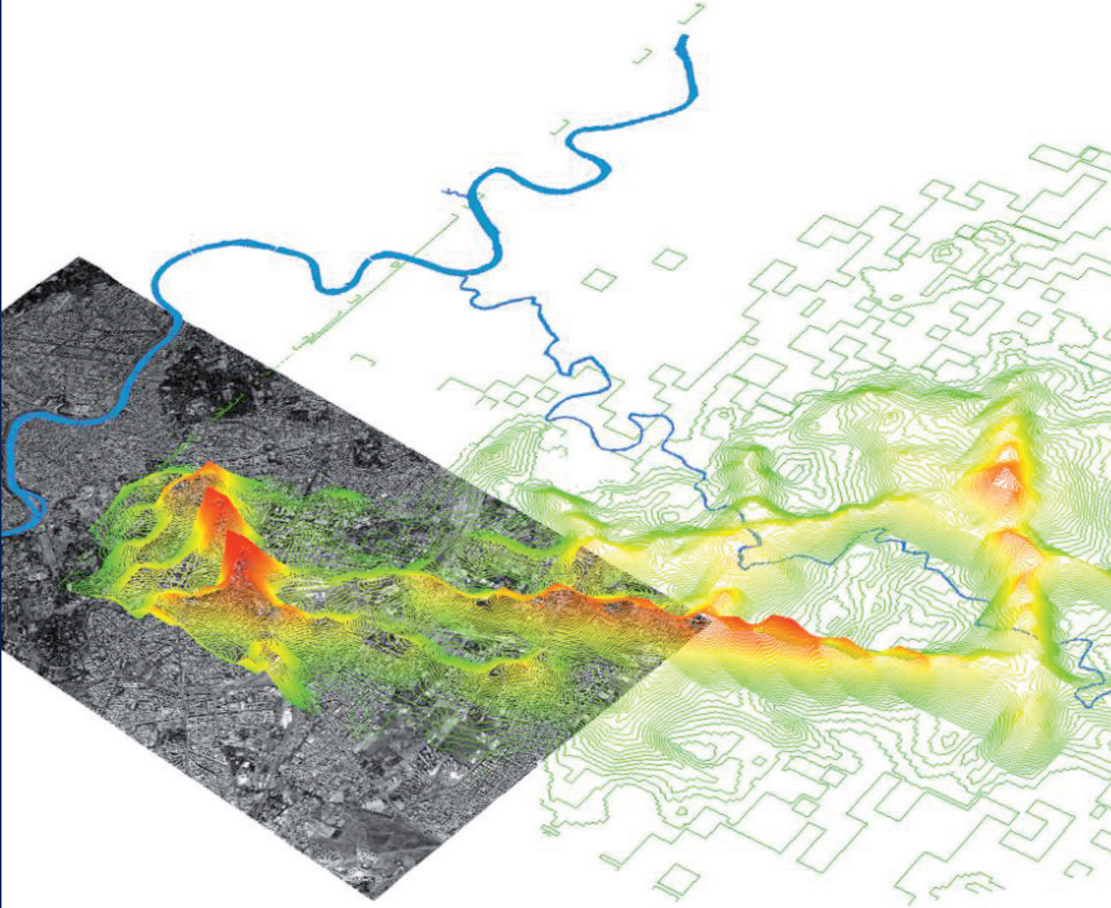
TING LI

Informedness and Customer-Centric Revenue Management



INFORMEDNESS AND CUSTOMER-CENTRIC REVENUE MANAGEMENT

Ting Li

INFORMEDNESS AND CUSTOMER-CENTRIC REVENUE MANAGEMENT

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To my parents

and Hailiang

Preface

The recent pervasive adoption of modern IT in the marketplace has profoundly changed information availability to consumers and firms. This improved information endowment results in changes in consumer behavior and corporate strategy. Better informed consumers know exactly what is available to them with the precise service attributes and prices. And they are able to find exactly what they want and are willing to pay premium prices to obtain products and services with perfect fit for them. As a result, firms are increasingly introducing new product portfolios and designing more diverse and even more precisely-targeted service offerings to what the consumers truly want. This latest development has provided firms with the opportunity to better determine a customer-centric strategy than ever before.

The purpose of this research is to improve the understanding of the role of information in making revenue management decisions. Revenue management is short-term demand management to promote flexible real-time capacity allocation, customer segmentation, and pricing optimization. The increased adoption and development of revenue management in recent years can be attributed to the increased availability of demand data, the ease of changing prices due to information technology, and the availability of decision support tools that can handle large-scale optimization. We introduce the concept of *informedness,* including firm informedness and consumer informedness. *Firm informedness* refers to what a firm knows about its customers and the capability of learning what the customers want in order to satisfy customers and impact their willingness-to-pay. C*onsumer informedness* refers to the degree to which consumers know what product or service is available in the marketplace, with precisely which attributes and at precisely what price. We leverage this informedness explanation to evaluate what drives the performance of revenue management. We employ a multi-method research design using multiple case studies, stated choice experiments, and computational simulation.

First, we focus on the firm level and examine the value creation process of firms, using the explanation of firm informedness. Using multiple cases where firms adopt smart cards and mobile technologies in America, Europe, and Asia, we investigate the value creation process of mobile ticketing technologies and their enablement of revenue management strategies. We find that firms that use more sophisticated mobile ticketing technologies, such as smart cards and mobile devices, and have real-time and complete information on customers' actual travel are more likely to adopt price differentiation and service expansion strategies. Further, these firms are more likely to have higher performance gains compared to the ones that only use the cost reduction strategy.

Next, we focus on the consumer level and study consumer behavior in the presence of consumer informedness. Using stated choice experiments, we empirically demonstrate heterogeneous consumer preferences and their willingness-to-pay. We find that in the presence of increased information, some consumers exhibit stronger preferences for choosing the cheapest product (evidence of trading down behavior), whereas other consumers exhibit stronger preferences for choosing the products that best fit their needs (evidence of trading out behavior). We demonstrate that with the availability of smart cards and mobile devices, firms will be informed of consumers' individual demand preferences and, thus, can better leverage the effective use of strategies such as hyperdifferentiation and resonance marketing.

Finally, we focus on an environment with increased firm and customer information, and propose a customer-centric approach toward revenue management. Using a stated choice experiment and a simulation, we explore the opportunity of devising service offerings to capture profitable consumer responses, considering demand-driven revenue and capacity management. We find that firms utilize all available information efficiently to establish an initial basis for the expected value of their performance, and then continue to obtain new information over time to learn about the optimal value of the firm performance. We argue that firms can tailor differentiated products and services, both in temporal and spatial service differentiation terms, to efficiently shift demand away from high-demand periods and locations to those with lower demand.

Overall, this research contributes to the ongoing discourse on IT and firm performance in the competitive strategy and economics of information systems literature. Theoretically, this research proposes new theoretical perspectives – firm informedness, customer informedness, and informedness through learning – to re-conceptualize the decision making process of customer-centric revenue management. Practically, this research introduces methods, models, and principles to guide organizations to manage informational challenges and strategize the fully informed market environment.

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My academic journey started four years ago with a 'simple' request for a part-time PhD position at RSM while I was still working in industry. I appreciate the fact that Prof. Peter Vervest and Prof. Eric van Heck kindly took me on board and convinced me to work on the PhD with a full-time dedication. It turned out to be an absolutely wise decision and it did not take me long to recognize this is a serious profession that requires more than five-day a week work. I am very thankful to my advisors. Peter, thanks for fulfilling my desire to work on an industry-relevant dissertation research and for bringing me to the nation-wide smart card project. And thanks for continuously challenging me with your business insights, helping me to sharpen my thoughts, and encouraging me to gain business exposure. I have been really blessed to have Eric as my advisor. Eric, thanks for giving me the freedom to pursue my own research interests and encouraging me to experiment with different research methods. Thanks for listening and being so patient with me especially during some of my frustrating times. You are the advisor who is always there for his doctoral student and who provides support in numerous ways.

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The development of this dissertation is a balancing act between scientific rigor and practical relevance. As such, many people and companies have helped to realize this research throughout the years. Freek Hofker generously took over the mentoring role of this research project in the Netherlands Railways and made documents and data available to me. I am thankful to him for opening up the doors for me to participate in the strategic pricing projects and for sharing his marketing research expertise with me. I also would like to thank the other members of the 'Tariefhuis Project', Wiebo Drost, Louis Weesie, and Rene Rietvel, and the data collection effort from SDG. The stated choice experiments and the development of the simulation would have not been possible without the financial support of the Netherlands Railways, in particular, Paul Rooijmans, the chief architect of the smart card project, and Theo van der Star, the department head of MOA. I also would like to acknowledge the support of Louis Schijve, the CEO of InControl, and Fred Jansma and Jan Thiermann for their participation during the initiation phase of the project. Thanks to Leanneke Loeve and Erwin Jongerden, who have made my work in the Maarssen office such a delight.

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Ting Li

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Chapter 1 Introduction

Identified as the "number one emerging business strategy" by the Wall Street Journal in 2004, revenue management is predicted to be "a practice poised to explode". The past decade has witnessed an increase in the application of revenue management in many industries, where firms use various quantitative analysis techniques such as customer segmentation and pricing optimization to deal with flexible real-time capacity allocation and demand management. In particular, the demonstrated successes in firms such as American Airlines, with revenue increases of US$500 million per year and National Car Rental, with revenue increases of US$56 million per year, are encouraging even more firms to explore the potential benefits from revenue management.

This process is only being further accelerated by the increased implementation of advanced information technologies (IT) and information systems (IS), such as ubiquitous computing devices and application, smart cards and biometrics, global positioning systems (GPS), radio frequency identification (RFID), and enhanced information search and discovery services. These technologies allow firms to have fine-grained observations of consumer behavior and rapidly customize their marketing strategies by identifying individuals at a particular point in time and under particular demand conditions. Increasingly, firms are designing a variety of product and service offerings that are differentiated by the individual customer's preferences. This has the potential to dramatically impact existing markets.

We observe this kind of strategic information-empowerment happening all around us. It ranges from book purchases via Amazon.com (www.amazon.com), Internet retailing (www.albert.nl), to services such as person-to-person financial lending (www.prosper.com), casino gaming (www.harrahs.com), hotel stays, rental cars and airline ticket reservations (www.priceline.com, www.farecast.com). The success stories of the firms that leverage informational challenge and benefit from an information-based strategy have been reported in academic publications and business magazines (Loveman 2003, Clemons and Thatcher 2008). There has been a growing interest in research to further understand and advance the next generation of revenue management.

1.1 Motivation

Recently, the study of strategic pricing and competitive strategy in the presence of IT has become an active area in the IS discipline (Brynjolfsson and Smith 2000, Clemons et al. 2002b, Bergen et al. 2005, Oh and Lucas 2006, Kauffman and Wood 2007). Previous research demonstrated that, on the demand side, IT lowers consumer search costs for product and service information (Bakos 1997), increases market transparency (Granados et al. 2006a, Soh et al. 2006) and provides mass customization options (Dellaert and Dabholkar 2008) or personalization (Murthi and Sarkar 2003). On the supply side, IT creates opportunities for firms to capture a vast amount of individual-level data and to understand consumer behaviors (Johnson et al. 2004), increases product and service variety through differentiation (Brynjolfsson et al. 2003, Clemons et al. 2006), transforms distribution channels (Kuruzovich et al. 2008), and intensifies competition (Clemons et al. 2002b, Kauffman and Wood 2007). Research has suggested that the increased adoption and development of revenue management can be attributed to the increased availability of demand data, the ease of changing prices due to IT, and the availability of decision support tools that handle large-scale optimization (Elmaghraby and Keskinocak 2003).

In today's new information economy, IT is readily available to all firms in competitive markets and is thus limited in terms of generating distinctive competitive advantage (Clemons et al. 1993). What matters is not just IT but, most importantly, the information it yields. To succeed in the marketplace firms must use IT and the information it generates to leverage and exploit firm-specific and intangible resources. This becomes increasingly crucial in industries with heterogeneous customers and with costs that vary widely across customers. Though the role of IT in revenue management is often acknowledged (Kimes 2001, Elmaghraby and Keskinocak 2003, Talluri and van Ryzin 2004b), there has been little systematic research examining the role of information in the decision making relating to revenue management. We feel it is extremely valuable at this time to explore the impact of increased information on firm performance. We believe it is likewise valuable to examine how firms can use the enhanced information endowment and develop competitive strategies to increase their profitability as well as their customer satisfaction in a complex business environment.

1.2 Research Question and Objective

In response to observations of the recent pervasive adoption of advanced IT in the marketplace and to calls from several scholars to understand the performance impacts of employing modern IT and enhanced information endowment (Boyd and Bilegan 2003, Clemons and Gao 2008), we raise the following research question:

Why does informedness impact the performance of revenue management? How does it affect revenue management strategy and customer behavior?

Our notion of *informedness* further refines a concept set forth by Clemons (2008), so that it covers both firm informedness and consumer informedness. *Firm informedness* refers to what a firm knows about its customers and its capability of learning what the customers want in order to satisfy customers and impact their willingness-to-pay. C*onsumer informedness* refers to the degree to which consumers know what product or service is available in the marketplace, with precisely which attributes and at precisely what price. The objective of this research is to improve the understanding of the role of information in making revenue management decisions. In particular, we leverage these informedness explanations to evaluate what drives the performance of revenue management.

We use the smart card adoption in public transport networks in the Netherlands as the research context to investigate this research question. This IT investment reflects the recent pervasive adoption of mobile payment technologies around the world (Turban and Brahm 2000, Shelfer and Procaccino 2002, Chau and Poon 2003, Au and Kauffman 2008). These technologies allow service providers to capture more real-time information on consumer travel behavior. The new information includes the location to and from which they travel, what time they travel, how frequently they travel, what ticket they purchase, and what transport mode they use. This enhanced information endowment provides service providers with the opportunity to develop effective strategies. The goal of these strategies is to deliver better transport services that suit consumer needs and preferences, and at the same time, increase service providers' profitability and capacity utilization.

We conduct three empirical studies to answer our research question. In the first study, we focus on firm informedness and examine the effects of firm informedness on the development of revenue management strategies. We use the resource-based theory (Bharadwaj 2000) and take a process-oriented view (Barua et al. 2004) to investigate how mobile ticketing technologies enable revenue management. The use of these technologies changes the cost and the value of capturing the complete customer information from individual transactions. This increased firm informedness drives firms' differentiation and value creation strategies, and provides opportunities for firms to achieve new "best practices" in revenue management.

The second study focuses on consumer informedness and answers the questions of why consumer informedness impacts consumer behavior and enables resonance marketing. Resonance marketing is a strategy of developing products and services that produce the strongest favorable responses among targeted segments of the consumer population (Clemons et al. 2006). Consumer informedness plays a critical role in determining consumers' willingness-to-pay. Better informed consumers know exactly what is available to them with the precise service attributes and prices. And they are able to find exactly what they want and are willing to pay premium prices to obtain products and services with a perfect fit for them. As a result, firms increasingly introduce new product portfolios and design more diverse and even more precisely-targeted service offerings geared to what the consumers truly want.

The third study focuses on an environment with increased firm and consumer information. It answers the question of how firms design service offerings to capture profitable consumer responses, considering demand-driven revenue and capacity management. This is an important issue because for a capacity-constrained firm, some service attributes cost more to produce and others less. For example, in the transport industry, there are natural differences in passenger load factors based on the day of the week. It usually costs more for service providers to serve customers who travel during peak hours than off-peak hours. Using the theories of rational expectation (Muth 1961) and adaptive learning (Sargent 1993), we investigate how firms can take a customer-centric approach, incorporate consumer behavior when employing revenue management, and obtain new information over time to learn about the optimal value of the firm's performance.

1.3 Research Design

We adopt a multi-method approach to investigate the proposed research question. Multiple research methods provide a richer picture of the complex and multi-dimensional research situations (Mingers 2001). Three methods are used: a case study, a stated choice experiment, and a computational simulation. We will detail these three methods in Chapter 3.

The first method is a case study method. We employ a multiple case study (Eisenhardt 1989) approach and test the plausibility of our arguments through multiple cases where service providers adopt smart cards and mobile technologies in America, Europe, and Asia. We use unstructured and semi-structured interviews, firm archival data, public reports, and email exchanges to establish a clear picture of smart card adoption and related revenue management and pricing decisions for a number of selected cases.

The second method is a stated choice experiment. We employ a large-scale stated choice experiment (Louviere et al. 2000) to examine consumer behavior toward revenue management and pricing strategy. The data were collected using experimental designs where customers were presented with some hypothetical travel products and asked to state their preferred choice between these alternatives. Modeling of stated choice data allows for the assessment of market response to new products and services, and provides demand forecasting for new concepts.

The third method is a computational simulation. Following the customer-centric approach that we propose, and using activity and travel demand theory (Ben-Akiva and Lerman 1985), we design and develop a behavioral revenue management simulation. The purpose is to demonstrate the efficacy of integrating travel product design and capacity management. We leverage this simulation to evaluate the performance impacts of introducing different travel products on consumer demand, revenue production and capacity utilization in transportation networks.

1.4 Contribution of the Dissertation

We contribute to the scientific theories in the following ways. First, we contribute to the ongoing discourse on IT and firm performance in the economics of IS literature (Banker and Kauffman 2004). In particular, motivated by the process-oriented view of the business value of IT, we theoretically develop and empirically evaluate a research model that examines the use and impact of mobile ticketing technology and improved customer behavior information at the firm level. We demonstrate that increased firm informedness leads to the use of an advanced value creation strategy and higher firm performance. Second, in the presence of consumer informedness, we empirically test consumers' trading down (purchasing the product with the lowest price) and trading out behavior (purchasing a product that suits a specific need). Third, we provide an empirical assessment of how service providers explore the relevant attribute space; design their service offerings to capture the most profitable consumer responses; and profit from an information-based strategy. Fourth, we add an IS perspective to the present understanding of revenue management and explain its decision making in terms of the informational characteristics of the process. We add a needed customer-centric perspective and re-conceptualize the process that provides a basis for integrating service attribute bundles and capacity management to achieve higher performance. Last but not least, we develop a dynamic perspective that allows for learning to take place in the decision making of revenue management that spans a longer time horizon. We explain this end-to-end business process based on the theory of rational expectations and the theory of adaptive learning.

This research further contributes to management practice by demonstrating in a real-world case how improved informedness drives revenue management and increases the performance of firms. First, this research yields general principles to guide organizations in customer-centric revenue management thinking that could potentially yield strategic payoffs. Second, it proposes a solution to public transport service providers to evaluate the performance impacts of the revenue management strategies they deploy. Third, this research is timely in that there is a general discourse, as well as an intensive debate, surrounding the application of mobile payment technologies. This research demonstrates the importance of understanding the business value of these technologies, and also improved informedness, in enabling revenue management, which is also critical in evaluating and rationalizing IT investments.

1.5 Structure of the Dissertation

The rest of this dissertation is organized as follows (see also Figure 1-1). Chapter 2 provides a literature review on four related topics: IT and performance, the value of informedness, firm informedness and revenue management, and consumer informedness and resonance marketing. Further, we propose three detailed research questions and an overall conceptual framework to guide the three empirical chapters. Chapter 3 presents the research context and methods that are used in our research. Subsequently, Chapters 4, 5 and 6 each address one research question and together cover firm informedness, customer informedness, and informedness through learning. Finally, in Chapter 7 we draw a number of conclusions from this dissertation research, highlight the scientific and managerial contributions, discuss its generalizability and the limitations of the research we have done to date, and conclude with a future research agenda.

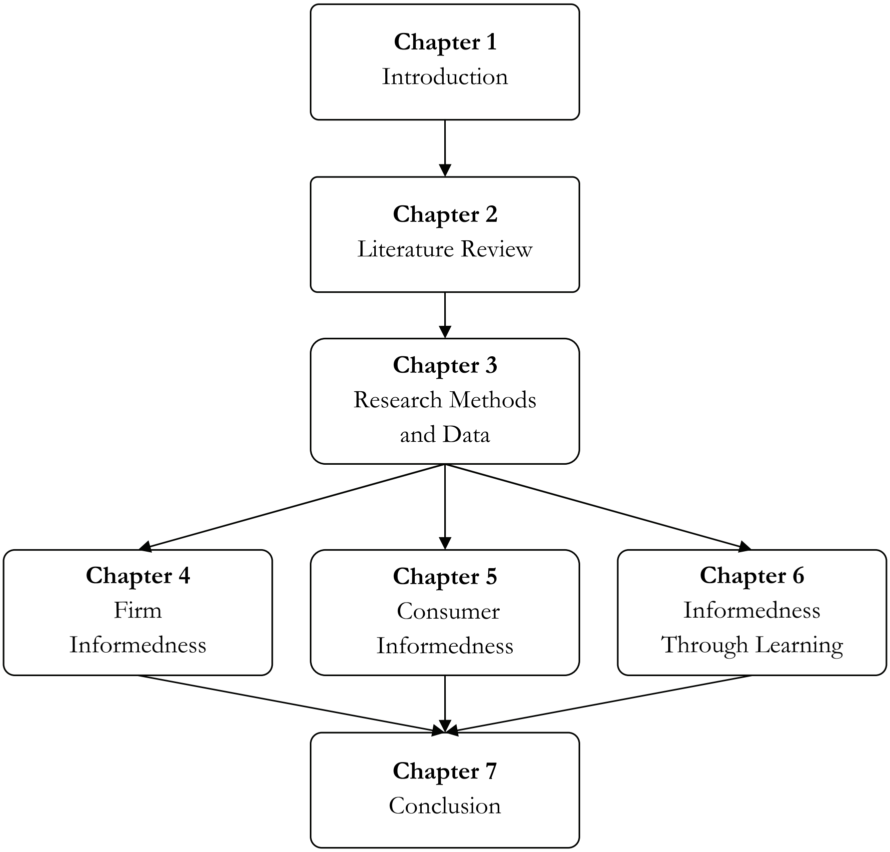

Figure 1-1: The structure of the dissertation

Chapter 2 Literature Review

This chapter will review the existing literature on the performance impact of information, introduce the concept of informedness, and discuss revenue management and resonance marketing in order to develop the research questions concerning the value of informedness in revenue management. In section 2.1 we will first examine what are the performance impacts of IT on performance at three levels: firm level, market level, and network level. We then focus on how information impacts a firm's performance in section 2.2. Having established the importance of information on firm performance, we will then turn to the concept of informedness and its relationships to firm performance. We distinguish between firm informedness and consumer informedness.[1] First, in section 2.3 we will focus on firm informedness and the current development of revenue management. This section analyzes what drives a firm to exercise revenue management and hence what makes a firm eligible to practice revenue management. Then in section 2.4 of this literature review, we focus on the concept of consumer informedness, and examine how consumer informedness drives the development of hyperdifferentiation and resonance marketing. The final section develops three research questions that will be answered by Chapters 4, 5 and 6.

2.1 Business Value of IT and Firm Performance

The literature on the performance impacts of IT can be divided into four streams based on the level of analysis. The first stream analyzes the impact of IT on the individual- or group-level performance, where the focus is on the influences of IT on individual and group decision making process. The second stream analyzes the impact of IT on firm level performance. Its focus is on how IT reduces cost, increases profit or improves flexibility within the firm. The third stream analyzes the impact of IT on market level performance. Its focus is on how IT influences the choice of coordination mechanism (e.g., electronic market vs. electronic hierarchies), and the comparison between electronic markets and traditional markets. The fourth stream analyzes the impact of IT on network level performance. Its focus is on the performance impact of IT

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[1] We distinguish between customers and consumers. "Customers" are nested in the larger category of "consumers". "Customers" belong to a specific firm, and "consumers" are just out there in the economy.

on a collection of firms. We will focus on the second, third and fourth streams in the sections below. Using different theoretical lenses, we will explain the performance impacts of IT based on two theories: the information processing view and resource-based theory. Before we continue with the discussion, we will first define the term "IT" using Shapiro et al. (1999):

> **Definition: Information Technology (IT)**: *Information technology* is about both information and the associated technology. Anything that can be digitized is information. And technology is the infrastructure that makes it possible to store, search, retrieve, copy, filter, manipulate, view, transmit, and receive information.

