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A TRANSACTION COST ANALYSIS OF MICROPAYMENTS IN MOBILE COMMERCE

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Abstract: *Personalised, location-related and differentiated services in the mobile digital economy create a demand for suitable pricing models. In the case of disaggregated "microservices" (e.g., small digitalized information or service units), as well as for the acquisition of low-value physical goods, the deployment of micropayments seems appropriate.*

This paper analyzes the economic efficiency of marginal transaction amounts in the m-commerce area by applying the theoretical approach of transaction cost economics. For this purpose, a separation of technical and cognitive transaction costs is applied. The influence of selected determinants such as specifity, uncertainty and bounded rationality on transaction costs in mobile commerce micropayments is analyzed. The result is a more likely application of micropayments for physical goods such as beverages or parking tickets than for digital goods and services, given the theoretical assumptions of the model. In addition, indicators for a significant above-zero lower limit of transaction amounts in mobile commerce are presented.

Keywords: *m-commerce, micropayments, m-payment, microservices, mental transaction costs.*

1. INTRODUCTION

By supplying location-related, differentiated and individualised value-added services, the economic potential of wireless telecommunications networks is utilized. One possible application is using mobile devices for payment ("M-Payment"). The purchase of low-value physical goods (beverage can at vending machine, parking ticket etc.) as well as the supply of digital (information) goods and services require the possibility of transmitting small transaction amounts (*micropayments*). This particularly applies in the case of personalised, specific and commonly used "microservices" in the age of ubiquitous computing: "*In this world, we are in an almost constant conversation with the provider*" [2].

The purpose of the following theoretical analysis is to contribute to the discussion surrounding "per-use" pricing models and micropayment schemes in particular. One question especially will be emphasized: Is an almost infinite reduction of transaction

amounts in the case of increasingly disaggregated digital goods in m-commerce – though technically possible – realistic from an economic point of view?

2. MICROPAYMENTS AND THEIR IMPLICATIONS

In recent research, one can find a multitude of different definitions of suitable ranges for micropayments [13; 5; 14]. For the purposes of this analysis, micropayments are defined as electronic payments that do not exceed 1 €. As it will be pointed out during the course of this analysis, the upper limit of micropayments will be of subordinate importance, whereas the successive approaching of the lower limit zero implies a *discretionary divisibility of transaction amounts* [13]. This raises the question of the efficiency of very low payment amounts regarding transaction cost economics.

Even years ago, micropayments were assumed to play an outstanding role in the Internet Economy [8] – e.g., for the financing of digital contents (by paying a marginal amount for accessing a website). But these forecasts did not prove true – despite available technological basics and a multitude of existing micropayment systems (MicroMint, Millicent, SubScrip etc.). Various arguments are being cited as possible reasons, e.g. lacking standardisation on the side of the suppliers, negative preferences of customers regarding per-use pricing schemes, the attractiveness of alternative models, such as aggregation ("flat fee" etc.) or subsidisation by advertising, as well as *web culture* [5; 3; 9; 1].

In addition, suppliers of micropayment systems face two fundamental conflicts of incentives [13; 5]. Firstly, there is a collision of minimal transaction costs (because of the small transaction amounts in question) and security requirements. Security is connected with technical transaction costs, such as data transmission costs for authenticating transaction parties or computation costs for encrypting and decrypting. Secondly, there is a conflict between minimisation of transaction costs on the one hand and maximisation of profits on the other. This conflict arises from the very nature of *transaction fees*, which are the main source of micropayment suppliers' profits as well as part of the to-be-minimized transaction costs.

3. FROM E- TO M-COMMERCE

The term e-commerce during this paper describes the *carrying out of transactions via electronic networks by using a wired access*, while m-commerce is defined as "*… any transaction with a monetary value that is conducted via a mobile telecommunications network*" [7].

The transition dynamics from e- to m-commerce are demonstrated by introducing *mobility attributes* [7; 14]:

- *Ubiquity:* Users are enabled to access information and services independent of their current location and in real-time by deploying mobile and wireless devices.

