The Demand for Stored Value Payment Instruments

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Abstract

Due to their functionality, stored value purses based on smart card technology are prominent candidates for being the dominant medium of exchange for micropayments. However, the overall prospects of these payment systems are yet ambiguous, both from the perspective of practice and monetary theory, because their potential to substitute for cash is still largely unknown. As a contribution to the field, a model is proposed founding the potential utilization of stored value cards in microeconomic calculus. As a result, the model provides insight into the crucial parameters determining usage. Moreover, the model suggests that issuers should maximize demand and profits by offering interest payments or insurance against loss.

1. Introduction

A large number of new payment instruments for conducting electronic commerce have evolved. "Traditional" payment instruments have advanced like e.g. credit cards through SET. Besides, today stored value cards as well as online payment instruments arise, leading way to the latest generation of multi-application smart card schemes. There was some enthusiasm about these solutions that has been quenched lately: usage lags behind expectations. Thus the question arises what factors does usage of new payment instruments depend on or how can the issuer of the payment system push its utilization? This potential is questioned in a microeconomic model.

First, the characteristics of cash and smart cards as offline payment means will be compared according to their transaction costs. The German system *Geldkarte* will be used as a sample scenario. The *Geldkarte* is a prepaid rechargeable electronic purse which is used offline without authentication by PIN (there is a minority of PIN-based cards in circulation). The card may be loaded with a maximum amount of DEM 400 (= EUR 205). There are, roughly, 60 Million cards in circulation, and in August 1999, there were 60,000 terminals for conducting transactions [2]. High card penetration is due to the fact that, with regular card renewal, chips have been added by default. Yet, these numbers do not reflect the low level of activity of card transactions, which is a general problem of all electronic purse schemes, at least in Europe. There have been less than 0.2 transactions per card per month in January 2000 [20, Fig. 6a], and only 2.5% of all cards have been "active" (i.e., used at least once a month) in December 1999 [8]. Although European purse schemes are somewhat incomparable, the *Geldkarte* even falls short in contrast to other purse schemes, considering usage for transactions as well as terminals for accepting transactions [20] – despite the high penetration of cards among the population. Thus, the question arises, why customers not use the card as much as expected.

To address this problem from a theoretical point of view, as a second part, optimal behavior – profit maximization – of three major participants in a payment system will be modeled: Customers, merchants, and issuers. Customers decide whether or not to use the stored value card for a specific transaction. Merchants choose whether to accept cards or to restrict usage by implementing e.g. a minimum transaction value. Issuers maximize their profits by setting fees and, eventually, interest rates on money holdings, which now become technically feasible.

The optimization calculus gives insights to effects of cost-reducing technological advances on the usage, and its dependence of new parameters like interest payments. It particularly allows for the issuer to identify the crucial cost parameters of a payment system and respond to them with profit maximizing fees.

2. Payment Systems and Monetary Theory

The choice of a payment instrument – among several available - for conducting a specific transaction is a relatively new field of research in monetary theory. This is due to the fact that cash has been the prevailing medium of exchange throughout large parts of the twentieth century. Non-cash payments with debit cards, credit cards, and – nowadays – electronic purses have gained neither significant market share nor scientific attention until some decades ago. The first who turned to the question of optimal cash holdings for transactions were BAUMOL (1952) and TOBIN (1956) [3, 19] (in fact, the formulas of the Baumol-Tobin model have been derived from a previous French publication by ALLAIS [1; 6, p. 4]). The basic question they resolve is that individuals minimize costs of using cash by deciding how often to go to the bank and how much cash to withdraw from the checking account. Their idea was that there is a trade-off between the costs of converting personal savings to cash and the opportunity costs of holding cash because of foregone interest earnings. Besides several extensions, the Baumol-Tobin model was deployed as the single model explaining cash holdings, and it was revised not until WHITESELL (1992) proposed a model explaining the choice of one of the payment instruments cash, checks, or credit cards [22].

