

Research Statement

Dan Ma
School of Information Systems, Singapore Management University
Tel: (65) 6828-0926; Email: madan@smu.edu.sg
18 December 2024

Background

My research focuses on the strategic interactions of information technology (IT) and business, in particular, how firms use IT to create innovative services and transition from product providers to service providers. I solve problems in different types of **IT services markets** – the cloud business services, financial services, and e-commerce and online services markets – from economics and strategic management perspectives.

My works aim to generate new knowledge and deliver practical solutions. They assist firms to evaluate the value and risk of service-oriented business model, make recommendations for IT adoption decisions, examine services provision and pricing mechanisms, suggest optimal strategies in competition, and forecast market structure and trends. My research makes original and pioneering contributions to both the academia and industrial practices.

Research Areas

1.1. The Cloud Services Market

Computing resources, such as CPUs, networks, data storage and software applications, all can be provided as *services* to customers through a network. In the past two decades, the cloud services market has grown dramatically. My work in this area is pioneering. Unlike researchers in Computer Science whose main focus in this field is in various technique-related issues, I examine the strategic management issue in cloud computing. My contributions are two-folded. I have formulated a number of practical competitive strategies and proposed services provision and pricing mechanisms for cloud services vendors; for cloud services users, I have developed approaches to support the cloud adoption decision-making. There are three main streams in my cloud computing research.

Stream 1. Competitive strategies for cloud services vendors.

The first stream of my research in the cloud services market examines various vendors' competitive strategies. I study the competitive pricing strategies of an incumbent perpetual software vendor in the presence of a SaaS competitor, in the most recent publication, *A Model of Competition Between Perpetual Software and Software as a Service* (MISQ 2018). The findings enable us to recommend

practical competitive strategies to software vendors. We suggest that, depending on both the SaaS quality improvement rate and the network effect, the perpetual software vendor adopts one of three different strategies: (1) an entry deterrence strategy, (2) a market segmentation strategy, or (3) a sequential dominance strategy. We further show insights into how the incumbent perpetual software vendor can defend its market position by providing incremental quality improvement through patching and/or by releasing consecutive versions with major quality upgrades.

I also examine and recommend the competitive strategy to the software-as-a-service (SaaS) vendors. My paper, *Analyzing Software-as-a-Service with Per-Transaction Charges* (ISR 2015) develops an analytical model to capture the SaaS and traditional software vendors' differences in cost structure, pricing methods, risk management, and capacity hedging approaches. The major contribution of this work is to highlight the importance of the lack-of-fit costs between a firm's computing needs and the SaaS solution. Lack of fit is a unique by-product of the multi-tenancy structure of SaaS. When the lack-of-fit costs decrease, the software market is expected to shift more toward the services model. This result has far-reaching implications for the SaaS vendors' application design and long-term development strategies. It explains why the fast growth of SaaS has been observed mostly in services marketplaces such as email, office productivity, accounting, billing, and human resource management software, but not for complex applications such as enterprise resource planning (ERP) or electronic medical record (EMR) systems. Moreover, it supports the efforts of big SaaS vendors, for example, Microsoft, Oracle, IBM, Hewlett-Packard, and Salesforce.com, in facilitating technical standards and launching large-scale uniform cloud computing services platforms.

This research recommends a counter-intuitive "higher quality but lower price" strategy to SaaS vendors in competition. SaaS vendors should charge less when their value and cost efficiency are enhanced. This will enable them to compete aggressively for large users. Large users are more valuable to a SaaS vendor because they generate high revenue due to the unique "per as you go" pricing method of SaaS. This result sheds light on the SaaS' continuous price-cutting behavior. Microsoft has reduced prices three times for its Office 365 cloud-based software portfolio and Amazon Web Services has done it 37 times.

I am interested in investigating the competition among SaaS vendors and finding effective competitive strategies for them as well. In the paper *Competition between Software-as-a-Service Vendors* (IEEE Transactions on Engineering Management 2014), we suggest that SaaS vendors use a *differentiation strategy* to avoid head-to-head price competition among them. It explains the great

diversity in cloud services provision observed in the market. In addition, we show that users' switching costs, mainly as data recovery costs and set-up costs with the new vendor, can be a double-edged sword. The vendor should help to lower users' switching costs, and protect users' interests by offering them flexibility to back-source. This finding enhances the managerial understanding of the common free-trial practice offered by SaaS vendors. For example, Salesforce.com and Oracle On-demand give 30-day free trial of their services. They essentially offer potential users the flexibility of "sampling and switching," which is highly appreciated by users and nurtures a good long-term relationship with them in the first place. As a result, giving users the flexibility to switch creates further value for the vendor.

