

A CRITICAL REVIEW OF MOBILE PAYMENT RESEARCH

Tomi Dahlberg², Jie Guo^{1,2} and Jan Ondrus^{3,*}

¹ School of Finance and Economics, Xi'an Jiaotong University, China

² Åbo Akademi University (IAMSR), Finland

³ ESSEC Business School, France

Email: tomi.dahlberg@utu.fi, jie.guo@abo.fi, ondrus@essec.edu

ABSTRACT

This article aims at assessing the progress of mobile payment research over the last 8 years. A previous literature review (Dahlberg et al. 2008b), covering articles published between 1999 and 2006, showed that the majority of research had only focused on a few topics. In order to address this issue, a research agenda was formulated to encourage researchers to explore new topics. Almost a decade later, our review reveals that researchers have continued to focus on the same topics (especially consumer adoption and technology aspects) with a limited accumulation of new knowledge and similar findings. In addition to reviewing the literature, we discuss the possible reasons for the lack of research diversity and propose new recommendations to enhance future mobile payment research.

Keywords: mobile payments, literature review

* Corresponding author. Tel. +33 1 34 43 36 73, ondrus@essec.edu (Jan Ondrus)

This paper has been published in:
Electronic Commerce Research and Applications.

To find the proper citation: <http://dx.doi.org/10.1016/j.elerap.2015.07.006>

1. INTRODUCTION

Mobile payment research started soon after the first payment transaction was conducted with a mobile device in 1997. In Finland, Coca Cola experimented with vending machines that accepted SMS payments. After a decade of research, a literature review written by Dahlberg et al. (2008b) was published in the *Electronic Commerce Research and Applications* journal. The review reflected the authors' cumulative understanding of mobile payments, which they had independently investigated in several countries and continents for several years. After producing a fair part of the literature on this topic themselves, the authors felt that there was a need to provide guidance for future research. Their main motivation was that mobile payment issues were not fully explored by the academic community.

In fact, a considerable number of the publications focused mainly on two issues: *technology* and *consumer adoption*. Interestingly, at the time, few consumers were able to experience mobile payments. And a great number of mobile payment initiatives failed before they even reached their intended end-users. Due to the complexity of the phenomenon, it was clear that the investigation of consumer adoption in isolation would only provide a limited understanding of mobile payments.

In their article, Dahlberg et al. (2008b, p. 165) also proposed a definition for mobile payments to clarify the concept, which had been subject to different interpretations. *Mobile payments* were defined as "payments for goods, services, and bills with a mobile device by taking advantage of wireless and other communication technologies". Furthermore, they stated that "a mobile payment is carried out with a mobile payment instrument such a mobile credit card or a mobile wallet". Mobile payments were thus distinguished from any specific type of electronic or mobile money, the use of mobile devices to access electronic payment services, and electronic banking (unless there was a separate mobile payment "instrument", or an account reserved for mobile payments). With this definition in mind, Dahlberg et al. (2008b) also crafted a multi-dimensional framework to describe mobile payment markets (and the literature). Their framework consisted mainly of two parts: i) the mobile payment service market based on Porter's Five-Forces model, and ii) the contingent factors impacting markets based on general contingency theory.

Today, the accumulation of articles on mobile payments published after 2006 motivates a new critical review of the literature. We performed a systematic literature search and identified 188 articles published during the last eight years (2007-2014), of which 87 were in major conferences or in journals with an impact factor greater than 1.0.

After carefully reading the recent articles, we found that researchers have often been "re-inventing the wheel". Several studies showed by 2006 that "security" and "trust" are important pre-requisites for the adoption and use of mobile payments. In more recent literature, the same findings were put forward as principal theoretical contributions, which awarded publication in respectable outlets. We admit that confirming earlier findings could be sometimes justified. Yet, this practice led us to wonder why past research findings were ignored.

Dahlberg et al. (2008b) outlined 22 research proposals for future research. Interestingly, their well-cited article has had limited impact on the kind of research that has been conducted after its publication. Overly-researched topics have continued to attract researchers. In 2008, Dahlberg et al. (2008b) already considered that there is little need for additional studies on consumer adoption of mobile payments (i.e., with TAM and UTAUT models), especially since we knew – and still know – so little about merchant adoption. Yet, consumer adoption (based on the mentioned models) has remained one of the most investigated research topics, providing few new insights.

But why is there so much eagerness to conduct consumer adoption studies for mobile payments? We speculate that empirical data from consumers on their attitude and intentions could be easier and more convenient to collect. Another reason may be that journals are still keen to accept such studies, even though the relevance and the contributions are clearly limited. If these reasons can be confirmed, we are curious to know what signals this practice sends to the industry and the academic communities. Overall, we fear that the limited progress made over the years has created a gap between practice and academia.

The purpose of this article is to critically analyze mobile payment research carried out after the publication of the previous literature review (Dahlberg et al. 2008b). We aim at comparing the volume, research methods, research themes, and other statistics about mobile payment research between the two periods (1998-2006 versus 2007-2014). We also examine which recommendations of the previous literature review have impacted mobile payment research. In order to improve future mobile payment research, we also provide an updated list of recommendations. As a whole, our article aims at answering the following two research questions:

- *Why have we seen limited progress in several mobile payment research themes during the last eight years?*
- *What should researchers do in order to improve their research on mobile payments?*

To address the first research question, we present in Section 2 the methodology of the literature review and compare the statistics between the two periods studied. In Section 3, we review and comment on the progress of the three dominant themes of mobile payment research: strategy and ecosystems, technology, and adoption. In Section 4, we provide critical comments and recommendations for future research. We conclude in Section 5.

2. LITERATURE REVIEWS THAT WERE CONDUCTED

Since Dahlberg et al. (2008b), several literature reviews about mobile payments have been written. In 2013, Slade et al. (2013) exclusively reviewed mobile payment adoption papers. More recently, Dennehy and Sammon (2015) reviewed the 20 mobile payment articles most cited in Google Scholar. Moreover, de Albuquerque et al. (2014) performed an exhaustive review by including articles addressing mobile payment issues in developing countries. We believe that mixing articles focusing on developing and developed markets could cause confusion about the progress of mobile payment research. In fact, mobile payment services from developing markets are unlikely to penetrate developed economies with their advanced financial markets and sophisticated telecom, merchant and consumer

infrastructures. Consequently, we prefer to avoid the inclusion of both type of markets into our review and solely focus on developed economies.

While the three above-mentioned reviews have their own merits, there is still a need to perform an inclusive literature review and provide recommendations for future research on developed countries.

To ensure consistency with the previous literature review of Dahlberg et al. (2008b), we used the same method to search and classify articles. This approach facilitates reliable statistical comparisons between the two periods. Unless indicated otherwise, we use the same framework and definitions of concepts as those presented in (Dahlberg et al. 2008b). Beyond providing consistency between the two literature reviews, we also demonstrate that the framework and concepts are still valid to classify literature and to structure research on mobile payments.

The framework shown in Figure 1 consists of two parts. The inner part represents (the actors and forces) of a mobile payment service market with concepts taken from Porter’s Five-Forces model. The outer part describes contingent factors impacting the market with concepts derived from the *contingency theory*. As a result, the framework describes both the actors and factors of a market, as well as the competitive forces and environment.

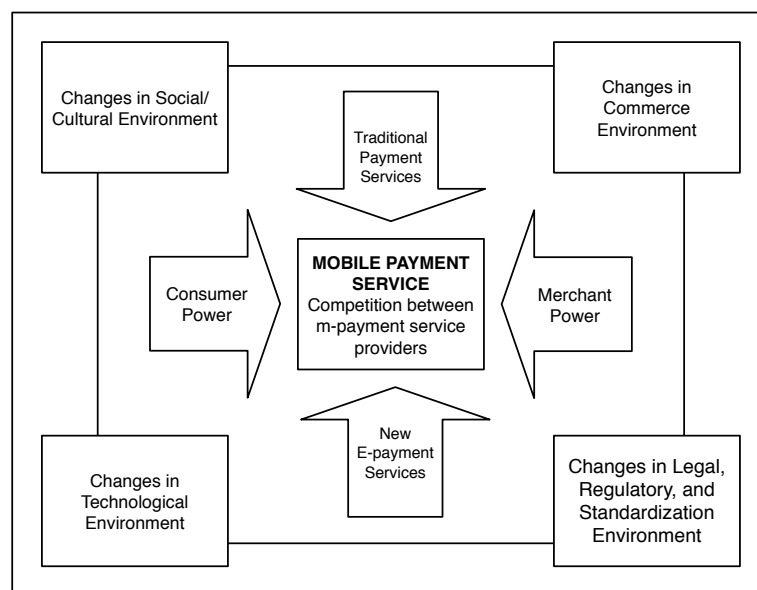


Figure 1: Framework used to classify the mobile payment literature

Mobile payment service providers have a key role in the ecosystem. However, the actions of other market actors (regulators, financial institutions, device manufacturers, merchants) as well as the influence of market factors (available network, banking, merchant and consumer technology, legislation, payment instrument use habits) could impact the service providers and other market actors. Therefore, this framework enables to study how different strategic options could influence the competitive position of an actor or the performance of the entire market. Contingent factors impact in systematic ways the actors and the market itself but are outside the direct influence and control of any market actor.

Contingency theory is essential to capture differences between mobile payment service markets (especially different countries). In recent studies, these issues have mainly been embedded into strategy and ecosystem studies. We will use the term *ecosystem* in the next sections as a synonym to "m-payment market & providers".

For more details and explanations about the framework used, we invite the readers to refer to (Dahlberg et al. 2008b).

2.1. Literature Search

We reviewed the literature with a systematic scan of online academic journal and conference databases, similarly to Dahlberg et al. (2008b). Table 1 depicts the databases that were used for the two reviews. Note that we were not able to use the M-Lit database, as it has been discontinued for several years now.

Table 1: Sources used to search literature in the two reviews (journals)

Sources	Dahlberg et al. (2008b)	Current
ProQuest Direct	X	X
EBSCO	X	X
ScienceDirect	X	X
IEEE Xplore	X	X
ACM Digital Library	X	X
AIS eLibrary	X	X
Google Scholar	X	X
M-lit	X	
Scopus		X
Web of Knowledge		X
Emerald Fulltext		X
Wiley InterScience		X

To search the literature, we used the following descriptors: "mobile payment(s)", "m-payment(s)", "proximity payment(s)", "contactless payment(s)", and "NFC payment(s)", and searched them from the titles and abstracts of the articles. We excluded articles where mobile payments were just a minor section of the article on, for example, mobile commerce or electronic payments. Moreover, from the articles identified, we went backwards by reviewing other work of the authors as well as citations in the articles (Webster and Watson 2002).

Similarly to Dahlberg et al. (2008b), we included articles from a few established conferences in the fields of IS, electronic commerce and mobile business to include conference articles with sufficient quality. Again, this selection was done to ensure consistency between the statistics of the two reviews. Table 2 lists conferences included in the two reviews. The Mobility Roundtable Conference merged in 2010 with the International Conference on Mobile Business (ICMB). After 2006, we did not come across any proceedings.

Table 2: Sources used to search literature in the two reviews (conference proceedings)

Sources	Dahlberg et al. (2008)	Current
ICIS	X	X
HICSS	X	X
AMCIS	X	X
ECIS	X	X
PACIS	X	X
ACIS	X	X
BLED	X	X
ICEC	X	X
ICEB	X	X
IEEE Proceedings	X	X
IADIS E-Commerce	X	X
IADIS WWW/Internet	X	X
Mobility Roundtable	X	

2.2. Descriptive Statistics

Our systematic literature search identified 188 articles published during the last 8 years (2007-2014), of which 87 were in major conferences or in journals with an impact factor superior to 1.0. We classified the articles for the descriptive statistical analysis as follows. Two researchers independently reviewed the title, abstract and discussion or conclusions sections of each article and determined the categories of the article according to the 9 categories of the framework of Dahlberg et al. (2008b). In the case of differing results between the two researchers, a third researcher repeated the classification. The dominant category for the article was then selected.

If an article investigated mobile payments by involving two different categories (e.g., Zhang et al., 2011; Alshare and Mousa, 2014), we included that article in both categories. We added a new category for them, which we labeled *multiple category studies*, similarly to Dahlberg et al. (2008b). A few articles addressed several categories, none of them in a detailed way and/or with a clear focus. The articles of Ghezzi et al. (2010), Kshetri and Acharya (2012), and To and Lai (2014) presented market overviews by describing the status of mobile payment services with their challenges and potential. We classified them as "overviews", following Dahlberg et al. (2008b). These two additions increased the final number of categories to 11 in both literature reviews (see Figure 2).