In this basic model (see figure 1), each of the payment instruments has different transaction costs and opportunity costs, depending on the respective transaction amount, and thus the choice of a payment medium solely depends on the size of a transaction. Credit card costs are simply normalized to unity, i.e., a credit card transaction costs one unit (all other transaction costs are measured in terms of this), and as the credit card account bears interest, there are no opportunity costs. Check costs are given by fees and opportunity costs of foregone interest earnings (the check deposit account is assumed to pay less interest than the market rate). Cash costs are fixed costs of handling cash as well as foregone interest. Cash handling costs are high for large transaction amounts because of the danger of loss or robbery. With smaller values, cash handling costs decline because convenience of time saving exceeds the inconvenience costs of writing a check. Note that, with the illustration in figure 1, costs of cash transactions decrease with higher transaction numbers meaning decreasing costs with lower volumes.

Customers will minimize transaction costs by choosing the payment instrument offering lowest total costs as given in figure 1, resulting in cash for low values, checks for medium values, and credit cards for high values.

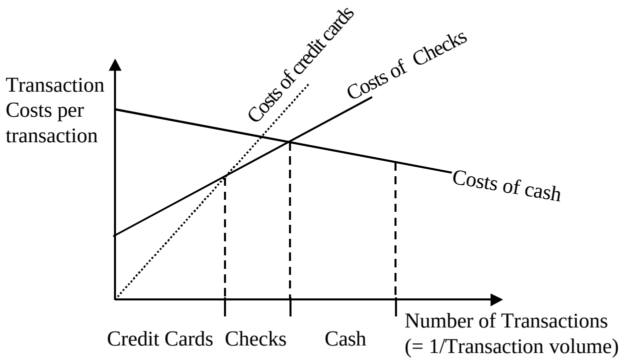

Figure 1: Utilization of different payment systems according to the Whitesell model [22]

Within the Whitesell model, the number of transactions is the reciprocal value of transaction size because, as an assumption, for each period under observation, the amount spent on each goods basket, and the number of transactions to purchase the entire basket, are assumed to be constant. In other words, if there are i good baskets with Y_i as constant spending per i during the period, and v_i the size of each transaction, than there are $n_i = Y_i / v_i$ transactions per period per goods basket.

The purpose of the model is to show, besides optimal behavior by customers as in figure 1, how issuers of checking accounts may maximize profits. They will set check fees and spread, i.e. the difference between market and deposit interest rates in an optimal way. Thus, issuers control for which transaction sizes customers will select check payments. This strong correlation between transaction amount and the choice of a payment instrument, with each payment instrument occupying a certain "range" of transaction sizes, is fundamental to all subsequent models, and there seems to be empirical evidence for such market segmentation according to transaction volumes in aggregate [4]. All models aim for an evaluation of cost curves and, subsequently, of the utilization range of a specific payment instrument.

The introduction of smart card technology brought forth several extensions to the Whitesell model.[1] KABELAC utilizes the Whitesell model to explain the potential penetration of „online" money [9]. SHY / TARKKA propose a model reflecting decisions of several participants in a payment system: customers, merchants,

[1] Besides the "cash-in-advance" models mentioned here, where individuals decide at the beginning of each period how to distribute their assets on different payment systems, "inventory" models like the original Baumol-Tobin model have been improved as well, where individuals also decide about converting assets to cash (their "trips to the bank") within the period; [17] is the most recent. However, the reduced analytical complexity of the former permits a better reflection of the interdependence between costs and utilization of a payment system.

and issuers [18]. Thus, the fact that transaction costs of a payment instrument incur at different levels throughout the economy is reflected. FOLKERTSMA / HEBBINK include chip cards to the analysis which enable micro-payments [6]. Thus, a new cost curve may be drawn for stored value cards raising the question of this curve's position and thus the payment range where stored value payments are optimal (see figure 2).

