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ABSTRACT

The recent launch of Google Wallet has brought the issue of technology solutions in the mobile payment (m-payment) area to the forefront. In deciding whether and when to adopt m-payment technology, senior managers in banks are naturally concerned about uncertainties regarding future market conditions, technology standards, and consumer and merchant responses, especially their willingness to adopt. This study applies economic theory and modeling for decision-making under uncertainty to bank investments in mobile payment technology. We assess the projected benefits and costs of investment as a continuous-time stochastic process to determine optimal investment timing. We find that the value of waiting to adopt jumps when the related business environment experiences relevant shocks. Our analysis shows that when the volatility of the expected payoff, the time horizon for decision-making, and timeframe of the choice changes, the recommended investment timing will change too. We also consider how network effects influence managerial decision-making for this IT investment analysis context.

Categories and Subject Descriptors

H.1.0 [**Models and Principles**]: General

General Terms

Management

Keywords

Decision-making under uncertainty, economics, e-payments, investments, mobile payments, network effects, stochastic processes, value

1. INTRODUCTION

We have seen enormous interest in mobile services recently, as the global smartphone market has rapidly grown. A *mobile payment* (m-payment) is any payment in which a mobile device is used to initiate, authorize and confirm an exchange of financial value in return for goods and services. Google Wallet (www.google.com/wallet), a real "tap and go" mobile payment solution, was launched in the U.S. in 2011. It uses near-field communication (NFC) technology (www.nfc-forum.org/aboutnfc). Its biggest competitor, Isis (www.paywithisis.com), which has arisen from a joint venture involving Verizon, AT&T and T-Mobile, announced that it is set to launch an NFC application in the summer of 2012. Meanwhile, PayPal (personal.paypal.com) announced that it decided not to use NFC at its technical basis for mobile payments.

Technological uncertainty and the search for a workable technological standard have created some interesting business issues for senior managers at banks that would like to have their customers begin to use mobile payments. How should a bank maximize the business value of mobile payments technology adoption, in view of the uncertainty? Is adoption now too soon? Or will adoption later be too late? When should adoption occur, and what theoretical and economic perspectives will effectively support the tough choices that need to be made? Senior managers are faced with questions of "Who will do what and by when?" Such is the nature of uncertainty: it goes beyond the purely technical issues and involves consumers, banks and merchants, and their uncertainty with respect to adoption.

The potential profits from implementing m-payments in the marketplace are huge. An industry prediction is that investments in m-payments systems using NFC should reach US$670 billion by 2015. With the global adoption of smartphones, there are an increasing number of mobile handsets with NFC connection capabilities that have been released by their manufacturers. Also, there are other innovative schemes which take advantage of third-party applications on various smartphone platforms to process payments.[1]

Banks typically need to participate in a cross-industry alliance to establish a set of common operational, process and technology standards for technological innovations like m-payments. Au and Kauffman [1] discussed a number of key stakeholders for m-payment technologies. They include consumers, merchants, mobile network operators, mobile device manufacturers, financial service firms, software and technology providers, and government agencies. Hence, in deciding whether and when to adopt, bank senior managers will be naturally concerned about a variety of factors, including market conditions, consumer and merchant responses, technological changes, and so on. They affect managers' and consumers' beliefs about the likely benefits and costs associated with m-payments. This also gives rise to concerns about whether any specific underlying technological solution is better in defending against undesirable financial losses. Based on what is known from the industry record up to the present, fraud typically constitutes most of the transaction-related financial losses associated with various kinds of electronic payments technologies (e.g., credit cards, debit cards, Internet banking, etc.). Other hurdles are the lack of retail locations and relatively fewer NFC-capable mobile phones that support m-payment processes.

Other observers believe that NFC-based m-payment solutions lack compelling value for consumer adoption. In addition, merchants face other uncertainties. They may not know about the likely extent of consumer adoption, and the nature and timing of bank adoption. The banks face infrastructure development issues,

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[1] Examples of these innovative schemes include Intuit (www.intuit.com), PayPal Here (www.paypal.com/webapps/mpp/credit-card-reader) and Square (www.squareup.com).

changed transaction costs, and security problems, and they may not be able to estimate the beneficial network effects that will accrue in the longer run. So they may lack strong incentives to adopt the new technology.