2.1.1 IT and firm level performance

The value of IT and its impact on the firm level performance have been debated since the 1970s (e.g., Lucas 1975). There are two distinct groups of arguments. On the one hand, several authors have suggested that IT positively impacts firm performance and the improvement ranges from productivity (Brynjolfsson and Hitt 1996, Hitt and Brynjolfsson 1996), value appropriation (Duliba et al. 2001), organizational decisions, intelligence and decision making (Huber 1990), market efficiency (Bakos 1991), competitive advantage (Porter and Millar 1985, Powell and Dent-Micallef 1997) to customer service (Ray et al. 2005). IT not only adds value to the product that firms produce; these benefits can also accrue to customers. Using a case in which the traded good is a homogeneous commodity – commercial fueling – Nault and Dexter (1995) demonstrated that the value of the IT-enabled service is exhibited in the premium prices. This value ranges between 5% and 12% of the retail fuel price relative to the same good without IT.

On the other hand, several authors have reported on the IT "productivity paradox" (Brynjolfsson 1993), and suggested that IT has not had any substantial impact on business profitability (Barua et al. 1995, Gubarxani et al. 1997). This is because the drivers of IT impacts are not the investment in the technology, but the actual usage of the technology (Devaraj and Kohli 2003, Zhu and Kraemer 2005). From a resource-based viewpoint, IT is a resource that will generate competitive value only when it leverages pre-existing firm resources and skills. And firms benefit from IT capability only when they embed IT in a way that produces valuable, sustainable resource complementarity (Powell and Dent-Micallef 1997, Bharadwaj 2000).[2]

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[2] Bharadwaj (2000) defines the "IT capability" as its ability to mobilize and deploy IT-based resources in combination with or co-present with other resources and capabilities, such as tangible resources (i.e., IT

2.1.2 IT and market level performance

Starting from the late 1980s, IS researchers have examined the impact of IT on market institutions and market structures (Malone et al. 1987, Kambil and van Heck 1998, Weber 1999). IT allows closer integration in the value chain and significantly reduces the coordination costs among sellers and buyers. Malone, Yates, and Benjamin (1987) were among the first to analyze how factors such as the ease of product description and the degree to which a product is specific to particular customers affect whether these interconnections will take the form of an electronic market or electronic hierarchies. In their well-known "electronic market hypothesis", they predicted that IT leads to an overall shift toward proportionately more use of the electronic market, rather than electronic hierarchies, to coordinate economic activities. To take this one step further, through their "move to the middle hypothesis", Clemons, Reddi and Row (1993) argued that IT lowers the coordination costs without increasing the transaction risks, which leads to more outsourcing activities and less vertical integration. This implies that firms can more safely invest in interfirm coordination. This results in a move toward long-term relationships (e.g., outsourcing) with a small set of suppliers.

Using a multi-case study approach, Kambil and van Heck (1998) examined the success of electronic markets in the Dutch flower industry using the proposed process-stakeholder analysis framework. They proposed that ITs enable increased efficiency and change the amount of information available to different parties, and affect their acceptance. They stated that market organizations are the meeting point for multiple stakeholders. Given existing or competing market alternatives, no new IT-enabled initiative is likely to succeed if any key stakeholder is worse off after an IT-enabled innovation. In related work, Weber (1999) compared the new screen-based futures exchange systems for derivatives trading to the traditional open-cry mechanism in the financial trading market. He used a simulation model and demonstrated the comparative advantage of a first-in-first-out order-matching algorithm used in the new system. He found that imposing time and price priority improves market quality, customer satisfaction and reduces trading costs for investors too.

2.1.3 IT and network level performance

Firms do not exist in isolation but are embedded in the networks that are built around collaborations such as alliances, long-term buyer-supplier relationships, and joint ventures (van Heck and Vervest 2007). They make different linkages, combine different

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infrastructure); human IT resources (i.e., IT skills); and intangible IT-enabled resources (i.e., knowledge assets, customer orientation and synergy).

capabilities from many different parties, and collaborate and compete simultaneously. Straub et al. (2004) stated that "the purpose of any collection of local actions is to act in concert for a global optimum. Correspondingly, the purpose of any collection of organizational elements as a network of firms is to overcome the complexity of the organizational connections in order to achieve maximal efficiencies". The organizational capability to interact with other firms has been greatly improved because of the modern information and communication technology. However, it was not until recently that scholars started examining the impacts of IT on networked organizational performance (Hoogeweegen et al. 1999, Kauffman et al. 2000, Straub et al. 2004, Vervest et al. 2005, van Heck and Vervest 2007). The difficulty of research on IT impacts on network level performance lies in the definition and operationalization of network performance. Drawing on the theory of information sharing and dependence, Straub et al. (2004) defined network performance as the structure of its nodes as well as the way in which the network is architected, and examined the impact of IT and networked organizational performance. Kauffman et al. (2000) empirically examined the impacts of network externality on network adoption and diffusion. They suggested using the expected effective network size as a measure of network externalities. They found that banks in markets tend to have early adoptions of ATM networks if they can generate a larger effective network size and a higher level of externalities.

So far, we have discussed the impacts of IT on firm level, market level, and network level performance. We summarize and present the key empirical literature in Table 2-1. For the purpose of this research, we will focus our discussion on firm level performance.

Performance Level	Study	Industry	Independent Variable	Performance Measure and Findings
Firm Level Performance	Brynjolfsson and Hitt (1996)	Across industries (manufacturing and services)	Computer capital and IT staff labor	Positive output
	Nault and Dexter (1995)	Fuel industry	General IT	Higher price premium
	Duliba, Kauffman, and Lucas (2001)	Airline industry	Computerized reservation system	Higher market share
	Zhu and Kraemer (2005)	Retail industry	E-business	Higher usage and value
Market Level Performance	Malone, Yates, Benjamin (1987)	General industry	Electronic market	Reduce coordination costs
	Clemons , Reddi, Row (1993)	General industry	General IT	Move to more outsourcing
	Kambil and van Heck (1998)	Flower industry	IT-based trading mechanism	Affect exchange organizations
	Weber (1999)	Financial industry	Future exchange order-matching system	Faster trade completion / reduced transaction costs
Network Level Performance	Kauffman et al. (2000)	Financial industry	ATM network	Shorter elapsed time to adoption
	Straub, Rai, and Klein (2004)	Networked organization	Information sharing and dependency	Greater information sharing and dependency lead to higher networked organizational performance.

Table 2-1: Impact of IT on different levels of the performance

2.1.4 Theoretical lens

The information processing view and resource-based theory are often used to explain the performance impacts of IT. These two theories originate from the organization theory and strategy management literature.

Information processing view. Firms have long been depicted as a distributed system designed for information processing. From an information processing view of organizations, organizational problems arise from the human limitation in processing information and interacting with environmental complexity and uncertainty. This limitation is often referred to as bounded rationality (Bakos and Treacy 1986). The bounded rational behavior of the individual can create inefficiencies in the form of excessive contracting and transaction costs, but can be affected by IT. IT affects the efficiency and effectiveness of the organization, primarily by reducing the effects of the bounded rationality of individual and group decision making. Further, IT helps decision makers and organizations to manage sufficient information and communications capability and to assuage the effects of environmental complexity and uncertainty.

The resource-based theory. Rooted in the strategic management literature (Barney 1986, Barney 1991, Powell and Dent-Micallef 1997), the resource-based theory posits that firms create value by combining heterogeneous resources that are economically valuable, difficult to imitate, or imperfectly mobile across firms (Peteraf 1993). It begins with the notion of resource heterogeneity, arguing that firms hold heterogeneous resource portfolios and that this resource heterogeneity is responsible for the observed variability in financial returns across firms (Peteraf, 1993). If a firm produces consistently superior returns, competitors will seek causal connections between resources and performance, and will attempt to imitate high-performing resources, and acquire them, or to develop alternative resources that produce similar benefits. In order to sustain performance advantages, firms need to accumulate resources that are relatively scarce, can produce economic value and can sustain competitive advantage (Barney 1986). In the IS literature, the resource-based theory has been used to analyze IT capabilities and to explain how IT business value emanates from the organization's skills in leveraging IT (Bharadwaj 2000). That is, IT business value creation depends on the extent to which IT is used in the key activities in the organization's value chain. The greater the use, the more likely the firm is to develop unique capabilities from its core IT infrastructure.

2.2 Informedness and Firm Performance

Today, ITs are readily available for all firms and have become a strategic necessity. What is essential for increased firm performance is not only the technology, but the information it yields. This information creates the possibility for firms and consumers to achieve a new level of informedness. Our definition of informedness extends the consumer informedness concept developed by Clemons (2008), and includes both firm informedness and consumer informedness. We define "informedness" as follows:

> **Definition: Informedness:** *Informedness* is the degree to which firms and consumers know and have access to complete, reliable and timely information to make informed decisions. In particular, it refers to (1) a firm knowing its consumers and being able to learn their choice behaviors and their performance impacts, and (2) consumers knowing firms' available service attribute space and exhibiting heterogeneous preferences.

This definition captures the immersion (completeness) and intensity (timeliness) of the degree of information that today's modern IT can offer.

2.2.1 The strategic necessity hypothesis

The notion that IT *per se* does not generate sustainable performance advantage has received increasing support in recent IS research, and has produced a perspective known as the *strategic necessity hypothesis* (Clemons and Row 1991). This hypothesis consists of two propositions. First, IT provides value to the firm by increasing internal and external coordinating efficiencies, and firms that do not adopt IT will have higher cost structures and therefore competitive disadvantage. Second, firms cannot expect IT to produce sustainable advantage because most ITs are readily available to all firms – competitors, buyers, suppliers, and potential new entrants alike – in competitive markets. As a result of this, firms must use IT to leverage or exploit firm-specific and intangible resources (Powell and Dent-Micallef 1997). So, IT becomes a "strategic necessity" but not a source of competitive advantage, unless it can lead to sustained profits: patents, economies of scale, search costs, product differentiation, or preferential access to scarce resources (Hitt and Brynjolfsson 1996).

Rather than IT, information has been argued to be the source of competitive advantage for firms. Table 2-2 lists a number of quotes about firms needing to leverage information opportunities to improve business profitability. In a study on information and communication technologies and electronic market performance, Koppius (2002) argued that an important driver of the electronic market performance is the information architecture of the market, which describes what information becomes available to whom during the market process. He argued that IT affects the information architecture of the market process and that there are consequences for market behavior. In a laboratory experiment in a multi-dimensional auction, he found that by having more information available in the marketplace, buyers and sellers can "divide the money left on the table" and achieve Pareto improvement.

Author(s)	Quotes about why firms need to leverage information opportunities for profitability
Clemons and Weber (1994)	"A firm that bids for business without using available information will find itself subject to winner's curse."
Hitt and Brynjolfsson (1996)	"…using information provided by the IT to radically change the way products or services are produced and delivered… pairing the benefits of IT with an available market opportunity."
Bharadwaj (2000)	"…a key source of generating competitive advantage through IT investment is customer orientation…", "…a key capability for superior customer orientation is the ability to track and predict changing customer preferences [using available information], especially in volatile markets."
Rockart (2004)	"…processes underlying the use of information in an organization should be clearly defined before systems in this area are implemented."
Clemons and Gao (2008)	"… consumers use information in different ways in different shopping experiences, …, the best predictors of the success of different online products will therefore vary depending on what consumers are buying and why and how they are buying it."
	"The enormous range of information that is readily available to consumers, … has increased competition among interchangeable commoditized products…"
	"Recent improvements in information availability have significantly changed the marketplace…"

Table 2-2: Quotes about why firms need to leverage information opportunities for profitability

2.2.2 Information and strategic pricing

The study of strategic pricing in the presence of advanced IT and improved information has become an active research area in the IS discipline (Bakos 1997, Brynjolfsson and Smith 2000, Clemons et al. 2002b, Bergen et al. 2005, Oh and Lucas 2006, Kauffman and Wood 2007). This is because the ability to access transaction price data, using for example software agents, now allows researchers to explore pricing and price adjustment patterns at a previously unimaginable level of micro-economic detail. These studies cover a wide range of products and services, such as books and CDs (Smith and Brynjolfsson 2001, Chevalier and Goolsbee 2003), online travel (Clemons et al. 2002b), and mortgage loans and insurances (Vroomen et al. 2005).

Pricing presents a rich opportunity for firms to creatively apply IT for competitive advantages (Beath and Ives 1986). We highlight four areas, outlined below.

Pricing lower. Increased availability of price and produce information significantly reduces the search costs in online markets and subsequently reduces the prices substantially (Bakos 1991). This has led to highly competitive and "frictionless" commerce (Brynjolfsson and Smith 2000).

Pricing higher. The reduced search cost of buyers is not a single and major economic factor influencing the price of goods in the electronic market. Lee (1998) demonstrated that the use of IT in a second-hand automotive electronic auction market in Japan led to an increase in buyers' costs rather than lower prices. Two reasons can explain the price increases. First, the market power of sellers is increased because of lowering the logistic costs, for example the transportation costs of bringing the unsold products back home. Second, the benefits realized by individual sellers increase as more buyers join the electronic market – these represent buyer externalities.

Pricing dispersion. Widespread price dispersion, or variations in prices across different providers, has been observed (Smith and Brynjolfsson 2001, Clemons et al. 2002b). In a study of price rigidity, Bergen et. al (2005) posited that as long as the cost of price adjustments go beyond the bounds of the technologies that produce prices, the fluidity of daily price adjustments will hold across product categories, retailers, and industries.

Pricing in multi-channels. Firms may adjust prices differently in online markets than in physical markets (Kuruzovich et al. 2008). In a physical market, firms post different prices over time to develop an understanding of the demand curve for their products. An online market provides lower search costs, more effective price monitoring, lower menu costs, and easier price modification. Using these features, firms actively engage in making strategic pricing decisions and exploring price adjustments over time (Oh and Lucas 2006).

2.2.3 Theoretical lens

The use of IT could reduce price stickiness, accelerate the information cycle, and eliminate information asymmetry.

First, the use of IT reduces, or even removes, price stickiness. *Price stickiness* (or price rigidity) is the phenomenon by which prices tend to remain the same despite changes in a firm's cost structure and market demand. Price stickiness may occur for two reasons. First, the physical costs are high for sellers to set, change and communicate the price to the buyers. Second, price changes do not always reflect changes in demand, especially in low-tech environments (Ball and Romer 1991, Blinder 1994). Price stickiness represents inefficiency in the market. This inefficiency has two sources. The first is output inefficiency. If prices cannot adjust enough then either too many or too few products will be produced. The second is allocation inefficiency. If prices are not set based on the market conditions, products will not go to the buyers who have the highest valuation. The use of IT, for example electronic market, makes it easier to change prices in a database, reducing menu costs for online sellers and providing economic incentives for more active adjustment of prices.

Second, the use of IT accelerates the information cycle. *Information cycle* is defined as the natural market process of matching supply and demand, which involves a continuous cycle of information collection and dissemination. This cycle has three steps. First, prices change to reflect changes in supply or demand. Second, buyers and sellers adjust their decisions in view of the new prices. Third, the decisions of individual buyers and sellers aggregate into changes in total supply and demand. And there is an iteration back to the first step. The use of IT speeds up the information cycle because it reduces the cost of collecting and disseminating information.

Third, the use of IT eliminates information asymmetry. *Information asymmetry* refers to the difference between the information that buyers and sellers possess. Individual decision makers need to use certain information to make optimal choices. For example, customers need to know what their personal preferences are and firms need to know their own cost structure and how much they can sell at each price. What they each do not know but need to is what choices are being made by other buyers and sellers. Prices are the essential summary information about the choices of other buyers and sellers. Moreover, when there is a change in total supply and demand, price changes lead to a new equilibrium. A reduction of information asymmetry between sellers and buyers affects the extent of their opportunistic behavior. IT can help reduce information asymmetry in two ways. First, the cost for the customers to acquire information is reduced. Second, customers can check prices of different sellers before buying the products, and thus can reduce the risk of lock-in. They can even specify their prices, products or services, for example in the "name-your-own-price" Internet site Priceline (www.priceline.com), and obtain an information advantage.

2.3 Firm Informedness and Revenue Management

Businesses face very complex selling decisions. For example, how can a firm segment buyers by providing different conditions that profitably exploit their varying buying behavior or willingness-to-pay? How can a firm design products to prevent cannibalization across channels? Once it segments customers, what prices should it charge each segment? Answering these questions is a complex task, requiring that a firm knows not only its own operation costs and availability of supply, but also how much the current customers value the product and what the future demand will be. Therefore, to charge a customer the right price, a firm must have an abundance of information about its customer base and be able to set and adjust its prices at minimal cost. Until recently, firms had limited ability to track information about their customers' tastes and faced high costs in changing prices (Elmaghraby and Keskinocak 2003). Today, IT allows firms to collect information not only about the sales, but also about demographic information and customer preferences. We use the term *firm informedness* to describe what a firm knows about customer information (purchase, demographic, and preference information) and its ability to capture, store, analyze and interpret this information.

> **Definition: Firm Informedness:** *Firm informedness* refers to what a firm knows about its customers and the capability of learning what the customers want, in order to satisfy customers and impact their willingness-to-pay.

This informedness enables firms to develop and implement informed, sophisticated, and detailed revenue management decisions. In this section, we will introduce revenue management, examine the required conditions to implement it, introduce two main methods of doing so, and explain the economics of revenue management.

2.3.1 Revenue management definition and its performance

Revenue management deals with the decision of selling the right product to the right customers at the right time for the right price. Different from inventory management and supply chain management, it is concerned with demand-management decisions. Instead of answering the question of "how many product should we order in the face of uncertain demand", firms use revenue management to explain "how to stimulate demand to use fixed capacity". One particular example is the revenue management strategy used by budget airlines. Some examples are easyJet and Ryanair in Europe and jetBlue in the U.S.. These airlines typically offer only one type of ticket on each flight, a non-refundable, one-way fare without advance-purchase restrictions. However, they offer these tickets at different prices for different flights, and moreover, during the booking period for each flight, vary prices dynamically based on capacity and demand for that specific departure. Based on Talluri and van Ryzin (2004b), we define "revenue management" as follows:

> **Definition: Revenue Management:** *Revenue management* is short-term demand management to promote flexible real-time capacity allocation, customer segmentation, and pricing optimization.

Revenue management addresses three categories of decisions: structural decisions, price decisions, and quantity decisions (Talluri and van Ryzin 2004b). Structural decisions answer questions such as which selling format to use (e.g., posted prices, auctions); which segmentation or differentiation mechanisms to use; what restrictions to use (e.g., cancellation, refund options); how to bundle products; and so on. Price decisions answer questions such as: how to set posted prices, individual-offer prices; how to price across product categories; how to price over time; and so on. Quantity decisions answer questions such as whether to accept or reject an offer to buy; how to allocate output or capacity to different segments, products or channels; and so on.

Why are firms so keen on implementing revenue management? During the period of deregulation of the American airline industry in the 1980s revenue management (also called yield management) quickly established itself in the transportation and hospitality industry. More recently it has received enormous attention due to its recent success in various industries: restaurants, cargo, retailing, media and broadcasting, nature-gas storage and transmission, tour operating, cruises, golf, equipment rental, healthcare, manufacturing, and many other industries (Bertsimas and Shioda 2003, Kimes and Thompson 2004, Talluri and van Ryzin 2004b, Agatz et al. 2008). Testimonials on revenue management's quantifiable results have been received for management practice (Cross 1997). Bill Brunger, deemed Continental Airlines pricing guru by the Wall Street Journal (McCartney 2000), simply pointed out that "revenue management is all of our profit, and more." The following facts of so-called high-yield firms that have benefited from implementing revenue management are even more encouraging:

- Airlines: American Airlines had an estimated benefit of $1.4 billion over a period of three years and an annual revenue contribution of over $500 million (Smith et al. 1992).
- Automotive rentals: National Car Rental improved revenue by $56 million in the first year after a successful implementation of a revenue management system (Geraghty and Johnson 1997).
- Healthcare: Texas Children's Hospital improved revenue by $17 million annually on contracts renegotiated.

2.3.2 Critical conditions to employ revenue management

Not all firms can benefit from employing revenue management strategies in their business. The ones where such strategies are possible have these characteristics.

On the demand side. The greater the heterogeneity of consumer preferences, the more potential there will be for a firm to exploit this heterogeneity to improve revenues. Demand should exhibit some kind of informational complexity, like variations due to weather, or changing patterns on holidays, or day of the week.

On the supply side. A firm should operate with relatively fixed and inflexible capacity and production constraints, and it may not be able to cope with variations in demand. Also, the products and services it offers should be perishable (e.g., rental cars, hotel rooms) and cannot be held in inventory beyond a certain time.

Cost and pricing structure. The typical cost structure of a firm that encourages the use of revenue management is high production costs and low marginal costs. High production costs include both the costs of producing existing products and services, and the costs of extending the capacity beyond the current full production limit. However, it is relatively cheap to produce additional units of supply and results in a lower marginal sales cost. For example, operating a flight is expensive but the cost of carrying additional customers within the capacity limit and providing services to the additional customers are not large. On the other hand, exercising revenue management requires an adequate pricing structure that allows for a flexible allocation of capacity in response to the variable demand.

Data and information system. A firm should have the capability to capture abundant consumer data via IT. Advanced infrastructure is needed to collect and store demand data and to automate pricing decisions. This applies to firms as well as industries as a collection of firms with similar characteristics.

2.3.3 Multidimensional demand and revenue management methods

A firm's demand for products and services has multiple dimensions. The main dimensions are the products the firm sells, the heterogeneous customers the firm targets, and the time at which the product is sold to the customer. See Figure 2-1 for an illustration of these three demand dimensions. A single cube such as (a) indicates a particular customer's valuation of a particular product at a particular point in time. Using revenue management, a firm exploits the potential of this multidimensional demand landscape (Talluri and van Ryzin 2004b) by making combined quantity, price, and timing decisions. For example, a line such as (b) indicates the classical price discrimination, such that firms fix the product and time dimension and try to exploit heterogeneity in customers' valuations of a single product at a single point in time. A plane such as (c) indicates firms' analysis of heterogeneous customers' valuations of a given product over time. A plane such as (d) indicates a firms' solution for a given customer segment and for multiple products across time dimensions.