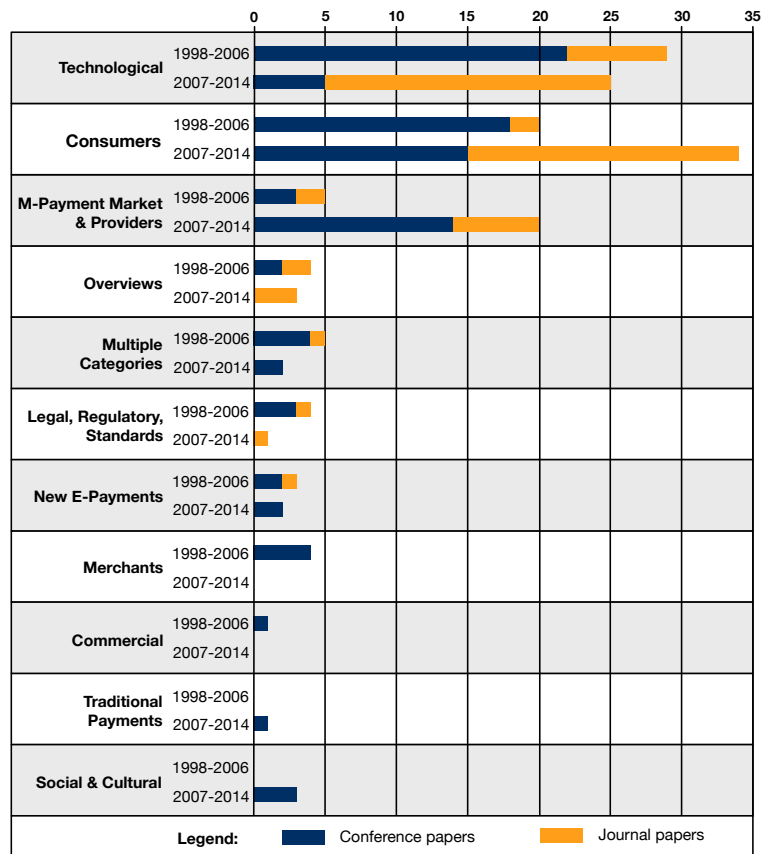


Figure 2: Categories of conference and journal articles

Figure 2 shows that three categories dominate mobile payment research after 2007. "Consumer studies" accounts for 34 articles (including 2 multiple category articles), followed by 25 in "technology", and 20 in "m-payment market & providers" (= mobile payment strategy and ecosystems). The other 8 categories have only 12 articles (including 2 multiple category articles). Furthermore, three of them belong to "overviews". This leaves 7 articles to the remaining 6 categories. Despite the large number of consumer adoption articles, there is no single merchant adoption study after 2007. Between 1999 and 2014, the cumulative numbers of articles – 54 for "consumer" versus 4 "merchant" is even more striking. Figure 2 illustrates well that most of the research has been done on three aspects with very little research on the other categories.

In terms of outlets (conferences versus journals), there are differences between the three dominating categories regarding the proportions of journal and conference articles. While 80% of technology articles have been published in journals after 2007, the proportion is 60% for consumer articles and only 30% for m-payment market & provider articles (=mobile payment strategy and ecosystem). The recent emergence of mobile payment "strategy and ecosystem" studies could justify this difference.

We then looked at the methodology of each article and classified articles as *empirical studies* or *conceptual studies* (Figure 3). While conceptual articles dominated the early years, the ratio of empirical versus conceptual has changed gradually over the years, and finally in 2014, the cumulative number of empirical articles surpassed the number of conceptual articles.

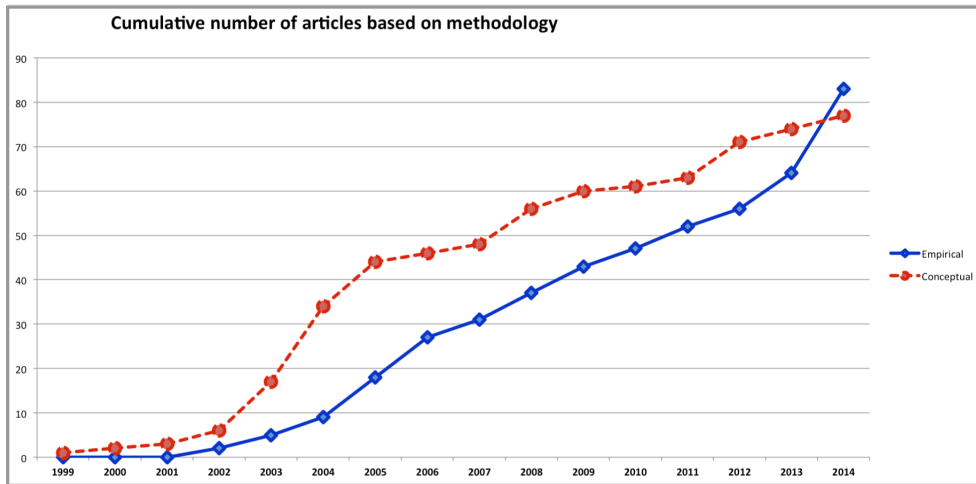


Figure 3: Empirical and conceptual articles from 1999 to 2014

In the next subsections, we discuss papers from our literature review in the dominant three categories. When relevant, we also included more recent papers (2015 or forthcoming), especially in the “ecosystem” subsection. The technology subsection discusses all 44 articles published after 2007, including the 25 articles used in the descriptive statistics section. Moreover, in all subsections, we discuss important articles published pre-2007, when required.

3. ANALYSIS OF THE LITERATURE WITH CRITICAL REMARKS

Because of their clear dominance, we decided to concentrate our analysis on the articles in the three main categories: *mobile payment strategy and ecosystems*, *technology*, and *consumer adoption*. As we previously explained, only 7 articles have addressed the other 6 categories of the framework after 2007. They do not constitute a sufficient base for review.

Figure 4 illustrates the annual numbers of papers published in the three dominant categories. The graph shows that the amount of consumer (adoption) articles increased in 2013 and 2014, as well as that the number of ecosystem (= m-payment market & providers) articles started to grow in 2011.

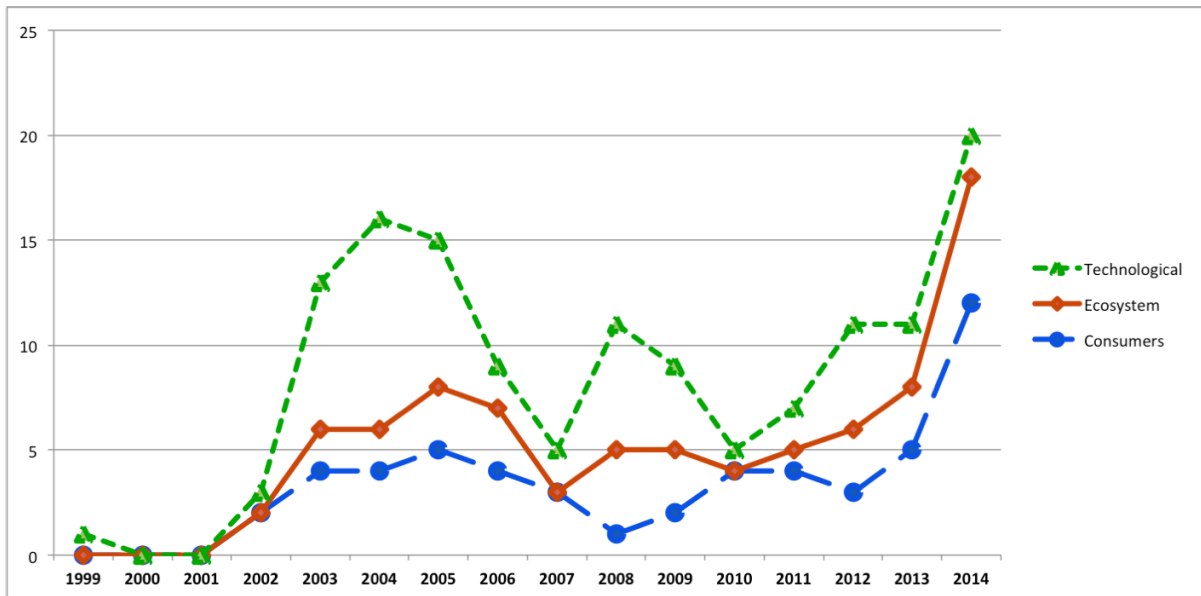


Figure 4: The evolution of the three most popular categories in mobile payment research

3.1. Mobile Payment Strategy and Ecosystems

Consumer adoption and technology have traditionally attracted a lot of attention in academia. Yet, these studies offered limited contributions to the understanding of the causes that have hindered the developments of mobile payments over the years. Most mobile payment initiatives have failed before reaching consumers and merchants. The recent emergence of multi-perspective and multi-level research on mobile payment platforms at the ecosystem level may eventually address the research gaps.

Already in 2005, several researchers suggested that multi-perspective approaches should be used. Their claim was that a focus on one single aspect at a time could only provide limited explanations about the complex phenomenon of mobile payments.

Early work from Ondrus et al. (2005) investigated mobile payments by using what they called a *technology environment assessment framework*. It combines three complementary perspectives: the market, the actors, and the issues. The *market perspective* examines ability to create and maintain a profitable relationship with consumers by providing a relevant value proposition that addresses consumers' needs. The *actor perspective* investigates the roles of the actors, the ecosystem structure, the economics and competitive conditions. The *issues perspective* deals with different uncertainties related to the future of mobile payments (e.g., physical forms of devices, sizes of payments). Ondrus et al. (2005) explained how the perspectives are linked and why they should be studied simultaneously. In line with their suggestion, Ondrus and Pigneur later performed a number of multi-perspective studies on the Swiss market (e.g., Ondrus and Pigneur, 2006a, 2006b).

Zmijewska and Lawrence (2005) proposed an alternative multi-perspective framework, based on the work of Damsgaard and Gao (2005). This framework comprises a *user adoption perspective* (e.g., customer and merchant adoption) and an *infrastructure*

perspective (e.g., stakeholder collaboration, regulation, business models) to analyze the success of mobile payments. Zmijewska and Lawrence claimed that both perspectives are equally important and depend strongly on each other, so they should be studied together.

After 2007, the number of articles on mobile payment ecosystems has gradually increased. Dahlberg et al. (2008a) proposed a theoretical framework to understand why a dominant design did not emerge during 10 years of failed mobile payment initiatives by Finnish actors, who had chaired international standardization committees that made attempts to conquer the world in the wake of Nokia. Their framework was built on theories taken from standardization and market emergence research. Dahlberg et al. (2008a) claimed that multi-disciplinary and multi-level analyses provide more insights than single theory models. Hence, their framework on the emergence of mobile payment markets comprised institutional, key market actors, and economic, business and technology factors.

Relying on other strategic and economic perspectives, Au and Kauffman (2008) proposed a framework to identify the relevant stakeholders of mobile payment ecosystem (i.e., technology producers, merchants, consumers, and regulators) and economic theories that are applicable to analyze mobile payments.

In an effort to provide an integrated view on mobile payment business models and to address RQ22 of Dahlberg et al. (2008b), Pousttchi et al. (2009) proposed an extension to the 'Business Model Canvas' of Osterwalder et al. (2005). Their article explains how complex mobile payment platforms are and how important it is to take into account interdependencies between technical, human, and market factors.

Through the use of three existing frameworks, Ondrus et al. (2009) analyzed several Swiss initiatives that had failed. Moreover, to overcome the static nature of previous frameworks, Ondrus et al. (2009) proposed a dynamic model to cover various diffusion stages, which encompasses the notion of time and sequence. By doing so, their framework aimed to understand better why mobile payment platforms had failed and provide guidance for future architecture designs.

Hedman and Henningsson (2012) studied how technological payment innovations influence payment ecosystems. They explained that digitalization of payments has caused ecosystem instability by impacting the competitive and collaborative dimensions of ecosystems. In other words, this digitalization creates a new arena for competition and requires new collaboration schemes between stakeholders.

Using institutional theory, Magnier-Watanabe (2014) proposed that the development of mobile payment systems depends on country-level institutional constraints – including compliance with industry-based and resource-dependent views.

By applying a strategic resource-based view, Gaur and Ondrus (2012) looked at what strategic assets make the presence of banks and financial institutions mandatory in mobile payment ecosystems. They demonstrated how certain assets provide a competitive advantage to the banks.

Kazan and Damsgaard (2013) constructed a framework to study digital payment systems and to analyze the strategies of current market actors. They analyzed three cases using the

multi-sided platform literature. Factors such as network effects, homing and switching costs, and bundling and envelopment were considered to be essential for the creation of a viable payment platform. In a follow-up work, Kazan and Damsgaard (2014) proposed an updated version of the framework, which combines platform, technology, and business design aspects.

