

A Multi-stakeholder Multi-criteria Assessment Framework of Mobile Payments: An Illustration with the Swiss Public Transportation Industry*

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As wireless technologies are becoming more mature for payment systems, the public transportation companies are facing great challenges in designing their next fare collection system. They have to decide whether they want to keep their legacy systems or innovate with the implementation of new mobile technologies for their upcoming payment instrument. Therefore, they need to consider various technical and business aspects during the design process. Moreover, in such an industry, a technological consensus between the stakeholders involved is desirable to eventually reach a global market. In this paper, we propose a multi-actor multi-criteria framework to facilitate the assessment of mobile payments for the Swiss public transportation industry. To compute our proposed model, we recently conducted a first set of structured interviews with Swiss key experts to collect data.

1. Introduction

As already observed in some existing fare collection system, such as Octopus, mobile payments have great potential for the public transportation industry (1). As they improve the payment process in terms of speed, ease of use, and convenience, mobile payment schemes based on contactless technologies appear to have a bright future ahead in this industry. Interestingly, this great enthusiasm is also shared by the different mobile payment service providers. In fact, financial institutions such as Visa, Mastercard, and American Express are already embedding contactless chip in their cards (e.g. Visa Wave, Mastercard PayPass, American Express ExpressPay). Moreover, in Japan, NTT DoCoMo, the major mobile network operator (MNO), and the East Japan Railway will soon propose a fare collection and e-cash application named Mobile Suica based on "i-mode FeliCa" handsets.

The micropayment market attracts general attention as it seems to be very lucrative. In Japan, NTT DoCoMo estimated a \$258 billion market to which you can add even more billions of dollars coming from transit fares (2). Given the expected revenues, it is understandable that this project is generating a lot of interest worldwide.

Even though mobile payments are seen by many as the natural evolution of current payment procedures, there is still a great amount of uncertainty surrounding its implementation. One major issue is the lack of a technological consensus between the involved stakeholders. As a result, each actor launches its own payment scheme usually accepted only by a few merchants. Therefore, this limited universality could explain the low level of consumer interest and acceptance rate.

The current situation on the mobile payment market appears to be complex, variable, and uncertain. Thus, decision makers of the public transportation industry are facing difficult decisions

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concerning wireless technologies for their payment systems as they evolve in a potentially disruptive environment. They need a more structured approach to support technology evaluation and selection during the design process of their next fare collection system. As a matter of fact, the choice of the appropriate enabling technology is key in order to offer a satisfying payment schemes to consumers.

In previous research (3), we studied two potential disruptions in the mobile payment market in Switzerland. Our first insights did not show evident signs of disruption possibilities for a switch of the physical support (i.e. from card-based to phone-based solutions) as well as for the displacement of current dominant mobile payment service providers (i.e. from operator-driven to self-organized solutions). Following this first exploratory and somewhat qualitative analysis, we decided to deepen our study by collecting empirical data and using a structured methodology. For this purpose, we designed a tool, more specifically a decision support system (DSS) based on a multi-criteria decision making (MCDM) method called ELECTRE I (4). To obtain these essential data to run our model, we conducted a set of structured interviews of Swiss key experts from different relevant industries. The objective was to uncover their preferences on several technologies which are potentially usable for payments in the public transport industry.

In this paper, the objective is to propose a multi-perspective framework to assist decision makers assessing mobile payments, providing an illustration with the Swiss public transportation industry. Firstly, we present a multi-actor multi-criteria model comprising the preferences of various stakeholder. Secondly, we introduce a tool to facilitate the assessment of mobile payments. Thirdly, we provide some preliminary insights into the Swiss mobile payment market for public transportation industry based on empirical evidence collected from the main actors of this industry.

This paper is organized as follows. The next section briefly presents some previous research done in this area. In section 3, we discuss the current state of the Swiss mobile payment market. In section 4, we present ELECTRE I and the DSS we developed in our research group. Then, in section 5, we describe the MDCM model which comprises the selected payment technologies and several evaluation criteria. In section 6, we introduce the technique used for the data collection. In section 7, the data collected are shown. In section 8, we present the preliminary results obtained. Finally, in section 9, we conclude with a short discussion and further proposed research.

2. Related work

There has been a considerable amount of research focusing on the adoption of mobile payments using a consumer centric view (5, 6, 7, 8). Most of these research efforts led to a better understanding and describe the adoption factors influencing the consumer in its intention to use the payment solution. Other research has focused on finding the most critical factor of success and the different requirements of mobile payment systems (9, 10). Plouffe et al. studied the adoption intentions of consumers and merchants toward a new electronic payment system (11). However, in the research field of mobile payments, we believe that there is still research to conduct with a multi-perspective approach (12). To the best of our knowledge, only few studies were done to assess mobile payment technologies in order to support decision making during mobile payment system design process. Zmijewska (13) evaluated mobile payment wireless technologies using adoption criteria derived from the technology acceptance model (14) and other extensions (7, 15). Chou et al. (16) evaluated the performance of different payment systems by using the analytic hierarchy process (17) with technological, economic, and social criteria. Other large projects were also conducted in order to study the application of mobile technologies in the public transportation industry. One example is the EU project named Trascom (TRavellel ASsistance for COmbined Mobility: <http://www.trascom-ec.net>).