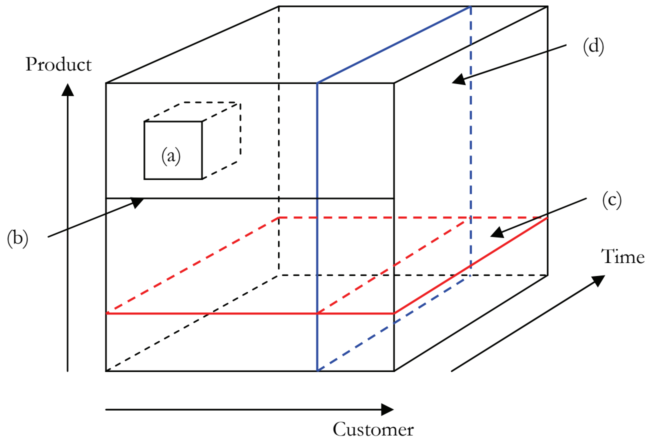

Figure 2-1: Multidimensional demand landscape (adapted from Talluri et al. (2004))

The revenue management literature distinguishes between two revenue management methods (Talluri and van Ryzin 2004b): quantity-based revenue management and price-based revenue management. Quantity-based revenue management concerns product rationing and availability control – how much to sell to whom and whether to accept or reject requests for products. It is similar to seat inventory control, which is the process of limiting the number of seats to be made available at different price levels on a future flight departure (Belobaba 1987). There are three main techniques of quantity-based revenue management: single resource capacity control, network capacity control, and overbooking. Price-based revenue management concerns the price decisions on how to price to various customer groups or how to vary prices over time. Dynamic pricing and auction are the most often used techniques.[3]

2.3.4 Theoretical lens

We explain why using different prices can maximize revenue by introducing the concept of price discrimination and the economics of revenue management.

The notion of price differentiation from the microeconomics literature generally follows the taxonomy of Pigou (1932). *Price discrimination* is a pricing policy under which a seller sets prices to earn different incremental margins on various units of the same or a similar product. It extracts a higher price from existing buyers while extending sales to new buyers who would not be served with uniform pricing. The relevant literature

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[3] For a more detailed discussion on the classification of static, dynamic, and posted-price mechanism, the interested reader should see Kannan and Kopalle (2001) and Elmaghraby and Keskinocak (2003).

concludes that discriminatory pricing is the appropriate policy because of its ability to shift the demand from certain segments that have discretion over a particular aspect of a product.

There are three types of price discrimination. *First-degree price discrimination* means that every customer is charged the maximum they would be prepared to pay for the good. If the seller has sufficient information to determine the maximum willingness-to-pay for each consumer, it will be able to capture the entire consumer surplus from the market, and therefore, it yields an optimal outcome. *Second-degree price discrimination* refers to a situation in which everyone faces the same menu of prices for a set of related products. The price the consumer pays varies according to their consumption. Greater consumption leads to a lower price. If the seller cannot identify the precise willingness-to-pay for each user, it may want to adjust the characteristics of the good being sold so that users can self-select the product targeted for them (self-selection mechanism). In this case, the outcome may be less efficient than it would be if perfect price discrimination were possible. *Third-degree price discrimination* involves selling at different prices to different groups. This is the most common form of price discrimination, where a firm divides customers into different groups based on some identifiable characteristics (sorting mechanism).

The revenue maximization process is accomplished through exercising multiple prices, as illustrated in Figure 2-2. If a product is sold at a single price, the maximum revenue obtained is denoted in (a) with a linear demand function. If the monopolist sells the product at multiple prices (b), assuming the monopolist can exercise perfect price discrimination, customers who have the maximum willingness-to-pay (maxWTP) higher than p_3 will buy the product at p_3. Those with maxWTP in the interval between $[p_2, p_3]$ will buy the product at p_2. And those with maxWTP in the interval between $[p_1, p_2]$ will buy the product at p_1. The shaded area represents the maximum revenue the monopolist obtains by selling the product at multiple prices. By comparing the shaded areas, we can see that the revenue generated by the multiple price selling is significantly higher than what a single price yields. Thus, we can conclude that the more prices used by the monopolist the higher the revenue generated through price discrimination.

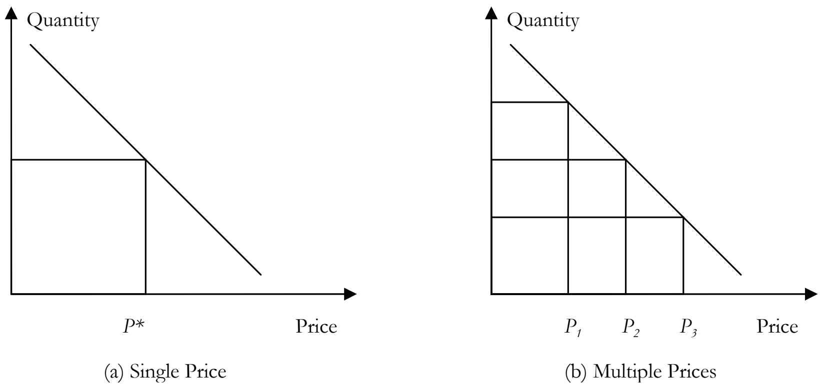

Figure 2-2: Illustration of product revenue from selling at single price and multiple prices

2.4 Consumer Informedness and Resonance Marketing

The impact of increased information availability is considered by the theories of hyperdifferentiation and resonance marketing. These have been used to explain the behavior of well-informed consumers and the strategies that firms should follow in order to sell to them most effectively. Consumer informedness becomes an important factor in determining their willingness-to-pay. As opposed to the traditional way of designing a product that targets the mass market and attracts the largest number of consumers, using a hyperdifferentiation strategy, firms can design and differentiate a variety of products so that they are suitable for a small number of consumers and benefit from the *long-tail* (Anderssen 2006). Increases in willingness-to-pay occur due to the improved fit between consumer needs and service attributes. Informed consumers will pay more for what they want, and will stop buying services with which they are dissatisfied. Rather than seeking strategies to change the behavior of consumers, firms are actively searching for strategies to provide choices to consumers. When firms fail to use their data efficiently and price too low, they may face a "winner's curse" (Akerlof 1970). This section is devoted to discussing consumer informedness and how it drives resonance marketing. We will focus on the theory of hyperdifferentiation and resonance marketing, the role of informedness in the advent of resonance strategies, and the consumer behavior.

2.4.1 Hyperdifferentiation and resonance marketing

Hyperdifferentiation. Hyperdifferentiation reflects an organization's increasing ability through IT to produce almost anything for a market that it thinks might sell (Clemons et al. 2006). It involves differentiation without limits, and so hyperdifferentiated products can be as diverse as the needs and desires of the consumers who buy them. For example, hyperdifferentiation by a food and beverage retailer involves the choices it makes to alter the flavors in its food and beverage products. Other hyperdifferentiating actions in marketing include colors and styles, or options packages in consumer durables. Some firms also may vary parameter settings in software that supports services, for a unique level of service to a specific customer. In essence, this approach involves implementing new approaches to developing, marketing, and selling anything the firm chooses to offer to consumers who express heterogeneous demand preferences (Clemons 2008). With hyperdifferentiation, pricing is no longer the principal determinant when consumers choose among alternative products and services. We define "hyperdifferentiation" as used in Clemons et al. (2006):

> **Definition: Hyperdifferentiation:** *Hyperdifferentiation* refers to the situation where firms can produce almost anything that appeals to consumers and they can manage the complexity of the increasingly diverse product portfolios that result.

Two reasons explain why firms are increasingly engaging in hyperdifferentiation. First, they are under pressure to differentiate their products to achieve superior profitability. The growth of e-markets on the Internet has reduced search costs (Bakos 1997) and increased market and price transparency (Granados et al. 2006a), making it difficult for firms to compete without tailoring strategies for Internet-based selling. Firms that fail to differentiate their service offerings will be less competitive. Second, with the availability of new ITs, firms now have the capability to hyperdifferentiate their products and services in ways that were never possible before. For example, firms now have access to more information with which they can make effectively differentiated products and services. They can also communicate with the market easily about their products, and emphasize unique value propositions that will enable them to retain and obtain customers. Hyperdifferentiation is enabled by information, which has the capacity to generate unprecedented profitability for the firm. We observe this kind of strategic information-empowerment happening all around us. The products affected range from physical products such as books to services such as person-to-person lending, casino gaming, hotel stays, and airline ticket reservations.

Resonance marketing. The essence of resonance marketing is harnessing and guiding the supply side of hyperdifferentiation (Clemons 2008). Although firms can produce anything, they typically find it most beneficial to produce exactly what their customers want to buy. We also use the definition provided by Clemons et al. (2006) to define "resonance marketing":

> **Definition: Resonance Marketing:** *Resonance marketing* is a strategy of developing products and services that produce the strongest favorable responses among targeted segments of the consumer population.

In the craft beer industry today, for example, consumers can obtain hundreds of reviews about thousands of beers by using websites such as Ratebeer (www.ratebeer.com). Using these reviews consumers are better informed of the taste and quality of a particular product. They will buy the ones they really like and stop buying the ones that disappoint them. These kinds of reviews also allow beer brewers to make highly differentiated products, because now they have the capability to measure the tastes of the consumers and send clear signals about the quality of their products. It is reported that this website has significantly altered the sales pattern and profitability of brewers (Clemons et al. 2006).

Air Canada, another example, has recently shifted to a simplified fare structure with "branded products" including Tango, Tango Plus, Latitude, and Executive. Each branded product has unique characteristics that are essentially soft qualifiers that allow customers to self-select themselves into the targeted segmentation. For example, with "Tango Plus", the newly launched low-fare pricing option, customers can purchase flights in the form of multi-trip passes, in ten or 20 one-trip increments. Prices start at CAN$189 each-way and are valid for travel anywhere within the route network of Air Canada, Jazz, or their regional partners.[4] It is reported that "Tango Plus" sales increased by 39% in 3Q 2007, and 34% in the 4Q 2007 over 2006, an indication of the efficacy of the approach.

2.4.2 Consumer informedness as a driver

Consumer informedness is viewed as the critical driver for the success of resonance marketing. We first define "consumer informedness" as in Clemons (2008):

> **Definition: Consumer Informedness:** *Consumer informedness* refers to the degree to which consumers know what product or service is available in the marketplace, with precisely which attributes and at precisely what price.

More information will reduce consumer uncertainty about a product, and thus a consumer will be willing to pay more for what he wants. The upshot is that the consumer will experience a sense of "delight" in the presence of the increased information. Clemons et al. (2008) argue that this approach comes close to "near-elimination of all aspects of uncertainty, allowing latent differences in preferences to become manifest in consumers' preferences for less common products, and allowing these preferences to manifest themselves in terms of what these consumers buy and what they are willing to pay". Resonance marketing requires an understanding of the demand side. It emphasizes what the firm knows about what each consumer segment wants to buy and is willing to

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[4] Koshy, J. 2007. Changing the Game. 27th New York Air Finance Conference, April, 2007, Available at www.aircanada.com/en/about/media/presentations/documents/NBF_April24.pdf.

pay. This understanding will help to make sense of the observed long-tail of consumer purchases and identify un-served and under-served market segments.

2.4.3 Theoretical lens

We explain how consumer informedness affects compromise discount, competition discount, and uncertainty discount. And we introduce choice theory that is used to study consumer choice.

Compromise, competition, and uncertainty discount. There are three types of discount in the traditional market that are eliminated when resonance marketing is introduced: compromise discount, competitive discount, and uncertainty discount (Clemons and Gao 2008). *Compromise discount* occurs when customers purchase a service that is different from their ideal offerings. When there is more than one firm that has a service offering in the marketplace, in order to maintain the market share, firms need to offer *competitive discount* to the customers. Because of the information asymmetry, customers do not have the full information of the service attribute space, this is when the *uncertainty discount* occurs. Consumers' willingness-to-pay for a specific service is determined by their willingness-to-pay for their ideal service and by how closely the service they are considering matches or how much it deviates from this ideal. The difference between these two is referred to as "fit". A greater distance between consumer preferences and a specific service results in worse fit, and higher fit cost, which reduces the customers' willingness-to-pay. Consumers' lack of information and the resulting uncertainty discount and reduction in willingness-to-pay will reduce innovation and the profitability of innovative firms (Clemons 2008).

Choice theory. People make purchase decisions based on many criteria simultaneously. Thus, it is a challenge to understand consumer choice under complex market conditions. Generally, there are three steps to follow in order to understand consumers' preferences in an experimental field study setting. First, we need to understand the range of possible choices that may be observed. Second, we need to design an experiment and ask respondents to select one of the available options. Third, we need to employ statistical or econometric modeling methods to identify the key patterns present in the data (Ben-Akiva and Lerman 1985, McFadden 1986, Erdem et al. 2005).

We have identified the appropriateness of a discrete choice model to study consumer choice. This area of modeling and theory in Marketing and Economics has developed rapidly during the past decade (Ben-Akiva and Lerman 1985), due especially to the research innovations of economist and Nobel Laureate, Daniel McFadden (McFadden 1974, 1986). Discrete choice models are based on the idea of random utility-based choices, a related theoretical perspective that originated in economic theory. Random utility models are based on the following principles: (1) Choice behavior is systematically related to the attributes of the considered alternatives. (2) For each attribute of an alternative, individuals assign or attach a psychological weight as a means of expressing their perception. These perceptions, according to random utility models, are connected systematically with measurable values of the corresponding attributes. (3) Individuals then aggregate the weights of the individual attributes to create an overall evaluation of a given alternative. (4) This valuation is made up of a systematic utility component based on the observable aspects, and a non-observable random utility component based on the unobservable aspects. The assumption here is that a consumer will reliably select the most advantageous alternative, and so can be viewed as a utility maximizer.

2.5 Summary

This chapter has explained how IT impacts performance at the firm level, market level, and network level. It also explained why IT has become a strategic necessity, whereas information is the source of a firm's competitive advantage. We discussed the concept of informedness from two perspectives: firm informedness and the increased practice of revenue management; and consumer informedness which has driven the advent of resonance marketing.

Based on the central research question and as a result of our literature review, we derive three detailed research questions.

Research Question 1 (Firm Informedness): Why and how does increased firm informedness impact firms' revenue management?

Research Question 2 (Consumer Informedness): Why and how does consumer informedness impact consumer behavior and enable resonance marketing?

Research Question 3 (Full Informedness): In an environment with a higher degree of firm informedness and consumer informedness, how do firms design service offerings to capture profitable consumer responses and improve firm performance?

To guide our further research in answering these questions, we present our conceptual framework as depicted in Figure 2-3. It includes five main constructs (IT, informedness, revenue management strategy, consumer behavior, and firm performance) and their relationships. We conduct three studies to answer these three detailed research questions and discuss them in Chapters 4, 5 and 6 respectively. The main focus of each study is highlighted in Figure 2-3.

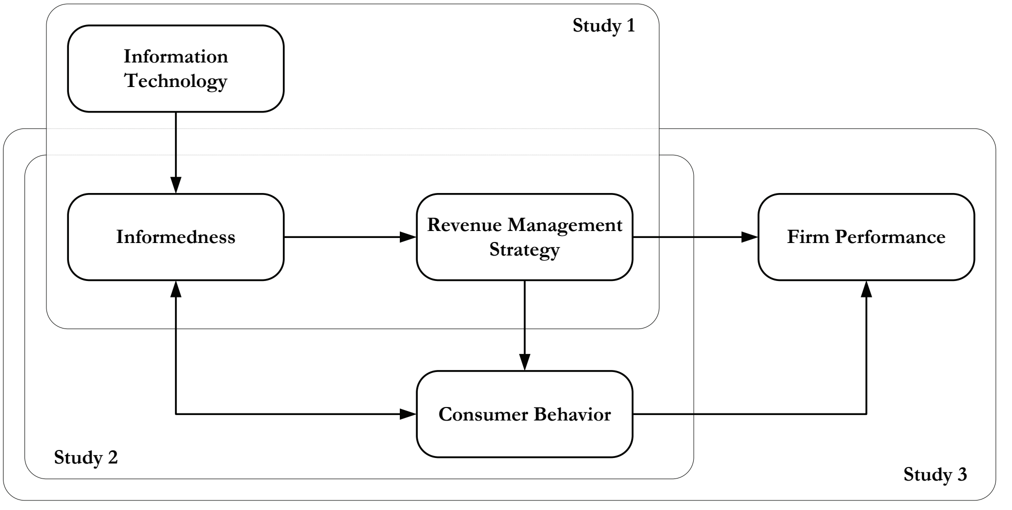

Figure 2-3: Overall conceptual framework

Chapter 3 Research Methods and Data

In this chapter, we will describe the empirical setting of our research and the research methods we applied. First, we will introduce the Dutch public transport industry as the research context and justify it for conducting our research. In particular, we will introduce the smart card implementation in the Netherlands, and explain how the use of smart cards increases the informedness of public transport service providers.

We raised several research questions in Chapter 2. Why and how does enhanced firm informedness improve revenue management strategies? Why and how does consumer informedness impact consumer behavior and enable resonance marketing? And how should we assess the firm performance impacts of revenue management when consumer behavioral responses and capacity constraints are considered? We next move on to explain the research methods we choose to collect the data to answer these questions. This also gives the methodological background of the research methods applied in Chapter 4, 5 and 6. We follow a multi-method research strategy, as suggested by Mingers (2001). Our motivation for the choice of methods is to capture the real-world complexity of the research situations. According to Mingers (2001), all research situations are inherently complex and multi-dimensional. So it is beneficial to form a rich picture based on multiple research methods. We use three research methods to answer our research questions in three separate studies. They are multiple case studies (Benbasat et al. 1987, Eisenhardt 1989, Yin 2002), a stated choice experiment (Louviere et al. 2000, Hensher et al. 2005), and a computational simulation (Law and Kelton 1982). Table 3-1 relates the three research questions with the three research methods. The combination of these three methods can provide a rich picture of the relationships that we wish to study.

Research Question	Level of Analysis	Case Study	Field Experiment	Computational Simulation	Chapter
RQ1	Firm	*			4
RQ2	Customer		*		5
RQ3	Customer / Firm		*	*	6

Table 3-1: Relationship between research questions and research methods

3.1 The Public Transport Industry as Research Context

In this section we will explain why the public transport industry has been chosen as the research context for this research. And we will introduce smart card adoption in the public transport sector in the Netherlands.

3.1.1 The current status and role of the public transport industry

We choose the public transport industry as the research context for three reasons. First, the increased adoption of ITs such as smart card technology in the last decade has allowed public transport service providers to explore the opportunities for revenue management that were not possible earlier. Second, there is a strong need for revenue management within the public transport service. This enables the providers to reduce the concentrations of peak travel, which cause enormous problems such as over-crowding, dissatisfied customers, low capacity utilization and low revenue. Third, given public transport service providers' social responsibility and public pressures, the ones who fail in justifying the impacts of implementing price differentiation may be subject to heavy criticism from the public and politicians (e.g., Deutsche Bahn (Link 2004) and MTR in Hong Kong (Li and Wong 1994)).

Current status of public transport. Public transport systems generally rely on government subsidies to supplement fare collections, though a few systems run as unsubsidized commercial enterprises or are entirely paid for by governments. The reasons that governments pay subsidies are to alleviate road traffic, reduce pollution and greenhouse emissions, and promote economic growth.[5] What is the current public-private status of public transport? All nationalized industries have to satisfy statutory requirements, and in the case of public transport there are both financial and service criteria to be met. Achieving both of these objectives at once has become more difficult in recent years. This has been due to two main external influences. One has been the growing popularity of privatization of public transport companies, which has meant that the level of government financial support has been reduced. As a consequence, an increasing proportion of the income stream has to come from passenger transportation itself. Second, there has been a continuing increase in competition, with increased car ownership and air mileage. There exist many alternative modes for passengers for both short-distance (within city) and long-distance (inter-city) traveling, for example, car,

[5] American Public Transportation Association. 2007. Public Transportation Use Substantially Reduces Greenhouse Gases." Press Release, September 26, 2007, Available at www.apta.com/media/releases/070926_climate_report.cfm.

bicycle, taxi and airplane. These external influences have pushed public transport companies toward more revenue-driven commercial organizations. It is in this context that revenue management strategies become a possibility, and more and more such companies are striving to make it a success.

The critical role of the public transport industry. The public transport industry plays an essential role in most economies. The American Public Transportation Association (APTA) has reported that 81 percent of people link public transport to improved quality of life.[6] Increased public transport investment in this sector strengthens the economy, creates jobs, reduces traffic congestion and air pollution, and saves energy. In 2007, APTA reported that public transport use saves 1.4 billion gallons of gasoline every year, and can reduce household expenses by $6,200 - more than the average household pays for food in a year.[7] In California alone, public transport carries over 1.2 billion passengers annually, seven times the number of passengers carried by the state's 14 largest airports. A person using one of California's largest 25 bus and rail transit systems consumes about 53% less energy per mile than if they were driving. Further, taking public transport in lieu of driving an SUV saves 62% in energy use.[8]

3.1.2 Smart card adoption in the Dutch public transport industry

The way in which people use public transport in the Netherlands is changing, as it is in cities and countries across the globe. Trans Link Systems (TLS) (www.translink.nl) plans to deliver a seamless ticketing and fare collection solution for the complete public transport system throughout the Netherlands.[9] The system was initially rolled out in Rotterdam in January 2007 and will be extended to cover the whole country. Using smart cards and reader technologies, this all-encompassing contactless ticketing infrastructure will cover trains, metro, trams and buses, providing travelers with increased convenience and added satisfaction. Once it has been fully implemented, the system will have to contend with an estimated 1.5 billion transactions each year. The use of smart card

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[6] American Public Transportation Association. 2003. The Economic Importance of Public Transit. Press Release, November 3, 2003, Available at www.apta.com/research/info/online/economic_importance.cfm.

[7] American Public Transportation Association. 2007. Public Transportation Saves $6,200 Per Household, 1.4 Billion Gallons of Gasoline. Press Release, January 9, 2007, Available at www.apta.com/media/releases/070109_energy_report.cfm.

[8] Odyssey 2003. Advocating for Transit through Partnership: Coalition Stories from Across America. Available at www.odyssey.org/coalition/1-2.pdf.

[9] TLS "was established in 2002 by Connexxion, GVB (Amsterdam), HTM (The Hague), the NS and the RET (Rotterdam). These five companies provide 80% of public transport services in the Netherlands … [and] also works in partnership with the remaining public transport companies, united in the trade association MOBIS."

systems will simplify the purchase and use of public transport services across the nation – as similar systems have done for people around the globe (e.g., Hong Kong and London). Travelers will use smart cards with an e-purse, which can be combined with additional services. Each smart card can be loaded with value via easy-to-use ticketing machines at stations. When a traveler boards a transport vehicle, the traveler simply places the card in front of an electronic reader, which scans it to calculate the fare, and then deducts this from the card's current balance. The system will also ensure that all fares are credited to the appropriate public transport company. When fully operational, it will improve the travel experience of more than one million travelers every day.

Smart cards represent one of the most promising technologies that have the potential to dramatically impact the existing market.[10] For example, using smart cards and mobile devices, transportation firms are able to learn about their customers' travel behavior regarding the locations to and from which they travel. They also can learn about what time and how many times they travel, what tickets they purchase, and what mode of transport they use, all with far more precision. This permits them to adjust their services or prices accordingly to improve their service revenue, capacity management, and customer satisfaction. Mobile payments are also particularly attractive to retail segments where speed and convenience of payment are essential. By moving customers more quickly through the payment process, service providers will be able to differentiate themselves and improve customer satisfaction in highly competitive markets. An additional benefit will come from eliminating cash shrinkage, by reducing errors when manually processing cash and by reducing the risk of theft. A study by analysts Datamonitor suggests that "top and go" cards could replace the use of cash in purchases totaling of 38 billion euros a year globally within five to ten years.

As far as the public transport industry is concerned, we analyze the benefits of smart card adoption from both the experience of service providers and customers, and we summarize these benefits in Figure 3-1.