Stream 2. Service provision and pricing mechanisms for cloud vendors.

The second stream of my research sheds light on cloud vendors' choices for service provision and pricing mechanisms. All my works are motivated by the real observations and cases. For example, my paper *Pricing Strategy for Cloud Computing: A Damaged Services Perspective* in (DSS 2015) uses Amazon EC2 services as a motivating case and establishes the value of a *hybrid strategy* from the vendor's viewpoint. In 2009, Amazon introduced the spot-price on-demand instances together with the fixed-price reserved services. To understand this hybrid strategy of offering two types of services and charging different prices for them, we examine clients' self-selection behavior, the resulting market segmentation, and vendor profitability. We show that the vendor should use service interruptions as a quality differentiator between its two services to assure the efficacy of the hybrid strategy. The presence of interruptions also provides the vendor with resource reallocation flexibility. We contribute to the literature by proposing a *damaged services perspective* in the cloud services market. This is analogous to 'damaged information goods' and versioning in packaged software. To my best knowledge, it is the first research attempt to understand strategic management in the IT services market from the perspective of damaged goods strategy in Economics.

I summarize and interpret current practices in cloud computing, and identifies future research directions for cloud computing mechanism design, in the paper *On the Financification of Cloud Computing: An Agenda for Pricing and Service Delivery Mechanism Design Research* (International Journal of Cloud Computing 2015). This research conducts a comprehensive survey on various services delivery mechanisms and pricing strategies in the current cloud market. It covers 19 major services vendors and 27 types of services. The research demonstrates a practice-led set of scientific observations and examples in cloud services delivery and pricing, including on-demand and reserved services, spot prices and

dynamic prices, cloud insurance, and brokered cloud services. We interpret them from the perspective of relevant financial economics theory and offer the theoretical *financification* view of the cloud services market.

This is a useful contribution to managerial understanding. The cloud services market is experiencing a fundamental shift from the traditional model of software sales to computing capacity provision mechanism designs. This evolution is similar to what financial markets have done. Through the lens of financification, managers and consultants will be empowered to make more confident predictions and thoughtful explanations for what is to come. Furthermore, this new perspective lays out a research agenda related to the fundamental mechanism design issues in the cloud market.

Stream 3. Adoption decision-making for cloud services users.

The third stream of my cloud research tries to assist user firms regarding their decisions of cloud computing adoption. From my contacts and consulting experience with local organizations, I realized that firms, especially small and medium enterprises, need support and guidance in making cloud adoption decisions. Is cloud computing for them? When is the best time to switch to this service-oriented business model? What are the factors they need to consider before, during and after adoption? What are the changes and impacts that they should expect after adoption?

To address these concerns, I did survey work under the help of SingTel. We designed the questionnaire focusing on understanding what are the economic factors a potential cloud user cares. I also conducted cost-and-benefit analysis for several Singapore Small and Medium Enterprises (SMEs) with the support of Singapore National Cloud office. In specific, in the paper *Cloud Computing Adoption Readiness: Empirical Evidence for the Efficacy of a Firm-Level and Cloud Business Model-Specific Metrics Suite* (Electronic Markets 2016), we propose and design a metrics suite for measuring an individual firm's cloud adoption readiness. The research focuses on four relevant categories, including technological, organizational, economic and environmental factors. Based on a series of empirical mini-cases, and supporting evidence from industry white papers, business press sources, and field interviews with vendors and government agencies, we explore empirical evidence for the efficacy of the metrics suite application to different cloud services models.

1.2. The Financial Services Market

In the past several years, have extended my research interests to the financial services market. My mission in this area is to help managers and financial

analysts to understand the nature of IT-based financial innovations, support and evaluate managers' adoption decision-making.

I studied several FinTech services, including high frequency trading (HFT), mobile payments, and fast retail payment and settlement systems. All these technology-driven financial services are very new to both the financial institutes and users, and their overall economic impact on the underlying financial ecosystem is unclear. It thus is very important and useful if the research can give guidance and prediction to the adoption, evolution pattern, management, and governance.