3. Brief overview of the Swiss mobile payment market

In this section, we provide an overview of various initiatives known of mobile payments more or less related to the public transportation industry. Based on a rapid survey, our results show that there is not any globally accepted mobile payment solution in the Swiss market. Nevertheless, there have been some trials running and some project developments in this field but nothing major for the consumers.

3.1. Contactless card schemes

Most of the popular contactless card schemes were developed for ski resorts and closed corporate environments. The Kudelski Group is very active in these domains with Skidata and SportAccess. Moreover, during December 2004 and April 2005, in a joint initiative with PostFinance (i.e. the Swiss Post financial branch), they ran a pilot project for which some test subjects had a second chip embedded in their Postcard (debit card) for ski ticketing. On their side, some public transportation companies are also using contactless cards for ticketing and subscription verification such as the Galilée card of the TL (i.e. Public transportation of Lausanne) and other schemes in touristic regions (e.g. Engadin Card).

3.2. Mobile phone schemes

Recently, PostFinance in partnership with Unisys also presented their latest mobile payment trial based on mobile phones using SMS technology. PostFinance planned a test pilot from July to December 2005 with a thousand participants. During this trial, some merchants will accept this payment instrument at twelve specific locations. These companies are the two largest Swiss retailers (i.e. Migros, Coop), McDonald's, two popular electronic retailers (i.e. Interdiscount, Mobilezone), the Postshops, and the Swiss national railways (i.e. SBB). The merchants see benefits not only in terms of payment process improvement but also for target marketing purposes (e.g. offering coupons using a cutting-edge and cheaper distribution channel). Besides, this payment scheme is cross-MNO. PostFinance claims that their open solution could integrate other financial institutions as well.

The payment process is initiated at the point of sale (POS) by the consumer by (i) scanning the barcode stuck on the back of the mobile phone and (ii) typing a PIN code on a terminal. Then, (iii) the merchant enters the amount of the purchase on the same terminal using a small externally attached keyboard. From there, (iv) the information is directly transmitted to the PostFinance m-payment platform. A few seconds later, if everything is ok, (v) the consumer gets an SMS with a barcode and some information concerning the purchase (name of the merchant, the amount of the purchase, and the date). If the consumer agrees, (vi) the barcode in the SMS has to be scanned by the terminal to conclude the transaction. Finally, (vii) the terminal confirms the purchase and the consumer gets a receipt of the purchase. The payment amount is debited in real time from the customer's PostFinance account.

Depending on the success of this trial, PostFinance intends to launch it nationally in 2006. This could have a major impact on the payment market. In fact, PostFinance is a dominant actor in the payment traffic market in Switzerland. PostFinance has 2.9 million accounts in a country of 7.4 million habitants. Moreover, they process about 800 million transactions per year for a value of 70 million Swiss Francs in 2004 (about US\$55 million). Therefore, this innovative initiative could rapidly become a large payment scheme accepted at many merchants (already more than 90'000 POS terminals accept PostFinance current cards).

As already presented in our previous research (3), there was also a project called m-Maestro that regrouped the three national mobile network operators and other major payment service providers such as the financial institutions. The m-Maestro project was mostly paperwork and nothing has really been implemented, at least insofar.

Despite various trials in public transportation, nothing has yet emerged from previous experiences.

3.3. Relative strategic positions of the stakeholders

After conducting two yearly consecutive sets of interviews, we have been able to divide our sample of experts into two separate groups. On one side there are experts who are optimistic about the future of mobile payments in the public transport industries. On the other side, some experts think that there are big barriers (e.g. technical implementation issues, user acceptance uncertainty, lack of business cases) before using wireless technologies for payment instruments. Nonetheless, all experts agree that mobile phones might be one day used as a payment instrument. For this analysis, we involved two groups of stakeholders: the providers (i.e. MNOs, financial institutions, and newcomers/intermediaries) and the merchants (i.e. public transport companies).