Service provider experience: cost. From the cost perspective of service providers, we identify five benefits of using smart cards made possible by electronic ticketing. (1) Cost saving is realized through acceleration of ticket purchase and reducing unnecessary clerical work. (2) All micro-payments are made electronically, so this simplifies cash handling by the transport drivers. (3) Based on more accurate origin-destination information on travel demand, service providers could make more precise decisions on the number of vehicles to dispatch and improve operational efficiency. (4) Knowing the

[10] Five of these technologies are identified. They are enhanced search services, biometrics and smart cards, enhanced computational speed, m-commerce, and GPS tracking (Shugan 2004).

number of passengers that need to be served in close to real-time would allow service providers to dynamically allocate employees (e.g., more conductors on congested vehicles) and would lead to reduced staff handling costs and improved staff utilization. (5) Conducting surveys, especially nation-wide travel behavior surveys, is a time and resource-intensive task. Electronic data collection is a complementary method, if not a complete replacement, for the current survey methods.

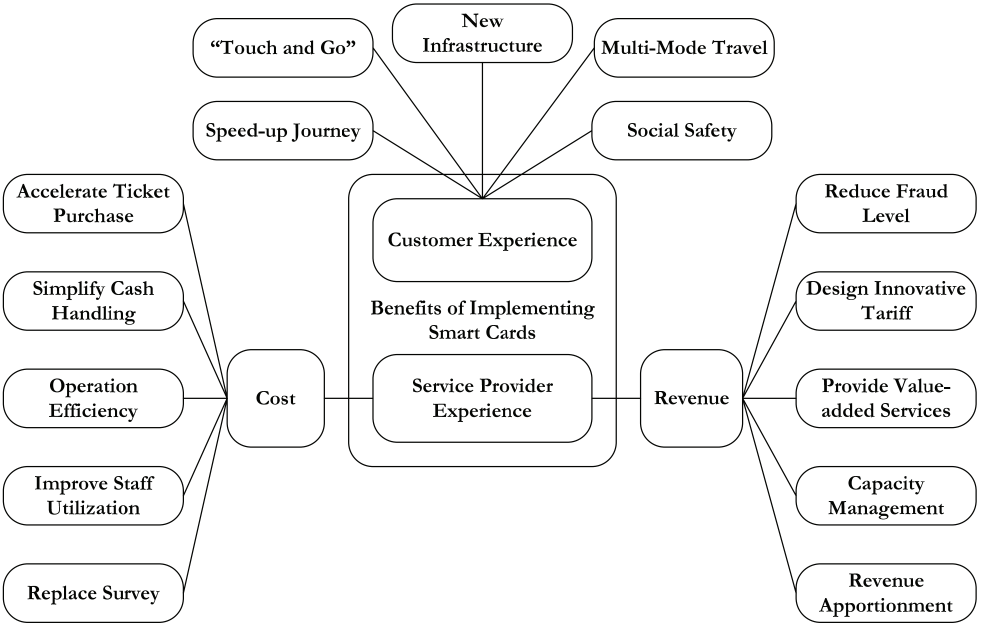

Figure 3-1: Enhanced experiences of service providers and customers with smart card adoption

Service provider experience: revenue. From the revenue perspective of service providers, we also identify five benefits. (1) Electronic gates are used for access control, which helps to reduce fraud levels. (2) Service providers can use smart card data to better understand their customers and design flexible fare products and tariff structures to better suit their needs. (3) If the smart card is not anonymous, service providers can link travel patterns with individuals and provide customized product and value-added services. For example, linking smart cards to travelers' mobile devices, service providers can send real-time travel information to customers while traveling. (4) Knowing detailed customers' travel patterns, service providers can adjust their vehicles for better capacity management. (5) Formerly there was limited information available on how much revenue each service provider made because the accurate data on patronage were not available. After the implementation of smart card systems, all service providers will be able to link their computer networks to a central data clearing house, which will undertake revenue apportionment and fund transfer.

Customer experience. Using smart cards, customers will be able to travel across different transport modes without changing to different types of paper tickets. Rather than contact cards or slot-based cards, smart cards allow travelers to place their cards in proximity to the readers, the so-called "touch-and-go" technology, and sometimes even keep them in their wallet or purse. This improves processing efficiency and convenience. By reducing the incidence of fare evasion, the use of smart cards also helps to increase social safety and speed up the journey by reducing ticket purchasing queues and shortening transaction times.

3.1.3 Revenue management initiative

We discuss a number of issues with respect to the current public transport operation in the Netherlands and introduce the revenue management initiative of the Netherlands Railways.[11]

Problems of the current operation. We identify several issues related to the current public transport operation. First, on the demand side, there are two major issues. (1) Inconvenience. Different types of tickets are being used for different types of transport systems in the Netherlands. For example, printed paper tickets are used for trains; a "strippen" card (involving stamps on a number of strips for the amount of journeys undertaken by a traveler) is used for metro, bus and tram; and cash is sometimes accepted for bus and tram services. For the travelers who use different transport systems, it is extremely inconvenient to switch between different transport modes using different types of ticket. This inconvenience is one of the reasons why some people avoid travelling by public transport. (2) Fare erosion. Fare dodgers, or people who travel without paying the fare, cause many problems across the transport networks. These problems include the possibility of aggressive behavior when they are confronted by conductors. They also threaten and cause danger to other travellers or service employees. This results in lost income for the service providers.

Second, on the supply side, there are three major issues. (1) Inefficient capital spending. The capital costs of each service provider, in terms of the number of vehicles purchased, is largely based on peak-hour travel demand. If transport vehicles are mainly used during peak hours and under-utilized for the rest of the day, the capacity utilization

[11] Netherlands Railways (Nederlandse Spoorwegen, or NS) operates 5,500 passenger trains on a network of 2,700 kilometers. It transports approximately 1.1 million passengers on an average workday. In 2006, almost nine million different passengers traveled about 15.8 billion passenger kilometers by train. On average, each Dutch citizen travels approximately 1,000 kilometers by train per year. NS transports the most passengers on a kilometer of railway line in Europe. The operating revenue is €1.5 billion per year. In 2006, its operating income was approximately €200 million (Kroon et al. 2009).

is undoubtedly low. This leads to inefficiency in capital spending. (2) Lack of customer information. Ticket and travel card sales data may indicate how many people use the transport in an aggregate level for a given period of time. Likewise, different travel surveys are used to understand the demographics of travelers (e.g., age, profession, travel purpose). However, information concerning who are the customers, what type of travel product they use, and when exactly they use them is outdated, inaccurate and even unknown to the service providers. (3) The high-frequency and short-distance nature of the railway service in the Netherlands makes the adoption of reservation system a challenging task. We compare the railway system, in particular high-speed-trains, and airline operations, and illustrate their major differences in Table 3-2.

Items	Airline	High-Speed-Train
Seat Reservation	Obligatory Limited Seats	Recommended but not necessary Number of passengers on the train is not dependent on number of seats, passengers may also stand
Checkpoint	Before boarding Closed access	Not applicable Open access
Ticket control	Centralized computer booking system Online control	Decentralized Offline control (limited by existing infrastructure) On board trains
Travel flexibility	Not flexible, with fixed travel plan Fixed passenger lists, e-ticket is possible and verified at given checkpoint.	Flexible, usually not limited to trains or trips, with options to break / interrupt journeys (depending upon tariff) No passenger list. No fixed exit points
Online booking and cancellation	E-ticket needs to be converted to boarding pass upon checking in After confirmed online booking, online cancellation or changes to travel plans not possible (without penalty)	Tickets are boarding passes, with or without reservations Online cancellation or modification is possible even after confirmed bookings

Table 3-2: Key differences between airlines and high-speed-trains

The revenue management initiative of the Netherlands Railways. This smart card adoption will allow service providers to employ more flexible tariff structures. The revenue management initiative of the Netherlands Railways is the first step in this direction. A senior manager whom we interviewed stated that "fare policy is the key to achieving the goals of railways, that is, to ensure financial targets are achieved; to manage demand and ensure the most effective use of transport resources and, from the perspective of government, to maximize the social benefits of public transport provision."

A series of issues must be addressed in determining an appropriate tariff structure and the range of ticket options. (1) Market segmentation. The current fare structure fails to adequately segment the available market between more and less elastic segments. Price structures should aim to differentiate between groups with different price elasticities. This means premium rates for peak period travel and lower prices at off-peak times, with the aim of generating revenue through stimulating additional trips. (2) Competition. The main competitors of the Netherlands Railways are privately-owned automobiles. The rail price elasticity is influenced by levels of car ownership and journey times on competing road corridors. (3) Regulation. Fares are currently regulated in a "basket type" arrangement. This means that it is practical to implement a package of changes that includes both raising and lowering certain "full" tariffs differentiated according to the time of day or day of week, while maintaining overall compliance. (4) Communication. If a revised fare structure is to be successfully implemented, it must be able to be easily communicated by those who offer it and readily understood by potential users. And the number of options must be limited. Otherwise, it might cause confusion and lower a consumer's willingness to pay. An effective advertising and communication strategy should be in place too.

3.2 Research Method 1 – Multiple Case Studies

We next move on to explain our choice of research methods. We employ a multiple case study (Benbasat et al. 1987, Yin 2002) as our first research method and study all large-scale smart card adoptions in the public transport industry between 1997-2006. Our choice of method is based on three reasons. First, the utilization of multiple cases allows for cross-case analysis, which can enhance the investigation of the proposed research model (Benbasat et al. 1987). Second, we focus on smart card adoption in the public transport industry, and thus control for industry, which eliminates variations related to the performance of different industries. Smart card adoption in other industry markets exhibits different performance levels, so controlling for industry focus is necessary. Third, studying the population in an industrial sector is useful given the relatively small numbers of selected service providers of this type.

3.2.1 Case selection

Smart card technology has been adopted all around the globe over the last decade for data collection in public transport. We use the directory of "List of Smart Cards" in Wikipedia to identify relevant cases.[12] The list proved to be comprehensive and accurate,

[12] List of Smart Card. http://en.wikipedia.org/wiki/List_of_smart_cards, last accessed on August 8, 2008.

because we also use alternative search methods (e.g., Google searches, industry magazine listings). We use five criteria to select our cases. First, we only include cases from North America, Asia, and Europe, which cover more than 90% of the world-wide implementation of smart cards. Second, the list we adopt is rather comprehensive and includes various types of smart card implementations. We only include cases where smart cards are used for public transport (usually through different modes of transport) and exclude cases where smart cards are used only for retail or identification purposes. Third, we choose cases where the smart card was introduced between 1997 and 2006. 1997 was when the first Octopus card was introduced in Hong Kong to the public. And we exclude cases where we did not have information on the time of introduction. Fourth, we are interested in the large-scale smart card implementation in public transport; however, technology adoption is an on-going process and it is difficult to obtain the total number of cards that are sold and in use. Thus, we use the population of the location as a proxy for the size of a given smart card implementation. We focus on locations with a population of more than four million. This guarantees more than 400,000 daily riders who use smart cards for public transport. The argument here is that in large metropolitan cities public transport is more important than in smaller cities where daily ridership is not so high. Fifth, for some cases there is more than one smart card used, so we eliminated the secondary card of the two. Although the directory listed 139 smart card cases worldwide, only 17 cases met our criteria: four cases in the US, ten cases in Asia and three cases in Europe (see Table 3-3 for a list of the selected cases).

Introduction	Place	Transportation Service Provider / Issuing Authority	Name of Smart Card
1997	Hong Kong	Octopus Cards Limited	Octopus
1999	Washington, D.C.	Washington Metropolitan Area Transit Authority	SmarTrip
1999	Shanghai	Shanghai Public Transportation Card Co.	Shanghai Public Transportation Card
2001	Singapore	EZ-Link Private Ltd	EZ-Link
2001	Tokyo	JR East and other 5 operators	Suica
2001	Guangzhou	Yang Cheng Tong Corporation	Yang Cheng Tong
2001	Moscow	Moscow Metro	Transport Card
2002	Taipei	Taipei Smart Card Corporation	EasyCard
2002	Chicago	Chicago Transit Authority	Chicago Card
2004	Bangkok	Bangkok Metro	Bangkok Metro Smart Card
2004	London	Transport for London	Oyster Card
2004	Seoul	Korea Smart Card Co. Ltd.	T-money
2004	Shenzhen	Shenzhen TransCard Corporation	Shenzhen TransCard
2005	Atlanta	Metropolitan Atlanta Rapid Transit Authority	Breeze Card
2006	Beijing	Beijing Municipal Administration and Communications Card Co.	Yikatong
2006	Boston	Massachusetts Bay Transportation Authority	Charlie Card
2006	The Netherlands	Trans Link Systems	OV-chipkaart

Table 3-3: Worldwide large-scale smart card technology adoption (selected cases)

3.2.2 Data collection

Data were collected from various data sources using different data collection methods with the objective of enabling triangulation (Eisenhardt 1989). The data collection was conducted in two phases. At the beginning, in order to establish a good understanding of smart card adoption and related revenue management and pricing decisions, we selected three representative cases and collected data through unstructured and semi-structured interviews, firm archival data, public report, and email exchanges. The three cases are: the Octopus card in Hong Kong, the Oyster card in London and the OV-chipkaart in the Netherlands. These were chosen for exploratory in-depth study for two reasons. First, we focused on cases that represent different stages of smart card adoption. Octopus was the first and most successful adoption in the world so far (Chau and Poon 2003). Oyster reached a high penetration rate within a relatively short period of time. OV-chipkaart will be the first nation-wide implementation, though it is still in its early phases of development. Second, these three cases also had large societal impacts and received widespread media attention. In total we conducted 16 interviews relating to these three cases (see Table 3-4). The interviewees were managers in strategy, pricing and revenue management, and business development in three geographically different locations. Each step of the research process is well documented, which enhances the reliability of our approach (Yin 2002).

Cases	# Respondents	Business Unit / Functions
Octopus	6	General Manager
		Marketing Department (department manager)
		Operations Department (department manager)
		Strategy Development Department (department manager)
Oyster	3	Pricing Department (researcher)
		Transport Research (consultants)
OV-chipkaart	7	Business Development Department (department manager)
		Tariff and Pricing (project manager)
		Marketing Research & Advice (senior project leader)
		Revenue Management (department manager)
		Independent Research Firms (independent consultants)

Table 3-4: Overview of interviewees

After gaining a clear picture of the value creation activities, in the second phase of the data collection process, we collected archival data for the remaining cases from various sources such as company websites, corporate brochures, newspapers and magazine reports. We reviewed relevant web pages from press releases that made reference to any of the 17 cases, and news articles relating to the service providers from LexisNexis Academic and some local news sources, such as the Boston Globe. Capturing data both from the firm as well as from external reports increases validity and reliability in our data collection process.

3.3 Research Method 2 – Stated Choice Experiments

We choose a stated choice experiment method as our second research method. In this section, we will first introduce this method and justify why it is appropriate for this study. Next, we will explain the experimental procedures we followed to collect data.

3.3.1 The stated choice experiment

A stated choice experiment, also called stated preference experiment, presents hypothetical choice situations to decision makers and asks them to state their preferences between different alternatives. Stated choice experiment involves a careful design of multiple experimental attributes and levels of each attribute (Louviere et al. 2000). Multiple alternatives (for combinations of attributes and their levels) are presented to decision-makers in a choice set. Decision-makers are asked to evaluate all of the alternatives and choose the most preferred one (McFadden 1986, Ben-Akiva et al. 2002, Erdem et al. 2005). This method is based on the premise that any product or service can be described by its characteristics or attributes, and that the extent to which a decision-maker values or expresses utility depends upon the nature and levels of these characteristics. Stated choice experiments have been used in a wide spectrum of research and industry domains such as marketing, transportation, and health economics (Bhat and Castelar 2002, Louviere et al. 2005, Viney et al. 2005).

Why is this method appropriate? First, this experimental method allows us to present consumers with purchase choices for travel products and services that are unavailable at the time of the study, so they can compare them with the existing offerings and with one another. Second, consistent with our proposed theory of informedness, in the stated choice experiment transport service consumers are fully informed of the different product offerings consisting of different product attributes and levels they can select from. They are able to decide what they want, evaluate the available choices well, and decide to pay what they think the service is truly worth. Third, to understand consumer preferences for different travel products, we also need to consider the relative benefits that consumers attach to various attributes of the products that are available to them at the time of purchase. Using this method, we are able to measure the unique effects of each of the attributes and their corresponding levels relative to the consumers' choice decisions. Last, the choice data collected through stated choice experiments allow us to assess the market responses to new products and services, and thus provide a basis for demand forecasting (Louviere et al. 2000).

3.3.2 Experimental procedure

We will explain our stated choice experiments in the following three phases: identification of determinant attributes and specification of attribute levels, the experimental design, and the presentation of the experiment.

Identification of determinant attributes and specification of attribute levels. We summarize our efforts in identifying the key determinant attributes in the following five steps. First, we interviewed several high-level executives and requested them to suggest attributes and levels of their new services. Second, we reviewed the academic and practitioner literature to find the market drivers for designing a new revenue management strategy. Third, we examined the existing service offerings and designed a framework that covers all of the market drivers. Fourth, we discussed this framework with two other industry executives and also with the executives we interviewed in the first step. This enabled us to refine the original list of attributes and levels. Finally, we further discussed the resulting list of attributes with two transport research experts and asked them to verify the findings.[13] The service attributes that we found to be of interest include: travel mode, price, travel time, the time window for travel, the percentage of refund options, and the availability of a reserved seat. Table 3-5 lists the final set of attributes and their levels.[14]

Experimental design. Once the attributes and levels were finalized, the number of choice sets and the number of alternatives in each choice set had to be specified. An *efficient choice design* was used to fill the choice sets, which leads to higher efficiency in parameter estimate, because a *full factorial design* will lead to 324 choice sets ($2 \times 3 \times 3 \times 3 \times 3 \times 2$) (Louviere 1991). Efficient choice designs satisfy four criteria. First, to obtain the estimates for the attributes independently, we need to maintain *design orthogonality*. Second, a *minimal overlap of attribute levels* is required, that is, as few equal attribute levels in a choice set as possible. Third, to achieve balance, each attribute level should appear with *equal frequency* across all the choice sets. Fourth, we need to make sure that *alternatives of similar preferences* occur in each choice to obtain a balanced reading on consumer utility.

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[13] The inter-rater reliability was near 100%. Discussions resolved any differences. Such procedures are necessary to avoid missing potentially important attributes and also to restrict the number of experimental factors from being too large.

[14] The descriptions of the attributes are disguised to protect private information.

Attribute	Definition	Levels
Travel Mode	Mode of travel	• New service • Current service
Price	Trip price (by current or new service)	• Level 1: High price • Level 2: Medium price • Level 3: Low price
Travel Time	Amount of in-vehicle travel time	• Level 1: Short travel time • Level 2: Medium travel time • Level 3: Long travel time
Time Window	Validity of travel times	• Level 1: Valid all day • Level 2: Invalid AM peak • Level 3: Invalid AM/PM peak
Refund	% refund if consumer cancels prepaid trip	• Level 1: High % refund • Level 2: Medium % refund • Level 3: Low % refund
Reservation	By SMS, mobile, at platform, and online	• Yes • No

Table 3-5: Attributes and levels of the stated choice experiment

Customers who travel with different frequencies are expected to have different acceptance levels for different travel services. In order to account for this difference, different travel service designs are targeted to different customer groups. Dividing customers into high, medium and low travel frequency groups, we designed three travel services to target these three groups. This led to three separate stated choice experiments: general pricing (for low and medium-frequency travelers), subscription pricing (for high-frequency travelers), and super-saver pricing (also for low and medium-frequency travelers). A sample choice set in a "general pricing" experiment is illustrated in Table 3-6.

In order to avoid order effects, three types of randomizations are used in the experimental design. First, choice design randomization is used. For each choice experiment, several efficient choice designs are generated and offered to each respondent in random order. This increases the variation in the total task, and leads to lower standard errors for the model estimates. Second is the randomization of choice sets for presentation to the respondents. So what is the first choice set for one respondent can be the last choice set for another respondent. This compensates for the potential loss of statistical accuracy due to fatigue effects that may occur in choice experiments that involve a large number of choice sets. Third is randomization of attributes. The attributes are offered in different orders to different respondents; however, they remain in the same order for the same respondent. This avoids overestimation of the attributes listed at the top of the choice set.

Travel Service Attributes	**You are traveling from *Amsterdam* to *Rotterdam* (Choice Set 5 out of 15 Sets)**		
Travel Mode	High-speed-train	High-speed-train	Current mode
Price	€4 higher than current price	€17 higher than current price	Current price
Travel Time	24 min faster than current travel time	30 min faster than current travel time	Current travel time
Time Window	Valid for entire day	Valid between 9am – 4pm and after 6pm	–
Refund	50% refund	90% refund	–
Reservation	No	Yes	–

Table 3-6: A sample choice set in a stated choice experiment

Presentation of experiment. An interactive computer-aided survey questionnaire was designed to collect data from the internet panel of a leading marketing research company. The survey consists of four parts. The first part consists of screening questions for selecting the relevant respondents. Respondents were considered appropriate to be included in the study if they considered using high-speed-train for the entire or part of a journey they made by car or train within the relevant catchment area. A "catchment area" is defined as the postal area where customers have potential travel time gains when traveling by high-speed-train compared to using their current mode. Students were excluded from the sample because they receive free travel passes from the government. Depending on their current travel frequency and current mode of transport, customers were divided into three groups: high-frequency customers, medium-frequency customers, and low-frequency customers. This segmentation was made to ensure a sufficient distribution of respondents across the different choice experiments to permit reliable estimation.

The second part of the survey consists of questions with regard to the respondents' travel behavior. These were different for train users and car users. Train users are asked to provide information on trip origin place, origin station, departure time (onward and return journey), access mode, access time, travel time, egress time, egress mode, destination station, destination place, door-to-door travel time, door-to-door distance, purpose, train class, subscription, and reimbursement options. These data were used to reconstruct the actual journey customers make and calculate the actual train costs per trip (using information on ticket and subscription tariffs from Netherlands Railways). Car users were asked to provide similar types of information for a hypothetical train trip that would replace the actual car trip. In addition, fuel type and vehicle weight were requested calculate the actual car cost per trip.

The third part of the survey includes three choice experiments. The choice experiment “general pricing” is a revenue management strategy targeted to low and medium frequency customers. The choice experiment “subscription pricing” is used to evaluate the behavioral responses from the high-frequency customers. And the experiment “super-saver” is designed to assess the response from low and medium-frequency customers. To reduce the survey length and minimize the boredom, irritation and fatigue that may arise during the choice experiments, respondents are asked to work on two of the three experiments, depending on their travel frequency. In each experiment, the tasks consist of 15, 12 and 6 choice sets, respectively. Each choice task was preceded by instructions on the task. Furthermore, extra information on the attributes and levels could be obtained through “pop-up” textboxes in each choice set.

The fourth part of the survey centered on the acquisition of demographic information (age, gender, educational level, household composition, car ownership, employment status).

The experiment is real and dynamic. It is real because we asked a consumer to evaluate a specific trip that he most frequently travels between an origin-destination city-pair and with a specific travel product, being either his current choice or a new service offering. It is dynamic because, based on the consumer’s earlier answer on his current travel behavior, we designed individualized experiment that has the actual origin-destination city-pair, and the associated actual price and travel time. For example in Table 3-6, the city-pair Amsterdam-Rotterdam is given by this consumer as the most frequently traveled origin-destination; we then calculated the associated price and travel time and presented it to this particular consumer.

We pre-tested the questionnaire with 20 randomly selected employees in the high-speed-train organization to ensure the validity of the questionnaire. Average task completion time was approximately 20 minutes and respondents did not indicate difficulty in task comprehension. Further discussion resolved any differences. Next we selected 100 customers from the panel to participate in another check for comprehension related to the choice task. We analyzed the testing data and found that the signs were correct.

3.4 Research Method 3 – Computational Simulation

We choose to use simulation as our third research method. We design and develop a computational simulation - *Behavioral Revenue Management Simulation* - that leverages activity-based demand theory to model consumer travel behavior and evaluate performance impacts of service attribute bundles. In this section we will discuss the reasons why we use the simulation method and explain the design of the simulation.