With the arrival of new market actors to mobile payment markets, most notably Google, Paypal, Apple and AliBaba, researchers have started to investigate their impact on technology ecosystems (Ondrus and Lyytinen 2011). They examined mobile payments solutions from third parties. The strategic impact of merchant payment platforms, such as MCX in the U.S., which is the substance of *RQ21* in Dahlberg et al. (2008b) has not been investigated yet.

In their study on how nascent mobile payment markets emerge, Ozcan and Santos (2014) showed how firms from different industries struggled to agree on the architecture of a mobile payment market and how that led to resource allocation deferment. They disclosed that the participating firms had a history of dominance in their respective industries and lacked collaboration experience. Similarly, de Reuver et al. (2015) found that differences in strategic objectives and interests between banks and mobile network operators lead to the dissolution of a mobile payment platform in the Netherlands.

Hedman and Henningsson (2015) proposed a multi-level framework, consisting of micro, meso, and macro levels, to depict cooperation strategies in mobile payment ecosystems. Their framework is grounded on market cooperation theories, technology ecosystem theory, and business ecosystems theory. To validate their framework, Hedman and Henningsson (2015) conducted a case study in Denmark. The conclusion was that "market cooperation strategy in mobile payment ecosystems can be understood as a balance between defensive and offensive technology-based strategies" (Hedman and Henningsson, 2015, p.12).

Ondrus et al. (2015) investigated the impact of openness strategies on the market potential of platforms, using a multi-level framework as well. Their research draws on the experiences of multiple cases from different mobile payment markets. Ondrus et al. (2015) demonstrated that a number of strategic, technological, and user-related decisions have to be made before the launch of a mobile payment platform in order not to limit its diffusion potential. The unveiled conditions are necessary but not sufficient for ensuring success.

A recent framework proposed by Staykova and Damsgaard (2015) aims to identify optimal entry and expansion strategies of digital payment platforms. According to them the ability to time entry and expansion decisions optimally is key factor in the success of a platform. If the timing is non-optimal, previously gained competitive advantage could be lost.

In line with our previous comments, we point out that a number of recent studies have mainly confirmed the results of prior mobile payment ecosystem studies. Similar reasons for the failures of mobile payment platforms have been identified: lack of collaboration between multiple stakeholders, difficulties in finding win-win business models and the lack of standardization (Apanasevic, 2013; Au and Kauffman, 2008; de Reuver et al., 2015; Gannamaneni et al., 2015; Liu et al., 2015; Lim, 2008; Ondrus et al., 2009; Ozcan and Santos, 2014; Pousttchi, 2008). Despite these similar findings, the newer articles are in

general theoretically and empirically stronger. One obvious reason for this progress is that researchers have adopted established models and theories from other literatures, such as the multi-sided platform literature, strategic asset theory, and collective action theory. Similarly, the more recent case studies are more rigorously constructed, as more data has become publicly available.

In our opinion, research on mobile payment ecosystems has demonstrated that multi-level and multi-perspective approaches are required to obtain the necessary holistic understanding. Moreover, *RQ19* and *RQ20* suggested by Dahlberg et al. (2008b) called for research on the roles of each stakeholder and on how to organize collaboration between the stakeholders. Despite being examined by previous studies, these two research questions remain topical as the ecosystem is still evolving.

In summary, several multi-perspective frameworks have been proposed over the decade of research on the mobile payment ecosystems. Table 3 provides the classification of the main themes in these articles. It includes the themes of all 20 articles on ecosystems (2007-2014), which are listed in the Table A in the Appendix.

Table 3: Themes of ecosystems research

Themes of research	References
Multi-perspective framework for mobile payment ecosystems	2, 4, 5, 6, 7, 8, 10, 12, 17, 18
Framework to identify the actors and their role	2, 5, 10, 11, 12, 16, 17, 18, 19
Analysis of the business models	1, 5, 7, 8, 9, 14, 16, 17, 18
Study of strategic issues	2, 3, 4, 6, 7, 9, 11, 12, 13, 14, 15, 16, 17, 18, 24, 20

In general, we also found that the articles on ecosystems do not systematically build on the findings of previous studies, even though they have similar perspectives. Rapidly changing technology and the lack of successful mobile payment ecosystems, as well as the immaturity and exploratory nature of mobile payment ecosystem research, could probably explain this issue. The variety of frameworks also indicates that there are several ways to examine mobile payment ecosystems.

RQ19 and *RQ22* by Dahlberg et al. (2008b) proposed that researchers should investigate: i) what the optimal roles of each stakeholder are; ii) how to organize collaboration between stakeholders; and iii) how to capture and measure the value each stakeholder is able extract from the participation to a mobile payment ecosystem. Although all these research questions have been touched upon during the last 8 years, there are still opportunities for further research on these topics. Our assessment is that the proposed frameworks have been unable to offer definite recommendations on what needs to be done for mobile payment platforms and ecosystems to break through and succeed.

3.2. Technology and Technological Environment

In the literature review of Dahlberg et al. (2008b), the technology category was populated with the highest amount of publications between 1998 and 2006 with 29 articles. Technology and technological environments continue to be popular topics. In this review, we use 44 articles published between 2007 and 2014 (37 journal and 7 conference articles)¹, which are listed in the Table B in the Appendix.

The main issue addressed by the technology articles prior to 2007 was their fragmentation. Unfortunately, this issue has continued, with a new twist: security clearly became the dominant topic. Approximately 75% of the articles focus entirely on security, and security is one of the main topics (see Table 4). Some of the remaining articles also have small sections on security.

Table 4: Topics of technology and technological environment research

Name of the topic	# of articles	References
20 most popular topics		
Security including privacy	33	1-8; 10-11; 13-20; 22; 24; 26-27; 29-30; 32-33; 37; 39-44
Message protocols	14	1; 3-5; 7-8; 13; 16; 20; 22; 30; 38; 40-41
Security proofs	8	1; 3-5; 10; 20; 30; 39
PKI / WPKI /Public key; symmetric key	8	2-3; 5-7; 17-18; 22
Authentication	8	2; 4; 7; 8; 11; 17; 26; 40
Electronic coin; electronic cash; electronic money technologies	7	1; 8; 13; 21; 24; 34; 38; 42
Mobile payment protocols	6	5-6; 16-17; 22; 30; 41
Micro-Payment technology	6	8; 11; 15; 24; 27; 41
Trusted Device	5	4; 7; 21-22; 40
Cryptography	5	13; 16; 19; 37-38
Non-repudiation technology	4	2; 8; 20; 22
E-Payment technology	4	4; 8; 34; 38
Secure protocols	4	5; 11; 17; 43
3D secure and its modifications	4	5-6; 9; 14
Mobile Financial services technology	4	8; 14; 17; 33
RFID	4	10; 28; 30; 40
NFC	4	15; 29-30; 40
Proxy certificate	3	2; 7; 10
Technology performance evaluation	3	5-6; 10
Restricted connectivity	3	3; 5; 19
Other topics with their number		
<i>Topic discussed in 2 articles</i>	10	
<i>Topic discussed in a single article</i>	38	
<i>Total number of topics</i>	68	

The technology articles have become increasingly one-sided or uni-dimensional. However, at the same time, the related body of knowledge remains fragmented. The strong focus on security has not prevented the proliferation of other topics though. As Table 4 also shows, technology articles have cumulatively addressed 68 topics. However, other topics are still largely explored through the security lens. For example, security messages are a

¹ In Section 2, we used 25 articles for our descriptive statistical analysis, following our selection criteria. While reviewing the 25 papers, we started to see a fragmentation in the literature. In order to fully explore the technological literature, we then decided to include all the 44 articles in the analysis in Section 3 (i.e. in showing the fragmentation of topics and themes).

typical part of message protocols, which represents the second most popular topic.

The fragmentation can be illustrated by the fact that 38 topics have appeared only once in an article, and 10 in two articles. Another symptom of the fragmentation is that articles seldom build on each other or establish a series of articles by the same or related research teams. The findings of prior mobile payment studies, if discussed, are often described as related work rather than theoretical background or prior research findings. Furthermore, sections on related work in the research articles most often focus on the specifics of the technology investigated in the article, or those mobile payment and security-related problems that the technology aims to solve, or on the technical background of the investigated technology.

One research stream, which started from lightweight security with restricted connectivity scenarios, is an exception to what was stated above. Restricted connectivity means that a payer has limited or no online access to the merchant or bank at the time of the payment transaction execution (or vice versa). This stream of research started over a decade ago with Lam et al. (2003) and Kungpisdan et al. (2004). It has continued through the years in related studies by Hassinen et al. (2008) and Li et al. (2012). Building on previous studies, Isaac and Zeadally (2013) covered other issues than the lightweight security and restricted connectivity scenarios. They have also compared alternative technological solutions (Isaac and Zeadally 2014), which is another rare feature of technology articles (see Table 5).

Table 5: Themes of technology and technological environment research

Category	References	# of Descriptions Including Speculations	# of Proposed Constructions	# of Empirical, Prototype, Field, Design, Simulation	Evaluation of Alternatives
Proposals of m-payment systems	1; 11, 13, 15, 18, 32, 34, 38, 44	6	1	2	32
Proposals of tools or mechanisms for m-payment transactions	7, 8, 10, 12, 14, 17, 20, 25, 42	3	3	3	7, 8, 14
Proposals of protocols for m-payment transactions	3, 5, 6, 16, 22, 24	1	5		5, 6, 24
Proposals of tools or mechanisms for security and trust	2, 27, 29, 37, 40, 41, 43	4	3		2, 27, 43
Technology descriptions with a focus on security and trust	4, 30		1	1	30
Technology descriptions of m-payments	9, 19, 21, 26, 31, 33, 35, 2	7		1	26
Semiconductor elements, SIM cards, antennas	23, 28, 36			3	23
Total number of papers	44	21	13	10	13

Table 5 presents the different themes explored in the technological studies. Each article is classified in terms of one primary theme. We added a theme “Semiconductor elements, SIM cards, antennas” to the comparable table used in the 2008 literature review. We also added a new column to show, which articles compare alternative technological solutions even if such comparison would be limited. As Table 5 shows, there are numerous descriptions about specific technologies, their applications or usage (21 articles). During the years 2007-2014, it became more difficult to publish speculative descriptions about what technology in general or mobile technology could be or could do for payments. Contrary to this, a few articles published during the years 1998-2006 had a limited understanding about

technology: they were closer to science fiction than science. This is no longer the case, and the maturity of technology literature has grown.

We found fewer propositions for new technologies. The reason could be that the majority of descriptive articles discuss how to improve the deployment, use or impact of the described technology without proposing new technological designs. Furthermore, most of the 13 articles classified into the proposed constructions have a mathematical or logical evaluative section about the merits of the construction. The relative proportion of empirically evaluated constructions with prototypes has remained at the same level – slightly under the 25% level. As a whole, the technological articles are more mature and sophisticated than before, though they are more fragmented and one-sided.

Based on our review, we wonder: how it is possible that over 30 articles on security could produce a fragmented picture? One reason could be that technology articles published at any particular time may address technologies from different generations of mobile networks, mobile devices, SIM cards, POS terminals and other technology components used in a mobile payment service. In addition, the articles may have investigated different payment scenarios. A *payment scenario* may describe micro-payment money transfers between peers (P2P payments), proximity payments at vending machines with various short-wave radio frequency technologies (NFC, RFID), or the use of swipe cards or mobile device swiping in public transportation. Payments with mobile money, mobile wallets or mobile credit cards at the points of sale in shops or remotely, as purchases from electronic commerce or application stores, are other payment scenarios. We can add to these variations: micro and macro payments of purchases and electronic invoices with mobile banking payment services, payments handled with mobile network operators' network billing applications and payments handled with mobile service operators' service billing applications. In addition to payment transaction execution, it is necessary to consider how to: prevent fraud; achieve secure non-repudiation; and treat canceled, nullified, and reversed transactions with transaction rollback.

Since requirements for security, such as identification, authentication, security message protocols, messaging, data encryption, differ for each technology generation and layer and for each payment scenario, it is understandable why the literature is fragmented. The consequence is that the reader needs to consider carefully what constitutes the underlying technology, and the payment scenario of each article.

Research funding is another factor that may contribute both to the security focus of technology articles and their fragmentation. The first mobile payment adoption studies reported that security and trust are prerequisites for mobile payment adoption. Moreover, security is important to all parties of the ecosystems. The development of an improved message protocol, encryption method, token, device, software, or secure element feature may appear as a well-defined research project with clear objectives. One of the outputs of the project may be to report how the security construct was designed, implemented and validated mathematically, logically or empirically. In their acknowledgments, several articles thank the funding providers of their projects. Since there are seldom articles that would continue from these studies and build on the results that were achieved, it appears that the researchers have then moved to other topics. Knowledge has accumulated more slowly for this reason.