3.3.1. The MNOs position MNOs are clearly pushing mobile payments based on mobile phones. Their position is understandable as their business model might be threatened by technologies such as Voice over IP (VoIP). Soon they might not be able to charge for phone calls and traffic volume anymore. Some recent trends indicate that MNOs would offer flat fees for connectivity and would become mobile service integrators. Thus, a mobile payment service might become a requirement for their next potential business model. Moreover, as illustrated by interesting Japanese business cases, MNOs are expecting great success of the upcoming Near Field Communication (NFC¹), an RFID-based technology with interconnection capabilities embedded in mobile phones. This technology promises to enable simple information exchanges in security by simply bringing two devices close together. A great number of new opportunities to offer innovative services have already been imagined by the MNOs. One of them is clearly mobile payments.

3.3.2. The financial institutions position Financial institutions in Switzerland are closely watching this market evolution and the different trials. They recently massively invested in the EMV specifications (i.e. a standardization effort concerning cards and terminals for interoperability) to improve their current payment schemes. They likely want to push their card-based solutions before going wireless. In other words, financial institutions do not necessarily envisage investing in a new technology as they are already satisfied with the one they operate today. In the same industry, PostFinance, known for its willingness to constantly innovate, perceives payments using mobile phones as a promising new channel for their current payment scheme.

3.3.3. The newcomers/intermediaries position On the newcomers' and intermediaries' side, they still plan to act and secure their position in niche markets. However, they need to continuously monitor their environment as external global payment solutions could be a threat for their business. Moreover, some are already partnering with major financial institutions to extend their business model and strengthen their position as experts in the field of contactless payments and ticketing.

3.3.4. The public transport companies position For this industry, the payment instrument is not seen as a strategic tool to gain a competitive advantage. However, the payment process still remains crucial. Mobile payments are just considered as a new channel that could make fare collection more convenient. The public transporters still have interest in mobile technologies, especially for mobile ticketing which is usually linked to mobile payments. The national railways company (SBB) monitors constantly its environment for any potential innovation from which it could benefit. Moreover, the SBB had developed several projects around the payment and ticketing issue. As the financial institutions are becoming more demanding with their EMV standard (e.g. replacement of the terminals at the POS, special requirements to handle sensitive data), some companies might consider supporting other payment schemes in the future. However, for the moment there are no concrete plans. Several regional transportation companies, such as the public

¹ NFC forum (founded by Nokia Corporation, Royal Philips Electronics and Sony Corporation): <http://www.nfc-forum.org>

transports of Lausanne (TL) and Geneva (TPG), have their own payment card, usually based on a prepaid smartcard wallet. Even if cash is still the most used payment instrument (about 80% of the transactions), their own payment scheme represents about 15% of the transactions (i.e. Galaxy).

A global payment solution for the public transports in Switzerland has already generated some interest. However, the market is still very segmented. This situation gives the impression that only a national company, such as the SBB, will be able to reunify the various regional companies.

4. A multi-actor MCDM approach

Technology assessment often leads to difficult choices for decision makers. In this activity, there are a relatively high number of parameters and different possibilities for their respective weights. By definition, multicriteria analysis is a very good candidate method to deal with this type of complex problems. Moreover, we contend that decision makers need to model the decision process in order to be as logical as possible.

4.1. Introduction to ELECTRE I

Given this issue, we propose to use the MCDM method ELECTRE I (4). This approach allows the decision maker to select the ideal technology with a maximum of advantages and a minimum of inconveniences in the function of various criteria. ELECTRE I was inspired by a very old democratic rule of Condorcet, a French Enlightenment Philosopher. When an action A is better than an action B in relation to most decision criteria and there are no criteria on which A is much worse than B then we can state without too many risks that A is preferred to B. In other words, if A outranks B ($A \rightarrow B$), the criteria to which A is better than B are sufficiently important and the criteria remaining (to which A is worse than B) do not raise significant opposition to the proposed relation.

ELECTRE I gives the possibility to model a decision making process by using the concordance and discordance indexes and the outranking relations. The concordance index measures the degree of dominance of one action over another, based on the relative importance weightings of the decision criteria. The discordance index measures the degree to which an action is worse than another (18). In summary, concordance and discordance indices can be viewed as measurements of satisfaction and dissatisfaction that a decision maker senses when choosing one action over another.

The outranking relations are usually obtained with a combination of a high level of concordance and a low level of discordance. These levels are fixed by a concordance and a discordance threshold which can be seen as severity levels over and under which an action could outrank another.

Based on relatively simple hypotheses, the objective of ELECTRE I is modest as it simply proposes a subset of alternatives (in our case, technologies) which definitely excludes the "best" solution. As a result, the decision maker has to be conscious that the kernel (i.e. the set of non-dominated alternatives) includes not only the "best" solution but also all the alternatives that are hard to compare between each other.

4.2. ELECTRE I: algorithm

In order to better understand how results are obtained using ELECTRE I, we present the algorithm of this method. To help illustrate, we will use a pair of technology a and b. Each criterion is assigned a weight w_j ($j = 1, n$; $n =$ number of criteria). The *concordance index* is defined as follows:

$$c_{a,b} = \frac{1}{W} \sum_{\forall j: g_j(a) \geq g_j(b)} w_j$$

where $W = \sum_{j=1}^n w_j$ and $g_j(a)$ is the score for technology a under criterion j.