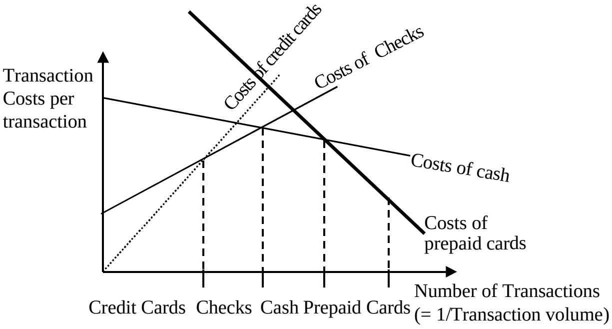

Figure 2: Utilization of payment systems after the introduction of prepaid cards[2]

With all models, the frontier separating stored value card from cash payments is explored. Following, we will as well focus on this single frontier between stored value cards for micropayments and cash, ignoring other means of payment. Common to all the theoretical approaches cited above is the „policy view". That is, the authors address the question of potential market penetration of a payment system in order to identify potential market failures (note that the three recent models have been proposed as working papers by European central banks). Thus, eventual counter measures by central banks can be evaluated. However, as this paper suggests, microeconomic theory can also be utilized in order to optimize strategy. That is, issuers of payment systems might turn to the microeconomic fundamentals of the choice of a payment system by customers in order to response to their behavior with optimal strategies. Issuers can identify the underlying variables defining the potential market space for stored value card based payment systems, and thus they can design their systems in a way to maximize profits.

[2] See [6, p. 19]. Note that the cost curve for prepaid cards differs from the original. This is due to the fact that the authors assume higher per-transaction costs for the prepaid cards because of inconveniences of entering a PIN, resulting in a less steep slope of the curve. However, we focus on a rather convenient electronic purse without this necessity.

3. The Basic Model

In this section, the basic model for payment instrument choice proposed by SHY / TARKKA [18] will be illustrated, reflecting the determinants of the participant's decisions. Extensions to the original model are marked in table 1. Additional services, interest payments and insurance, are modeled in section 4.

3.1. Cost comparison of Payment Systems

Payment systems have many different characteristics. E.g., WINN [23] analyzes different payment systems according to their liquidity, finality of payment, transactional risks, and systemic risks (systemic risk refers to the risk that the failure of one participant in a payment system, e.g. a bank unable to fulfil liabilities in time, may have unforeseen consequences for other participants, e.g. the payee himself being unable to cover his own liabilities). Partly, these are hard to measure. Liquidity, for instance, depends not only on the specific set up of a payment instrument, but also on its acceptance. Security risks may be even harder to compare: SET is based on a completely different security architecture and institutional surroundings than the German electronic purse system *Geldkarte*. How to calculate the risk of successful attacks on tamper resistant hardware or the breach of a digital signature?

However, there are some arguments in favor of comparing different payment systems. On the one hand, acceptance problems, or – more generally – network problems of payment systems are an issue that affects all payment instruments in nearly the same way (except for cash as legal tender). Thus, in order to compare the *specific* characteristics of payment systems, this may be neglected. Of course network problems, i.e. the problem of reaching a critical mass of users, are a very important issue in the market penetration of new payment systems. However, this issue is not addressed here. It will be focused on a „steady state" analysis, assuming the analyzed payment systems are already widely accepted. Network issues, applied to payment systems, are – in general – discussed in [5] and [10]. Recent studies include [12] and [7].

On the other hand, some research is under way to compare security risks of payment systems, according to the criteria of "Multilateral Security", a set of standardized criteria to evaluate security hazards (for security comparison of payment systems see [15] and [16]. For the concept of multilateral security see [11]).

Thus, different payment systems – cash and stored value cards – are going to be compared according to their transaction costs, their associated opportunity costs of foregone interest earnings, and their (transactional) risks, referred to with probabilities of loss; other characteristics will be ignored (another model focusing on security levels of different payment systems and explaining payment instrument choice depending on - rudimental – cost parameters is proposed in [14]).

Costs include monetary costs as well as non-monetary costs like inconvenience of usage. The costs of using a payment system can be categorized as follows: There are fixed costs, e.g. costs of handling cash registers or annual fees, variable costs on a per-transaction basis, e.g. time and effort for writing a check, and variable transaction costs on the basis of the amount of the transaction, e.g. percentile fees or the probability of loss of the transaction amount. Different payment systems represent different sets of transaction costs for the participants in a payment system - customers, merchants, and issuers – and thus may be directly compared.