- *Reachability:* By the entrainment of mobile devices (cellphones, smartphones etc.) that are permanently in "standby" mode, an increased level of reachability compared to "classical" e-commerce is realized. In addition, with 2.5G and 3G mobile networks (GPRS or UMTS respectively), users are permanently connected to the Mobile Internet ("instant connectivity").

- *Security*: The *standardized* integration of SIM cards in mobile phones increases security in terms of identification and authentication of transaction partners. For

m-commerce suppliers, this increases the security concerning customers' credit history. Despite the relatively secure transaction environment compared to e-commerce, there are also new security threats which mobile commerce has to face (e.g., "man in the middle" attacks on ad hoc networks) [4; 16].

- *Convenience:* The simple, often intuitive usability of mobile devices contributes to a higher penetration compared to e-commerce devices (personal computers at large).
- *Personalisation:* Mobile phones, notebooks and other mobile devices can be assigned to a single user more clearly than in e-commerce, where often several users share one device. This increases the possibilities of delivering *personalised goods and services* in m-commerce.
- *Localisation / Location-Reference:* GPS, other localisation methods as well as the participation in mobile networks with relatively low reach (e.g., Bluetooth or Wireless LAN) provide the opportunity to deliver location-related goods and services to end customers ("location-based services" etc.). While the importance of the user's physical location disappeared in e-commerce, wireless mobile networks renew the economic relevance of location.

By applying these mobility attributes, terms that are widely used in the m-commerce context, such as "value-added services" and "product differentiation", can be separately defined. Both are enabled by the "mobility dimensions" *ubiquity, personalisation, security* and *localisation*. In this context, *product differentiation* is the result of skimming different willingnesses-to-pay in the vast majority of consumers. *Value-add*, on the other hand, exploits the increased willingness-to-pay of particular customer segments.

Furthermore, different categories of m-commerce services can be defined with mobility attributes. This includes *location-based services* (enabled by *localisation / location-reference*), *situation-based services* (*location-reference* and *personalisation*) and *person-based services* (*personalisation*) [6; 12].

After having highlighted the particular characteristics of micropayments as well as the differences between e- and m-commerce, the foundation for the following transaction cost analysis has been laid.

4. TRANSACTION COST ANALYSIS OF MICROPAYMENTS

4.1. TRANSACTION COST TYPES REGARDING MICROPAYMENTS

The costs for conducting a micropayment transaction in the m-commerce area can be split up into *technical* and *mental* (= *cognitive*) transaction costs (adapted from [15]):

$$C_{TA} = C_{Tech} + C_{Cog} \quad (1)$$

Technical transaction costs include costs for communication, computing and data storage (C_{IT}). These costs largely emerge on the supply side. In addition, the demand side is confronted with the expenditure of time and fees for arranging the payment of small amounts (which may as well occur on the supply side):

$$C_{Tech} = C_{IT} + C_{Time} + C_{Fees} \quad (2)$$

with:

$$C_{IT} = C_{Computation} + C_{Transmission} + C_{Storage} \quad (3)$$

On the other hand, *mental* transaction costs (C_{Cog}) exist which cannot be quantified the way *technical* transaction costs can. Every buying decision is implicitly connected to a cost-benefit analysis which the consumer has to undertake. C_{Cog} represents the mental efforts connected to this implicit cost-benefit analysis. These cognitive transaction costs occur with every single transaction when per-use pricing schemes are applied. In some publications, they are also referred to as a "hassle factor" [3]. All transaction cost components have to be minimized while successively approaching the definitive lower boundary of transaction amounts (zero) when applying micropayments. This process is shown in figure 1.