The *discordance index* is defined as follows:

$$d_{a,b} = 0 \text{ if } g_j(a) \geq g_j(b) \forall j$$

Otherwise,

$$d_{a,b} = \max_j \left[\frac{g_j(b) - g_j(a)}{\delta_j} \right]$$

where δ_j is the range of the scale associated with the criterion j .

Both index values are then compared with the respective threshold (s_c and s_d) to determine their significance. A concordance and discordance value are considered significant if

$$c_{a,b} \geq s_c$$

$$d_{a,b} < s_d$$

The outranking relation $r_{a,b}$ is defined as:

$$r_{a,b} = \begin{cases} 1 & \text{if } c_{a,b} \geq s_c \text{ and } d_{a,b} < s_d \\ 0 & \text{otherwise} \end{cases}$$

4.3. A group decision extension for ELECTRE I

As previously claimed, a consensus between the major stakeholders of the market is desirable. As a result, the success probability of a global payment scheme based on a unanimous technology choice would be higher. Following this requirement, we had to use a group decision approach. Bui and Jarke have previously proposed a method based on ELECTRE I for group decision making (19). They suggested applying the min-max concept of game theory (20). In other words, to reach a consensus, this method takes the most severe technology evaluations for each criteria done by any actor. The group concordance ($c_{a,b}^G$) and discordance ($d_{a,b}^G$) indices could be defined as:

$$c_{a,b}^G = \min [c_{a_u, b_u} \mid u = 1, \dots, n]$$

$$d_{a,b}^G = \max [d_{a_u, b_u} \mid u = 1, \dots, n]$$

and the group concordance (p^G) and discordance (q^G) thresholds can be respectively computed as follows:

$$p^G = \max [p_u \mid u = 1, \dots, n]$$

$$q^G = \min [q_u \mid u = 1, \dots, n]$$

where n is the number of actors.

4.4. A Multi-actor MCDM-based DSS

To process the data collected, we used a computerised-based tool (PylaDESS) developed in our research group. It implements the two algorithms presented in the previous section. The programming language used to build this IT artefact is Python with wxpython as the graphical user interface (GUI) library. Particular attention was paid to the design of the GUI in order to facilitate the visualization of the data and the outcomes (see Figure 1).

The IT artefact allow us to have any number of actors, criteria and alternatives (in our case, technologies). It is very flexible as we can change any parameter at any time during the analysis (e.g. add/remove/modify actors, criteria, technologies, and other parameters).

The current version permits us to use qualitative values ("weak to excellent" scale) and transform them using an ordinal-to-cardinal grading system. This scale can be customized and some three pre-built scales are also proposed to assist the decision maker. In addition, an assistant guides the user to create any new model.

Some sensitivity analysis features were also added to provide the possibility to test the robustness of the model as well as to enable scenario building with a dedicated built-in assistant. It is also

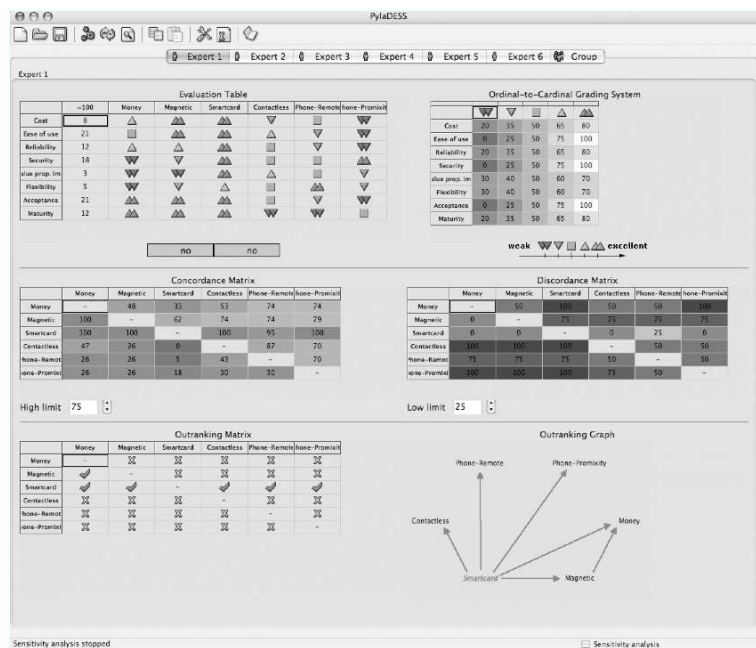


Figure 1 The GUI of the DSS

possible to isolate two technologies in order compare them to each other. This IT artefact is still in constant evolution and more features are being added regularly.