Table 1: Cost Comparison of Cash and stored value cards

	Cash	Stored value card
Customer		
Fixed costs	F^{C}_{Cash} (*): cash handling costs exceeding card costs	$f^{0}_{SC,C}$ (*): annual fees
Variable costs per transaction	V^{C}: time and effort exceeding card costs	
Variable costs per amount	$(l + vi)\,p$: risk of loss, opportunity costs	$(l + m_{SC} + vi)\,p$: risk of loss, risk μ of mal-function/security, opportunity costs
Merchants		
Fixed costs	F^{M}_{Cash} (*): costs for handling cash registers etc exceeding card costs	$f^{0}_{SC,M}$: fees including leasing rates for terminals, etc
Variable costs per transaction	V^{M}: time and effort exceeding card costs	f^{1}: per transaction fees
Variable costs per amount	$(l + i)\,p$: risk of loss or theft of cash, opportunity costs	$(f^{2} + m_{SC} + i)\,p$: fee, malfunction/security risk μ (*), opportunity cost
Issuer		
Fixed costs	F^{IS}_{Cash} : fixed costs for offering cash services	$F^{IS}_{SC,C} + F^{IS}_{SC,M}$: costs for distributing devices, connecting merchants
Variable costs per transaction		V^{IS} (*): clearing and settlement costs
Variable costs per amount		
Revenues		$f^{0}_{SC,C} + f^{0}_{SC,M}$: fee earnings per period f^{1}: fee earnings per transaction $(f^{2} + i(v + 1))\,p$: fee earnings, float income (*)

(*) parameters added to the original model

Costs the customer faces:

With cash, the customer faces fixed costs because he must carry a wallet for coin storage, be prepared to protect his currency, etc (these fixed costs are those exceeding the fixed costs of carrying a stored value card, see below). For each transaction, he invests time and effort for handling cash. These costs are not monetary values, but rather inconveniences the customer must take into consideration. Also, he faces a certain risk of loss or theft of cash, i.e. there is a chance l that he looses the total transaction amount. Finally, for each day v he holds cash in his purse, he looses interest payments ip he would otherwise receive from his checking account (i.e., *i*: interest rate per day; *v*: average number of days of money holding; *p*: transaction volume; see table 1 for a survey of all variables deployed).

With a stored value card, the non-monetary costs of handling cash are reduced to negligible amounts, thus fixed and variable costs are set to zero, except for eventual fees. The stored value card's opportunity costs are equal to those with cash. Finally, the customer faces loss risks with a stored value card as well. The card may be lost or stolen (as the German *Geldkarte* is not password protected, the balance on the card may be lost just like cash). This risk is assumed to be the same as with cash, and thus it is referred to with l (it may be argued that l's differ because loss of the card results in loss of total value while, with cash, loss of partial value - like dropping a coin - is possible; however, for analytical simplicity, this is not accounted for). There is even an additional risk m of loss because the card may malfunction and loss may occur due to technical failures (e.g., chip breaking due to card bending, see [21]). The parameter m also reflects increased security risks due to the fact that breaking the security mechanism of the *Geldkarte*, tamper resistance, imposes a global threat to the whole payment system. This threat exceeds the threat of forging banknotes, as a "hacked" card may be used for several transactions, other than a banknote. This risk must be accounted for by customers calculus (for simplicity of the model, the risk of maximum loss is assumed to be the total transaction amount).

Costs the merchant faces:

The merchant basically faces the same "physical" costs with cash as the customer: He must maintain cash registers, invest time to exchange currency, etc. However, since merchants usually return cash daily to their bank, their opportunity costs of foregone interest are lower.

With stored value cards, merchants reduce their non-monetary costs to negligible amounts. However, they are now confronted with several fees. As SHY / TARKKA [18] point out, fees for card usage usually are raised from the merchant, and customers are subsidized because banks want to cross-sell other products to their customers. It is assumed that loss or theft of the merchant's card reader does not result in loss of money, therefore l is set to zero. There may be the risk of malfunction of the device or acceptance of a forged card, though, which is again reflected by m, in addition to the original model.