The previously discussed features of technological research tend to have negative consequences. By reading any set or all of the technological articles, the reader will be unable to establish a holistic picture about the technologies used in mobile payments. Similarly, the reader will be unable to learn about the most typical technology platforms that are used to conduct various mobile payment scenarios, and how they differ. Dominant technologies, such as those used to implement the EMV 3D secure model, mobile Internet protocol, credit card access, and secure identification and authentication in most popular mobile payment services (e.g., Google Wallet or PayPal) are under-represented in the technology literature. One obvious reason is that the service providers are reluctant to provide detailed information about their technologies. The disclosure of such information is often restricted. To understand technology, it is thus necessary to read trade journals, insightful blogs, service providers' documentation, and other similar materials. We encourage researchers who initiate new mobile payment research to read about mobile payments, whatever their research topic is. The rejection of a rather well-written article can be avoided if the focus is not based on imaginary payment scenarios or technologies, and the underlying business processes in the banking context are properly understood.

The clock-speed of technologies used in mobile payment services varies also. For example, the clock-speed of underlying IS and network infrastructure technologies, such as the shift from 3G to 4G, are close to 10 years – or even longer. Merchants renew their POS terminals every 3 to 7 years, whereas the lifecycle of mobile and smart phones is typically between 6 months and 2 years on average. Thus, there should be a better recognition of the role of clock-speed in technical research. For example, developing a security and trust protocol related to a payment scenario for a specific mobile device makes little sense if that device is no longer available after one year – unless the protocol can be easily ported to other devices. Those 25% of the articles that compare alternative technical solutions would benefit greatly from standardized tests to evaluate protocol performance, software quality, data transmission and handling speed. We also point out that many technological articles lack a solid theoretical basis, which is required for repeated studies and the accumulation of knowledge over time.

The literature review of Dahlberg et al. (2008b) proposed three research questions for future research. One of them encouraged researchers to investigate what security and trust mechanisms fit the various types of mobile payment services (*RQ6*). As discussed above, the majority of the technological research addresses this issue. Yet, the literature does not really provide answers to the question, as no article addresses research questions from this perspective. The question appears to have become too wide for any single article but we would benefit from studies, which compare security and trust mechanisms in specific payment scenarios or a specific security issue across several payment scenarios.

Fortunately, a few studies have tackled this issue though. Ou and Ou (2009) compared their own and six other non-repudiation protocols in terms of five criteria. Konidala et al. (2012) proposed a new anonymity solution and compared it to credit / debit cards, contactless (RFID) debit / credit cards such as mobile NFC, prepaid contactless cards, and anonymous electronic cash solutions. Yang and Wu (2013) developed three alternatives for micro-payment schemes with an ability to return changes based on different hash modes (counter-mode encryption hashing, aggressive mode hashing and balance mode hashing). They then compared those to schemes with single and multiple PayWord chains in terms of

ability to return changes, computational requirements, storage costs and keying of hash operations. The use of hashing in micro-payments has also been investigated by Nan et al. (2009). Their solution is based on a chaotic hash function, and is compared to the PayWord protocol and to the division PayWord protocol techniques.

Time itself has solved another research question noted by Dahlberg et al. (2008b). The standardization of transaction protocols and inter-operability mechanisms help to solve the roaming problem between networks and facilitate mobile commerce and payment transactions (RQ7). Standardization has not progressed, but the mobile Internet has solved most inter-operability issues and provides a means to reduce the dependency on mobile network operators.

The final research question is about the technological and technology-related strengths and limitations of the main technology architectures (RQ5). This research question has not been investigated. We feel that it is unrealistic to expect that researchers can contribute significantly to the technology of real-world mobile payment services and write about that. This question needs reformulation as we do later in Section 4.3.

In addition to the articles cited above, we find the following articles to be representative of good quality technology-related studies from 1999 up to the present: Misra and Wickamasinghe (2004), Valcourt et al. (2005), Hwang et al. (2007), Kousaridas et al. (2008), Lin et al. (2008), and Ma et al. (2013).

3.3. Mobile Payment Adoption Studies

As we explained earlier, all of the mobile payment adoption studies that we covered investigate consumer adoption. Understanding consumer preferences and the reasons to use or not use a specific technology-enabled service is important to design viable services that generate value to consumers and the other stakeholders of an ecosystem. Several models on the adoption of information technologies, such as the *technology acceptance model* (TAM), the *unified theory of acceptance and use of technology* (UTAUT), and *diffusion of innovation* (DOI) *theory* had been used in conceptual and also in empirical studies before 2007, as described by Dahlberg et al. (2008b). In addition to the factors in those models, trust, security, and cost were reported to strongly influence the adoption of mobile payments (Dahlberg et al., 2003; Pousttchi, 2003; Zmijewska et al., 2004).

The situation has not changed after 2007. On the contrary, consumer adoption has become the largest category of mobile payment research measured by the number of articles. Authors have continued to use well-established adoption and diffusion theories: TAM, UTAUT, DOI, but also *task-technology fit* (TTF) *theory*, the *theory of reasoned action* (TRA) and the *theory of planned behavior* (TPB). It is probably just a matter of time before first UTAUT2 article is published. On the one hand, continued research contributions on consumer adoption have confirmed the findings of earlier adoption studies, sometimes with better empirical data collection and more rigorous statistical analyses. Cumulatively, we probably know quite well the range of mobile payment service characteristics that are relevant to consumers. On the other hand, the 34 articles included in the statistical analysis in Section 2 rely on the same set of traditional adoption factors as the studies prior to 2007 and adoption studies in general. In our opinion, consumer adoption studies after 2007 have

thus failed to introduce innovative constructs or approaches into mobile payment research. Table 6 lists the adoption factors by the number of articles published after 2007.

The two factors of TAM top the list followed by trust and risk. The same two factors topped the comparable list of factors found important in prior 2007 articles. Trust shared the fourth position cost, which was in third place, in articles prior to 2007. Risk shared the sixth place in articles prior to 2007 together with security, social influence and convenience. The only factor not reported to be important in articles prior to 2007 among the top-10 factors after 2007 is demographics.

Table 6: Adoption factors in the literature

Construct	# of articles
Perceived ease of use	23
Perceived usefulness	22
Trust	22
Risk	21
Demographic	15
Security	15
Compatibility	10
Social influence	10
Cost	10
Mobility	10
Convenience	7
Subjective norm	7
Personal innovativeness	6
Habit	6
Privacy	5
Self-efficacy	5
Quality	5
Experience	4
Payment scenario	4
Income	3
Image	3
Knowledge	3
Satisfaction	2
Uncertainty avoidance	2
Technological impulse	2
Complementarity	1
Complexity	1

In addition to relying mainly on traditional consumer adoption factors, the authors of articles published after 2007 have played it safe with their methodological choices by avoiding newer and riskier approaches. One of the 34 articles applied the design science methodology, two are based on interviews, and the remaining 31 articles have collected empirical data with survey questionnaires to be analyzed statistically, mainly with alternative structured equation model methods. Due to these characteristics of consumer adoption research after 2007, it appears that researchers have not responded to the recommendations outlined by Dahlberg et al. (2008b), according to which future research could try to understand the actual meaning of each adoption factor for consumers, as well as their relationships to each other (RQ10).

23 articles after 2007 and 12 articles before 2007 reported that *perceived ease of use* is an important adoption factor for mobile payment services. The problem is that we do not know what *ease of use* means and is compared to. Ease of use and other adoption factors have been investigated largely at a generic level, as opposed to the contexts of actual real-world payment scenarios. In real-world payment scenarios, mobile payment is only one alternative rather than the only alternative. Another means to support the development of mobile payment knowledge could be the use of mixed-method approaches (e.g., a survey followed by interviews, or a field experiment).

Although we hoped that adoption research on mobile payments as a whole had addressed other stakeholders and had been more innovative regarding consumers, there are a few promising openings. The use of other theories from other disciplines than those already applied in IS research – especially in TAM and UTAUT – might result in a deeper understanding on the factors that impact consumer acceptance of mobile payment services. Alshare and Mousa (2014) investigated the effect of cultural dimensions, Cheng and Huang (2013) incorporated mental accounting theory into TAM, and Jia and Hall (2014) examined the transfer of learning theories by analyzing the habitual behavior of mobile payment users. Other alternatives could achieve richer conceptualizations of the dependent variable(s). Instead of *intention to use* mobile payments, for example, it may be possible to offer such alternatives as postponement of a decision, intention to use later, intention to use in the near future, and steps taken to start the use. New conceptualizations are possible also for the independent variables. For example, it may be possible to evaluate each adoption factor on a scale from *nice to have* to a *vital necessity*, or to enquire about activities taken to adopt a mobile payment service.

Another possible direction to increase our understanding is to compare the significance of adoption factors in various payment scenarios. Goeke and Pousttchi (2010) investigated the use of mobile payments to pay parking fees, to buy fare tickets and to make money transfers. There are also articles that address the adoption factors for different technologies, most notably NFC but also mobile wallets, in different payment scenarios, such as mobile ticketing and payments for governmental services. Such studies could be made more realistic by involving choices among competing payment instruments. Dahlberg and Öörni (2007) did so and introduced the concept of *payment habit*, which maps payment instruments and payment scenarios. They compared the choice of 11 payment habits in payments at the point of sale (e.g., the use of cash, credit card / debit cards, a mobile device etc.) and remotely (e.g., the use of electronic banking, credit / debit cards, a mobile device etc.). It is also possible to investigate the antecedents of adoption factors. For example, Xin et al. (2013) investigated trust from four perspectives: trust in a mobile service provider, mobile payment vendor, institutional environment, and the technology component.

Dahlberg et al. (2008b) put forward another recommendation for future research regarding consumer studies. In the only qualitative study after 2007, Mallat (2007) discovered with focus group interviews that the advantages of mobile payment services are different than those in established IS adoption models. A mobile payment service is seen as a means to behave (= pay for purchases), not as an IS to be taken into use. According to her, time and place independence, queue avoidance and possibilities for remote payments are perceived to be valuable. The second recommendation of Dahlberg et al. (2008b) (RQ11) encouraged researchers to investigate the involvement of consumers in the development of mobile payment services. Rapidly developing design science methods

provide tools for that but we found only 1 design science article that addressed this issue. Olsen et al. (2012) involved intended users in the design of functionalities and interaction with the services of a mobile wallet.

Consumer-centric mobile payment adoption research has tried to extend TAM, UTAUT and other established adoption models with numerous extensions during the last 15 years. The scientific sophistication and rigor has increased during this period. It was perhaps viable to investigate mobile payment adoption in general 15 years ago. It was perhaps also acceptable to use convenience samples such as students, and to conduct descriptive statistical analysis of data collected with surveys, which applied generic constructs of adoption models. Currently, however, we need hypothesis-based studies, which rely on strong theoretical background, and are conducted in real-world payment scenario contexts. There is enough real-world data about actual mobile payment usage and the volume of this data is increasing. This has made convenient samples less justified. Reliance on a wider variety of research methods, including mixed-method studies, would also deepen our understanding.

Currently, the challenge of mobile payment adoption research is not in rigor but in relevance. Mobile payments should be investigated as dynamically evolving services – rather than IT or IS – in their real-world contexts, where they compete with other payment instruments for popularity in payment scenarios applicable to these services. Similar to multi-sided platform and ecosystem studies, there is a need for multi-sided adoption studies within the same ecosystems. Such studies, for example, could investigate with field research what payment instruments the various stakeholders of an ecosystem (consumers, merchants, issuers, acquirers, traffic carriers) prefer and why. It also may be possible to examine the impact of financial and other incentives and payment fees on these decisions. Classic adoption factors are probably useful when contextualized for such mobile payment studies.

3.4. Authorship Analysis

Overall, our review of literature from 2007 to 2014 showed fair progress in the quantity and quality of the research. It is possible to argue that mobile payment research is getting more mature, since there have been more journal articles and empirical studies in recent years. We also discovered that newer mobile payment researchers do not systematically refer to prior work though. Hence, we have tried to understand the lack of cumulative research by investigating the longevity of mobile payment researchers. The majority of authors have published less than 3 articles in the selected outlets of this descriptive literature review. We identified 23 authors who published more than 2 articles between 1999 and 2014.

In Figure 5, we listed the authors in chronological order according to their first article published. One can see that there are several generations of authors. The pioneers published their first papers in 2002-2003. Another group started in 2004 when the topic seems to have been the hottest. More recently, other dedicated researchers have joined the mobile payment research community. We found that only a few researchers who started early and kept a consistent production of papers over the years though. The lack of committed researchers may explain why newer research tends to be "re-inventing the wheel".