3.4.1 Simulation preliminaries

The reasons to use the simulation method are threefold. First, a limitation of using an experimental approach is that the impacts on customer loading, and hence the capacity utilization of the transport networks, remain largely unknown. Evaluating these impacts requires not only demand information but also supply information, and the interaction between these two. Second, using simulation is necessary. Determining the composition of a large number of consumer behavior choices may be possible, but the understanding of their impacts on capacity management on large transport networks for the present case is beyond the scope of the usually-available computational abilities. Transport networks, particularly in metropolitan cities or more so on a country-wide scale, are complex systems that often involve several thousand passenger vehicles and millions of passenger journeys. Third, we can also simulate a larger number of price changes, which is impossible in a field experiment. For similar reasons, Shmanske (1993) also used simulation to study efficiency improvement from discriminatory tolls on the San Francisco Bridge.

The simulation uses a highly modular approach in which the sub-modules can be added, altered, or replaced without affecting the other components of the system. The simulation consists of two main components: demand simulation and supply simulation. The demand simulation is based on the activity and travel demand theory (Ben-Akiva and Lerman 1985). Each customer (population generation module) has his own daily activity plan. The customer constructs an activity-schedule (activity schedule construction module) that consists of a list of activities and journeys between these activities (if necessary), with timing and location information. These journeys together with the appropriate travel services are selected (journey selection and product selection module) from a number of possible journeys (journey planning module). The customer must then execute this activity-schedule (schedule execution module). At the same time, a supply simulation simulates the scheduled operation according to the timetable of each carrier (e.g., bus, train, metro) in a given public transport network. We illustrate the simulation and its different modules in Figure 3-2.

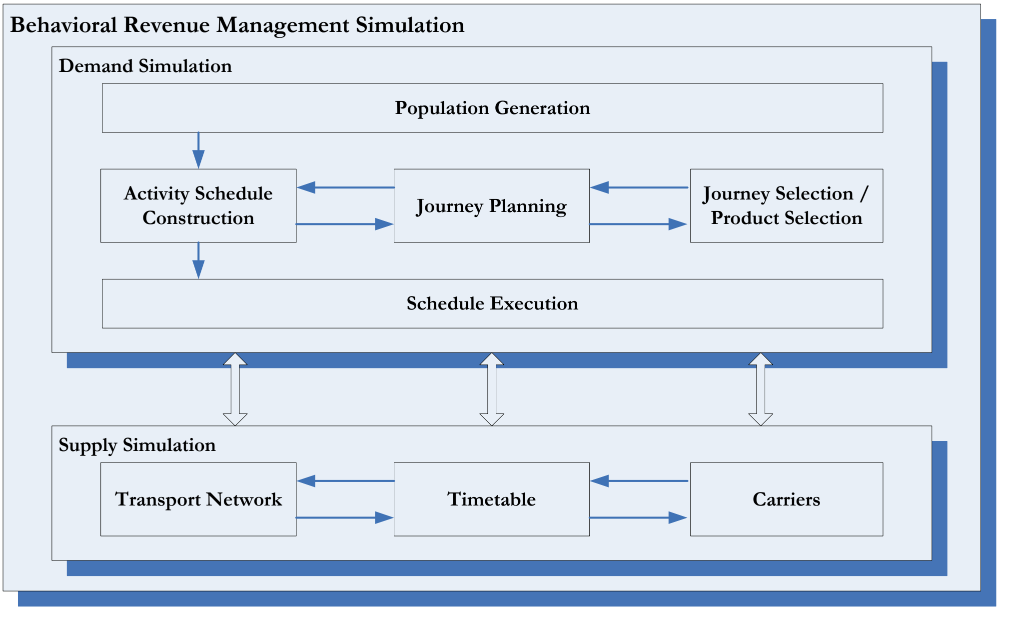

Figure 3-2: Framework of behavioral revenue management simulation

3.4.2 Assumptions and simulation models

Next we introduce the simulation modules and explain our assumptions.

Population generation. A person, as an agent, is created with a set of demographic characteristics, such as home location, age, gender, and education. He also has the possibility of working for an employer, which has a name and an office location. We use standard geographic coordinates – latitude and longitude – to define locations.

Activity schedule construction. Activity and travel demand theory suggests that travel demand is derived from demand for conducting activities at specific times and locations. Thus we assume a person plans his travels based on his activity plan. An *activity* describes what a person wants to do, when and where he wants to be during the day. There are various activity-related decisions. *Activity type choice* deals with questions such as "Should I go shopping?" *Activity sequence choice* determines in what order activities are executed during the day. For example "Should I go shopping before I go visiting friends?" *Activity location decision* answers questions regarding where the activities take place. The activities can be frequent activities such as staying at home and going to work. Sometimes they can also be infrequent activities such as "Shall I spend the weekend in Amsterdam or New York?" *Activity timing choice* is also important, determining when an activity starts, how much time to allocate to it, and what time it should finish. It is clear that activity-related choices are complex and each of them can be modeled using separate decision modules. Nevertheless, we assume that the information in regard to the activity type, sequence, location, and timing are known to each person.

Each person has a 24-hour *activity plan* that consists of a number of activities that they would like to conduct. Each activity consists of five properties: (1) activity type such as get up, work, and go shopping; (2) activity location; (3) activity timing including start time and end time; and (4) activity timing tolerance, which indicates how much variation in time a person could allow for a given activity. From this activity plan, a person could construct his *daily plan*, which includes both activities and the associated journeys. A *journey* describes how a person moves from one activity to another including transport mode, origin-destination, departure time, and arrival time. Starting from an empty daily plan, activities are added according to their start time and tolerance. If the adjacent two activities are not in the same location, this person will plan a journey to reach the location of the next activity. A routine is also designed to check for time overlaps. For example, if a journey cannot finish before the start time of the next activity, either the adjacent activities or the journey is shifted in time.

Journey planning. If a journey is required between two activities, the person will start the journey planning module. This is a process of searching for a set of alternative journeys between the given origin-destination city-pairs and within the start and end time of these two activities. As a result of this process, a set of possible journeys is generated. These journeys may vary in cost, departure time, arrival time, transport mode, and service class.

Journey selection. Among these alternative journeys, we assume a person will choose the journey that permits him to arrive at the destination the earliest. This is because the value of travel time savings is the most important factor for transport consumers. It refers to the monetary value that is attached to the possibility to save a determined amount of time. The argument here is that the time saved can be reallocated to other activities. We used a modified version of Dijkstra's algorithm to obtain the journey with the earliest arrival time.[15] As a result of this process, a journey with a specific route, departure and arrival time and travel mode is selected.

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[15] Dijkstra's algorithm (Ahuja et al. 1993) is a graph search algorithm that solves the single-source shortest path problem for a graph with non negative edge path costs, outputting a shortest path tree. For a given source node in the graph, the algorithm finds the path with the shortest path between that node and every other node. Instead of searching for the shortest path, our implementation uses arrival time as the weight of each link (rather than distance) and identifies the journey with the earliest arrival time given by the timetable information. Further, we also include the available transportation mode to determine the minimal arrival time and the order of the carriers that are used by each traveler.

Product selection. We assume a person is presented with a number of alternative fare products for the chosen journey. These fare products can be described as a number of attributes such as price, time validity restriction, usage restriction, and travel class. We adopt the discrete choice model (McFadden 1986) to model this product selection process. It describes how a person makes a choice from a set of mutually exclusive and collectively exhaustive alternatives that are available to him. This person calculates the utility of each alternative as a function of the observed service attributes, and the unobserved random element. This randomness could be caused by unobserved attributes, unobserved taste variations, measurement errors and imperfect information, and instrumental variables (Manski 1977). The theory of random utility suggests that the person will have higher probability to choose the fare product that has the greatest utility among all available alternatives. Figure 3-3 illustrates the journey planning, journey selection, and product selection process in an activity diagram.

Schedule execution. Until now, for each required journey between activities, a person has to choose the journey with the earliest arrival time, and selects the fare product with the greatest utility. This process iterates until the daily plan is fully constructed. A person then executes his daily plan: conducts an activity in one location, makes a journey by traveling to another location for the next activity, and so on.

Supply simulation. Making a journey, a person will board on the chosen scheduled carrier. The supply simulation consists of transport networks, carriers and a timetable. There are three types of elements in transport networks: nodes, links, and routes. *Nodes* represent positional entities or places, such as road junctions, stops and stations. *Links* are physical entities connecting nodes. Links include railway tracks or highways. *Routes* refer to services between an origin-destination city-pair provided by service providers. Carriers can be trains, metros, trams, and buses. Each carrier has a number of attributes: the number of wagons, class levels, and most importantly, number of seats as a measure of its capacity. A carrier offers scheduled transportation services according to timetable information.

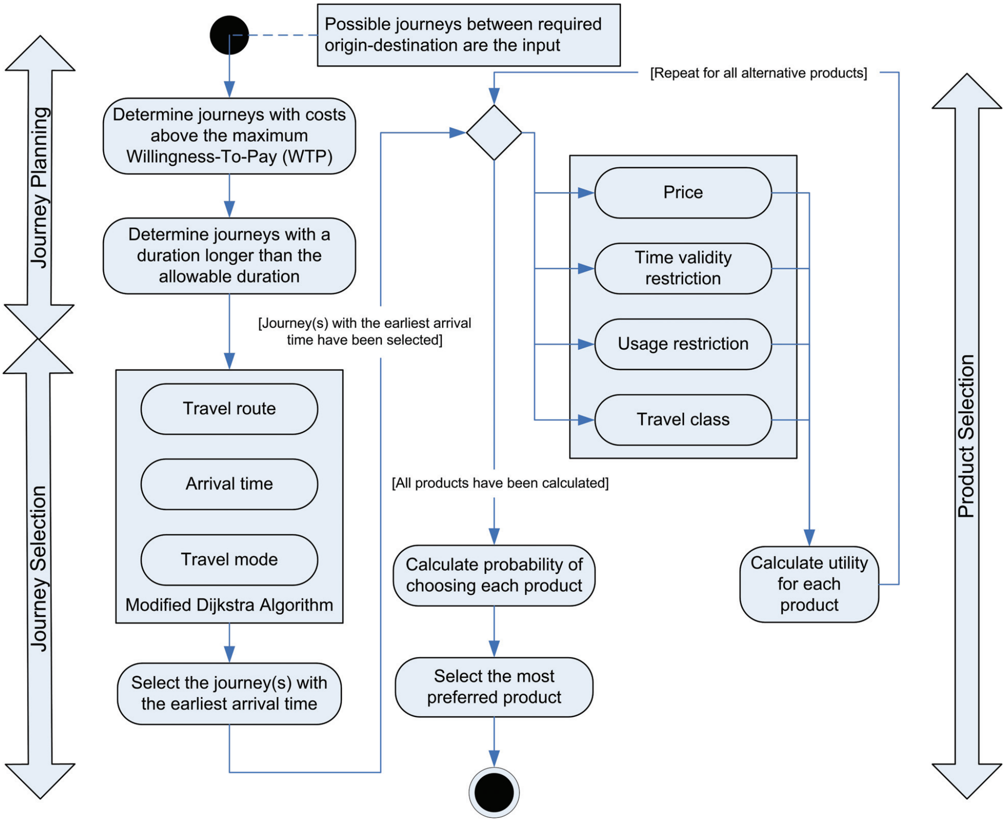

Figure 3-3: An activity diagram of journey planning, journey selection, and product selection

Behavioral Revenue Management System. Once the simulation modules are verified and validated, we can further extend and integrate the simulation into a decision support system – *Behavioral Revenue Management System*. The potential users are business development, strategy, and revenue and pricing managers who make travel product and pricing decisions, and also those who need to forecast the performance impacts of their policies. Working closely with these managers, we found three areas that deserve attention: input, visualization, and output. Next we present a brief discussion of these three aspects and illustrate a mockup of the proposed system in Figure 3-4.

Input. Decision makers should be able to identify the right type of pricing strategies as inputs for the simulation. We surveyed a number of pricing managers and found a variety of pricing strategies being considered. These pricing strategies can be broadly categorized into two groups: customer-based pricing and journey-based pricing. Customer-based pricing occurs when the provider divides customers into groups based on some identifiable characteristics (e.g., age, profession) and then sets a separate price for each group. Journey-based pricing uses journey attributes (departure time, travel route) to discriminate indirectly among numerous customer segments. In this case, journey attributes are used as proxies for customer characteristics. A number of pricing strategies are shown on the left hand side of Figure 3-4. Decision makers can create new strategies, edit existing ones and remove the unwanted ones.

Visualization. Through our interviews we learned that, to implement a decision support system of this kind, give performance indicators alone are not sufficient. This is because decision makers have less confidence in results that come out of a "black-box." They find it useful to have a visualization of transport networks that allows them to zoom in and out to examine the effects on different levels: the network level, the carrier level, and the customer level. We illustrate this multi-level network perspective in the middle section of Figure 3-4. The colors indicate a pre-specified performance indicator, for example, the percentage of passenger loading. And the lines are links in a pre-specified transport network.

Output. We developed a set of key performance indicators on demand, revenue, and capacity to measure performance impacts. (1) Demand. Key performance indicators for passenger demand are: *total passenger trips* and *total passenger kilometers*. *Total passenger trips* are the total number of trips passengers make in a given time interval in a transport network. The more customers travel, the higher will be for the total number of kilometers they generate across the network, under the premise that a customer travels between a pre-defined origin-destination city-pair. *Total passenger kilometers* is calculated by summing up the total distances in kilometers for all passengers who travel in a day. (2) Revenue. We measured service revenue using two indicators: *total revenue* and *average revenue per train*, which is calculated by dividing the total revenue by the number of trains in a daily operation. The pricing scenario that results in higher revenue does not always translate to higher capacity utilization. This is because a service attribute bundle that has a higher price will be less attractive to some consumers. This will lead to a lower purchase rate and less travel, even though the total revenue might be higher due to the price increase. (3) Capacity. Capacity utilization is also an important factor in examining the performance impacts of pricing scenarios. Different passenger load factor levels translate into different levels of capacity utilization; a higher load factor implies higher capacity utilization and vice-versa. It is measured by *average load per train,* which is calculated by dividing the average number of passengers on board by the total number of seats.

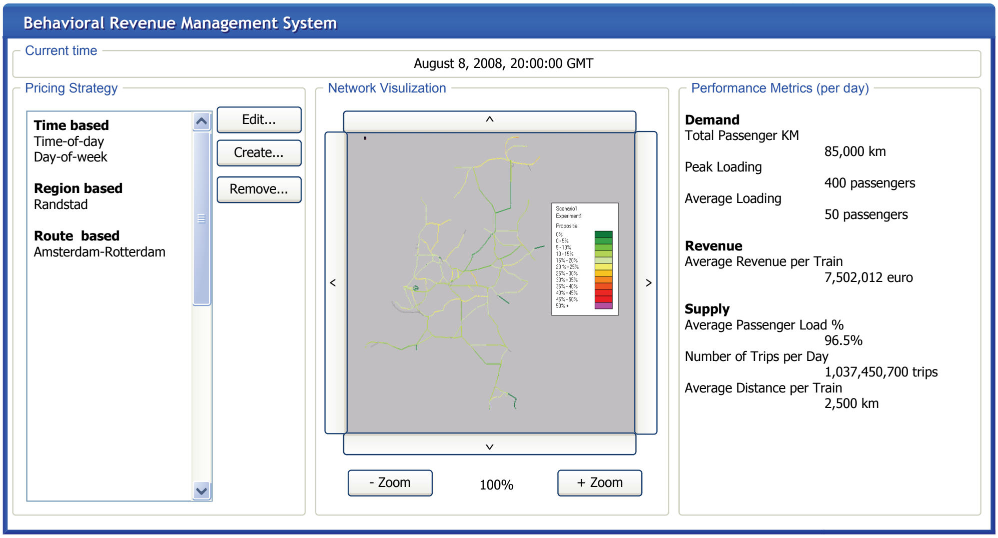

Figure 3-4: A mockup-of a behavioral revenue management system

3.5 Summary

This chapter has discussed three research methods. First, we introduced a multiple case study method that we used to explain why increased firm informedness has improved revenue management capability. Second, we introduced a stated choice experiment to investigate how to characterize consumer responses toward revenue management. Third, we introduced a computational simulation to assess the performance of impacts of service attribute bundles when consumer behavioral responses are considered. The following three empirical chapters address our three research questions more fully.

Chapter 4 Firm Informedness and Value Creation Strategy

4.1 Introduction

Using mobile ticketing technologies enabled by smart cards and mobile devices, firms are better informed and can learn customer behavior with far more precision. From both IT and information perspective, this chapter[16] explains why mobile ticketing technologies can successfully enable revenue management strategies, and empirically examines how firms can use their information capabilities to create value. We explore the following research questions: What is the business value of mobile ticketing technology? Why and how does the improved IT and customer information advance firms' revenue management? And consequently what are the impacts on the firm performance?

Using the process-oriented view, we argue that firms that use smart cards and mobile technologies will create a higher-order process capability (i.e., value creation strategy), which then leads to performance gains for them. In particular, we suggest that the use of mobile ticketing technologies enables firms to benefit from revenue management. We employ a multiple case study approach (Eisenhardt 1989) and test our arguments through a study of 17 cases in which mobile ticketing technologies were implemented over the last decade. The results provide evidence that firms using detailed customer behavior information are able to use very advanced price differentiation and service expansion strategies. And these firms are also most likely to achieve higher performance. These results contribute to the ongoing discourse on IT and firm performance in the IS literature (Devaraj and Kohli 2003, Zhu and Kraemer 2005).

The remainder of this chapter is organized as follows. First, we introduce our main theoretical perspectives. Next, we explain our research model and develop the propositions. And then we introduce our research methodology and construct measurement. Subsequently, we present the analysis and results. And finally we conclude with a discussion and directions for future research.

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[16] This chapter is based on Li, T., van Heck, E., and Vervest, P. 2008. Information Capability and Value Creation Strategy: Advancing Revenue Management Through The Use of Mobile Ticketing Technology. *European Journal of Information Systems* (forthcoming).

4.2 The Process-Oriented View

The process-oriented view and resource-based theory help us identify a basis for formulating our research model and propositions.

The business value of IT has long been a subject for research and intensive debate (Brynjolfsson and Hitt 1996, Dewan and Kraemer 2000). Using production theory, previous research has demonstrated the payoffs of IT investment at the firm level (Brynjolfsson and Hitt 1996, Gurbaxani et al. 2000, Duliba et al. 2001), the industry level (Devaraj and Kohli 2003), and the economy level (Dewan and Kraemer 2000). Recent IS studies have reframed the discussion, from the direct performance impact of IT investment (Brynjolfsson and Hitt 1996, Hitt and Brynjolfsson 1996) to how and why IT shapes the higher-order process capabilities that create performance gains for firms (Barua et al. 2004). Using the process-oriented view, this stream of literature focuses on the usage and value creation of IT innovations (Zhu and Kraemer 2005). The *process-oriented view* suggests that firm level impact of IT can only be measured through its intermediate process contributions (Barua et al. 2004). The argument here is that IT is deployed in support of specific activities and purposes, and therefore, the impact of IT should be assessed at the place where the first-order effects are expected to be realized.

Focusing on post-adoption activities, Zhu and Kraemer (2005) identify the key antecedents of e-business use and value and demonstrate how these factors differ across different economic environments in the retail industry. In another research that investigates the impact of IT capability on supply chain performance, Bank et al. (2006) use the process-oriented view to examine how the integrated IT infrastructures enable firms to develop supply chain integration capability, which encompasses information flow integration, physical flow integration, and financial flow integration. The study finds out that through these three intermediate process integrations, IT infrastructure creates higher supply chain integration capability, and furthermore results in significant and sustained firm performance gains both in operational excellence and revenue growth.

This approach is also consistent with a second stream of research that takes a contingency approach, suggesting that the need is to consider other variables that may mediate or moderate firm performance. Firms first focus on their business strategies and then allocate IT resources to support their core competencies. IT is viewed as an enabler of specific strategies designed to achieve superior performance (Fairbank et al. 2006).

Strongly based on the strategic management literature, the resource-based view of the firm posits that firms compete on the basis of unique corporate resources that are valuable, rare, difficult to imitate, and non-substitutable by other resources. In the IS literature, the resource-based view has been used to analyze IT capabilities and to explain how IT business value resides more in the organization's skills to leverage IT in the key activities in a firm's value chain (Bharadwaj 2000). The greater the use, the more likely the firm is to develop unique capabilities, and the higher value the firm is going to create from its core IT infrastructure (Bharadwaj 2000, Zhu and Kraemer 2005). According to Zhu and Kraemer (2005), the resource-based theory provides a theoretical basis for linking IT use and value creation.

4.3 Research Model and Propositions

4.3.1 Research model

Using the process-oriented view and the resource-based theory, we now develop a research model to explore the use and value of mobile ticketing technology in developing revenue management strategies. We present our research model (see Figure 4-1) and then explain the key elements of the model and propose two propositions.

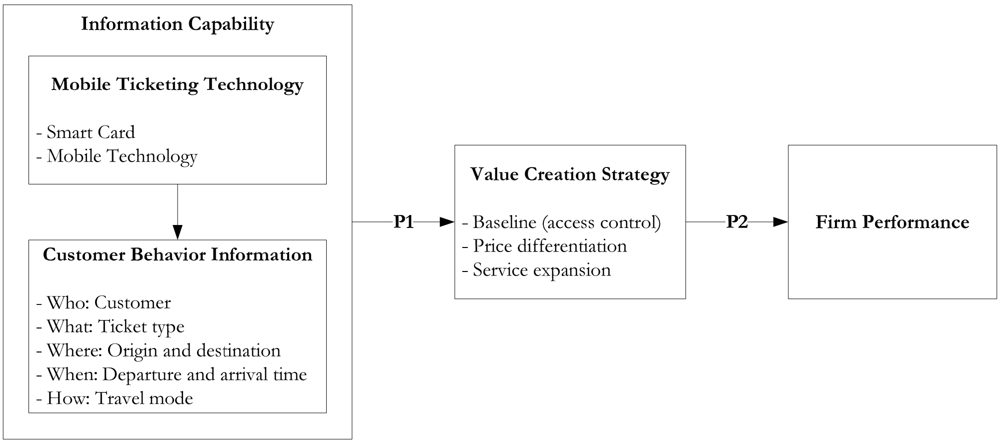

Figure 4-1: Information capability, value creation strategy, and firm performance

Information capability. We define *information capability* as a firm's ability to capture the complete customer behavior information. In our research context, customer behavior information refers to the customer (who), the ticket type (what), the origin and destination (where), the departure and arrival time (when), and the travel mode (how). This is measured by the ability of the IT to capture the dimensions and attributes of customer behavior information that becomes available.

Mobile ticketing refers to the process whereby customers order, pay for, obtain, and validate tickets using mobile devices (including RFID[17] or NFC[18]) or contactless technologies such as smart cards. In the public transport industry today, four types of technologies are commonly used: paper tickets, magnetic cards, smart cards, and mobile phones. Paper tickets are the most basic form and are used by a large number of public transport operators (PTOs). Dating back to 1960, magnetic cards, together with electronic gates, were introduced to the transportation systems to provide customer access control. Since 1997 smart cards have become increasingly popular and are gradually replacing magnetic cards. When a customer uses a smart card, either to make a trip or to purchase a travel service, the service details are captured and linked to the card. If the customer has registered the card under his name, all product and trip details will be added to this individual customer's record. Mobile technology is being adopted at an accelerated rate. For example, Tokyo's "Mobile SUICA" (www.jreast.co.jp/suica/), which includes a RFID chip, is embedded into *i*-mode FeliCa's mobile handsets. The device was introduced in January 2006 in Tokyo and gained more than 20,000 subscribers within a week.