One purpose of this DSS is to conduct market simulations based on the model built with the experts data. We will discuss this topic as further research in the "Conclusion" section.

5. The MCMD model: payment technologies and evaluation criteria

In this section, we present various potential technologies for payment in the public transport industry. Then, we will describe a set of selected criteria derived from the literature as well as other criteria judged relevant by the experts.

5.1. Payment technologies

Various wireless technologies can enable mobile payments services. We selected three technologies that are good candidates for mobile payments. The first choice is the contactless card embedded with a RFID (Radio Frequency Identification) tag. These cards tend to become very popular for many reasons. They are relatively cheap, somewhat reliable, and very easy to use. They are mainly used in the transport industry and other quick-services oriented industries. Then, we chose mobile phones using proximity networks such as Bluetooth, RFID, and Infrared. This type of solution is good for proximity payments in the real world. Finally, we included mobile phone using remote networks (e.g. GSM, GPRS). These devices are suitable for remote payments such as e/m-commerce transactions. We also included three popular payment technologies such as money (cash), magnetic cards (e.g. VISA, Mastercard) and smart cards (e.g. Proton) for benchmarking purposes.

Each of the introduced technologies has its advantages and drawbacks. Some have limitations that others do not have. For that reason, a mobile payment service provider should consider all of these options before launching a scheme. Running an analysis with all these different technologies should not only help us to compare their performance but also give us good insights about the current situation on the market.

Table 1 The selected technologies

Money (M)
Magnetic card (MC)
Smart card (SC)
Contactless card (RFID tag) (CC)
Mobile phone "remote" (GSM, GPRS, ...) (PR)
Mobile phone "proximity" (Bluetooth, RFID, Infrared) (PP)

5.2. Evaluation criteria

A first collection of criteria was proposed to the experts. From this set, they had to select the relevant ones and eliminate the others. They could also add other criteria if they wanted. Each expert had to feel that every criteria covered their domain of technology evaluation. We have to emphasize that the experts had to select the relevant criteria to just evaluate technologies and not solutions (i.e. business cases and models).

Ease of use This criterion refers to "the degree to which a person believes that using a particular system would be free of effort" (14). Several researchers already underlined the importance of this criteria for mobile payment systems (7, 15, 5).

Cost Cost is a broad criteria regrouping many different facets. In fact, there are the direct costs (e.g. price of the technology, cost of implementation) and the indirect costs (e.g. infrastructure operation and maintenance). Cost is certainly an important concern in a micropayment market. The profitability of the payment system is linked to the different costs. In their multi-criteria analysis, Chou et al. selected the cost criteria as one of the technological factors useful to evaluate mobile payment systems (16).

Reliability The purchase process should be flawless as it involves a financial transaction. Moreover, reliability is highly desirable in order to enhance trust into the payment technology. This criteria was also proposed by (16).

User/Market Acceptance We define this criteria as the degree to which the user and the different stakeholders are already consenting to accept a technology for payment in the public transports.

Security Since we ask the experts to evaluate the technology and not the solution implemented, this criteria represents the different security features a technology already embeds, such as encryption. Secondly, the experts had to take into account the degree of ease to implement security around the technology. This criteria was also present in (16).

Flexibility Flexibility defines the degree to which the technology can be adapted in many different applications. Payments can be conducted at the POS but also remotely from somewhere else.

Value proposition improvement This criteria takes into account the improvement a technology could bring to the customer when implemented.

Maturity Some technologies have already been developed and integrated for quite a few years. Therefore, the technology can be considered as technically well known.

Speed In the public transport industry, the payment process has to be fast. Different technologies have varying capabilities in terms of speed.

Scalability Payment systems should be able to grow in time (i.e. number of customers and merchants). Therefore, the technology should be scalable to be used in both small and large environments.

6. Techniques used for data collection

For this study, we collected empirical data from several Swiss key experts involved in different industries. We conducted each structured interview separately during June 2005. On average, each interview lasted between 45-60 minutes.

For the mobile network operators, we interviewed a manager in the strategic department responsible for mobile payment at Swisscom Mobile, the market leader in Switzerland (with 65% of the

market share with an estimated market penetration rate of almost 90% in 2005). On the side of the financial institutions, we collected data from a mobile payment expert working for Telekurs Multi-pay, a leader for cashless payment transfers in Switzerland. We also interviewed project managers working on the mobile payment trial of PostFinance. To diversify opinions, we met an expert working for SportAccess (a Kudelski Group company) which has very strong expertise in contactless payment schemes. As we wanted to study micropayments in the public transportation industry, a logical decision was to interview mobile payment experts of the SBB, the national railway transport company in Switzerland. In this industry, we also collected data from another project manager at the TL (public transportation of Lausanne).