Authors	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	#
Mallat, N.	1	2	1	2	2	1	2	1						12
Dahlberg, T.	1	2			2	1	2							8
Pousttchi, K.		3			1	1	1	1	1			1		9
Öörni, A.		2			1	1	1	1						6
Karnouskos, S.		1	3											4
Le, P. D.		1	2											3
Srinivasan, B.		1	2											3
Ondrus, J.			1	2	5		1	2		1	1			13
Pigneur, Y.			1	2	4			2						9
Zmijewska, A.			3	2			1							6
Tuunainen, V.			1	2			1	1						5
Lawrence, E.			3	1										4
Steele, R.			3											3
Sue, K.		1	2											3
Rossi, M.				1			1	1						3
Wiedemann, D.					1	1		1						3
Damsgaard, J.										1	1	1		3
Isaac, J.T.										1	1	1		3
Kauffman, R.							1				1	1		3
Zhou, T.								1		1		1	1	4
Munoz-Leiva, F.													3	3
Sanchez-Fernandez, J.													3	3
Zeadally, S.											1	1	1	3
# per year	1	10	20	12	14	4	9	10	1	2	5	6	10	

Figure 5: Mobile payments researchers with more than 2 papers in our literature review

We took a closer look at the 23 authors in our list and examined their affiliations². A pioneering team from Aalto University School of Business (formerly Helsinki School of Economics) in Finland published several articles, which belonged to the earliest academic work on mobile payments. Their activity started during the rise of Nokia to the number one position as a mobile handset manufacturer. At the time, Nokia together with Finnish telecom operators and banks chaired most mobile payment standardization and industry consortia (Dahlberg et al 2008a). They funded Dahlberg, Mallat, Öörni, Tuunainen and Rossi's research projects. The EU project SEMOPS (Secure Mobile Payment Service) project was led by Karnouskos from the Fraunhofer Institute in Germany, and included a number of industry researchers from Hungary and Greece, such as Vilmos. This project was technically-oriented and the researchers sought to develop an architecture for mobile payments. This team wrote early articles on mobile payments. Also involved in SEMOPS, Pousttchi established a research team at the University of Augsburg in Germany. His team, called "Wi-mobile" involved a number of Ph.D. students working on mobile payments (e.g., Wiedemann, Goeke). Wi-mobile has remained active in mobile payment research for a long time. In 2004, Ondrus and Pigneur, based at the University of Lausanne in Switzerland, published their first article on mobile payments. Ondrus wrote his Ph.D. thesis under the supervision of Pigneur. In 2007, Lytinen joined the team while he was on sabbatical in

² The list of authors and teams is based on our literature review and therefore may not be exhaustive. There are most likely some omissions, and we apologize for them.

Lausanne. More recently, Ondrus started collaborations at the ESSEC Business School with his students, in particular Gaur and Gannamaneni. In 2004, another research team was organized around the late Lawrence in Australia. Her team at University of Technology Sydney included Steele and her Ph.D. student Zmijewska, who ceased to work on mobile payments after her graduation. Also, Zeadally from the University of Kentucky wrote a number of technical papers on mobile payments. Some were co-authored with Isaac from the Universidad de Carabobo in Venezuela.

In recent years, other teams in the northern part of Europe became actively involved in mobile payment research. In Denmark, Damsgaard, Hedman and Henningsson at the Copenhagen Business School recently formed a productive research group with several Ph.D. students (e.g., Kazan, Olsen, Staykova). Their research is supported by the Copenhagen Finance IT Region, which hosted the first International Cashless Society Roundtable. Teams from Ireland (with Carton) and Sweden (with Markendahl, Arvidsson, and their student Apanasevic) organized follow-up editions of the Roundtable. Both groups have been actively involved in mobile payments research during the past years. Another group of researchers led by Bouwman and de Reuver at TU Delft in the Netherlands has investigated mobile payments lately. In Spain, Sanchez-Fernandez, Munoz-Leiva and Liebana-Cabanillaz from the University of Granada also contributed to mobile payment research with papers on acceptance and adoption, mostly published in 2014. Zhou from the Hangzhou Dianzi University published several papers by himself. At Singapore Management University, Kauffman and Ma have been working on mobile payments with their Ph.D. student Liu for the last several years.

4. CRITICAL COMMENTS AND RECOMMENDATIONS FOR FUTURE MOBILE PAYMENT RESEARCH

In the previous section, we reviewed and commented studies in the three dominant categories of mobile payment research: *mobile payment strategy and ecosystems*, *technology and technological environment*, and *mobile payment adoption*. Now we will discuss issues that have impeded the harmonious development of mobile payment research. We also will propose what mobile payment research should be aiming at. We hope that researchers will maintain rigor where it has been reached, strive for it elsewhere, and finally engage in more relevant research during the coming years especially in adoption research. We believe that the conditions to perform such research exist but will require consistent effort and new ideas.

4.1. Overall Comments on Mobile Payment Research

Overall, mobile payment researchers have rarely engaged in empirical longitudinal studies. Dahlberg et al. (2008a) is one of the few exceptions. It drew on repeated interviews with the same 12 experts over 6 years. Mobile payments have turned out to be a highly complex topic to study. A mobile payment service or market evolves continually. Even failed services may evolve for several years prior their discontinuation. Consequently, one-time studies with one or a few articles have been and are probably likely to provide limited contributions. We hope that the authorship description above helps new researchers to join productive and insightful teams. Even academic and industry experts involved with mobile payments for more than a decade still struggle to comprehend the phenomenon. Despite

hundreds of scientific articles and probably even more pilots and service launches, we still do not know when and how mobile payment services reach mass markets in developed economies. Although anything is possible, it is unlikely that opportunistic researchers will be able to make breakthroughs with a short-term vision and limited knowledge about the topic. Many pioneers have left the field and even academia. Newcomers are encouraged to review prior work since they will benefit from it to strengthen their new ideas. We discovered that numerous articles published in recent years ignored the findings and contributions of past work – or simply did not cite them – and reached the same results as the uncited articles did.

Our second comment is about the quality of data. During the early days, empirical data were difficult to collect as the phenomenon was only emerging. There were only a few industry experts that could be interviewed also. Mobile payments were almost the stuff of science fiction to most consumers and merchants. Moreover, secondary data were non-existent in the early 2000s, with the exception of some consulting reports. But later, the availability of experts, experiences and sources increased significantly. So we expect researchers to use better quality data to validate their research. The use of student and other convenience samples to assess mobile payment adoption will be more difficult to justify. Similarly, technology articles that do not include proper evaluations of the technology construct or comparisons with alternative constructs will be much less viable. To conclude, we strongly encourage researchers to collect data from the real world. For example, field tests, experiments and experiences about real services, or data about the actual usage of mobile payment services will improve the relevance and impact of academic research.

Early conceptual articles seldom relied on theories to properly frame their research problems. When a phenomenon is emerging, research often lacks an appropriate and sound theoretical basis. As a result of this, a limited number of articles were published in major journals. Over the years, using exploratory approaches and by importing theories from other disciplines, researchers have attempted to create and adapt theories that were suited to mobile payments research. Our third comment is that theory development and the strengthening of the relevant theory base were still essential to improve the rigor and relevance of mobile payment research.

The fourth comment regards the fragmentation of research and the lack of a holistic view about mobile payments and the related services. This comment does not mean that we should investigate mobile payments as one issue but that ecosystem characteristics, technology features and adoption factors impact each other. Thus studies on ecosystem, technology or adoption in isolation only are able to contribute to a partial understanding of mobile payments. After 15 years of research, it is troubling that we know next to nothing about merchant adoption, competition between mobile and other payment instruments, and the impacts of changes in commercial, legal, regulatory, social and cultural environments.

The fifth comment addresses the generalization of the research findings. Mobile payments have created both global and local issues. For example, Google Wallet and Apple Pay are available only in North America, AliPay is available only in China, and in Europe most services are available locally in one or a few countries. The most popular credit cards are the only global payment instruments. Crossing borders has proved to be difficult in developed countries, since local banks, merchants, telecom companies and regulators feel that their vested interests are threatened. Even if this were not the case, each market is

different. Telecom, banking, and retail, as well as other economic infrastructures, regulation, culture, commerce habits and payment instruments used, differ significantly across markets. Therefore, many mobile payment research findings are not necessarily generalizable. We encourage multi-country and multi-market studies whenever possible.

In Table 7, we list the 15 most-cited articles from our literature review. We made the cut at 100 citations from Google Scholar (as of April 20, 2015). The "overview" articles in journals with higher impact factors are the most-cited publications. These articles offer definitions and references about mobile payments. There is also a good representation of "adoption" and "ecosystem" articles published in journals and conferences. Surprisingly, the "technological" articles are not represented in the list at all. Despite the high number of articles published in this category, none of them has had enough impact to make the cut. The lack of cumulative research and fragmentation might explain this finding. We hope that the recommendations provided below for each research category will encourage authors to write in years to come more articles that are cited more than 100 times.

Table 7. List of the 15 most cited papers 1998-2015, as of April 20th 2015.

#	Title	Outlet	Year	Category	Citations
1	Past, present and future of mobile payments research: A literature review	Electronic Commerce Research and Applications	2008	Overview	340
2	Exploring consumer adoption of mobile payments - a qualitative study	Journal of Strategic Information Systems	2007	Adoption	319
3	Mobile banking services	Communications of the ACM	2004	Overview	252
4	Payments and banking with mobile personal devices	Communications of the ACM	2003	Overview	224
5	An empirical examination of factors influencing the intention to use mobile payment	Computers in Human Behavior	2010	Adoption	233
6	Understanding consumer acceptance of mobile payment services: An empirical analysis	Electronic Commerce Research and Applications	2010	Adoption	235
7	The impact of use context on mobile services acceptance: The case of mobile ticketing	Information and Management	2009	Adoption	208
8	The economics of mobile payments: Understanding stakeholder issues for an emerging financial technology application	Electronic Commerce Research and Applications	2008	Ecosystem	181
9	Mobile payment: a journey through existing procedures and standardization initiatives	Communications Surveys and Tutorials	2004	Ecosystem	163
10	Towards an understanding of the consumer acceptance of mobile wallet	Computers in Human Behavior	2009	Adoption	162
11	Understanding m-commerce payment systems through the analytic hierarchy process	Journal of Business Research	2004	Adoption	124
12	Trust enhanced technology acceptance model-consumer acceptance of mobile payment solutions: Tentative evidence	Stockholm Mobility Roundtable	2003	Adoption	124
13	Conditions for Acceptance and Usage of Mobile Payment Procedures	International Conference on Mobile Business	2003	Adoption	114
14	An empirical investigation of mobile ticketing service adoption in public transportation	Personal and Ubiquitous Computing	2008	Adoption	115
15	Towards a holistic analysis of mobile payments: A multiple perspectives approach	Electronic Commerce Research and Applications	2006	Ecosystem	106

4.2. Recommendations for "Ecosystem" Research

Although ecosystem research has increased in volume and quality, there are still a number of issues that require proper research-based responses. First, we do not yet understand what value mobile payments provide to the different stakeholders of an

ecosystem. Moreover, we know even less about how this unknown value should be distributed among the stakeholders of the ecosystem. Depending on the type of platform, value sharing can be quite complex. The ownership of consumers and customers is a recurring issue also. For example, if a service is driven by mobile network operators (MNOs) and banks, the implementation of the NFC secure element may determine who owns the consumer relationship. We recommend investigating this issue.

The next issue in need of research is the qualification of different ecosystems or markets. Researchers need to establish a list of characteristics that differentiate ecosystems. For example, we know that each market is different but do not know what factors best characterize the variations. Once the list of differentiating factors is validated, researchers should be able to contextualize their findings and see if they can apply them to other multi-sided markets.

Related to the previous recommendation, mobile payments generate local and global considerations. MNOs and banks typically have limitations in customer reach and are able to attract consumers and merchants primarily from their respective countries or regions. On the other hand, global actors such as Apple, Samsung, Google, Paypal, Visa and Mastercard can act globally with proper alliances and favorable regulatory frameworks. We need additional research on the ability of various actors to act locally or globally.

Inter-organizational ecosystem governance also may vary significantly across mobile payment markets. For example, in a highly-regulated market, the ecosystem could be established with the active involvement of the government or regulator. They could act as the catalyst and mediator needed to bring various stakeholders to the negotiation table. In markets dominated by the market participants, the orchestration of an ecosystem may emerge in different ways, for example, through a joint venture or through platform leadership-based resource dominance and co-dependence. Markets also develop in dissimilar ways. Some favorable infrastructure and economic factors could fertilize the ecosystem for successful mobile payments initiatives. Future ecosystem studies and frameworks should take into account a number of essential perspectives and be able to emphasize contextual factors at the same time.