Costs the issuer faces:

With cash, banks must maintain a largely fixed cost based network of points of cash acceptance, like branches, ATMs, etc., and facilities for handling banknotes and currency.

With a stored value card payment instrument, banks extend their electronic network to merchants and customers (which generates fixed costs). While cash handling takes place mostly at the branch, for card based payments a clearing must occur within the network. As the German system *Geldkarte* does not account for a pooling of transactions, transaction clearing is done separately for every single transaction, imposing significant variable transaction costs on the issuer (this is due to security concerns, see [13]). These variable costs are added to the original model.

Besides this, the issuer who voluntarily decides whether or not to invest in a stored value card payment system, obtains revenues from fees he can collect from customers and merchants. Fees may be imposed as fixed fees per period, variable fees per transaction, and variable fees on basis of the amount of the transaction. Besides, the issuer receives interest income from the float, i.e. the average balance outstanding on cards in circulation, which also has not been accounted for in the original model.

3.2. Profit maximization of participants within the basic model

Let's assume that the participants in the smart card based payment system have already invested in the technology, i.e. issuers provide the service, merchants accept electronic payments, and customers hold stored value cards. Thus, only variable costs affect the decision which payment instrument will be used in a specific transaction. This is obviously a very critical assumption. However, the purpose of this paper is to analyze the "final" steady-state of stored value card usage, i.e. the total potential market penetration, in order to circumstantiate their business case with microeconomic calculus.

Customers will use the stored value card device when total costs are lower than using cash, i.e. if. $V^C + (l + vi)\,p > (l + m + vi)\,p$. Thus, the price range for which customers whish to use smart cards is defined by equation (1a):

$$\text{(1a)} \qquad p < \frac{V^C}{m}$$

For all transactions with volumes higher than this, customers will prefer to use cash. In reality, the average transaction amount for *Geldkarte* transactions was DEM 7 (= EUR 3,60) as of December 1999 [8], while data about the variance of amounts was not available.

Merchants will accept stored value card payments if their (variable) transaction costs are lower than transaction costs with cash, i.e. if $V^M + (l + i)\, p > f^1 + (m + i + f^2)\, p$ or in the price range of

$$\text{(2a)} \qquad p < \frac{V^M - f^1}{m - l + f^2} .$$

Without fees and under the assumption that the card itself gets rather stolen than hacked, i.e. $l > m$, merchants will prefer stored value card payments for any amount p. Since the decision depends on fees, issuers control acceptance of the payment system; however, as we will see, condition (2a) will hold for all calculated fee settings. In reality, we see many merchants not accepting stored value cards contrary to the model. On the one hand, this may be due to network issues or fixed costs which have not been accounted for. These effects will subside as market penetration rises on the way to the "steady state" and issuers offer valuable leasing services for terminals. On the other hand, however, missing acceptance of card payments may be an indicator that cash handling by merchants is highly efficient yet. Thus, with low cash handling costs V^M, micropayment schemes will not succeed because they offer no comparative advantage to merchants. Issuers would have to lower their per transaction fee f^1 and thus subsidize their card product in order to capture market share – note that in reality, f^1 is already set to zero.

Issuers will not restrict stored value card payments to certain amounts as long as they make profits, i.e. if their fee and float income exceeds the variable costs for transaction clearing:

$$\text{(3a)} \qquad f^1 + p(f^2 + i(v+1)) > V^{IS}$$

Since income increases with higher transaction volumes, issuers will not restrict usage to maximum transaction amounts. As stored value card payment systems are, in general, designed to be micropayment systems, (3a) should hold for any amount, and thus there are no minimum restrictions as well. Otherwise, issuers would not have invested in the technology and would just offer to accept cash payments. Issuers will want to maximize their profits by setting optimal fees. However, fee setting depends on the market structure: In a perfectly competitive market, all fees will drop down to costs, whereas in a monopoly case, the issuer can try to extract all the surplus of customers and merchants.