Starting from the assumption of an almost unlimited reduction of technical transaction costs (enabled by continuous performance improvements of CPUs ($C_{Computation} \rightarrow 0$), transmission technologies ($C_{Transmission} \rightarrow 0$) and storage media ($C_{Storage} \rightarrow 0$)) which enables a proportional reduction of transaction fees ($C_{Fees} \rightarrow 0$) and time expenditures ($C_{Time} \rightarrow 0$), this poses the question of whether there are similar potentials for reducing cognitive transaction costs ($C_{Cog} \rightarrow 0$?). SZABO [15] argues with regard to the e-commerce area that mental transaction costs constitute the definitive lower price limit for micropayments significantly *above* several cents or even fractions of cents. The reason for this phenomenon

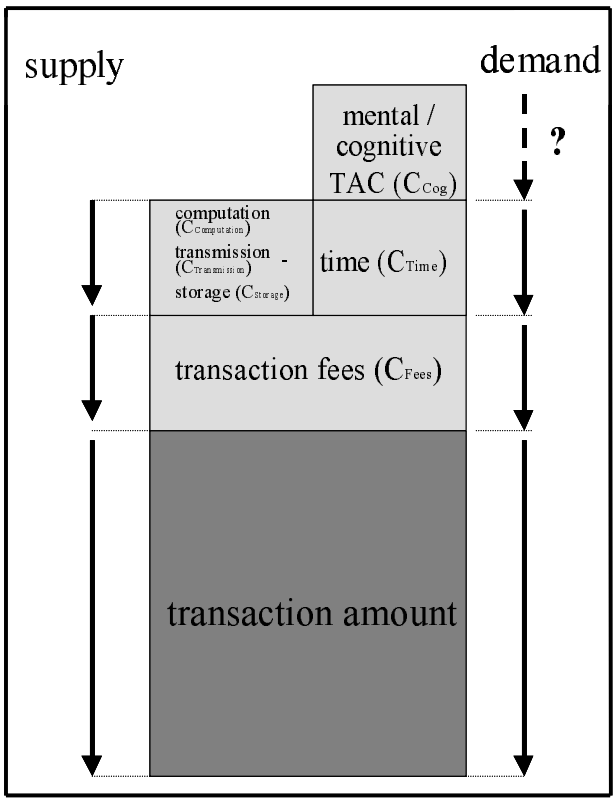

Figure 1: Successive reduction of transaction cost components

is, according to SZABO, the view of the human brain as *the* ultimatively limited ressource which accounts for significant and ubiquitous mental transaction costs.

These mental costs cannot keep up with the reduction of the aforementioned technical transaction costs and therefore become the crucial cost factor during the successive decline of transaction amounts. Based on this reasoning, the next step will be the analysis of selected factors of transaction costs [11] which have to be applied to the special case of cognitive transaction costs of micropayments in the m-commerce area.

4.2. DETERMINANTS OF TRANSACTION COSTS

4.2.1. Specifity

The **specifity** of a transaction is determined by the *utility difference* which results from using the transaction object for an alternative instead of the originally intended destination [10]. The higher this difference, the higher is the specifity of any given product or service. Most low-value physical goods for which micropayments are suited in m-commerce and which will most likely be sold at unmanned *points of sale* (POS), feature a low level of specifity. Parking tickets, beverages or candy usually have features that are known ex ante, which minimizes the probability of having to use a purchased transaction object for any other than the originally intended destination ($\Delta C_{Cog} = 0$). In the case of digital goods, the specifity level of transaction objects rises as new differentiated and "value-added" services are being offered. The reason is the increased deployment of mobility attributes such as *personalisation* and *localisation/location-reference* for products and services in m-commerce. If the information of such services cannot be utilised as intended, it becomes virtually worthless, as the levels of personalisation and location-reference increase (e.g., *location-based services* that are based on wrong data about the customer's location). This implies an increase of cognitive transaction costs ($C_{Cog} \uparrow$) for *digital goods* as regards *specifity*.

4.2.2. Uncertainty and Complexity

Closely related to the negative preferences of customers regarding per-use pricing schemes (see chapter 2) are the variables **uncertainty** and **complexity**. *Uncertainty* is a crucial obstacle, especially for estimating the information value of digital goods: Since information goods' (and therefore digital goods') properties are completely or partially unknown ex ante, consumers tend to use the information source as an *evaluation substitute* [5; 11]. This, in return, implies a contractual relationship with trusted content providers (e.g., *flat fees*). As a result of attainable *lock-in effects* as well as increased *customer loyalty*, this pricing scheme is appealing to suppliers as well.