In our opinion, ecosystem research should integrate findings from all mobile payment research categories due to its position. For example, the technical implementation of a NFC secure element has important repercussions on the roles of ecosystem stakeholders, and impacts also the adoption of consumers and merchants. Depending on the type of secure element, the potential size of the market could vary significantly. If a mobile payment platform requires the rollout of a new technology among consumers and merchants groups, the platform will most likely experience a slower diffusion curve. Technical choices can have a systemic effect on the ecosystem and the adoption. So technology, strategy, and adoption issues are inter-related and should be taken into account as a whole.

The final recommendation is to encourage researchers to synthesize their efforts better than in the past. This step is feasible, as most active mobile payment researchers know each other fairly well. Currently, there is no consensus on aspects to consider in mobile payment ecosystem research. Yet, the various frameworks that have been designed can help ecosystem researchers to establish a starting point for developing a jointly-accepted framework. Such a framework should be holistic enough to deal with the complexity of mobile payment ecosystems and open enough to allow alternative and complementary investigations.

4.3. Recommendations for "Technological" Research

Though numerous researchers have worked on the technological aspects of mobile payments, it is unclear what contributions academic researchers can offer to mobile payment services providers. The technology of mobile payment platforms appears to be developed in the labs of mobile payment service providers and their vendors. Academia seems to be limited in what it can offer to practitioners in terms of technology, unless companies want to actively involve academic researchers. Even when they are involved, non-disclosure agreements may prevent the researchers from writing articles. On the other hand, academic research risks becoming irrelevant if researchers are excluded from industry projects.

The development of various security, trust, and network traffic algorithms, based on software, and physical tokens and their combinations, used to be in various payment scenarios. This is probably the most promising area for cooperation, and also for academic research. This coincides with the technology research carried out so far. As a research community, we do not have a holistic picture of security and trust. Both practitioners and the research community may benefit from such a framework, to map payment scenarios with security and trust technologies and name them, for example, as security and trust methods. In addition to technology research, adoption researchers can work on the same topic to validate the preferences and needs of various security and trust methods in these scenarios.

Another area where researchers, again in cooperation with practitioners, can make contributions is the development of standardized tests. These can be used to evaluate calculation and processing performance, speed, costs and vulnerabilities of security, carry, encryption, and other algorithms and protocols. Similarly, a logical architecture of a payment platform may be possible to define. For example, by starting from the EMV 3D secure model, the framework could be used to place various technology components into their proper context and to compare the logical architectures for different payment scenarios.

Researchers can evaluate major mobile payment services from a technical soundness perspective. To have a holistic approach, they can work together with ecosystem researchers. Currently, this type of study has been left to the specialized press. An obvious challenge is to carry out such benchmarking research with academic criteria.

4.4. Recommendations for "Adoption" Research

In Dahlberg et al. (2008b), several possible venues for future research on adoption were proposed. The recommendations suggested to investigate the contextual meaning of adoption factors and to involve consumers in the development of mobile services. These recommendations are still valid.

The next recommendation was to strengthen the theoretical basis of adoption research and to conduct empirical data collection in real-life payment scenarios. In addition to or instead of adoption intention, the concept of acceptance should be elaborated to better represent real-life payment scenarios. We explained that the use of a mobile payment service is often one option among many. These choices can be investigated more thoroughly. For example, we should study the variance for payments at the points of sale in stores, shops, kiosks and vending machines. Data collection should be done at different points of time also to capture events such as rush hours and quiet hours, and long to short queues at the points of sale. By using mixed-method approaches, it would be possible to collect rich datasets of primary and secondary data to triangulate toward robust results. We

also wish to encourage researchers to conduct these studies in several countries to understand the impacts of differing ecosystem characteristics. The theoretical basis also can be extended by looking at the psychology of payments, behavioral and mental action theories, economic theories involving theories of money, the history of payment instrument usage in various countries, and the pricing of payment instruments. Practitioners and researchers will benefit from a framework, in which payment instruments with their attributes and payment scenarios with their attributes are integrated.

The most important recommendation is to investigate the simultaneous adoption of mobile payments by several groups. We called it *multi-sided adoption research*. In these studies, ecosystem and technology adoption researchers can work together to complement one another's views. They can investigate the impact of inter-organizational governance, business models, and data sharing of stakeholder adoption. The involvement of ecosystem researchers is useful because the decisions of chains of merchants will be different from those made by independent merchants. In any case, the preferences and technical capabilities of a merchant to accept payment instruments is one of the key adoption factors. If merchants are unable to accept mobile payments, it might be the end of the game.

5. CONCLUSION

In this article, we have provided an update to the previous literature review of Dahlberg et al. (2008b)³. We highlighted the differences between pre- and post-2007 research publications, in terms of quantity and quality. In addition, we offered qualitative comments about the progress made. By using the same framework as in the previous review, we discovered that technology and consumer adoption are still the dominant categories, followed by ecosystem research. Research in the 6 other categories has not attracted the attention we hoped for. Due to the lack of additional research in the six categories, we could only analyze in detail the literature published in "ecosystem", "technological" and "adoption" categories. We did our best to offer an overview of the contributions and to provide some critical remarks. In addition, we provided a visualization of how the community of mobile payment researchers has evolved over time. It helped us to highlight that only a handful of researchers have investigated mobile payments from the early years up to now. We concluded this by offering critical comments and recommendations to encourage more rigorous, relevant, and impactful research for the future.

Mobile payment researchers have continued to unnecessarily study a few categories of research, and do little work in the other categories. Moreover, there are only few researchers with long periods of activity. We also found that newer researchers have often ignored past research and investigated the same issues. This may explain why we have seen limited progress in several mobile payment research themes during the last eight years. This summary is our answer to the first research question presented in Section 1. The lack of cumulative research may also explain why the theoretical basis and the relevance of many studies have not reached the level that is required to publish in top journals. To improve their

³ Although we have tried to include as much as possible of the mobile payment literature published after 2007 to our article, we may have failed to identify important contributions. Articles without the descriptor keywords in their titles or outside the databases used to collect the literature have not been detected. It is also likely that there are insightful articles written in languages other than English. We may also have misinterpreted some article(s).

work, researchers need to strengthen the theoretical basis of their studies, collect quality data, use multi-perspective and multi-level approaches to conduct their investigations, and more importantly build more on past research findings. This summary is our response to the second research question.

Overall, the emergence of research at the "ecosystem" level is promising. This research tends to integrate the categories that have been not been studied enough. There is no doubt that contingency factors and other dimensions are beneficial to understanding mobile payment ecosystems in a more holistic manner. Thus, the increase of "ecosystem" articles will help to improve the quality of mobile payment research. The complexity of the topic and the constant evolution of the environment call for additional research. There are still numerous issues that require deeper attention from the academic community. Due to the growing number of teams working on mobile payments, we expect to see more high-quality research projects in the future. We hope that our updated literature review and our recommendations will provide useful guidance for the mobile payment research community.

REFERENCES

Alshare, K., Mousa, A., 2014. The moderating effect of espoused cultural dimensions on consumer's intention to use mobile payment devices. In: Proceedings of the 35th International Conference on Information Systems (ICIS). Auckland, New Zealand.

Apanasevic, T., 2013. Factors influencing the slow rate of penetration of NFC mobile payment in Western Europe. In: Proceedings of the 12th International Conference on Mobile Business (ICMB) Berlin, Germany.

Au, Y. A., Kauffman, R. J., 2008. The economics of mobile payments: Understanding stakeholder issues for an emerging financial technology application. *Electronic Commerce Research and Applications* 7 (2), 141–164.

Cheng, Y.-H., Huang, T.-Y., 2013. High speed rail passengers' mobile ticketing adoption. *Transportation Research Part C: Emerging Technologies* 30 (2013), 143 – 160.

Dahlberg, T., Huurros, M., Ainamo, A., 2008a. Lost opportunity: Why has dominant design failed to emerge for the mobile payment services market in Finland? In: Proceedings of the 41th Annual Hawaii International Conference on System Sciences. IEEE Computer Society Press, Washington, DC, USA.

Dahlberg, T., Mallat, N., Ondrus, J., Zmijewska, A., 2008b. Past, present and future of mobile payments research: {A} literature review. *Electronic Commerce Research and Applications* 7 (2), 165–181.

Dahlberg, T., Mallat, N., Öörni, A., 2003. Trust enhanced technology acceptance model: Consumer acceptance of mobile payment solutions. The Stockholm Mobility Roundtable 2003, Stockholm, Sweden.

Dahlberg, T., Öörni, A., 2007. Understanding changes in consumer payment habits: Do mobile payments and electronic invoices attract consumers? In: Proceedings of the 40th Annual Hawaii International Conference on System Sciences. IEEE Computer Society Press, Washington, DC.

- Damsgaard, J., Gao, P., 2005. A framework for analyzing mobile telecommunications market development. In: Proceedings of IFIP TC8 Working Conference on Mobile Information Systems (MOBIS). Oslo, Norway, pp. 169–182.
- de Albuquerque, J. P., Diniz, E. H., Cernev, A. K., 2014. Mobile payments: A scoping study of the literature and issues for future research. *Information Development*, 1–27.
- de Reuver, M., Verschuur, E., Nikayin, F., Cerpa, N., Bouwman, H., 2015. Collective action for mobile payment platforms: A case study on collaboration issues between banks and telecom operators. *Electronic Commerce Research and Applications*, 14 (5), in this issue.
- Dennehy, D., Sammon, D., 2015. Trends in mobile payments research: A literature review. *Journal of Innovation Management* 3 (1), 49–61.
- Gannamaneni, A., Ondrus, J., Lyytinen, K., Jan 2015. A post-failure analysis of mobile payment platforms. In: Proceedings of the 48th Hawaii International Conference on System Sciences (HICSS). IEEE Computer Society Press, Washington, DC.
- Gaur, A., Ondrus, J., 2012. The role of banks in the mobile payment ecosystem: A strategic asset perspective. In: Proceedings of the 14th Annual International Conference on Electronic Commerce (ICEC). ACM Press, New York, NY.
- Ghezzi, A., Renga, F., Balocco, R., Pescetto, P., 2010. Mobile payment applications: Offer state of the art in the Italian market. *Info* 12 (5), 3–22.
- Goeke, L., Pousttchi, K., 2010. A scenario-based analysis of mobile payment acceptance. In: Proceedings of the Ninth International Conference on Mobile Business and Ninth Global Mobility Roundtable (ICMB-GMR). Athens, Greece.
- Hassinen, M., Hyppönen, K., Trichina, E., 2008. Utilizing national public-key infrastructure in mobile payment systems. *Electronic Commerce Research and Applications* 7 (2), 214–231.
- Hedman, J., Henningsson, S., 2012. Competition and collaboration shaping the digital payment infrastructure. In: Proceedings of the 14th Annual International Conference on Electronic Commerce (ICEC). ACM Press, New York, NY, USA
- Hedman, J., Henningsson, S., 2015. The new normal: Market cooperation in the mobile payments ecosystem. *Electronic Commerce Research and Applications*, 14 (5), in this issue.
- Hwang, R.-J., Shiau, S.-H., Jan, D.-F., 2007. A new mobile payment scheme for roaming services. *Electronic Commerce Research and Applications* 6 (2), 184–191.
- Isaac, J. T., Zeadally, S., 2013. Design, implementation, and performance analysis of a secure payment protocol in a payment gateway centric model. *Computing* 96 (7), 587–611.
- Isaac, J. T., Zeadally, S., 2014. Secure mobile payment systems. *IT Professional* 16 (3), 36–43.
- Jia, L., Hall, D., 2014. The effect of technology usage habits on consumers' intention to continue use mobile payments. In: Proceedings of the Twentieth Americas Conference on Information Systems (AMCIS). Savannah, GA, USA.
- Kazan, E., Damsgaard, J., 2013. A framework for analyzing digital payment as a multi-sided platform: a study of three European NFC solutions. In: Proceedings of the 21st European Conference on Information Systems (ECIS). Utrecht, The Netherlands.