Rather than IT itself, information has been argued to be the source of competitive advantage for firms. Despite a considerable number of theoretical and empirical works on the role of IT in creating competitive advantage, the literature has identified a consistent lack of success by firms in achieving business value through their IT investments, and in particular the difficulties in obtaining a sustained competitive advantage (Earl 1989, Clemons and Row 1991, Powell and Dent-Micallef 1997). The notion that IT per se does not generate sustainable performance advantage has received increasing support in the IS literature (Earl 1989, Clemons et al. 1993). The "strategic necessity hypothesis" (Clemons et al. 1993) argues that firms cannot expect IT to produce sustainable advantage because most ITs are readily available to all firms – competitors, buyers, suppliers, and potential new entrants – in competitive markets. IT, hence, becomes a "strategic necessity" but not a source of competitive advantage. The exception is when firms use ITs to leverage or exploit firm specific intangibles (Powell and Dent-Micallef 1997) to obtain sustained profits.

Yet despite the success in industries such as airlines and car rentals, the public transport industry faces difficulties in fully taking advantage of revenue management. The reasons are twofold. First, PTOs have limited information about their customers' actual

[17] RFID: Radio Frequency Identification, it is an automatic identification method. RFID is used in many transportation payment systems.

[18] NFC: Near Field Communication, it is a short-range high-frequency wireless communication technology. NFC is primarily aimed at usage in mobile phones.

travel behavior. Operations of public transport are largely based on an open-access system, which limits PTOs' ability to obtain customers' information. In this situation, PTOs mainly depend on in-vehicle counting and periodic survey to obtain customer behavior information. However, these methods are usually expensive, labor-intensive, and time-consuming, and hence, customer travel information largely remains outdated, inaccurate or even unknown. Second, partially due to the limited information, PTOs have limited ability to predict the variable demand. As opposed to airlines, PTOs do not have reservation systems that allow them to predict customer arrivals. Thus, they are challenged in estimating the demand variations of their heterogeneous customers. A senior manager whom we interviewed stated that "it is difficult to implement a profitable operating environment where our entire business strategy is based on an 'open access' system for flexible traveling, and revenue management is nearly *impossible* for us."

This situation has started to change with the increased implementation of mobile ticketing technologies in the public transport industry in the past decade. With advanced ITs, PTOs are able to learn about their customers' travel behavior in regard to the location to and from which they travel, what time they travel, how frequently they travel, and what ticket they purchase, in (nearly) real-time. This permits the PTOs to explore the possibilities of developing revenue management strategies that were not possible earlier.

Value creation strategy. According to Porter (1996), a firm's *value creation strategy* is defined as a set of value creation activities it carries out in order to create and deliver value. We distinguish three value creation strategies that PTOs use: baseline strategy, price differentiation strategy, and service expansion strategy. This distinction is consistent with the two broad strategy categories that are discussed in the strategy literature (Porter 1980): low cost leadership, which is our baseline strategy, and differentiation, which is price differentiation or service expansion strategy.

Baseline strategy refers to basic value creation, which is the reason why PTOs implement mobile ticketing systems in the first place. Fare fraud is very costly for PTOs, for example, it has been estimated to cost Metropolitan Atlanta Rapid Transit Authority an estimated $10 million per year. The primary reason for most PTOs to adopt mobile ticketing is to control customer access, prevent fare evasion, and reduce fraud. Of course mobile ticketing also provides ease of use for customers, improves passenger flows, reduces ticket purchasing queues, and reduces PTOs' operating costs through accelerating ticket purchase and reducing clerical work.

Differentiation strategy includes price differentiation and service differentiation. Porter (1980) argues that differentiation strategy is an effective approach to create and sustain a firm's competitive advantage. Service providers that use differentiation strategy are able to provide products and services that customers perceive to be unique (Soh et al.

2006). An example familiar to most is airline ticketing. Airlines dynamically vary ticket prices and associated conditions based on real-time demand and available capacity at any given departure time.

Service expansion strategy is also rooted in the strategy literature. It resembles the concept of virtual value chain orchestration as discussed by Hinterhuber (2002). Service expansion strategy is a way to create and capture value by structuring, coordinating, and integrating the activities of previously separate markets. By relating these activities effectively to in-house operations, firms are able to develop a network of activities that create new markets. Service expansion is useful in this context because electronic ticketing systems can provide micro-payment infrastructures that permit other service providers to adopt them. As a result of this, service providers can increase their transactional efficiencies and expand their services quickly into other industry sectors.

Firm performance. Using mobile ticketing for value creation leads to the changes in PTOs' cost structure, revenue, and customer volume. What is even more important is the reputation that PTOs create. Given PTOs' social responsibility and public pressure through governmental regulation, PTOs who fail to justify the impacts of pricing strategies will receive heavy criticism from the public and politicians (Li and Wong 1994, Link 2004). Customers may express objections to crowding, unfairness and fare complexity. Consequently, this will lead to changes in customers' willingness-to-pay. Customers may even shift to other transport modes. For example, in December 2002, Deutsche Bahn (DB), using revenue management strategy, launched a program to reform its fare structure, focusing on the long-distance passenger market (Link 2004). Within half a year after the introduction the program failed. This failure, in part, was caused by low acceptance and widespread criticism of the new pricing structure. In the words of DB customers: "the price change is opaque and unfriendly", "the new price scheme is confusing", "the whole fare structure is in need of simplification to make it readily comprehensible and usable by staff and passengers".

4.3.2 Information capability and value creation strategy

Information processing in organizations is generally defined as the gathering of data, the transformation of data into information, and the communication and storage of information in the organization (Egelhoff 1982). The conceptual underpinning of information processing theory is to enhance the capability to handle information flow and thereby reduce uncertainty. Previous research suggests that the most effective organizational strategies are those that recognize an appropriate fit between an organization's ability to handle information and the amount and type of information that is available or required (Tushman and Nadler 1978, Egelhoff 1982). Mobile ticketing technology provides PTOs with detailed customer behavior information that was only partially attainable through traditional travel surveys. Using this information, PTOs can derive the cost that customers are willing to pay in different market segments. In contrast to time-consuming surveys, mobile ticketing technology gives almost instantaneous consumer feedback. The improvement in information quantity and information quality significantly reduces demand uncertainty. The information processing notion of the firms allows us to hypothesize a relationship between a firm's information capability and its choice of appropriate value creation strategy. PTOs, who recognize the opportunities that the improved information capability provides, will align their activities to create value. Thus, we propose the first proposition as follows (P1):

> **Proposition 1 (The Information Capability and Value Creation Strategy Proposition):** *Firms with a higher information capability are more likely to use an advanced value creation strategy (i.e. price differentiation or service expansion) than firms with a lower information capability.*

4.3.3 Value creation strategy and firm performance

Quantifiable results from revenue management are found in both management practice (Cross 1997). Revenue management success stories are encouraging. American Airlines had an estimated benefit of $1.4 billion over a period of three years and an annual revenue contribution of over $500 million (Smith et al. 1992). National Car Rental improved revenue by $56 million in the first year after a successful implementation of a revenue management system (Geraghty and Johnson 1997).

Grounded in the economics literature, price differentiation is the most important revenue management technique. It can date back to the concept of price discrimination (Pigou 1932). Price differentiation refers to any pricing policy under which a seller sets different prices on various units of the same or a similar product. It extracts a higher price from existing customers while extending sales to new customers who would otherwise not be served with uniform pricing. Economic theory indicates that price differentiation is inherently good for the profitability of the firm, because it allows the firm to capture a larger share of the consumer surplus. The economics of revenue management suggests that the more prices are differentiated by a firm the more revenue will be generated (Talluri and van Ryzin 2004b). Thus, we propose our second proposition as follows (P2):

> **Proposition 2 (The Value Creation Strategy and Firm Performance Proposition)***: Firms that use a more advanced value creation strategy (i.e. price differentiation and service expansion) will outperform firms that use a baseline strategy.*

4.4 Constructs and Measurements

We use a multiple case study method to examine these two propositions. We have introduced our case selection and data collection in Chapter 3. We now turn our effort to define the constructs and measurements that we use to operationalize our research model. Table 4-1 summarizes the description of and coding for each construct.

Information capability. As discussed earlier, the four types of technology commonly used in public transport are paper tickets, magnetic cards, smart cards and mobile technologies. First, we analyzed these four types of mobile ticketing technologies in terms of product characteristics, process characteristics, and usability. Second, on the spectrum of customer behaviour information, we analyzed the data attributes that could be obtained from each mobile ticketing technology. Depending on the unique characteristics of the type of technology and the number of data attributes that it captures, we distinguished between high and low levels of information capability. Ten PTOs had high information capability whereas seven PTOs had relatively low information capability.

Value creation strategy. PTOs or issuing authorities of smart cards pursue either a baseline strategy (access control/fare collection) or a differentiation strategy (i.e., revenue management strategy and service expansion). We examined the purpose of smart card implementation for each case and determined the construct of value creation strategy.

We identified a case as a baseline case if the PTOs or issuing authorities use smart cards primarily for access control, providing convenience to customers, and reducing operational costs, but not for pricing-related strategies.

We identified the degree of use of price differentiation strategy using the total number of pricing schemes that PTOs employ as a proxy. Price differentiation is very challenging to measure because nearly all PTOs use some form of differentiated pricing. Thus, it is difficult to determine to what extent a PTO uses price differentiation. Based on the price discrimination literature (Pigou 1932, Png 1999), we developed a taxonomy to characterize the pricing practices in the public transport industry. According to this taxonomy, we coded each pricing scheme that each PTO uses, and then computed a differentiation score by summing the value of each pricing scheme that we evaluated. If a PTO actively uses more than four types of pricing, we coded the case as actively exercising price differentiation.

We identified service expansion strategy through the use of smart cards for multiple purposes, such as retail, library, and identification, rather than only for transportation purposes (including highway toll gates, parking and ferries). We found that six PTOs use baseline strategy, six PTOs use price differentiation, and five PTOs use service expansion.

Firm performance. We developed three qualitative indicators of firm performance based on the revenue management and transportation literature (Talluri and van Ryzin 2004b). These indicators are growth in revenue and customer volume (Weatherford and Bodily 1992), reputation (Soh et al. 2006), and longevity (Soh et al. 2006). We calculated ordinal measures for each performance construct between 1997 and 2006, and we constructed a performance index from the sum of these measures. *Growth in revenue and passenger volume* measures how much new revenue and how many new customers have been attracted. *Reputation* is computed based on the positive or negative information stated in the press articles of the PTOs that we studied. Because PTOs have strong public roles, they cannot simply focus on revenue maximization. They need to satisfy customers and politicians. Given the same increase in revenue and customer volume, a firm with a better reputation can be considered to be more successful than the ones with worse reputations. *Longevity* is computed from the number of years since the introduction of smart cards as stated on the service providers' website. This measure is consistent with Soh et al. (2006). We computed an overall performance index for each PTO by summing the variables of the three dimensions. The indices show a fair degree of variance from 0 to 6. Eight PTOs have a score between 0 and 3, and seven PTOs have a score between 4 and 6.

Construct	**Definition**	**Measurement**
Information Capability	A firm's ability to capture the complete behavior information in regard to what, where, when, how and whom of their customers.	0 – Low: If less sophisticated information technology is being used and limited customer behavior information is captured in real-time 1 – High: If more sophisticated information technology is being used and (nearly) complete customer behavior information of actual travel is captured in real-time
Mobile Ticketing Technology	The sophistication of the mobile ticketing technology that is being used, which is measured as the unique characteristics of each technology.	Product - Usage mechanism (1 – Contactless; 0 – Contact) - Memory (1 – High; 0 – Low) - Durability (1 – Durable; 0 – Low, easily damaged) - Data security (1 – High; 0 – Low) Process - Acquisition (1 – Internet; 0 – Ticket office) - Transaction (1 – Can be viewed; 0 – Cannot be viewed) - Replenishment (1 – Can be reloaded; 0 – Cannot be reloaded) Usability - Convenience (1 – High; 0 – Low) - Speed (1 – Fast; 0 – Slow) - Personalization (1 – Yes; 0 – No)
Customer Behavior Information	The completeness of the customer information of actual travel.	Number of data attributes that are captured by each mobile ticketing technology: for example, the location to and from which the customer travel, frequency of travel, etc.
Value Creation Strategy	Value creation strategy that is used by the service provider.	0 – Baseline: Smart cards are primarily used for access control, fare collection and providing speedy and convenient services 1 – Price differentiation: If there are more than four types of pricing schemes used 2 – Service expansion: Besides public transport (including highway toll gates, parking, ferry), smart cards are also widely used for retail, library, identification, and other purposes
Price Differentiation	Price differentiation that the service provider uses.	Number of pricing schemes offered to the customers, minimum 0 and maximum 8. - Uniform pricing - Profile-based pricing - Usage-based pricing - Distance-based pricing - Time-based pricing - Route-based pricing - Origin-Destination-based pricing - Mode-based pricing

Firm Performance	The performance impact of the service provider, in terms of revenue / customer volume growth, reputation, and longevity.	Sum of coded values for revenue growth / operational excellence, reputation and longevity: - Minimum of 0 - Maximum of 6
Revenue / Customer Volume	The increase in revenue and/or customer volume of the service provider.	0 – reduced 1 – no change 2 – improved
Reputation	The reputation among customers, politicians and general public.	0 – negative 1 – neutral 2 – positive
Longevity	Number of years since the adoption of smart cards of the service provider.	0 – 0-2 years 1 – 3-5 years 2 – 6 years or above

Table 4-1: Construct, definition, and measurement

Table 4-2 summarizes the frequency distribution of the seventeen PTOs by information capability, value creation strategy, and performance.

Information Capability	**Performance**	**Value Creation Strategy**			
		Baseline	Price Differentiation	Service Expansion	**Total**
High	High	0	4	5	9
	Low	1	0	0	1
Low	High	0	0	0	0
	Low	5	2	0	7
Total		6	6	5	17

Table 4-2: Frequency cross-tabulation

4.5 Analysis and Results

As suggested by the literature, we employed nonparametric statistics rather than inferential statistics to test the propositions (Soh et al. 2006). Nonparametric methods are preferable for three reasons. First, although the number of selected cases is relatively small, we study the whole population of the large-scale smart card adoptions in the public transport industry and thus do not need to make assumptions relating to the population distribution. Therefore, the distribution-free nature of the nonparametric method is more appropriate for the analysis of the whole population and the small sample size. Second, the ordinal scale of our construct measurement calls for the use of a nonparametric method, which yields higher power than the corresponding parametric tests. Third, rank-based nonparametric statistical tests are not affected by outliers (Hollander and Wolfe

1999) and hence are more suitable for the analysis of PTOs, where outliers are common. For example, Octopus is a clear outlier based on adoption rates and transaction volumes.

4.5.1 Information capability

To operationalize the research model, we first looked at different types of mobile ticketing technologies used by PTOs. We then analyzed different data attributes of customer behavior information that could be obtained through mobile ticketing systems. We summarized the differences among paper ticket, magnetic card, smart card and mobile technology based on the unique characteristics of product, process and usability (see Table 4-3). Next, we examined the different data attributes obtained by each mobile ticketing technology. We categorized them into different information dimensions including service, purchasing, personal, temporal, and spatial (see Table 4-4). We found that paper tickets include the most basic information on buying dimension (i.e., travel product purchase time/date, location and price) and service dimension (i.e., travel mode and vehicle type). Additionally, magnetic cards can capture temporal dimension information (i.e., time and date of departure). Furthermore, smart cards add a detailed personal dimension (i.e., name, age, gender, address and profession), whereas mobile technology includes full spatial dimensional information (i.e., route and origin/destination) and permits PTOs to easily and precisely capture the full route and complete information of customer travel in the entire transportation networks.

	Paper Ticket	Magnetic Card	Smart Card	Mobile
Product Characteristics				
Usage mechanism	Purchase ticket before / while traveling	Contact: card has to be inserted into slot	Contactless: card can be read in proximity	Contactless: card is embedded into mobile
Memory	None	Limited	High, allow innovative pricing policy	Very high, allow interaction with other technology
Durability	Low	Easily damaged	Durable (plastic)	Durable
Data security	Low (lost, stolen)	Low (information lost through demagnetization)	Medium (encryption, value could be retrieved if card is lost)	High (mature security technology from telecom)
Process Characteristics				
Acquisition	Ticket office Ticket vending machine	Ticket office Ticket vending machine Internet	Ticket office Ticket vending machine Internet	Internet
Transaction	None	Transactions can not be viewed	Transactions can be viewed online	Transactions can be viewed on the mobile or online Payment can be incorporated into one single mobile bill
Replenishment	None	Card can not be reloaded	Card can be reloaded online Options are also available for automatic replenishment	Automatic replenishment
Usability				
Convenience	Low (cumbersome cash handling, needs exact change)	Medium	High (avoid ticket purchasing)	Very high (no additional card needed)
Speed (boarding time)	Slow	Slow	Fast, speed up journey	Fast, speed up journey
Personalization	No	No	Yes	Yes

Table 4-3: Mobile ticketing technology comparison

Data Attribute	Paper Ticket	Magnet Card	Smart Card	Mobile
Card number	X	X	X	X
Service Dimension				
Transport mode	X	X	X	X
Vehicle type	X	X	X	X
Purchasing Dimension				
Product purchase time / date	X	X	X	X
Product purchase location	X	X	X	X
Type and price of product	X	X	X	X
Personal Dimension				
Customer name / address			X	X
Customer age			X	X
Customer gender			X	X
Temporal Dimension				
Time/day of departure		X	X	X
Time/day of arrival		X	X	X
Travel frequency			X	X
Spatial Dimension				
Travel origin	X	X	X	X
Travel destination	X	X	X	X
Travel route				X
Others				
Travel purpose[19]				

Table 4-4: Mobile ticketing technology corresponding data attribute and its dimensions

4.5.2 Information capability and value creation strategy

Our validation of proposition 1 suggests that IT that provides effective customer information allows PTOs to develop advanced value creation strategies (i.e., price differentiation and service expansion). Table 4-5 shows that nine out of ten PTOs that have high information capability implemented revenue management strategy with price

[19] Consumer travel purpose is collected through periodic travel survey either by service providers or through external agencies. This information attribute cannot be captured by any of the information technology listed in the table. Nevertheless, it could be inferred from the travel frequency of the customers.

differentiation or service expansion. By contrast, five out of seven PTOs that have low information capability used baseline strategy. We used the Mann-Whitney U test to examine the differences in value creation strategy between high and low information capability. We tested against the null hypothesis of equal value creation strategy for both high and low information capability. We concluded that value creation strategy is significantly different across the information capability (p = .006). Table 4-6 summarizes the results of our nonparametric tests.

Value Creation Strategy	Information Capability Low	Information Capability High	Total
Access Control	5	1	6
Price Differentiation	2	4	6
Service Expansion	0	5	5
Total	7	10	17

Table 4-5: Value creation strategy and information capability crosstabs

Value Creation Strategy	Information Capability High	Information Capability Low
Mean Rank[20]	11.65	5.21
Sum of Ranks	116.50	36.50
Count	10	7
Mann-Whitney U	8.50	
Wilcoxon W	36.50	
Test p-value[21]	0.006***	

Table 4-6: Test of proposition 1

4.5.3 Value creation strategy and firm performance

Our validation of proposition 2 suggests that service providers are more likely to succeed with a value creation strategy of price differentiation or service expansion. Table 4-7 shows that all high performance PTOs implement either price differentiation or service expansion. The fact that two PTOs that use price differentiation are also low performers is not inconsistent with our argument. A good strategy does not guarantee success – many other factors influence success. In contrast, none of the baseline PTOs exhibited high performance. We tested proposition 2 using the same procedure used to test proposition 1. The main difference here is that we tested firm performance across

[20] Higher rank indicates higher levels of value creation strategy.

[21] Significant level: *** $p < 0.01$

the three value creation strategies. We concluded that PTOs that use price differentiation and service expansion outperform those with baseline strategies (p = .019 and .002). Table 4-8 summarizes the results of the pair-wise comparison using Mann-Whitney tests.

		Value Creation Strategy			
		Baseline	Price differentiation	Service Expansion	**Total**
Firm Performance	Low	6	2	0	8
	High	0	4	5	9
Total		6	6	5	17

Table 4-7: Firm performance and value creation strategy crosstabs

Firm performance	**Value Creation Strategy** Baseline	**Value Creation Strategy** Price Differentiation	**Value Creation Strategy** Baseline	**Value Creation Strategy** Service Expansion	**Value Creation Strategy** Price Differentiation	**Value Creation Strategy** Service Expansion
Mean Rank	4.50	8.50	3.50	9.00	5.17	7.00
Sum of Ranks	27.00	51.00	21.00	45.00	31.00	35.00
Count	6	6	6	5	6	6
Mann-Whitney U	6.00		0.00		10.00	
Wilcoxon W	27.00		21.00		31.00	
Test p-value	0.019***		0.002***		1.174	

Table 4-8: Test of proposition 2

4.6 Firm Informedness and Value Creation

The empirical validation of our propositions leads to two major findings.

FINDING 1: Service providers that use more sophisticated mobile ticketing technologies (such as smart card and mobile device) and have real-time and complete information on customers' actual travel, more likely to adopt price differentiation and service expansion strategy.

From a product, process and usability viewpoint, we examined the unique characteristics of three commonly-used mobile ticketing technologies and compared them to paper tickets. Combined with the analysis of the data attributes captured by each technology, we observed different levels of information capability among the selected cases. When a ticketing system is implemented by a PTO, the first goal is to reduce fare evasion and achieve operational efficiency. When PTOs start using more advanced mobile ticketing technologies such as smart cards or mobile devices, they are soon able to obtain more detailed individual customer behavior information. This information allows them to employ price differentiation strategies. Further, because smart cards and mobile devices move customers quickly through the payment process, they are particularly attractive to retail segments where speed and convenience of payment are essential. The technology adoption in the public transport industry creates a large customer install base; this makes it easier for the service providers to expand into other markets. The empirical results provide strong support for proposition 1. It suggests that service providers that have a higher information capability are more likely to use price differentiation and service expansion strategies, compared to the ones that have a lower information capability.

FINDING 2: *Service providers that adopt advanced mobile ticketing technologies and employ price differentiation and/or service expansion strategies are more likely to have higher performance gains compared to the ones that use only the baseline strategy.*

As theorized in the revenue management literature (Talluri and van Ryzin 2004b), the service providers that use price differentiation tend to achieve higher performance. Although ticketing systems are often seen as expensive investments in infrastructure, they can improve PTOs' access control and enhance their operational efficiency. Further, the systems also provide improved information on customer behavior, which creates an opportunity to optimize and individualize their service offerings. Improved products and service offerings can justify the investment premium. Our results suggest that the service providers that use price differentiation and service expansion strategy have a greater chance to be successful.

Mobile ticketing value hierarchy. We summarize this value creation process as a form of mobile ticketing value hierarchy and illustrate it in Figure 4-2.