Competitive Market:

If fees just cover costs, there will be $f^1 = V^{IS}$ and $f^2 = - i\,(v+1)$. Thus, merchants will actually receive refunds for attracting transactions, because issuers redistribute their float income. Assuming that the issuers clearing costs imposed as fee on the merchant are less than the merchants cash handling costs, i.e. $V^M > V^{IS}$, merchants will still prefer electronic purse payments as can be seen from (2a). Since equation (1a) is unchanged, the price range for micropayments with stored value cards remains unchanged.

Monopoly:

A monopolistic issuer will extract the entire merchant surplus by setting fees $f^1 = V^M$ and $f^2 = l - m$. Thus, merchants become indifferent between both payment systems. Since issuers operate profitable by the assumption $V^M > V^{IS}$ above (thus, the revenues of $f^1 + (f^2 + i\,(v+1))\, p = V^M + (l - m + i\,(v+1))\, p$ exceed the costs of V^{IS}), equation (1a), again, determines usage range.

In reality, for the *Geldkarte* $f^1 = 0$, and $f^2 = 0.3\%$ (at least DEM 0.02). There are also some fixed fees for customers differing from bank to bank, averaging around DEM 10 per year [2]. Additional revenues arise from card loading costing DEM 0.15 – 0.60 per loading incident [2] (neither this is nor cash withdrawal costs are accounted for as of the cash-in-advance model setting). Float was USD 70.8 million in August 1999 [2]. Thus, with either scenario, without a per-transaction fee, pricing is not optimal. However, this may be due to the fact that issuers still need to encourage merchants to invest in the payment scheme (see above).

As a result, independent of the market structure, customers will define the range for usage of stored value cards (given in equation 1a) within this slightly modified model, just as proposed by SHY / TARKKA [18].

4. Special analyses

4.1. Interest Payments

An issuer wanting to facilitate usage of a stored value card payment instrument could decide to pay interest on outstanding balances, which should be feasible with today's technology. The consequences will be discussed within the model proposed: A user would receive an extra amount of vi^*p (i.e., i^*: daily interest rate paid on outstanding card balances); the issuer's costs would increase by that amount. Paying interest would also increase the issuer's processing costs. This effect – an increase in V^{IS} - is not explicitly modeled here. The preferred usage range by customers now increases to

(1b) $$p < \frac{V^C}{m - vi*}$$

For $i \geq i*$, (3a) still holds, and issuers will provide services for all transaction amounts. Considering additional processing costs for interest payments, small transactions may turn not to be profitable anymore. However, as interest payments increase utilization (equation 1b), and issuer's revenues increase with utilization (equation 3a), the issuer should still have incentives not to restrict to interest payments; yet, without parameter estimations, this cannot be further investigated. Thus, since this does not influence the third participating party, merchants, the usage of stored value cards would increase if interest payments were offered. However, issuers still need to operate profitable. Therefore, their fee calculation should be modeled as well.

In case of the *competitive market*, $f^2 = vi^* - i\,(v+1)$ results. Thus, issuers just redistribute merchant surplus to customers. Merchants will still accept payments because (2a) still holds for any p.

Since the merchant receives no additional surplus from interest payments to customers, *monopolistic issuers* could not extract any additional revenue and thus will not change fees whether or not interest payments are being paid. The issuer still operates profitable, as revenues of $V^M + (l - m + i\,(v+1))\,p$ exceed costs of $V^{IS} + vi^*p$ (this holds under the assumption $V^M > V^{IS}$ above), but he now faces the trade-off between increased costs due to raised paid interest rates and increased fee income due to higher utilization of stored value cards. The optimum interest rate the issuer should pay is given by ($\overline{p}$ given by equation 1b):

$$\underset{i*}{Max}p = \int_0^{\overline{p}} V^M - V^{IS} + p\left(l - m + i(v+1) - vi*\right)$$

As long as the issuer operates profitable on the entire range of payment values (see above), the optimal rate of interest paid to customers is going to be the market rate (the integral – positive on the entire range – is maximized by maximizing $\overline{p}$, which is achieved by setting $i^* = i$).