In summary, we interviewed experts working for the major actors in the financial, telecommunication, public transportation, and contactless card industry in Switzerland.

The MCDM method requires a large number of data and the time granted by the experts was somewhat short. Thus, we had to find a way to collect the data in a very easy process for the experts. We opted for the use of the "Pack of Cards" technique proposed by Simos (21). The idea is to give to the experts cards with the name of each criterion inscribed. Then, we asked the expert to manipulate these cards, rank them, insert blank cards to reinforce ranking differences. We also used this approach to get the data concerning the evaluations of the technologies for each criterion. It appears that the active participation by the decision-markers in the procedure gives them an intuitive understanding of the approach (18).

We first proposed to the experts a set of criteria extracted from the literature and also discussed with one of the experts. Then, each expert could add any other relevant criteria for themselves or remove insignificant criteria. Once they considered that the set of criteria covered all the evaluation facet of a technology, the experts first had to "play" with the criteria cards and rank them in order of importance. Then, they had to use blank cards to emphasize the gap of importance from a group of criteria to another. The next step was to play with the technology cards, group and rank them. Finally they were asked to evaluate the groups made with a proposed scale (weak, fair, average, good, excellent).

From these preliminary data, we computed the model to find the first results. Then, experts will be showed their own results. To improve the first set of data obtained, we will use a Delphi technique (22). We will show the different actors' models to each other. Then, we will ask them to give some remarks on the overall result before they reconsider their evaluations. When they all give their approval on their respective models, we will have our first stable model on which we will start to build scenarios using an IT artefact presented in the next section.

7. The data collected

In this section, we expose the entire set of data we collected from the experts. These data are the first evaluations and might change after the Delphi. In a concern to preserve anonymity of the current limited number of experts, we cannot yet reveal their names and the industry. However, it is has been planned to interview more experts to solve this issue in the near future.

Table 2 Transforming the rankings into weightings (Simos Technique)

Groupings	# cards	Positions	Weights (non-norm)	Weights (normalised)	Total
S, R	2	1,2	$\frac{1+2}{2} = 1.5$	$\frac{1.5}{29} \times 100 \approx 5$	$2 \times 5 = 10$
F	1	3	3	$\frac{3}{29} \times 100 \approx 11$	$1 \times 11 = 11$
E, A, S	3	4,5,6	$\frac{4+5+6}{3} = 5$	$\frac{5}{29} \times 100 \approx 17$	$3 \times 17 = 51$
Blank card	1	(7)	—	—	—
C	1	8	8	$\frac{8}{29} \times 100 \approx 28$	$1 \times 28 = 28$
Sum	7	29			100

We performed the transformation of the rankings into importance weightings of the criteria using Simos Technique (21). We illustrate this process in Table 2 with the data of one expert. The groupings are arranged from worst to best, taking the blank cards into account.

The importance weights of the different experts (E_n) are represented in Table 3. The totals are displayed just to measure the score of each criteria. However, individual weights will be used in the analysis, not an average or normalized weight. We believe that each expert has different priorities. The spread is showed in the last column ($\Delta = \text{max. weight} - \text{min. weight}$). This enables us to indicate if the experts agree with the importance of each criteria (the lower the more the experts agree with each other).

Table 3 Weights of the criteria for each expert

Criteria	E1	E2	E3	E4	E5	E6	Total	Δ
Ease of use	17	24 **	17 ***	15	25	21	119	10
Cost	28	24	18	6	14	8	98	22
Reliability	5 *	24 **	17	19	14	12	91	19
User/Market Acceptance	17	4	8	6	12	21	68	17
Security	5 *	12	8	6	14	18	63	13
Flexibility	11	12	8	19	7	5	62	14
VP impr.	n/a	n/a	8	23	7	3	41	20
Maturity	n/a	n/a	8	6	7	12	33	6
Speed	17	n/a	n/a	n/a	n/a	n/a	17	n/a
Scalability	n/a	n/a	8	n/a	n/a	n/a	8	n/a
Total	100	100	100	100	100	100	600	
# Criteria	7	6	9	8	8	8		

* E1 considered these two criteria as standard today.

** E2 combined Ease of use & Speed, Reliability & Maturity, and Flexibility & Scalability

*** E3 combined Ease of use & Speed

Table 4 summarizes the experts evaluations with the with a proposed scale (w=weak, f=fair, a=average, g=good, e=excellent).