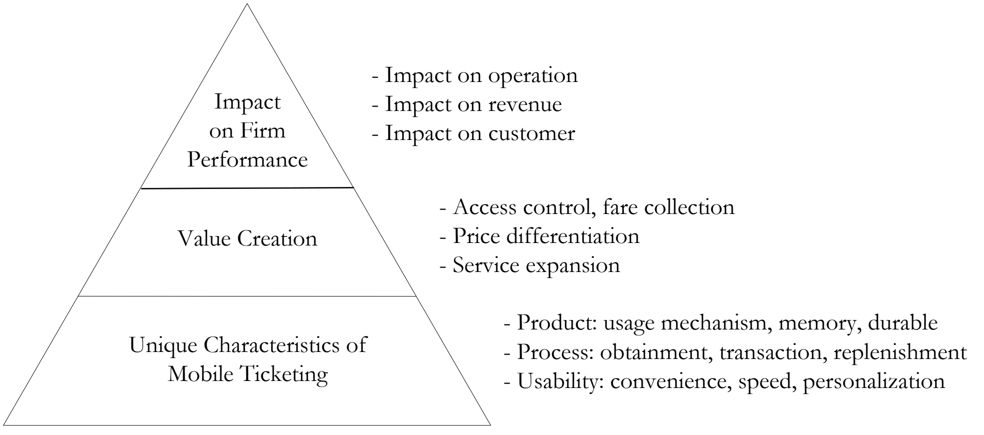

Figure 4-2: Mobile ticketing value hierarchy: from characteristics to value creation

Octopus: from baseline to service expansion. We use the example of Octopus to illustrate the value creation process of service providers. Octopus (www.octopuscards.com) is by far the world's most successful contactless smart card with over 13 million cards now in circulation and over 9.2 million transactions each day amounting to a total of US$ 3 billion a year. With the idea of developing an automated fare collection system based on contactless smart cards, five Hong Kong's local PTOs (bus and subways) formed a joint venture company, which is later named as Octopus. The card was introduced in 1997 with the purpose of access control and fare collection, and was quickly expanded to other transport services such as ferry and taxi. In 2000, Octopus entered various retail markets. Many stores in the city are all accepting Octopus, most notably, 7-Eleven, McDonald's, convenience stores, other fast food restaurants and Starbucks coffee shops. Firms ensure that their payment systems are compatible with Octopus in order to have access to the large installed customer base of Octopus. Continuing the expansion, Octopus successfully replaced all Hong Kong Government's 18,000 parking meters with a new Octopus card operated system in 2004. It further expanded to government facilities including public swimming pools and sports facilities. Not only aggressively expanding in its home base in Hong Kong, Octopus also succeeded in winning cross-border contracts to mainland China and successfully built its first overseas business expansion. Today 95% of the population aged 16-60 possesses the card, over 130 service providers accept Octopus and over 50,000 Octopus processors are in use over Hong Kong.

4.7 Conclusions

This chapter has theoretically developed and empirically evaluated a research model that examines the use and impact of mobile ticketing technology and improved customer behavior information at the firm level. This study was motivated by the process-oriented view of the business value of IT. It is grounded in the revenue management literature and the resource-based theory. Our model moves beyond "adoption versus non-adoption" as suggested by Zhu and Craemer (2005) and accounts for the actual usage (Devaraj and Kohli 2003) as a critical stage of the value creation. This is a significant contribution to the IS literature.

This study offers two other implications for research. First, it examines the business value of mobile ticketing by introducing a value creation strategy construct built on the revenue management and strategy management literature. This study contributes to the business value of IT literature by providing empirical support for the relationship between customer behavior information and firm performance. This understanding is critical in evaluating and justifying IT investments. Second, this study contributes to the literature on pricing and revenue management by examining the possibilities of revenue management in the public transport industry.

Our findings have several important implications for management. Service providers must understand real-time customer behavior so that they can adjust their product and services quickly and effectively. Proper use of this data will improve their operations and revenues. The public transport industry is (partially) subsidized by government and has very strong social responsibilities. The primary reasons for the government to pay subsidies are to provide transport services to the public, alleviate congestion, reduce pollution and promote economic growth. Therefore, there is a limit to how far PTOs can use profit-maximizing revenue management strategies. Customers are also an integral part of PTOs service operations. Thus, when PTOs evaluate the performance impacts of their strategies, customer satisfaction should be considered as an essential measure. Using revenue management strategies, PTOs not only capture customers' surplus, but also give customers the opportunity to "self-select" the service offerings that would suit them the best. This self-selection allows customers to participate in the operational process and to co-produce the operational outcomes.

Chapter 5 Consumer Informedness and Heterogeneous Consumer Choice

5.1 Introduction

In the previous chapter, we focused on firm informedness and its impact on value creation strategy. In this chapter[22,23], we will focus on consumer informedness and explain the heterogeneous consumer choices toward revenue management strategies.

The impact of increased information availability is considered by the theory of consumer informedness and the practices associated with resonance marketing. These have been used to explain the behavior of well-informed consumers and the strategies that firms should follow in order to sell to them most effectively. Clemons et al. (2006) define hyperdifferentiation as the situation where "firms can produce almost anything that appeals to consumers and they can manage the complexity of the increasingly diverse product portfolios that result". Resonance marketing is a strategy of developing services that produce the strongest favorable responses among targeted segments of the consumer population. Firms sell their services in a vast variety according to consumers' heterogeneous needs, and consumers react to the service that precisely meets their needs and desires.

Consumer informedness is considered as the key driver of resonance marketing (Clemons and Gao 2008). It becomes important in determining consumers' willingness-to-pay. Nowadays, consumers are increasingly informed of firms' service offerings. Their willingness-to-pay increases when there is a fit between consumer preferences and service attributes. Informed consumers will pay more for what they truly want, and stop buying services with which they are dissatisfied. As opposed to the traditional way of designing a

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[22] This chapter is based on Kauffman, R.J., Li, T., van Heck, E., and Vervest, P. 2008. Consumer Informedness and Information Technology: An Empirical Study of Heterogeneous Consumer Choice Using A Stated Choice Experiment. *Twentieth Workshop on Information Systems and Economics*, Paris, France.

[23] An earlier version of this chapter has appeared as Kauffman, R.J., Li, T., van Heck, E., and Vervest, P. 2009. Consumer Informedness and Hyperdifferentiation: An Empirical Test of the "Trading Down" and "Trading Out" Hypotheses. In Sprague, R. (ed.), *Proceedings of the 42th Hawaii International Conference on Systems Science*, Big Island, HI, IEEE Computer Society Press, Los Alamitos, CA.

service that targets to the mass market and attracts the largest number of consumers, today firms are actively searching for strategies to provide more choices to consumers, so that they can exploit consumers' willingness-to-pay, and design and differentiate services that are suitable for much smaller groups of consumers, all the way to individual.

Clemons and Gao (2008) suggest that, with consumer informedness, consumer purchase behavior can be characterized as trading down and trading out. Trading down means that the consumer wants to buy something because it is cheap, even if it does not offer the highest utility. Trading out, in contrast, means that a consumer is looking for the product or service that offers the best fit, irrespective of price. The objective of this chapter is to examine how firms leverage consumers' fully-expressed demand preferences, explore their service attribute space, and design their product and service offerings to capture the most profitable responses among the targeted segments of consumers. Our research questions are: What theoretical basis can aid us in understanding the impact of consumer informedness? And how can we characterize the consumer response toward revenue management in IT-enabled business contexts?

We use an innovative method – a stated choice experiment (Louviere et al. 2000) – and test for trading down and trading out for two types of travel services with 1,000-plus consumers in the public transport market. In our field experiments transport service consumers are fully informed of the different service offerings consisting of service attributes and associated levels they can select. They decide what they want, evaluate their choice well, and decide to pay what they think the service is truly worth. We seek to examine the heterogeneity of their preferences and willingness-to-pay in the presence of consumer informedness by including additional customer and journey characteristic. Additional extensions, including a comparison of market sensitivity for important product attributes, regressions based on segment data, an examination of customer profitability gradient, and an assessment of elasticity, marginal effect, and market share, are also included. Furthermore, we use an advanced choice model, the mixed logit model, to test the functional form of consumers' willingness-to-pay. We demonstrate that the use of mobile ticketing technologies enabled by smart cards and mobile phones help service providers to build a hyperdifferentiated public transport market, and generate performance gains resulting in higher social welfare.

The remainder of this chapter is organized as follows. First, we introduce the theory of consumer informedness and develop our hypotheses. Next, we introduce the stated choice experiments, specify our choice models and present our empirical results. Furthermore, we analyze consumer heterogeneity and willingness-to-pay and conclude with a discussion.

5.2 Theory and Hypotheses

The background theory and modeling ideas for this research involve hyperdifferentiation and resonance marketing, consumer purchasing behavior, revenue management, and choice theory and discrete choice models.

5.2.1 Consumer informedness and choice behavior

The essence of resonance marketing is harnessing and guiding the supply side of hyperdifferentiation (Clemons 2008). Although firms can produce anything, they typically find it most beneficial to produce exactly what their customers want to buy.

Consumer informedness, the degree to which consumers "know what is available in the marketplace, with precisely which attributes and at precisely what price" (Clemons 2008), is viewed as the critical driver for the success of resonance marketing. More information will reduce consumer uncertainty about a service, and thus a consumer will be willing to pay more for what he wants. The upshot is that the consumer will experience a sense of "delight" in the presence of the increased information. Clemons et al. (2008) argue that this approach comes close to "near-elimination of all aspects of uncertainty, allowing latent differences in preferences to become manifest in consumers' preferences for less common products, and allowing these preferences to manifest themselves in terms of what these consumers buy and what they are willing to pay".

Resonance marketing requires an understanding of the demand side. It emphasizes what the firm knows about what each consumer segment wants to buy and is willing to pay. This understanding will help us to make sense of the observed long-tail of consumer purchases. The long-tail is attributable to differences in the distributions of consumer preferences across different products. Further, firms can identify un-served and under-served market segments. They will benefit significantly from setting prices that maximize their firms' profitability. When firms implement hyperdifferentiation, consumers are likely to exhibit two kinds of purchasing behaviors that are different from the traditional consumer behaviors that are observed under the mass market strategies that have been applied by most firms in the last twenty years. They are trading down and trading out (Clemons 2008).

With *trading down*, consumers choose products that have not only the lowest price, but also the ones that are unlikely to disappoint them or create unnecessary uncertainty. In the case of airline travel, for example, these are the consumers who purchase the super-discount or last-minute tickets offered by the airlines. These consumers have a low willingness-to-pay. They also may have a threshold that defines how much of a trade-off they make for other service attributes.

With *trading out*, another type of consumer looks for services that can bring him the best fit. The extent of the fit between a consumer's needs and the attributes of a service is critical. This group of consumers is interested in other attributes (e.g., convenience) of a service than its price. For instance, business travelers will pay more to secure a non-stop flight with a short travel time. If the airlines can provide services that permit true *origin pickup* and true *destination delivery*, consumers would be more inclined to purchase that service.

5.2.2 Hypotheses

We chose the new high-speed-train (HST) service that is going to be launched in 2008 between Amsterdam, Netherlands and Paris, France as a unique setting for an empirical test of two theory-based hypotheses on consumer informedness. Our reasons for this choice are threefold. First, Trans Link Systems (TLS) plans to deliver a seamless ticketing and fare collection solution for the complete public transport system throughout the Netherlands. Using smart card technology, this contactless ticketing infrastructure will cover trains, metro, trams, and buses, providing travelers with increased convenience and added satisfaction. Second, the primary service provider faces a high cost of delivering the appropriate infrastructure and services (e.g., the Internet, SMS, mobile, platform terminal), while simultaneously competing with other modes of transportation, to gain market share. The service provider also is actively engaged in revenue management initiatives. Third, the firm has a strong need to develop an attractive travel product portfolio, and a variety of service packages for consumers, to derive sustainable market advantage.

Travelers are different. Their heterogeneity comes from their travel frequency, distance, origin-destination city-pair, number of interchanges, and payment ownership. Travel purpose is a driver of purchase behavior in most transportation industries. Commuters, business travelers, and leisure travelers are common market segments. Service providers design differentiated travel services to target them. Travel purpose cannot be captured by service providers without asking consumers. Instead, travel frequency, a near proxy for travel purpose, can be easily obtained by using mobile ticketing.

Thus, we chose to use travel frequency to characterize heterogeneous consumer demand. Consumers who travel with different frequencies will exhibit different purchase behaviors for different travel services. We distinguish among consumers who are high, medium and low-frequency travelers. Low and medium-frequency travelers are usually leisure travelers who mostly pay for the trips themselves, and thus are price-sensitive. High-frequency travelers are mostly commuters or business travelers, who receive travel reimbursements from their employers or tax benefits. They are less price-sensitive and seek the service that provides the best fit with their preferences. We propose the following two hypotheses:

Hypothesis 1 (The Trading Down Hypothesis). *Low and medium-frequency travelers will exhibit stronger preferences in choosing the cheapest products – evidence of trading down behavior.*

Hypothesis 2 (The Trading Out Hypothesis). *High-frequency travelers will exhibit stronger preferences in choosing products that best fit their preferences rather than relying on price – evidence of trading out behavior.*

5.3 Methodology – Stated Choice Experiments

To understand consumer preferences for travel services under the firm strategy of hyperdifferentiation, we need to consider the relative benefits that consumers attach to various attributes of the services that are available to them at the time of purchase. We used the stated choice experiment method that was explained in Section 3.3.

We used three main criteria to select respondents. First, we only invited respondents who considered using the HST for all or part of the trips they were making at the time of the survey. Second, we selected only those respondents who lived within the relevant catchment area. We operationalized a *catchment area* as the postal code areas where consumers are apt to have travel time gains when they choose to travel by HST for all or some of their trips, compared to continuing to use their current modes of travel. Third, the respondents are either train users or car drivers. We excluded travelers from our sample who traveled by air, since the comparative costs are prohibitive, and do not reflect meaningful comparisons for most people.

To collect data, we used an Internet panel from a leading marketing research firm – one of the largest in the Netherlands. Panel members receive a standard reward (“clix” that can be converted to money) for participating in the research. This approach has the advantage that respondents are experienced and can handle complicated stated preference surveys. Respondents are also likely to be motivated by the pay they receive for responding. In addition, the Internet panel respondents are reliable; members who fill in “suspicious” questionnaires are periodically removed. During data collection, each respondent received an email from the marketing research firm with an invitation to join the research project. After entering the secure website, the respondent was presented with a description of the future high-speed services and information on smart card ticketing and reservation systems implementation. After reading the core concept, each respondent was asked to respond to twelve or fifteen different choice sets similar to the one shown in Table 3-6, depending on their current travel frequency. The respondents were asked to choose among one of the three presented travel services, including the one they now use. Data collection occurred from November 15 to December 6, 2007. After we screened respondents and cleaned the data, 1,313 valid responses remained.

The sample contains 6% of respondents ranging from 18 to 24 years, 32% from 25 to 39 years, 37% from 40 to 59 years, and 25% older than 60 years. They are 52% male, 42% with two persons in the household, and 77% having a driver's license. 41% of respondents attended high school or college, and 12% hold degrees (bachelor's, master's or Ph.D). 52% of respondents earn less than €50,000, and 19% earn between €50,000 and €100,000. 2% have an above €100,000. 28% chose not to answer this question. In terms of the journey characteristics, 70% of the respondents are car drivers and 30% are train users. Nearly 10% of the respondents travel with high frequency, 71% with medium frequency, and the remaining 19% with low frequency.

5.4 Model Specification

Since service choice is a discrete individual decision, we use a *discrete choice model* to explain individual choice behavior. We first provide basis with a simple logit model. Next, as suggested by Hensher and Greene (2003), as a starting point of choice modeling, we should examine a *multinomial logit model*. We will discuss its limitations and explain how a more advanced choice model such as a *mixed logit model* enables us to relax overly-strict assumptions and account for consumer heterogeneity.

5.4.1 Logit model

We assume consumer i chooses a travel service j only if this option maximizes his utility. We cannot directly observe the utility that each service delivers to each consumer. So we assume a consumer's utility for a transport service is a function of the observable service characteristics. This utility is $U_{ij} = \beta X_{ij} + \varepsilon_{ij}$, where X_{ij} are observable service attributes of service j, β are estimated coefficients, and ε_{ij} is an error for utility differences resulting from the unobservable factors. Consumer i will select service j if and only if $U_{ij} > U_{im}$, $\forall\, j \neq m$ for another service m. A specific instantiation of such a model requires the analyst to make several choices involving the specification of the units of U_{ij} and the relationship among the explanatory variables. A *logit model* (Hosmer and Lemeshow 2000) is a handy model to use in our context, since it supports analysis of how consumer choices among the nominal alternatives will be affected by the characteristics of the alternatives, which vary across services. The predicted probability Y_j of a consumer i choosing a particular service j out of J possible services can be expressed as:

$$P_i(Y_j = 1) = \frac{\exp(\beta X_{ij})}{\sum_{j=1}^{J} \exp(\beta X_{ij})}$$

Every β indicates the separable effect of a service *alternative-specific variable* on the probability of a consumer choosing one service over another. The estimated values of β of a simple model of this form can be obtained using maximum likelihood methods. In general, for each variable X_{ij} there are J values of the variable for each case, but only a single parameter β.

5.4.2 Multinomial logit model

Alternative services consist of attributes that may explain consumer choices in the choice context. These include *travel mode* (*TM*), *price* (*P*), *travel time* (*TT*), *time window* (*TW*), an after-sales option for a partial *refund* (*REF*), and *reservation* (*RES*). Utility can be expressed with the following general functional form: $U_{ij} = f(X_{TM}, X_P, X_{TT}, X_{TW}, X_{REF}\ X_{RES})$. To take into account of both service alternative-specific variables X_{ij} and consumer-specific variables Z_i, such as an individual's origin-destination, travel frequency, travel distance, and demographical information, the logit form of such a model is *multinomial logit (MNL) model* (Ben-Akiva and Lerman 1985):

$$P_i(Y_j = 1) = \frac{\exp(\beta X_{ij} + \gamma_j Z_i)}{\sum_{j=1}^{J} \exp(\beta X_{ij} + \gamma_j Z_i)}$$

5.4.3 Mixed logit model

A major drawback of the MNL model is the assumption of independent and identically-distributed errors (IID). This is restrictive; it does not allow for the error components of different alternatives to be correlated. A *mixed logit* (ML) *model* relaxes this assumption (Hensher and Greene 2003). It recognizes that different customers have different preferences, and accounts for correlation in unobserved factors over repeated choices by each customer. To allow correlated alternatives, we partition the stochastic component into two parts. One part induces heteroscedasticity and correlation across unobserved utility components of the alternatives. The other part is IID over alternatives and individuals. Therefore, we can rewrite $U_{ij} = \beta X_{ij} + \varepsilon_{ij}$, as $U_{ij} = \beta X_{ij} + [\eta_{ij} + \varepsilon_{ij}]$, where η_{ij} is a random multivariate vector with zero mean. The density of η_{ij} is $f(\eta_{ij}|\Omega)$ where Ω is a distribution. The logit choice probability evaluated for parameter β for a given value η that individual i will choose alternative j is:

$$L_{ij}(\beta \mid \eta) = \frac{\exp(\beta X_{ij} + \eta_{ij})}{\sum_{j=1}^{J} \exp(\beta X_{ij} + \eta_{ij})}$$

The unconditional probability can be expressed in terms of the integrals of the standard logit probabilities over a density of parameters:

$$P_{ij}(\beta \mid \Omega) = \int_{\beta} L_{ij}(\beta \mid \eta) f(\eta \mid \Omega) d\eta$$

This form is a *mixed logit* (ML) model, which can capture a greater amount of true behavioral variability in choice-making on the part of the consumer. The ML model aligns itself with reality more than most discrete choice models; every individual has his own inter-related systematic and random components for each alternative included in his choice sets.

We adopted a simulation approach to make inferences, using random parameter values and their distributions for what real-world public transit managers expect to observe. These parameters define the degree of preference heterogeneity in two ways: (1) by the standard deviation of the parameters, and (2) through interactions between the mean parameter estimate and the deterministic segmentation criteria. They present rich preference information. We chose to use the Halton sequence draw (Halton 1960) in the mixed logit model (Train 1999, Train 2003). This is used in research on mobile phone (Ida and Kuroda 2005) and public transport demand (Hess et al. 2007), with the discrete consumer choice. This method of making parameter draws in simulation gives an analyst better coverage than the pseudo-random sequence draw to secure a stable set of parameter estimates (Bhat and Castelar 2002).

5.5 Effects Coding and Hypotheses Testing

We next present two sets of empirical results around our two hypotheses. First, we use effects coding for all attributes for the general pricing and subscription pricing experiments. We estimate MNL models with all attribute-level variables and use two graphs to illustrate the relative importance of the attribute levels to the part-worth utility.[24] And then we present evidence on trading out and trading down behavior.

5.5.1 Effects coding and model estimation

We implemented effects coding so that the non-linear effects of the attribute levels can be measured. We keyed off the lowest attribute level for each variable to accurately estimate the relative impact on respondents' choices. This removes any confounding of the base attribute level with the mean of the consumer's utility function (Hensher et al. 2005).[25] We estimated our MNL models using maximum likelihood estimation (Ben-Akiva and Lerman 1985, Louviere et al. 2000).

To account for the fact that some observations are independent across individuals but not always independent within individuals, we used robust standard errors for model estimation. A positive estimated β-value, or *main effect* for an attribute, means the probability of selecting the travel service will increase if this attribute is increased from the lowest level to this level.[26] We can see from the results that the probability of selecting the new travel service increases when the price is reduced (*high* to *low*), travel time is reduced (*long* to *short*), ticket validity is longer (*9am-4pm and 6pm on* to *entire day*), percentage of refund is increased (*low* to *high*), and a reserved seat is available (*no* to *yes*). To illustrate the relative impact of each attribute, we also calculated the main effects of each attribute.

5.5.2 Evidence for trading down

We first discuss the results of general pricing experiment, which applies to the low and medium-frequency transport services consumers. The results from our model estimation are shown in Table 5-1 and the relative importance of each attribute and its levels is plotted in Figure 5-1.[27]

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[24] *Part-worth utility* is an important concept in discrete choice model estimation. A consumer's total utility for a product is a function of its part-worth utilities for each of the attributes that describe the product.

[25] We varied *Price*, *Travel Time*, *Time Window*, and the after-sales *Refund* option at three levels; so two degrees of freedom and two variables are necessary. We coded for the lowest level with -1 and the other two higher levels with +1. The estimated parameters for the two variables show relative impacts of changing from the lowest to one of the higher levels. For attributes that only have two levels *Travel Mode* and *Reservation*, we coded just for the lower and higher levels. See Hensher et al. (2005) for a similar treatment.

[26] For the two-level attributes, the utility for the lowest level is $-\beta$. For attributes with three levels, the relative utility of the third level is the negative of the sum of the other two β-values.

[27] In total there are 1,313 respondents, among which 932 respondents are low and medium-frequency travelers that participated in the general pricing experiment. Each of them was presented with 15 choice sets, and each choice set

Attribute	Variables	MNL Model	Main Effects
Travel Mode	Current mode	0.848***	0.848
	High-speed-train	-0.848	
Price	Low	0.665***	0.572
	Medium	-0.093***	
	High	-0.572	
Travel Time	High	0.116***	0.139
	Medium	0.023	
	Low	-0.139	
Time Window	All day	0.25***	0.177
	After 9am	-0.073***	
	9am-4pm, 6pm on	-0.177	
Refund	High %	0.323***	0.388
	Medium %	0.065***	
	Low %	-0.388	
Reservation	Reserved seat	0.213***	0.213
	None	-0.213	

Notes: 41,940 obs., log-likelihood = -24,756.87***, McFadden R^2 (or pseudo-R^2) = 0.148. Signif.: = *p < 0.10; **p < 0.05; ***p < 0.01. We use the least favorable attribute level as the base attribute level.