Thus, interest payments could encourage usage of stored value cards. Opportunity costs of holding positive balances on a card are reduced because they bear interest. Customers' desires to use electronic purses are just bounded by potential security hazards which rise as the balance on the card rises. In this model, issuers could pay any interest rate up to the market rate and thus facilitate usage easily without encountering losses. Paying the market rate would yield maximum usage of the service and maximum profits to the issuer. This results from the idea that issuers can compensate reduced float income with higher fees from merchants. In reality this may not be the case because some merchants exert market power as well (again, network problems arise which are not encountered here: Merchants will decide whether or not to invest in the smart card system at all). For instance, as Kabelac [9] shows for online payment systems, issuers of online money, whose main source of income is float, will set interest payments well below the market rate in order not to encounter losses. Thus, the optimal rate of interest payments crucially depends on the ability of the issuer to raise fees from merchants.

4.2. Insurance against loss

Another possibility for an issuer to encourage usage of new payment instruments is covering potential losses by merchants and customers due to loss or fraud. For instance, it is common to credit card payment schemes that customers bear fraud risks only up to a specific amount, and merchants bear no risks at all as long as they comply with security requirements. For electronic purse systems, issuers could offer insurance services as well. This would affect payment instrument choice in the following way:

The potential loss for customers would drop from $(l + m)\,p$ to $(l + m)\,x_c$, for merchants it would drop from to mp to mx_m. For instance, merchants face no fraud risks in today's credit card industry as long as they comply with security requirements, e.g. authentication of customers, i.e. $x_m = 0$. The issuer's costs would increase by $l\,(p - x_c) + m\,(2p - x_c - x_m)$. Processing costs for the insurance service are not explicitly modeled here. However, their influence on the result – an increase in V^{IS} - is less crucial than in the previous section.

The incentives for customers to use stored value cards are now enhanced, because the opportunity costs of loss or fraud are reduced. Stored value cards may even be preferred for any transaction amount, if customer's maximum risk is

(1c) $$x_c < \frac{V^C}{l + m}$$

However, it should be analyzed whether issuers can afford this generous insurance service. Increased costs may lead issuers to require maximum amounts for payments or money holdings on the card in order to reduce loss and fraud risks. Issuers will now provide services if revenues exceed costs, i.e.

$$\text{(3c)} \quad f^1 + p(f^2 + i(v+1)) > V^{IS} + l(p - x_c) + m(2p - x_c - x_m)$$

In case of a *competitive market*, fees will just rise up to costs, and surplus will be redistributed. The result would be $f^1 = V^{IS} + lx_c + m(x_c + x_m)$ and $f^2 = l + 2m - i(v+1)$. A *monopolistic issuer* will, in order to extract entire surplus, set his fees $f^1 = V^M - mx_m$ and $f^2 = l$. From (3c) now follows

$$\text{(4)} \quad p < \frac{V^M - V^{IS} + x_c(l + m)}{2m - i(v+1)}$$

The equity ration of merchants does not influence the market structure, because in this model merchant surplus will be completely extracted by fees, and the distribution of security risks between issuer and merchant will not change. From (4) it can be concluded, that the issuer will accept higher transaction volumes the more risk customers take. As the maximum amount of risk customers are willing to accept without reducing usage of the stored value card, is defined by (1c), the issuer will set the equity ration of customers just as high, and in order to operate profitable, he will restrict the maximum transaction amount to

$$\text{(5)} \quad p < \frac{V^M + V^C - V^{IS}}{2m - i(v+1)}$$

Maximum accepted payment defined by (5) is higher than that defined by (1a), the more sophisticated payment systems get, i.e. with lower costs and risks, insurance services will facilitate usage of the electronic purse system. Thus, with a stored value card payment system with relatively low variable costs, the issuer will be able to offer attractive insurance services where customers need to bear less risk than they are ready to take.