Table 4 Data collected from each expert

Expert 1	Weights	M	MC	SC	CC	PR	PP	Expert 2	Weights	M	MC	SC	CC	PR	PP
Cost	28	a	g	g	f	a	f	Cost	24	f	a	f	f	e	e
Ease of use	17	a	a	a	e	f	e	Ease of use	24	a	g	g	g	f	f
Speed	17	a	f	f	e	f	e	Reliability	24	e	g	g	f	w	w
Acceptance	17	e	g	g	f	f	f	Security	12	w	f	e	g	f	a
Flexibility	11	f	e	e	f	g	g	Flexibility	12	w	a	a	a	e	a
Reliability	5	e	e	e	g	g	g	Acceptance	4	e	e	e	f	f	f
Security	5	a	g	g	a	a	a								
Expert 3	Weights	M	MC	SC	CC	PR	PP	Expert 4	Weights	M	MC	SC	CC	PR	PP
Cost	18	g	g	a	a	w	w	VP impr.	23	f	a	a	g	w	e
Ease of use	17	w	f	f	e	e	w	Versatility	19	w	f	f	a	e	e
Reliability	17	f	f	e	e	f	f	Reliability	19	a	a	e	e	w	g
Security	8	w	w	e	e	g	g	Ease of use	15	e	g	g	e	w	a
VP impr.	8	w	f	f	e	e	e	Cost	6	e	a	f	a	g	w
Flexibility	8	w	w	a	a	a	e	Security	6	f	g	e	e	g	e
Acceptance	8	e	e	e	e	g	g	Acceptance	6	e	g	a	a	w	w
Maturity	8	e	e	e	g	g	w	Maturity	6	e	g	a	a	f	w
Scalability	8	w	a	g	g	e	g								
Expert 5	Weights	M	MC	SC	CC	PR	PP	Expert 6	Weights	M	MC	SC	CC	PR	PP
Ease of use	25	e	a	a	e	f	w	Ease of use	21	a	e	e	g	f	w
Reliability	14	f	w	e	e	g	g	Acceptance	21	e	e	e	a	f	w
Cost	14	w	a	a	g	w	g	Security	18	w	f	e	a	a	e
Security	14	w	a	g	g	f	f	Reliability	12	g	g	e	a	f	w
Acceptance	12	e	g	a	a	f	w	Maturity	12	e	e	e	w	w	a
Maturity	7	e	g	g	g	w	w	Cost	8	g	e	e	f	a	w
Flexibility	7	a	a	e	a	e	e	Flexibility	5	w	f	g	a	e	f
VP impr.	7	f	a	a	a	g	g	VP impr.	3	w	w	e	g	a	f

M=money, MC=magnetic card, SC=smartcard, CC=contactless card, PR=mobile phone remote, PP=mobile phone proximity

8. Preliminary results

In this section, we present the first results obtained with the collected data from six experts involved in different industries. The results are presented with outranking relation graphs that are easily understandable. As presented before, if technology A outranks B, an arrow will go from A to B ($A \rightarrow B$). When there are not any outranking relationships between two technologies, it means that they are incomparable between themselves and all others. In other words, we cannot indicate which one dominates the other. If an arrow goes from A to B and B to A, it just means that the two technologies have the same evaluations (i.e. they are equivalent).

Figure 2 shows the outranking graphs of the six experts with a threshold of 75 for the concordance and 25 for the discordance (a rather standard degree of severity) for each model. Due to the limited space, we decided not to include the concordance and discordance of each experts. The circled solutions are the non-dominated technologies. In other words, they belong to the group of the "best" solutions and/or they are hard to compare to each other.