- Kazan, E., Damsgaard, J., 2014. An investigation of digital payment platform designs: a comparative study of four European solutions. In: Proceedings of the 22nd European Conference on Information Systems (ECIS). Tel Aviv, Israel.
- Konidala, D. M., Dwijaksara, M. H., Kim, K., Lee, D., Lee, B., Kim, D., Kim, S., 2012. Resuscitating privacy-preserving mobile payment with customer in complete control. *Personal and Ubiquitous Computing* 16 (6), 643–654.
- Kousaridas, A., Parissis, G., Apostolopoulos, T., 2008. An open financial services architecture based on the use of intelligent mobile devices. *Electronic Commerce Research and Applications* 7 (2), 232–246.
- Kshetri, N., Acharya, S., 2012. Mobile payments in emerging markets. *IT Professional* 14 (4), 9–13.
- Kungpisdan, S., Srinivasan, B., Le, P. D., 2004. Accountability logic for mobile payment protocols. In: Proceedings of the International Conference on Information Technology: Coding and Computing (ITCC). Las Vegas, NV, USA.
- Lam, K.-Y., Chung, S.-L., Gu, M., Sun, J.-G., 2003. Lightweight security for mobile commerce transactions. *Computer Communications* 26 (18), 2052–2060.
- Li, W., Wen, Q., Su, Q., Jin, Z., 2012. An efficient and secure mobile payment protocol for restricted connectivity scenarios in vehicular ad hoc network. *Computer Communications* 35 (2), 188–195.
- Lim, A. S., 2008. Inter-consortia battles in mobile payments standardisation. *Electronic Commerce Research and Applications* 7 (2), 202–213.
- Lin, P., Chen, H. Y., Fang, Y., Jeng, J. Y., Lu, F. S., 2008. A secure mobile electronic payment architecture platform for wireless mobile networks. *IEEE Transactions on Wireless Communications* 7 (7), 2705–2713.
- Liu, J., Kauffman, R. J., Ma, D., 2015. Competition, cooperation, and regulation: Understanding the evolution of the mobile payments technology ecosystem. *Electronic Commerce Research and Applications*, 14 (5), in this issue.
- Ma, D., Saxena, N., Xiang, T., Zhu, Y., 2013. Location-aware and safer cards: Enhancing RFID security and privacy via location sensing. *IEEE Transactions on Dependable and Secure Computing* 10 (2), 57–69.
- Magnier-Watanabe, R., 2014. An institutional perspective of mobile payment adoption: The case of Japan. In: Proceedings of the Annual Hawaii International Conference on System Sciences (HICSS). IEEE Computer Society Press, Washington, DC.
- Mallat, N., 2007. Exploring consumer adoption of mobile payments; A qualitative study. *The Journal of Strategic Information Systems* 16 (4), 413–432.
- Misra, S. K., Wickamasinghe, N., 2004. Security of a mobile transaction: a trust model. *Electronic Commerce Research* 4 (4), 359–372.
- Nan, J., Xiang-dong, L., Jing-ying, Z., De-Li, Y., 2009. A mobile micropayment protocol based on chaos. In: Proceedings of the 8th International Conference on Mobile Business (ICMB), Dalian, China.

- Olsen, M., Hedman, J., Vatrapu, R., 2012. Designing digital payment artifacts. In: Proceedings of the 14th Annual International Conference on Electronic Commerce (ICEC). ACM Press, New York, NY, USA.
- Ondrus, J., Camponovo, G., Pigneur, Y., 2005. A proposal for a multi-perspective analysis of the mobile payment environment. In: Proceedings of the 4th International Conference on Mobile Business (ICMB), Sydney, Australia.
- Ondrus, J., Gannamaneni, A., Lyytinen, K., 2015. The impact of openness on the market potential of multi-sided platforms: a case study of mobile payment platforms. *Journal of Information Technology*, in press.
- Ondrus, J., Lyytinen, K., 2011. Mobile payments market: towards another clash of the titans? In: Proceedings of the 10th International Conference on Mobile Business (ICMB). Como, Italy.
- Ondrus, J., Lyytinen, K., Pigneur, Y., 2009. Why mobile payments fail? towards a dynamic and multi-perspective explanation. In: Proceedings of the 42nd Annual Hawaii International Conference on System Sciences (HICSS). IEEE Computer Society Press, Washington, DC.
- Ondrus, J., Pigneur, Y., 2006a. A multi-stakeholder multi-criteria assessment framework of mobile payments: An illustration with the Swiss public transportation industry. In: Proceedings of the 39th Hawaii International Conference on Systems Science (HICSS). IEEE Computer Society Press, Washington, DC.
- Ondrus, J., Pigneur, Y., 2006b. Towards a holistic analysis of mobile payments: a multiple perspectives approach. *Electronic Commerce Research and Applications* 5 (3), 246–257.
- Osterwalder, A., Pigneur, Y., Tucci, C. L., 2005. Clarifying business models: Origins, present, and future of the concept. *Communications of the Association for Information Systems* 15 (1), 1–40.
- Ou, C. M., Ou, C. R., 2009. Adaptation of proxy certificates to non-repudiation protocol of agent-based mobile payment systems. *Applied Intelligence* 30 (3), 233–243.
- Ozcan, P., Santos, F., 2014. The market that never was: Turf wars and failed alliances in mobile payments. *Strategic Management Journal*, in press.
- Pousttchi, K., 2003. Conditions for acceptance and usage of mobile payment procedures. The Second International Conference on Mobile Business. Vienna, Austria.
- Pousttchi, K., 2008. A modeling approach and reference models for the analysis of mobile payment use cases. *Electronic Commerce Research and Applications* 7 (2), 182–201.
- Pousttchi, K., Schiessler, M., Wiedemann, D. G., 2009. Proposing a comprehensive framework for analysis and engineering of mobile payment business models. *Information Systems and e-Business Management* 7 (3), 363–393.
- Slade, E. L., Williams, M. D., Dwivedi, Y. K., 2013. Mobile payment adoption: Classification and review of the extant literature. *The Marketing Review* 13 (2), 167–190.
- Staykova, K. S., Damsgaard, J., 2015. The race to dominate the mobile payments platform: Entry and expansion strategies. *Electronic Commerce Research and Applications* 14 (5), in this issue

To, W. M., Lai, L. S. L., 2014. Mobile banking and payment in China. *IT Professional* 16 (3), 22–27.

Valcourt, E., Robert, J.-M., Beaulieu, F., 2005. Investigating mobile payment: supporting technologies, methods, and use. In: *Proceedings of the International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob'2005)*. Vol. 4, IEEE Computer Society Press, Washington, DC, pp. 29–36.

Webster, J., Watson, R. T., 2002. Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly* 26 (2), xiii–xxiii.

Xin, H., Techatassanasoontorn, A., Tan, F. B., 2013. Exploring the influence of trust on mobile payment adoption. In: *Proceedings of the Pacific Asia Conference on Information Systems (PACIS)*. Jeju Island, Korea.

Yang, C. N., Wu, C. C., 2013. MSRC: Micropayment scheme with ability to return changes. *Mathematical and Computer Modelling* 58 (1-2), 96–107.

Zhanga, A., Yue, X., Kong, Y., 2011. Exploring culture factors affecting the adoption of mobile payment. In: *Proceedings of the 10th International Conference on Mobile Business (ICMB)*. Como, Italy.

Zmijewska, A., Lawrence, E., 2005. Reshaping the framework for analysing success of mobile payment solutions. In: *Proceedings of the IADIS International Conference on E-Commerce*. Porto, Portugal.

Zmijewska, A., Lawrence, E., Steele, R., 2004. Towards understanding of factors influencing user acceptance of mobile payment systems. *IADIS WWW/Internet*, Madrid, Spain.

APPENDIX. Additional References

Table A: Articles used for 3.1 strategy and ecosystem (for Table 3)

#	Title	Authors	Year	Journal/conference
1	Mobile payment models and their implications for nextgen MSPs.	Van Bossuyt, M., and Van Hove, L.	2007	Info
2	The economics of mobile payments: Understanding stakeholder issues for an emerging financial technology application.	Au, Y. A., and Kauffman, R. J.	2008	Electronic Commerce Research and Applications
3	Mobile payment applications: an exploratory analysis of the Italian diffusion process.	Balocco, R., Ghezzi, A., Bonometti, G., and Renga, F.	2008	Proceedings of International Conference on Mobile Business
4	Lost opportunity why has dominant design failed to emerge for the mobile payment services market in Finland?	Dahlberg, T., Huurros, M., and Ainamo, A.	2008	Proceedings of Hawaii International Conference on System Sciences
5	A modeling approach and reference models for the analysis of mobile payment use cases.	Pousttchi, K.	2008	Electronic Commerce Research and Applications
6	Near field communication: an assessment for future payment systems.	Ondrus, J., and Pigneur, Y.	2009	Information Systems and E-Business Management
7	Why mobile payments fail? Towards a dynamic and multi-perspective explanation.	Ondrus, J., Lyytinen, K., and Pigneur, Y.	2009	Proceedings of Hawaii International Conference on System Sciences
8	Proposing a comprehensive framework for analysis and engineering of mobile payment business models.	Pousttchi, K., Schiessler, M., and Wiedemann, D. G.	2009	Information Systems and E-Business Management
9	Mobile payments market: Towards another clash of the titans?	Ondrus, J., and Lyytinen, K.	2011	Proceedings of International Conference on Mobile Business
10	Framework for mobile payments integration.	Carton, F., Hedman, J., Damsgaard, J., Tan, K. T., and McCarthy, J. B.	2012	Electronic Journal of Information Systems Evaluation
11	The role of banks in the mobile payment ecosystem: a strategic asset perspective.	Gaur, A., and Ondrus, J.	2012	Proceedings of International Conference on Electronic Commerce
12	Competition and collaboration shaping the digital payment infrastructure.	Hedman, J., and Henningsson, S.	2012	Proceedings of International Conference on Electronic Commerce
13	Investment timing for mobile payment systems.	Kauffman, R. J., Liu, J., and Ma, D.	2012	Proceedings of International Conference on Electronic Commerce
14	Factors influencing the slow rate of penetration of NFC mobile payment in Western Europe.	Apanasevic, T.	2013	Proceedings of International Conference on Mobile Business
15	Technology investment decision-making under uncertainty: The case of mobile payment systems.	Kauffman, R. J., Liu, J., and Ma, D.	2013	Proceedings of Hawaii International Conference on System Sciences
16	A framework for analyzing digital payment as a multi-sided platform: a study of three European NFC solutions.	Kazan, E., and Damsgaard, J.	2013	Proceedings of European Conference on Information Systems
17	Collective action for mobile payment platforms: A case study on collaboration issues between banks and telecom operators.	de Reuver, M., Verschuur, E., Nikayin, F., Cerpa, N., and Bouwman, H.	2014	Electronic Commerce Research and Applications.
18	An investigation of digital payment platform designs: A comparative study of four European solutions.	Kazan, E., and Damsgaard, J.	2014	Proceedings of European Conference on Information Systems
19	The market that never was: Turf wars and failed alliances in mobile payments.	Ozcan, P., and Santos, F. M.	2014	Strategic Management Journal.
20	Mobile contactless payments adoption challenge in the complex network actor ecosystem.	Silic, M., Back, A., and Ruf, C.	2014	Proceedings of Bled eConference

Table B: Articles used for technology and technological environment (for Table 4 s 5)

#	Title	Authors	Year	Journal/Conference
1*	Using service oriented architecture in a new anonymous mobile payment system	Bakhtiari, S.	2011	AISS: Advances in Information Sciences and Service Sciences
2	Adaptation of proxy certificates to non-repudiation protocol of agent-based mobile payment systems	Ou, C. M., and Ou, C. R.	2009	Applied Intelligence
3	An efficient and secure mobile payment protocol for restricted connectivity scenarios in vehicular ad hoc network	Li, W., Wen, Q., Su, Q., and Jin, Z.	2012	Computer Communications
4	Improving authentication of remote card transactions with mobile personal trusted devices	Bottoni, A., and Dini, G.	2007	Computer Communications
5	Design, implementation, and performance analysis of a secure payment protocol in a payment gateway centric model	Isaac, J. T., and Zeadally, S.	2013	Computing
6	A lightweight secure mobile payment protocol for vehicular ad-hoc networks (VANETs)	Isaac, J. T., Zeadally, S., and Cámara, J. S.	2012	Electronic Commerce Research
7	Utilizing national public-key infrastructure in mobile payment systems	Hassinen, M., Hyppönen, K., and Trichina, E.	2008	Electronic Commerce Research and Applications
8	A new mobile payment scheme for roaming services	Hwang, R. J., Shiau, S. H., and Jan, D. F.	2007	Electronic Commerce Research and Applications
9	An open financial services architecture based on the use of intelligent mobile devices	Kousaridas, A., Parisis, G., and Apostolopoulos, T.	2008	Electronic Commerce Research and Applications
10	Location-aware and safer cards: Enhancing RFID security and privacy via location sensing	Ma, D., Saxena, N., Xiang, T., and Zhu, Y.	2013	IEEE Transactions on Dependable and Secure Computing