In the research *Innovations in Financial IS and Technology Ecosystems: High-Frequency Trading in the Equity Market* (TFSC 2015), we propose a financial IS and technology ecosystem approach to understand innovations in the HFT area of financial services. The ecosystem model in this research brings together four original core elements: technology components, technology-based services, technology-supported business infrastructures, as well as stakeholder analysis. Analyzing HFT innovations, this work empirically validates the existence of several different patterns of the historical evolution of technology ecosystems. This research represents some of the first work that investigates how financial services innovations emerge in ways that are driven by both technologies and stakeholders.

The paper *Competition, Regulation, and Innovation: Understanding the Evolution of the Mobile Payments Technology Ecosystem* (ECRA 2015) studies another financial technology innovation, mobile payments. It shows that competition, cooperation and regulation play important roles in shaping the evolutionary path of technology innovations in the mobile payment ecosystem. To illustrate, we retrospectively analyze innovations that have occurred in the payments space in the past two decades. We also analyze cases such as Square, Google Wallet, PayPal and Alipay, and the most recent Apple Pay. This research helps managers to understand how competition is able to spur or stall financial services technology innovations, and how regulations can pave the way for them.

My recent works in FinTech are studying the fast retail payment settlement systems. Payment settlement system is a key element in the financial ecosystem. Nowadays, the rapid growth of Internet and mobile commerce has led to a boom in the volume of retail payments; meanwhile, alternative FinTech payment solutions and entry of non-bank competitors in the payments industry, such as Square, Apple Pay, AliPay, and PayPal are challenging the traditional interbank retail payments operation. It therefore becomes essentially critical for the banks, financial institutes and government regulators to understand the

potential benefits and risks in this unprecedented financial innovation process. I hope my research can help to address important issues related to the payments settlement system optimal design, governance structure, and policy analytics.

Supported by the SWIFT fund, in the project, *Near Real-Time Retail Payment and Settlement Systems Mechanism Design* (working paper 2022), we proposed a hybrid priority central-queue system that combines the features of netting and real-time settlements. We used computational methods and simulations to identify important features in the underlying financial system, such as the relative size of banks, the frequency of trading among banks, the difference among transactions, and show how would each of them affects the performance of the proposed settlement mechanism. In general, we find that in most cases, the hybrid priority central-queue system can outperform both the traditional netting and the newest real time settlement mechanism for retail payments, while it won't increase the related liquidity cost significantly. We therefore would like to recommend such a hybrid system to be considered in the real use.

I realize that any innovation to the existing intra-bank payment settlement infrastructure must rely on appropriate policy guidance, and sometimes, government interference. So, it is important in this financial innovation process, the regulator plays an active and positive role. My recent paper, *Catching the Fast Payments Trend: Optimal Designs and Leadership Strategies of Retail Payment and Settlement Systems* (MISQ 2023), tries to understand from a social optimal perspective, what is the best governance structure for a new fast payment settlement system, and under what conditions, government interference, namely the Government Mandate policy that requires all banks in the country to cooperate and act together, is beneficial. To my best knowledge, this is the first research that directly addresses the policy analytics in the FinTech field and thus I expect it to be influential.

The financial IS and technology research is important area with strong potential that has not been fully explored by academic researchers yet. Singapore is a leading Asian financial center and SMU has partnerships with a number of leading banks here. These create an unprecedented chance to gain access to financial industry people, problems and data. I am determined to commit my time and efforts more in related research questions, especially on problems regarding payments platform competition and pricing strategies for bank products and services. All my works in this area are trying to make two kinds of contributions. First, they need to extend existing theory and modeling methodology, and offer new analysis perspectives. Second, they also must demonstrate empirical applications of the proposed approach to real cases in financial services contexts.

1.3. Platform Management Strategies

Cybersecurity has become a more and more important issue in practice. In this area, the research question what interests me most is: when platforms, vendors, and end users are all participating in the cybersecurity investment game, how do they interact with each other and how one party's behavior will affect the others' decisions. I developed this new stream of research in most recent years and have worked on two projects.