Complexity, defined as a *sure situation whose interrelations cannot be completely overlooked by human beings* [10], is especially relevant for *specific* and *increasingly disaggregated* digital products and services in m-commerce. The implication of such "microservices" – the reduction of individual payment amounts ($p_i \rightarrow 0$) in connection with an increase of the number of requested services ($x_i \rightarrow \infty$) – raises the question of how micropayments behave on a cumulative level. This problem can be formalized by deploying the following marginal analysis:

$$S = \lim \Sigma (x_i \bullet p_i) \qquad (4)$$

$$x_i \rightarrow \infty; \; p_i \rightarrow 0$$

with: *S: sum of micropayments over a certain period*

x_i*: frequency of usage for service i (i = 1...n)*

p_i*: price of service i*

For this case, i.e. the increased disaggregation of digital goods and services in m-commerce, increased transaction costs as a result of higher levels of complexity are anticipated ($C_{Cog} \uparrow$). The negative consequences of this conclusion amplify as the assumption of consumers' risk-averse preferences holds true ("how much will I have to pay at the end of the month?"). Low-value physical goods, on the other hand, are traded more sporadically (compared to ubiquitous "*microservices*"). Their properties are usually known to customers, and the transaction amounts in question are significantly above fractions of a cent. Thus, the problems of complexity and uncertainty are of inferior importance here ($\Delta C_{Cog} = 0$).

4.2.3. Bounded Rationality

The illustration of the *complexity problem* (see previous paragraph) by deploying a marginal analysis gains additional significance when the assumption of **bounded rationality** is included. Then, equation (4) can be interpreted as a mathematical representation of the neoclassical *homo oeconomicus*' behaviour. The homo oeconomicus makes rational decisions by deploying cost-utility analyses on a continuous ($x_i \rightarrow \infty$) and marginal ($p_i \rightarrow 0$) basis. The assumption of this type of rational behaviour faces serious constraints in reality – limited information processing capabilities and communicative problems of human decision-makers in particular. Thus, the assumption of bounded rationality seems more realistic. By deploying this assumption, the marginal analysis of equation (1) points out that *ceteris paribus* there is a definitive lower limit for micropayments in the m-commerce area (in addition to SZABO's e-commerce scenario): With a continuously increasing frequency of interaction with a service provider, accompanied by a successive individualisation and atomisation of services, as seems technically possible in the age of ubiquitous networking, the application of micropayments leads to a gradual approximation towards a pricing scheme that requires the mental capabilities of the *homo oeconomicus* (steady marginal utility analyses, as represented by equation (4)). Due to their limited information processing capabilities, human decision-makers, in reality, are increasingly overtaxed with this kind of pricing scheme. Even with complete information, human beings are not capable of acting rationally in the sense of the *homo oeconomicus*, i.e. making *marginal* utility decisions by including *all* relevant information. This implies a rise of cognitive transaction costs ($C_{Cog} \uparrow$) for micropayments in m-commerce.

5. CONCLUSIONS

The analysis of micropayments as a possible pricing scheme for increasingly specific and disaggregated "microservices" as well as for low-value physical goods in the m-commerce area indicates that the marginal importance of this pricing scheme in the e-commerce area was a structural rather than a temporary problem. While the application of micropayments for *low-value physical goods* (ceteris paribus) seems appropriate (low specifity and uncertainty as well as sporadic transactions), *cognitive transaction costs* impose serious barriers for micropayments as a pricing scheme for *digital products and services*. This implies the application of alternative pricing models (e.g., *flat fees*). Moreover, the presented model indicates that m-commerce as well as e-commerce has an ultimate lower limit of micropayment amounts. This limit is likely to be significantly above zero.

Future research on this topic suggests the development of quantification methods for cognitive transaction costs or their determinants, respectively. This is likely to be a difficult task, for transaction cost theory's major flaw has always been the lack of a clear efficiency

criterion. Nevertheless, it can provide useful tools for analyzing the economic changes caused by the introduction of new technologies.

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