11	A secure mobile electronic payment architecture platform for wireless mobile networks	Lin, P., Chen, H. Y., Fang, Y., Jeng, J. Y., and Lu, F. S.	2008	Wireless Communications, IEEE Transactions on
12*	Mobile payments: Design of new terminal	Mezgec, Z., Medved, A., Chowdhury, A., and Svecko, R.	2008	Informacije MIDEM -Journal of Microelectronics Electronic Components and Materials
13	An anonymous mobile payment system based on bilinear pairings	Popescu, C.	2009	Informatica
14*	Alternatives for banks to offer secure mobile payments	Kanniainen, L.	2010	International Journal of Bank Marketing
15*	A new approach for credit extended mobile phone payment	Gackle, B., and Zuo, Y.	2014	International Journal of Business Information Systems
16*	The application of dynamic password technology based on ECC algorithm in mobile payment	Wang, C., and Feng, C.	2014	International Journal of Communication Networks and Distributed Systems
17*	Secure mobile payment framework based on UICC with formal verification	Ahamad, S. S., Sastry, V. N., and Udgata, S. K.	2014	International Journal of Computational Science and Engineering
18*	MPCS: Secure account-based mobile payment system	Kumar, S., Ramesh, B., and Rabara, S. A.	2010	International Journal of Information Processing and Management
19	Secure mobile payment systems	Isaac, J. T., and Zeadally, S.	2014	IT Professional
20*	An semi-anonymity offline mobile payment protocol based on smart card	WANG, X., and YUAN, C. W.	2010	The Journal of China Universities of Posts and Telecommunications
21*	An integrated mobile phone payment system based on 3G network	Dai, W., Cai, X., Wu, H., Zhao, W., and Li, X.	2011	Journal of Networks
22*	Design and analysis on error handling and controlling protocol in mobile payment	Xu, Y., and Yan, T.	2012	Journal of Networks
23*	High-precision high-sensitivity clock recovery circuit for a mobile payment application	Lichong, S., Wenliang, R., Na, Y., and Hao, M.	2011	Journal of Semiconductors
24*	TOMIN: Trustworthy mobile cash with expiration-date attached	Martínez-Peláez, R., Rico-Novella, F., and Satizábal, C.	2010	Journal of Software
25*	A model for context aware mobile payment	Abedi, L., Nematbakhsh, M., and Abdolmaleki, A.	2012	Journal of theoretical and applied electronic commerce research
26	The classic security application in M2M: The authentication scheme of mobile payment	Chu, J. F.	2012	KSII Transactions on Internet and Information Systems (TIIS)
27	MSRC:(M)icropayment (S)cheme with ability to (R)eturn (C)hanges	Yang, C. N., and Wu, C. C.	2012	Mathematical and Computer Modelling
28	Design of micro-sized differential antenna for 2.4 GHz mobile payment applications	Shen, J., Lv, B., Shen, F., Huangfu, J., and Ran, L.	2011	Microwave and Optical Technology Letters
29	Anonymous proximity mobile payment (APMP)	Almuairfi, S., Veeraraghavan, P., Chilamkurti, N., and Park, D. S.	2012	Peer-to-Peer Networking and Applications
30	Resuscitating privacy-preserving mobile payment with customer in complete control	Konidala, D. M., Dwijaksara, M. H., Kim, K., Lee, D., Lee, B., Kim, D., and Kim, S.	2012	Personal and Ubiquitous Computing
31*	A novel mobile payment scheme based on secure quick response payment with minimal infrastructure for cooperative enterprise in developing countries	Suryotrisongko, H., and Setiawan, B.	2012	Procedia-Social and Behavioral Sciences
32*	A proposal for a public transport ticketing solution based on customers mobile devices	Ferreira, M. C., Nóvoa, H., and Dias, T. G.	2014	Procedia-Social and Behavioral Sciences
33*	A survey on mobile payment systems security	Esmaili, L., Borhani-Fard, Z., and Arasteh, M. A.	2012	Research Journal of Applied Sciences
34*	Integration of a secure mobile payment system in a GSM/UMTS SIM smart card	Askoxylakis, I. G., Pramateftakis, M., Kastanis, D. D., and Traganitis, A. P.	2007	System
35	Compound real option valuation with phase-specific volatility: A multi-phase mobile payments case study	Cassimon, D., Engelen, P. J., and Yordanov, V.	2011	Technovation
36	Study of magnetic field coupling technologies in activating RFID-SIM card mobile payments	He, Y.	2012	Wireless Personal Communications
37*	Design and implementation mobile payment based on multi-interface of mobile terminal	Wan, Z., Yin, W., and Sun, R.	2009	WSEAS Transactions on Computers
38	Integration of a secure mobile payment system in a GSM/UMTS SIM smart card	Askoxylakis, I. G., Pramateftakis, M., Kastanis, D. D., and Traganitis, A. P.	2007	System
39	A risk assessment framework for mobile payments	Clarke, R.	2008	Proceedings of Bled eConference
40	Near-field communication-based secure mobile payment service	Kadambi, K. S., Li, J., and Karp, A. H.	2009	Proceedings of the International Conference on Electronic Commerce
41	Secure and efficient protocol for mobile payments	Godbole, R. M., and Pais, A. R.	2008	Proceedings of the International Conference on Electronic Commerce
42*	Ubiipay: minimizing transaction costs with smart mobile payments	Lehdonvirta, V., Soma, H., Ito, H., Yamabe, T., Kimura, H., and Nakajima, T.	2009	Proceedings of the International Conference on Mobile Technology, Application and Systems
43	A mobile micropayment protocol based on chaos	Nan, J., Xiang-dong, L., Jing-ying, Z., and De-li, Y.	2009	Proceedings of the International Conference on Mobile Business
44	Mobile payment pattern based on multiple trusted platforms: China case	Yang, D., Wang, H., Ren, Y., and Wang, J.	2010	Proceedings of the International Conference on Mobile Business and Global Mobility Roundtable

Note: The * denote the 19 extra articles that were added to the 25 articles used in Section 2

Table C. Articles used for 3.3 adoption studies

#	Title	Authors	Year	Journal/Conference
1	Community perception of mobile payment in e-government services	Ahsan, A., Chang, V., and Issa, T.	2012	Proceedings of the Australasian Conference on Information Systems
2	The moderating effect of espoused cultural dimensions on consumer's intention to use mobile payment devices	Alshare, K., and Mousa, A.	2014	Proceedings of the International Conference on Information Systems
3	Value added services and adoption of mobile payments	Augsburg, C., and Hedman, J.	2014	Proceedings of the International Conference on Electronic Commerce
4	Trusting m-payments-realising the potential of smart phones for m-commerce: A conceptual model and survey of consumers in Ireland	Duane, Aidan, Philip O'Reilly, and Pavel Andreev.	2011	Proceedings of the International Conference on Information Systems
5	A scenario-based analysis of mobile payment acceptance	Goeke, L., and Poustchi, K.	2010	Proceedings of the International Conference on Mobile Business and Global Mobility Roundtable
6	The effect of technology usage habits on consumers's intention to continue use mobile payments	Jia, L., Hall, D., and Sun, S.	2014	Proceedings of the Americas Conference on Information Systems
7	An empirical examination of factors influencing the intention to use mobile payment	Kim, C., Mirusmonov, M., and Lee, I.	2010	Computers in Human Behavior
8	Predicting the determinants of the NFC-enabled mobile credit card acceptance: A neural networks approach	Leong, L. Y., Hew, T. S., Tan, G. W. H., and Ooi, K. B.	2013	Expert Systems with Applications
9	Understanding the factors driving NFC-enabled mobile payment adoption: An empirical investigation	Li, H., Liu, Y., and Heikkilä, J.	2014	Proceedings of the Pacific Asia Conference on Information Systems
10	Role of gender on acceptance of mobile payment	Liébana-Cabanillas, F. J., Sánchez-Fernández, J., and Muñoz-Leiva, F.	2014	Industrial Management and Data Systems
11	Antecedents of the adoption of the new mobile payment systems: The moderating effect of age	Liébana-Cabanillas, F., Sánchez-Fernández, J., and Muñoz-Leiva, F.	2014	Computers in Human Behavior
12	Risks of using NFC mobile payment: Investigating the moderating effect of demographic attributes	Liu, Y., Kostakos, V., and Deng, S.	2013	Proceedings of the International Conference on Electronic Commerce
13	Dynamics between the trust transfer process and intention to use mobile payment services: A cross-environment perspective	Lu, Y., Yang, S., Chau, P. Y., and Cao, Y.	2011	Information and Management
14	An institutional perspective of mobile payment adoption: The case of Japan	Magnier-Watanabe, R.	2014	Proceedings of the Annual Hawaii International Conference on System Sciences
15	Exploring consumer adoption of mobile payments: A qualitative study	Mallat, N.	2007	The Journal of Strategic Information Systems
16	An empirical investigation of mobile ticketing service adoption in public transportation	Mallat, N., Rossi, M., Tuunainen, V. K., and Öörni, A.	2008	Personal and Ubiquitous Computing
17	The impact of use context on mobile services acceptance: The case of mobile ticketing	Mallat, N., Rossi, M., Tuunainen, V. K., and Öörni, A.	2009	Information and Management
18	Designing digital payment artifacts	Olsen, M., Hedman, J., and Vatrupu, R.	2012	Proceedings of the International Conference on Electronic Commerce
19	What influences consumers' intention to use mobile payments	Poustchi, K., and Wiedemann, D. G.	2007	Proceedings of the LA Global Mobility Round table
20	Understanding consumer acceptance of mobile payment services: An empirical analysis	Schierz, P. G., Schilke, O., and Wirtz, B. W.	2010	Electronic Commerce Research and Applications
21	The moderating role of income on consumers' preferences and usage for online and offline payment methods	See-To, E. W., Papagiannidis, S., and Westland, J. C.	2014	Electronic Commerce Research
22	Towards an understanding of the consumer acceptance of mobile wallet	Shin, D. H.	2009	Computers in Human Behavior
23	Modeling the interaction of users and mobile payment system: Conceptual framework	Shin, D. H.	2010	International Journal of Human Computer Interaction
24	NFC mobile credit card: The next frontier of mobile payment?	Tan, G. W. H., Ooi, K. B., Chong, S. C., and Hew, T. S.	2014	Telematics and Informatics
25	Adoption readiness, personal innovativeness, perceived risk and usage intention across customer groups for mobile payment services in India	Thakur, R., and Srivastava, M.	2014	Internet Research
26	Acceptance and use of mobile payments	Viehland, D., and Leong, R.	2007	Proceedings of the Australasian Conference on Information Systems
27	Exploring the influence of trust on mobile payment adoption	Xin, Hua; Techatassanasoontorn, Angsana A.; and Tan, Felix B.,	2013	Proceedings of the Pacific Asia Conference on Information Systems
28	Mobile payment services adoption across time: An empirical study of the effects of behavioral beliefs, social influences, and personal traits	Yang, S., Lu, Y., Gupta, S., Cao, Y., and Zhang, R.	2012	Computers in Human Behavior
29	Exploring culture factors affecting the adoption of mobile payment	Zhanga, A., Yue, X., and Kong, Y.	2011	Proceedings of the International Conference on Mobile Business
30	Exploring mobile payment adoption in China	Zhao, Y., and Kurnia, S.	2014	Proceedings of the Pacific Asia Conference on Information Systems
31	The effect of initial trust on user adoption of mobile payment	Zhou, T.	2011	Information Development
32	An empirical examination of continuance intention of mobile payment services	Zhou, T.	2013	Decision Support Systems
33	An empirical examination of initial trust in mobile payment	Zhou, T.	2014	Wireless Personal Communications
34	High speed rail passengers' mobile ticketing adoption	Cheng, Y. H., and Huang, T. Y.	2013	Transportation Research Part C: Emerging Technologies

Table D: Articles in the other categories (including multiple category)

#	Title	Authors	Year	Journal/Conference
1	Past, present and future of mobile payments research: A literature review	Dahlberg, T., Mallat, N., Ondrus, J., and Zmijewska, A.	2008	Electronic Commerce Research and Applications
2	Inter-consortia battles in mobile payments standardization	Lim, A. S.	2008	Electronic Commerce Research and Applications
3	Mobile payments in emerging markets	Kshetri, N., and Acharya, S.	2012	IT Professional
4	Mobile banking and payment in China	To, W. M., and Lai, L. S.	2014	IT Professional
5	Together we will find a Jugaad: Resource bricolage in the Indian mobile payments sector	Gaur, A., Avison, D., and Malaurent, J.	2014	Proceedings of the Americas Conference on Information Systems
6	A comparison of mobile payment procedures in Finnish and Chinese markets	Zhong, J.	2009	Proceedings of Bled eConference
7	Are mobile payment and banking the killer apps for mobile commerce?	Hu, X., Li, W., and Hu, Q.	2008	Proceedings of the Hawaii International Conference on System Sciences
8	The moderating effect of espoused cultural dimensions on consumer's intention to use mobile payment devices	Alshare, K., and Mousa, A.	2014	Proceedings of the International Conference on Information Systems
9	Exploring culture factors affecting the adoption of mobile payment	Zhanga, A., Yue, X., and Kong, Y.	2011	Proceedings of the International Conference on Mobile Business
10	Understanding changes in consumer payment habits: Do mobile payments and electronic invoices attract consumers?	Dahlberg, T., and Oorni, A.	2007	Proceedings of the Hawaii International Conference on System Sciences