In the first project, I studied how digital platforms could launch Bug Bounty Programs (BBPs) to help improve the reliability of third-party software. Although BBPs bring benefits to both the platform and vendors, meanwhile impose additional costs on them as well. In addition, the use of BBP may also change the software vendors' incentive of reliability investment in the initial application development stage, which makes the ultimate outcome (i.e., the overall software reliability) uncertain. To examine the impact of BBP use, we propose an analytical model to investigate the strategic decisions of launching and participating in a BBP for the platform and the third-party vendor, respectively. We show that the incentive of using BBP, for the platform and vendor, sometimes is inconsistent, and that using BBP is not always socially optimal. Under certain conditions, it reduces the overall software reliability, instead of improving it, makes the platform marketplace less secure, and thus hurts end users. This work has been accepted and presented in multiple conferences (ICIS 2023, CIST 2023, PACIS 2023) and got positive feedback.

The second project studies the BBP for open source software (OSS). In literature, developers' incentive of investing in OSS is a well-established research question. Although many researchers have proposed a number of rationales, such as self-satisfaction, reputation-building, to explain developers' motivations, there is no conclusive answer yet. When BBP is introduced to OSS, the problem becomes more interesting. When financial rewards are used in the free software, more hackers will be attracted. Will it help the developers to strengthen the software or deviate the developers away from the software improvement, given they have only limited attention capacity and in particular, when they are non-profit driven? We are in the midst of developing a model to understand developers' behavior changes after BBP is in use.

Selected Publications and Outputs

Catching the Fast Payments Trend: Optimal Designs and Leadership Strategies of Retail Payment and Settlement Systems, by GUO, Zhiling; MA, Dan. (2023). *MIS Quarterly*, 47(2), pp. 669-704.

An Economic Analysis of Third-Party Software Reliability Improvement using the Bug Bounty Program, by ZHOU, Tianlu; MA, Dan; FENG, Nan. ICIS (2023) *Proceedings: 44th International Conference on Information Systems*, Hyderabad INDIA, December 10-13.

The Use of Bug Bounty Programs for Software Reliability Improvement, by ZHOU, Tianlu; MA, Dan; FENG, Nan. (2023). *Pacific Asia Conference on Information Systems (PACIS) 2023 Proceedings*, Nanchang CHINA, 8-12 July 2023.

A Study of Platform's Security Strategy: Adoption of Bug Bounty Programs for Third-party Software, by ZHOU, Tianlu; MA, Dan; FENG, Nan. (2023). *Conference in Information Systems and Technology (CIST)*, 24 -25 October 2023, Phoenix, Arizona, USA.

Near Real-Time Retail Payment and Settlement Systems Mechanism Design, by GUO, Zhiling; KAUFFMAN, Robert; LIN, Mei; MA, Dan. (*working paper 2022*)

A model of competition between perpetual software and software as a service, by GUO, Zhiling; MA, Dan. (2018). *MIS Quarterly*, 42 (1), 1-46.

A service-specific metrics suite to assess firm-level cloud computing adoption readiness, by KAUFFMAN, Robert J.; MA, Dan; YU, Martin. (2016). *Electronic Markets*, 1-27. <http://doi.org/10.1007/s12525-015-0213-y> (Advance Online)

Innovations in financial IS and technology ecosystems: High-frequency trading in the equity market, by KAUFFMAN Robert J.; LIU, Jun; MA, Dan. (2015). *Technological Forecasting and Social Change*, 99, 339-354.

Pricing strategy for cloud computing: A damaged services perspective, by HUANG, Jianhui; KAUFFMAN, Robert J.; MA, Dan. (2015). *Decision Support Systems*, 78, 80-92.

Competition, cooperation, and regulation: Understanding the evolution of the mobile payments technology ecosystem, by LIU, Jun; KAUFFMAN, Robert J.; MA, Dan. (2015). *Electronic Commerce Research and Applications*, 14 (5), 372-391.

On the financification of cloud computing: An agenda for pricing and service delivery mechanism design research, by KAUFFMAN, Robert J.; MA, Dan; Shang, Richard; Huang, Jianhui; Yang, Yinping. (2015). *International Journal of Cloud Computing*, 2 (1), 1-14.

Analyzing software as a service with per-transaction charges, by MA, Dan; Seidmann, Abraham. (2015). *Information Systems Research*, 26 (2), 360-378.

Competition between Software-as-a-Service Vendors, by MA, Dan; KAUFFMAN, Robert John. (2014). *IEEE Transactions on Engineering Management*, 61 (4), 717-729.