With the uncertainties associated with investments in m-payments technologies in mind, effective strategic managerial decision-making requires understanding several key issues. (1) How can a bank maximize the business value of m-payments technology adoption under uncertainty? (2) How long can investment and commitment to a specific solution be postponed? (3) How will the adoption rates of other stakeholders influence the timing of a bank's own adoption as expectations of business and technology standards change? We will model dynamic changes in future benefits, investment costs and the flexibility of investment timing related to m-payments using financial economics theory for decision-making under uncertainty [4].

For a bank's m-payment investment decision-making, we conceptualize investment as a process of managing the balance between value and risk. We develop a model in which the benefits and costs of investment follow a continuous-time stochastic process, as a basis for determining the optimal investment time.

2. THEORY

McDonald and Siegel [9] studied the optimal timing of investment in an irreversible project, in which the benefits and investment cost follow a continuous-time stochastic process. Investing in m-payment technology is a similar irreversible investment. Uncertainties about future benefits and development costs cause their expected value to fluctuate over time. Farzin et al. [5] investigated the optimal timing of technology adoption for a competitive firm. They assessed a setting in which the technology choice is irreversible and the firm faces a stochastic innovation process, with uncertainties about both the speed of the arrival and the degree of improvement of the new technology.

Information technology (IT) investment risk can be evaluated with a family of methods that involve real option-based thinking and financial risk management methods. Benaroch [2] identified various IT investment options, including deferral, staging, exploration, scale alternation, outsourcing, abandonment, leasing, compound, and strategic growth options. Grenadier and Weiss [7] used similar methods from financial economics to determine the optimal investment strategy for a firm that is faced with uncertainty from a sequence of technology innovations. Benaroch and Kauffman [3] analyzed electronic banking network expansion, and suggested ways to overcome some of the methodological difficulties associated with decision-making under uncertainty.

Fichman [6] argued that when uncertainty and irreversibility are high, real option analysis should be used to structure the evaluation and management of project investment opportunities. Also, Schwartz and Zozaya-Gorostiza [10] contributed a cost-benefit diffusion methodology for different kinds of IT investment decision-making, when the investment costs and benefits are subject to change over time. Kauffman and Li [8] modeled investment timing strategy for a firm that is deciding whether to adopt one or two incompatible technologies, in the light of evolving expectations about future competition. Our modeling approach builds on these methods. We aim to contribute knowledge to support managers' decisions on m-payment technology investments.

3. RESULTS

Our analysis has yielded a number of results to date. We show that, when benefits of m-payment investment are expected to flow in the longer term or the volatility of the benefits is expected to increase, a bank should defer its investment decision to a later time. We next discuss the setup of a continuous-time model for decision-making under uncertainty by an expected value-maximizing risk-neutral bank related to the adoption of m-payment technology. This approach captures the uncertainty in investment costs and return cash flows, as well as the possibility that a relatively rare event may occur during the diffusion process – a cross-over to critical mass in adoption. We think of this as an event that occurs in a Poisson distribution. We demonstrate the usefulness of a mixed Poisson, Brownian motion-based Wiener process to model the dynamically changing value of the underlying mobile payment investment asset.

Our model is especially applicable to mobile payments technology adoption subjected to strong network effects. A bank decision-maker must process information related to interactions with other stakeholders in the marketplace. We capture this by the high volatility of profit and the positive drift parameter for benefits in our model. Our analysis also provides guidance for decision-makers about how to respond to uncontrollable exogenous risk. When a catastrophic event happens that reduces the value of the investment to a large extent, the decision-maker should abandon the investment opportunity permanently. Or if the value of the investment jumps beyond some critical threshold, our analysis will recommend making the investment decision immediately.

We are currently extending this research in two ways. We are continuing our modeling work, with the idea of combining together elements of the continuous-time stochastic process and the discontinuous jump diffusion process. We are also extending our work with the numerical analysis. We expect to discover systematic relationships between the model outcomes and the parameter values of interest

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