With insurance, all loss and fraud risks remain with the issuer. Because the costs of insuring the other participants in the payment system depress the issuer's profits, he will restrict usage of the system to small amounts, thus exposing himself to less risk. Therefore, should an issuer rather offer a payment system with high functionality and security (low risk m) or with a generous insurance service (low equity ration x_c)? Let's assume the issuer of an existing payment system could either upgrade the security or introduce insurance. Upgrading security results in higher costs for the issuer, but in increased utilization as well. As can be seen from (3a), without insurance services, the issuer's profits increase with higher transaction amounts (profits depend on p), because of fee income and float. Maximum transaction amount is restricted by customer's preference. Marginal profits are positive. With insurance services, the issuers costs increase with higher transaction volumes (costs depend on p) because of the risk the issuer is exposed to (see (3c)). Because of that, restrictions from the issuer will apply. Thus, utilization increases, but marginal profits decline.

In conclusion, as long as the costs of investing in higher security are low enough not to change the overall calculus of the issuer, i.e. $V^M > V^{IS}$ remains, the investment in new technology should rather pay out than a costly insurance service. However, as fixed costs have not been included, an attractive insurance service may yet be an interesting alternative approach to enhancing usage of stored value card systems.

5. Conclusion and Outlook

It has been shown within the model proposed that the utilization of stored value card payment instruments crucially depends on their specific security risks, as well as the *opportunity costs* of using cash as a medium of exchange. An issuer of a stored value card payment scheme may operate with profits, if he is able to collect revenues from merchants. He could raise profits and facilitate usage of the card if he offers interest payments on outstanding balances and insurance services against loss or fraud. However, while utilization of stored value payment systems depends on *customer's* costs for cash handling, issuer's profits depend on fee collection which is dependent on *merchant's* cash handling costs. Thus, for both groups opportunity costs must be reduced in order to facilitate usage of a micropayment scheme.

There are two important fields for further research:

5.1. The special case of online payment systems

Online payment systems like E-Cash may be considered within the model as well. With E-Cash, basically, the risk of physical loss or theft of coins, l, is eliminated (for instance, a hard drive crash does not lead to loss of E-Cash coins as they are protected by recovery mechanisms). However, risks of hacking E-Cash coins, m, may increase as they are, to-date, just software protected (without a secure hardware device, attacks by Trojan horses etc. are possible; for scenarios of this see [21]). Also, it may be assumed that the average number of days of holding E-Cash balances, v, will be reduced, because coins may be generated and used nearly instantaneously. E-Cash also introduces new cost parameters, as the creation of coins is time consuming for customers, which results in variable costs. Also, as the issuer must prepare for coin double spending detection, and other security measures, he faces significant per transaction costs. In addition, customers face increase fixed costs for more sophisticated card readers.

These parameters may simply be added to the model. Yet, as cash payments are not possible on the Internet, online payment systems must be compared to each other. Then, however, the comparative advantages of each payment instrument in comparison to others must be accurately evaluated. For instance, the inconveniences of E-Cash opposed to SET are harder to detect than those of stored value cards opposed to cash. This is an area of further empirical research.

5.2. Fixed costs, network issues and the role of merchants

So far, fixed costs have been excluded from the analysis. It may be argued that per-transaction cost savings of using a stored value card micropayment scheme easily exceed fixed costs of installing the system [18]. Yet, this is not satisfactory. Including fixed costs to the analysis, however, requires further insights about the utilization of the new payment instruments. In respect thereof, theory faces the same chicken-and-egg problem as practice, because as stored value card payment systems have not gained substantial market share yet, empirical studies will not produce significant results. As in Germany, where the diffusion of the *Geldkarte* with customers is already high enough, problems seem to occur rather with merchants who are still unwilling to accept cards on a broad basis, thus yielding low activity levels of the card. This should be further investigated.

In conclusion, as the choice of a payment instrument is a complex decision, issuers of a payment system should carefully design their systems, calculate their business case, and set their fees. Transaction costs *and* opportunity costs of both *customers* and *merchants* must be reduced in order to facilitate usage of a new payment system. Interest payments and attractive insurance services for balances held on stored value cards may be one way to do so.

6. References

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