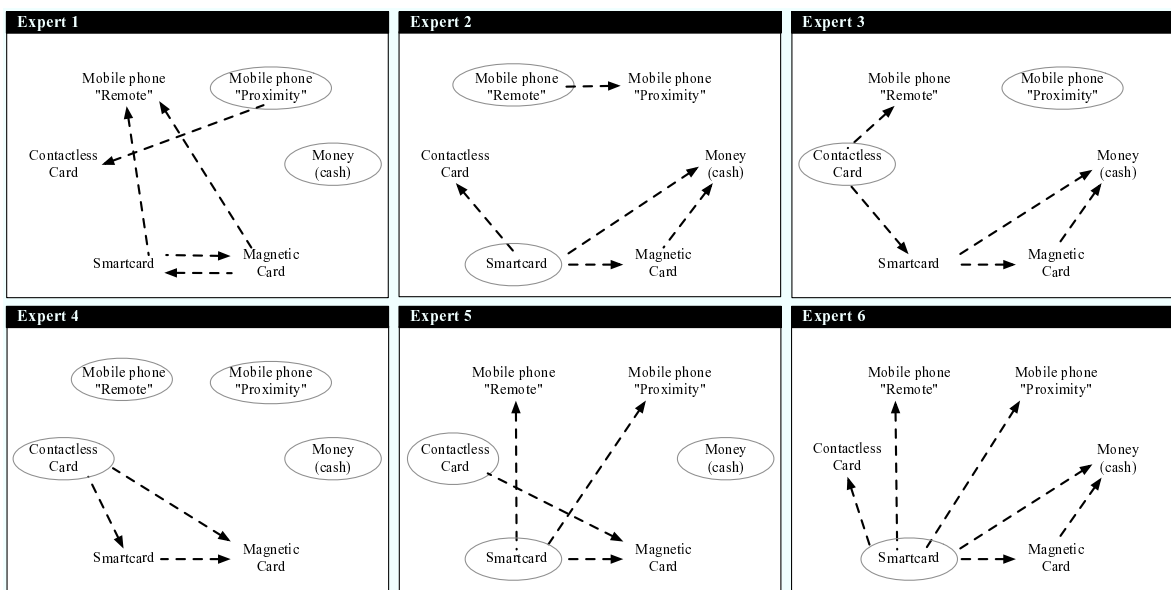


Figure 2 Results of the experts

These preliminary results already show that some experts are consciously or not pushing the solution they use or sell. This could be partly due to the fact that these experts know well the technology they work with. They might have fewer insights into the other technologies proposed.

Two experts (2 and 6) judged that the smartcard outranks the contactless card and two other experts (3 and 4) thought the opposite. The ease of use and value proposition improvement are two criteria proposed by an expert in favor of the contactless card dominance. Another expert considers smartcards to be more reliable, more secure, and already much more accepted by the users and the market in general.

In general, the mobile phone-based technologies do not perform well as reliability, acceptance, maturity, ease of use, and cost are evaluated to be insufficient compared to the other technologies. The evaluations can be seen in Table 4. During the interviews, all the experts recognized a future potential of these technologies for payment purposes. However, they all feel that the current market is not yet ready and some technical improvement should be done, especially in terms of the user interface.

As Figure 3 demonstrates, there is a group consensus on only one outranking relation. Every expert judged smartcards better or as good as magnetic cards. The reliability and security dominance of the smartcard usually explains this outranking relation. This is a trend that can be observed in the current market. To enhance security and reliability, financial institutions already started to replace their classic magnetic cards with smartcards. Moreover, the public transportation companies already have payment schemes using prepaid wallet on smartcards. Therefore, it is not a surprise that every expert designated smartcards to dominate magnetic card technology in the public transport industry context. Concerning the non-dominated technologies (the circled solutions), we cannot say much besides that the "best" alternative might be in this group and that these technologies are not comparable to each other. This is probably due to the fact that some experts evaluations were contradictory. In the case of extreme opposed evaluations, a Delphi technique is desirable to confirm or reduce these disparities between some experts.

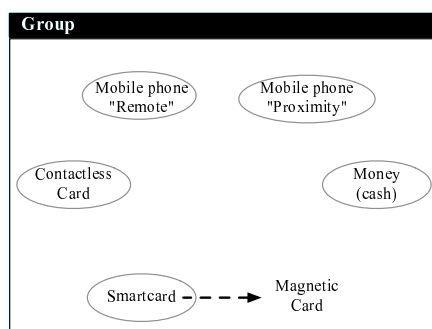


Figure 3 Results of group (consensus)

9. Conclusion

The mobile payments assessment for the public transportation industry remains a difficult task as the future market is still uncertain, complex, and variable. In light of the progress made in Japan, some stakeholders already recognize the possibility to innovate payment systems in the public transport industry. However, as our models shows, the experts' positions are still contradictory for several technologies. Therefore, a reevaluation of the preferences using a Delphi technique is desirable to unveil more precise results to confirm our first insights. Categorical interpretations should not be made at this current stage as some experts might change their opinion. However, some obvious trends can still be observed, such as the relative dominance of the card-based solutions.

Even though these results may seem weak at first sight, they nevertheless provide a fairly realistic view of the current condition of the Swiss market.

Using a MCMD method helped us to study the market with a more structured and rational approach. Moreover, the DSS we developed was very useful for data input, computations and outcome visualization. Another important capability of our tool is sensitivity analysis. This kind of activity would not be possible without the help of a dedicated computerized tool. Once we will obtain the reevaluations, we will be able to simulate changes and observe which criteria or experts could change the group consensus. This will help to unveil weak signals and therefore, give us insights to perceive new future potential scenarios. For example, we could simulate an improvement of mobile phones in terms of ease of use and reliability. We could also insert a new potentially disruptive technology and observe the reaction of the model to get first impressions of its performance compared to current technologies.

The promising preliminary results encourage us to continue our research by conducting a reevaluation of the preferences using a Delphi technique. In further research, we plan to build scenarios

based on the model we will obtain after the Delphi process. One or two experts will be asked to give comments and recommendations based on the situation described in the scenarios. Moreover, we plan to interview more experts in order to study if experts from the same industry already reach a consensus.

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