C(p)	11.00		6.6304		
Durbin Watson test	1.9521		1.9544		
White Test	97.69		32.77		
Breusch-Godfrey test	3.0676		3.0334		
F statistic	17.55***		25.02***		

Note: * $p < 0.1$,   ** $p < 0.05$,   *** $p < 0.01$

Comparing Model (b) with Model (a), the adjusted R^2 increases from 45.16% to 45.55%; the root mean squared error decreases from 0.5210 to 0.5191; and the F-statistics increase 17.55 to 25.02 (Table 1), which suggest that Model (b) is superior to Model (a) as a representation of the customer willingness to use the Octopus card. Actually, Model (b) further confirms that seven of the exogenous variables: perceived convenience (H2), add-value service (H4), secure personalized data (H5), perceived reliability (H6), perceived usefulness (H8), perceived ease of use (H9), and merchant support (H10) considerably explain the customer willingness to use the Octopus card. Therefore, Hypotheses 2, 4, 5, 6, 8, 9 and 10 are supported.

DISCUSSION

The Octopus smartcard has been extensively used in public transport and selected service sectors in Hong Kong. Over nine million Octopus cards issued are used to carry out more than eight million transactions daily, achieving a penetration rate of at least 95% (Octopus 2003). Individuals can purchase an Octopus card at customer service centres in all subway and railway stations. A minimum value of HK$150 is stored electronically in an individual Octopus card when it is issued. A particular amount of the stored value is reliably deducted from an Octopus card when it is placed on top of a card reader installed by a particular service provider. In addition, the Octopus card is reusable and rechargeable.

Subsequently, customers can add value to the card in different service centres when the remaining value falls below a particular level. Actually, a passenger can easily add value onto an Octopus card at a passenger service counter in any subway and train station, 7-Eleven convenience stores and selected designated outlets. In addition, one can add value to the Octopus card at a particular ticket vending machine using cash or Electronic Fund Transfer. A number of Added Value Machines (AVMs) are installed in subway and railway stations. A

pre-purchased card can be topped up at an AVM by inserting a particular amount of cash into the machine. As a stored value smartcard, it must possess sufficient value for a particular payment. The stored value of an Octopus smartcard is presently limited at a maximum of HK$1,000 in order to eliminate the potential risk. Alternatively, if the customer has authorized the transfer of a particular amount of fund to the card from a bank account or credit card number, the personalized Octopus card will be automatically loaded HK$250 if its previously stored value becomes negative. This arrangement provides customers with great convenience. However, because the user number of a personalized Octopus card has been linked to an individual bank account on a continuous basis, such an operation requires the participation of financial institutions. Based on the instructions given by the card owner, a predefined value can be added automatically to a personalized card when it reaches a particular balance.

The Octopus system has been recently adopted by a number of merchants. For instance, the food retail sector is an area where the Octopus has received considerable acceptance, because customers seem to be willing to use the Octopus card at fast food restaurants, coffee shops and dessert houses. Instead of paying by cash, the respondents feel that it is convenient to use the card as a form of payment for fast food, drinks and dessert. The other retail outlets that customers are likely to use the Octopus card include convenience stores and supermarkets. Our survey indicates that the respondents who are willing to use the Octopus card for shopping in convenience stores and supermarkets respectively, because they believe that it is convenient to pay through the Octopus. Therefore, the acceptance of the card could be easily gained. In addition, the credibility of these businesses encourages individuals to use the card. For instance, *Seven-Eleven* dominates the convenience store market, while large groups such as *Park N'Shop* and *Wellcome* basically dominate the supermarkets in Hong Kong. As these merchants with sizable market shares have implemented the Octopus devices in their retail outlets, consumers generally feel confident about the use of the Octopus card in their chain stores.

However, a number of e-payment instruments have been conventionally used in various business environments. For example, credit cards are generally acceptable in most circumstances, while customers are not predisposed to replace credit cards with the Octopus. This is because credit cards are usually used for a relatively large amount of payment. For instance, customers would not use the Octopus card for restaurant payment. They also tend not to use the Octopus for the purchase of relatively expensive items like electronic appliances. Similarly, customers show limited interest in using the Octopus at departmental stores, where one can easily use a credit card for different products. There is a little doubt that credit card is a major rival of the Octopus card, because the credit card allows customers to defer payments for a particular period. In particular, credit cards seem popular in a shopping environment where goods and services are relatively expensive. Therefore, the smartcard would be more competitive if it could substitute other e-payments.

CONCLUDING REMARK

The present work has identified determinants of customers' willingness to use the Octopus smartcard for micro e-payments based on the responses from individual customers. The smartcard is especially useful for the settlement of limited amount of payments selected retail and service sectors, instead of substituting it for other e-payment instruments like credit cards. In terms of the practical use of the Octopus, the availability of add-value services is essential, because it provides a great convenience for those customers who use the card in a frequent manner. Customers are able to automatically top up the stored value of a personalized card through automatic fund transfer from a pre-determined account, since local commercial banks have collaborated with the system developer for fund collection and settlement. As far as this is concerned, it is necessary to secure customer data and to protect individual privacy. Furthermore, the significantly high reliability should motivate customers to continuously use the card. Finally, the adoption of the Octopus by relatively large and reputable service providers should encourage customers to use the smartcard. Our empirical findings should provide useful information for appreciating the key factors of a sustainable smartcard. Future research could be conducted to explore the development and implementation of smartcards in different market environments.

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