Table 5-1: MNL model results in the general pricing experiment

The parameters represent the *part-worth utility* for each attribute level. We use the attribute *Travel Mode* to capture all unobserved attributes associated with the mode choice. This is the choice between consumers' current travel mode (car or train) and future travel mode (HST). This provides an assessment of *switching inertia* also. A negative coefficient means that the current travel mode was chosen more often than the future travel mode alternatives. Besides this switching inertia, the main effect of the attribute *Price* is the highest ($\beta = 0.572$, $p < 0.001$). We also see that the combined main effects of the after-sales *Refund* option ($\beta = 0.388$, $p < 0.001$) and *Reservation* ($\beta = 0.213$, $p < 0.001$) are almost equal to the effect of *Price*. This means some combination of the two services may be sufficient to overcome any price barriers. We note that the effect of *Travel Time* ($\beta = 0.139$, $p < 0.001$) is the lowest among all attributes. This indicates that any speed gain compared to the planned HST service will not attract more consumers compared to the

has 3 alternatives. Each alternative has one observation, being chosen or not chosen. Thus, we have 932 × 15 × 3 = 41,940 observations. And there are 381 high-frequency travelers that participated in the subscription pricing experiment, where 12 choice sets were used, thus, there are 381 × 12 × 3 = 13,716 observations.

changes in other product attributes. Note that our baseline travel time is the standard HST service, not the consumers' current transport.

A pseudo-R^2 of 0.148 ($p < 0.001$), and Hosmer and Lemeshow's *goodness-of-fit test* ($p < 0.001$) indicate our model fits the data well. Except for *Medium Travel Time*, the other variables are all significant ($p < 0.01$). Pair-wise correlations for the explanatory variables were all less than .40, except *High Validity* and *Medium Validity* at 0.748. In addition, all variance inflation factors (VIF) values are below the critical value of 10, indicating that multicollinearity is not an issue (Long and Freese 2006). According to Hensher et al. (2005), multicollinearity is not a problem for full orthogonal-designed stated choice experiment data, because the columns are independent from one another.

These results show that the attribute *Price* is the most important product attribute among all of the ones that we explored. This suggests that the low and medium-frequency consumers value price the most, and they are most likely to replace their current purchase with an alternative service that has lower quality (shorter validity or no reserved seat) but is less expensive. This provides evidence for trading down behavior. So, our Trading Down Hypothesis (H1) is supported.

5.5.3 Evidence for trading out

Next, we discuss the *subscription pricing* results. This approach is tailored to high-frequency travelers. Similar to general pricing, we calculated the main effects of each attribute. The results are shown in Table 5-2 and their relative values are plotted in Figure 5-2.

The pseudo-R^2 of 0.211 ($p < 0.001$) and Hosmer and Lemeshow's *goodness-of-fit test* ($p < 0.001$) indicate that the subscription pricing model fits well. Except for *Medium Travel Time* and *Medium Price*, the other variables were significant at the .01 level. We noted a relatively high correlation between *High Validity* and *Medium Validity* at 0.64. Multicollinearity is also not a problem based on the usual VIF diagnostics.

Consumer switching inertia is represented by the attribute *Travel Mode*, which is greater in subscription pricing than for the general pricing model. This means that consumers are more likely to select their current mode of transport based on their past behavior. The results suggest that consumers who travel frequently place a higher value on *Time Window*, which is the time validity of the monthly subscription product, compared to the low and medium-frequency travelers. In particular, we find that the level variables for part-worth utility for *Time Window*, *valid all day* ($\beta = 0.825$, $p < 0.001$) have the highest impact. The magnitude of impact is even bigger than the *Price* attribute levels ($\beta = 0.537$, $p < 0.001$).

This result is logical: high-frequency consumers are commuters, or business travelers who have much tighter schedules compared to the lower-frequency travelers, who are mostly are leisure travelers. They prefer to purchase a travel product that is valid all day. They will pay much more to have such a product so that they do not need to worry about peak and off-peak ticket validity. This result is preliminary, but nevertheless indicates that high-frequency consumers have a stronger preference for choosing a travel product that best suits their needs. This provides evidence for trading out behavior.

Attribute	Variables	MNL Model	Main Effects
Travel Mode	Current mode	1.095^{***}	1.095
	High-speed-train	-1.095	
Price	Low	0.537^{***}	0.524
	Medium	-0.013	
	High	-0.524	
Travel Time	High	0.035^{***}	0.109
	Medium	0.074	
	Low	-0.109	
Time Window	All day	0.825^{***}	0.326
	After 9am	-0.499^{***}	
	9am-4pm, 6pm on	-0.326	
Reservation	Reserved seat	0.126^{***}	0.126
	None	-0.126	

Notes: 13,716 obs., log-likelihood ratio = $-7{,}498.89^{***}$, McFadden R^2 (or pseudo-R^2) = 21.1%. Signif.: = $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$. We use the least favorable attribute level as the base attribute level.

Table 5-2: MNL model results in the subscription pricing experiment

We summarize two experimental results and plot the relative importance of the attribute levels. The x-axis corresponds to the attribute levels described in Table 5-1 and Table 5-2, for example TT1 indicates Travel Time Level 1. A positive estimated β-value for an attribute level means the probability of selecting the travel service will increase if this attribute is increased from the lowest level to this level. We can see from the graphs that the probability of choosing a new travel service increases when the price is reduced (from Level 1 to 3), travel time is reduced (from Level 1 to 3), percentage of refund is increased (from Level 3 to 1), ticket validity is longer (from Level 3 to 1), and a reserved seat is available (from Level 2 to 1). Figure 5-1 shows the results from the general pricing experiment. Figure 5-2 shows the results of the subscription pricing experiment. We can clearly see that Price has the highest impact on low and medium-frequency travelers, whereas Time Window has the highest impact on high-frequency travelers.

Figure 5-1: Relative impact of each attribute levels to the part-worth utility (general pricing experiment)

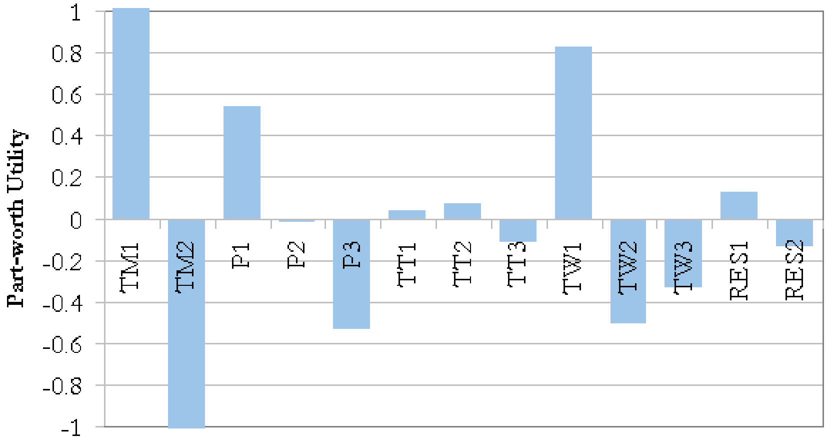

Figure 5-2: Relative impact of each attribute levels to the part-worth utility (subscription pricing experiment)

5.6 Heterogeneity in Consumer Choice

The previous section presented the base MNL model and analyzed several important basic modeling decisions. This section extends the analysis by examining four variants on the base model. We examine the consumer segment models, demonstrate customer profitability gradient, discuss performance measures and explore heterogeneity in willingness-to-pay using mixed logit model.

5.6.1 Consumer segment models

So far, we have used data from all our respondents to estimate our MNL models for two product experiments. Next, we use three segmentation criteria based on journey characteristics and estimate the MNL model for different market segment to explore the market sensitivity. These criteria are travel frequency, origin-destinations city-pairs, and the traveler's current main mode of transport. Consistent with the public transport service provider's practices, we categorize *travel frequency* into three levels: low, medium, and high-frequency. These are the same criteria we used for the two product experiments that we discussed so far. High-frequency travelers travel more than three times a week. Medium-frequency travelers travel less than three times each week but more than three times a year. Low-frequency travelers travel even less. The second segmentation criterion is *origin-destination city-pairs*. We consider three major origin-destinations – Amsterdam /Schiphol-Rotterdam (AS-R), Amsterdam/Schiphol-Breda (AS-B), Rotterdam-Breda (R-B) – which are served by high-speed trains operating in the catchment area. The third segmentation criterion is the *current mode of travel*, being car or train.

First, we examine the market sensitivity for the key product attribute and its levels in these market segments. For general pricing experiment, we have identified Price as the most important product attribute. To illustrate the price sensitivity for each consumer group, we plot the part-worth utility for Price by travel frequency, travel mode, and origin-destination city-pair. See Figure 5-3. The results show that the price sensitivity is the highest for medium-frequency train travelers that are traveling between Amsterdam and Rotterdam.

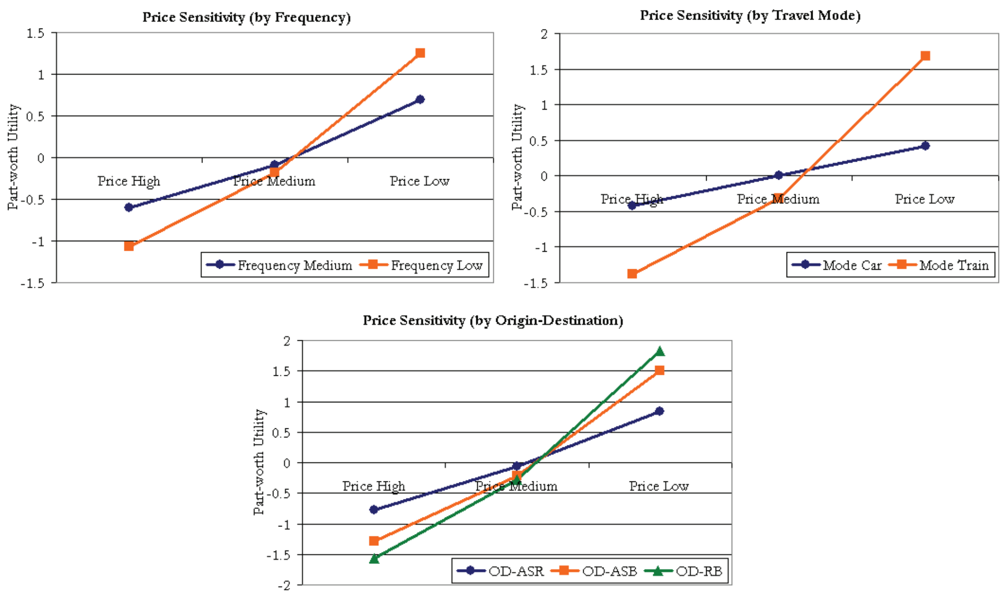

Figure 5-3: Price sensitivity by travel frequency, travel mode, and origin-destination city-pair

For the subscription pricing experiment, we have identified *Time Window* as the most important product attribute. Its market sensitivity is illustrated in Figure 5-4.

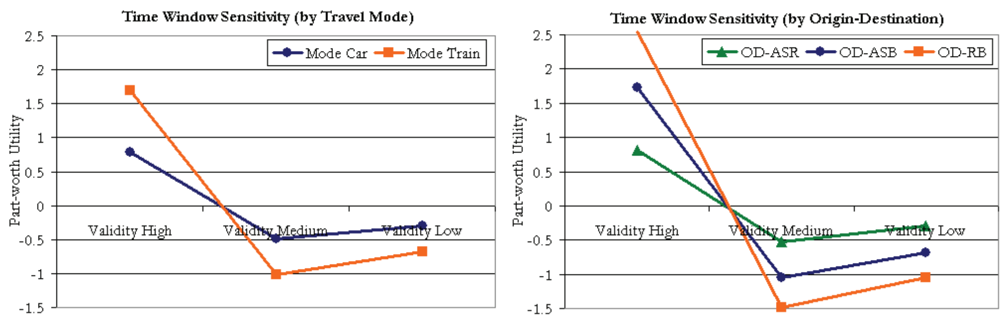

Figure 5-4: Time window sensitivity by travel mode and origin-destination city-pair

The results show that the train travelers are more sensitive to *Time Window* compared to the car users. The Rotterdam-Breda travelers have the highest sensitivity among all.

Next, we divide the transport market into 12 segments: two travel mode (car and train), two travel frequency (medium- and low-frequency), and three origin-destination city-pairs (ASR, ASB, RB). We estimate the MNL model for each of these segments and show the *relative effects* for each of the product attributes across market segments. (See

Figure 5-5 for general pricing experiment and Figure 5-6 for subscription pricing experiment.)

Each horizontal bar is scaled to 100%, to compare *relative weights* of attributes across different segments. The main effects are different across segments. The relative weight for price varies across segments. Medium-frequency travelers who currently use the train and travel between Amsterdam and Breda (AS-B-Train-Medium) are the most price-sensitive consumers. They have relatively higher utilities for price. Similarly, the users who travel by train between Rotterdam and Breda with low frequency (R-B-Train-Low) are most likely to purchase the service if a higher refund option is available. They have higher utility for the after-sales refund option. With different levels of consumer preferences within each segment, service providers can target the most value-bearing consumers, provide the most suitable product, and achieve higher profitability. For example, service providers will be better off serving higher-frequency travelers with a travel product that is valid for the entire day. This is because these consumers place higher value on this product attribute compared to other attributes. These results are of interest to service providers who want to enter and compete in a hyperdifferentiated public transport market. To wit: "Although the firm can now make whatever [it] wants to make, it is most beneficial to produce exactly what the customer wants to buy" (Clemons 2008).

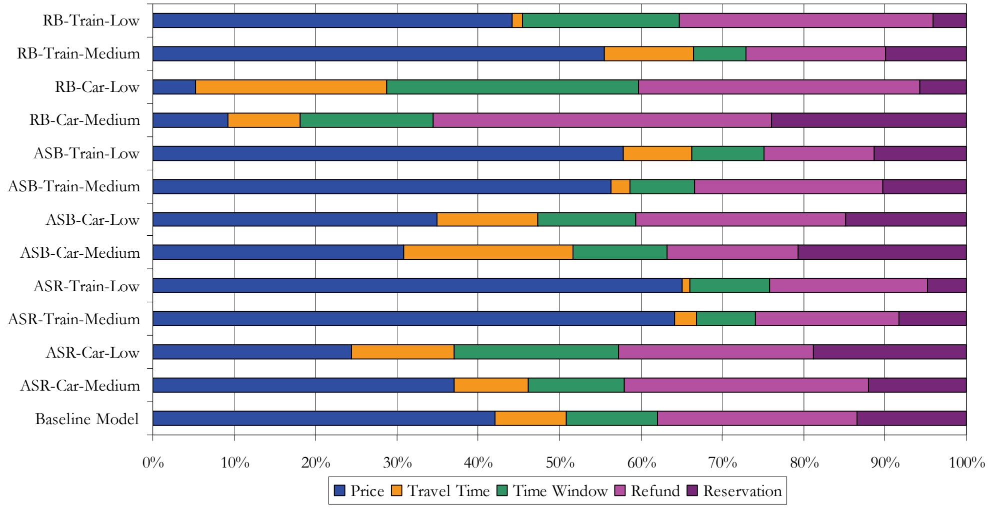

Figure 5-5: Main effects of attributes in segment (general pricing experiment)

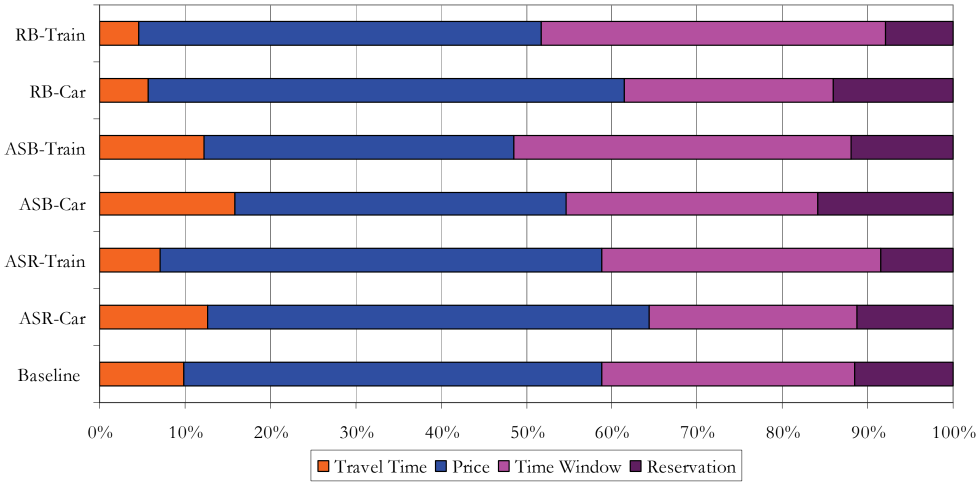

Figure 5-6: Main effects of attributes in segment (subscription pricing experiment)

5.6.2 Switching inertia

Switching inertia occurs for a number of reasons: reluctance to change, habits or preferences for the *status quo*, satisfaction with current service offerings, the lack of real or credible alternatives, and consumer loyalty. To explore consumers' reluctance to change, we compared the *Travel Mode* for the MNL segment models and show the results in Figure 5-6. The inertia increases when consumers travel with low-frequency, by car, and travel between Amsterdam and Breda (A/S-R). We also see that females have higher inertia than males. The results also show that consumers in all segments need to be offered recognizable value to persuade them to consider a new alternative. The combination of the after-sales refund option, time window for the validity of the ticket, and reservation could overcome the segment's switching barriers. Service providers need to reach an *inertia breaking point* to make a business case and encourage consumers not to return to their baseline *Travel Mode*. They also need to reveal their consumer needs-based segmentation map to move forward in developing hyperdifferentiation strategies.

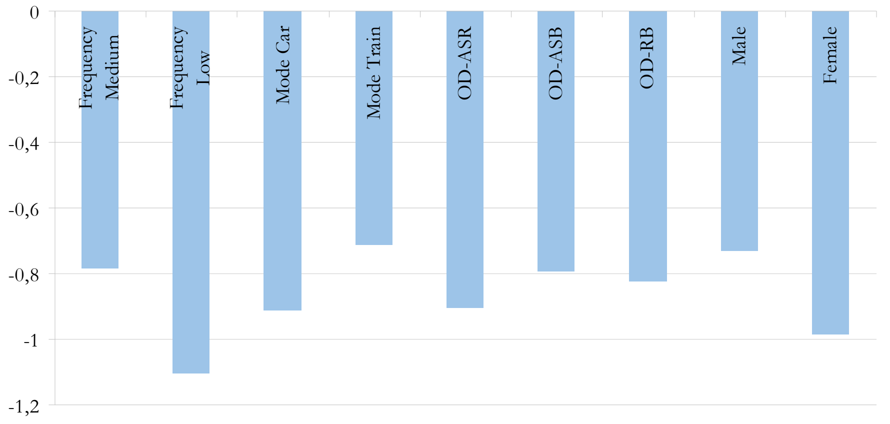

Figure 5-7: Switching inertia

5.6.3 Customer profitability gradient

Our transport market exhibits a strong *customer profitability gradient*, refers to "the presence of extreme differences in profitability between the best and the worst customers in a market" (Clemons et al. 2002a, p. 22). Service providers can take advantage of the customer profitability gradient identified for each of the micro-segment, along the dimensions of travel frequency, origin-destination city-pairs, and current mode of travel that we discussed.

The differences in profitability exist because there is a difference in firms' cost to serve customers (Clemons and Thatcher 2008). In public transport, providing services at peak hours (7-9am and 4-6pm), compared to off-peak hours, is very expensive. If a great difference exists among customers in preferences for departure time, firms can find the customer profitability gradient and focus on serving the most profitable customers during the peak hours and offload the unprofitable ones to the off-peak. We analyzed customer departure time preferences and plotted it by different travel purposes in Figure 5-7.

The results show that 51% of commuters and 41% of business travelers depart from home between 7-9am, whereas 34% of business travelers and 50% of leisure travelers travel right after the peak between 9-11am. The demonstrated large customer differences in travel time provide firms the opportunity to be profitable by reducing costs through lowering peak-load traffic while generating additional revenue.

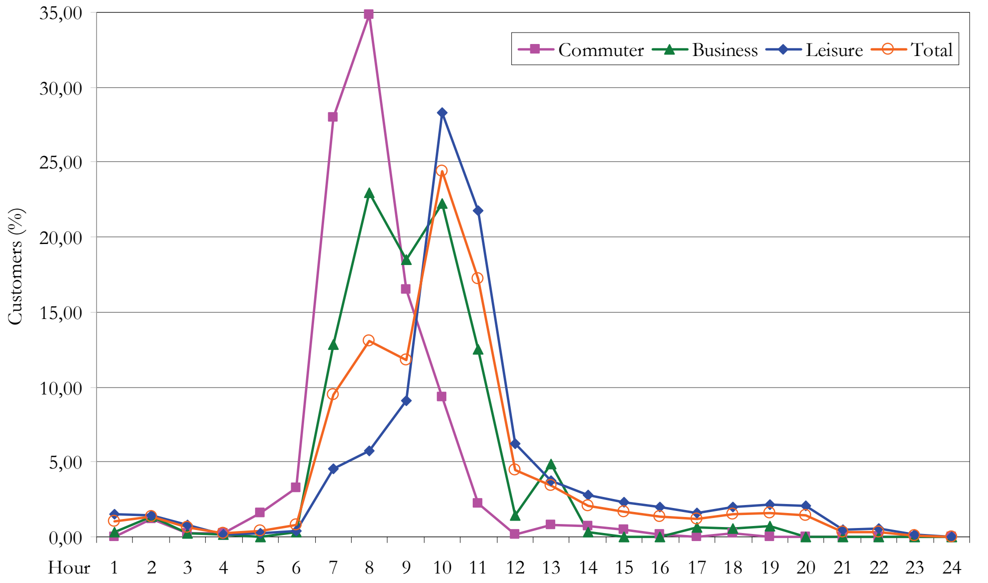

Figure 5-8: Departure time pattern by travel purpose

5.6.4 Elasticity, marginal effects and market share

So far, we have used effects coding for all of the attributes. To calculate performance measures such as market elasticity, marginal effects, and market share for the HST, we need to take into account the actual *Price* (in €) and actual *Travel Time* (in minutes).[28]

Elasticity. *Elasticity* is the relationship between the percentage change of two alternatives. We use a *probability-weighted sample enumeration* to calculate the elasticities for individual decision-makers and weighted them by the decision-maker's choice probability to yield $E^{\overline{P_i}}_{X_{jkq}} = \left(\sum_{q=1}^{Q} \widehat{P_{iq}} E^{P_{iq}}_{X_{ijq}} \right) / \sum_{q=1}^{Q} \widehat{P_{iq}}$, where $\overline{P_j}$ refers to the aggregate probability of choice of alternative *j*, X_{ijk} is the marginal change in the *k*th attribute of the *j*th alternative for consumer *i*, and $\widehat{P_{ij}}$ is an estimated choice probability (Hensher et al. 2005). We calculated the elasticity for the price attribute on the HST alternative equal to 3.65. This

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[28] To use actual price and actual time in model estimation, we eliminated the respondents that reported invalid travel time and included 1,094 respondents in the sample. We focus on train users in the general pricing experiment for the analysis. In the general pricing experiment, there were 369 current train users. This yielded 369 × 15 × 3 = 16,605 observations.

suggests that a 1% increase in the future HST fare will decrease the consumers' probability of selecting the HST alternative by 3.65%. This is an *elastic market*, so price increases lead to less revenue. The firm needs to justify the gain in revenue by any increase in fare and make up for the loss of patronage a fare increase brings. This fare hike increases demand for competing products and services. Direct effect of elasticity for time attribute is -1.81. This suggests that a 1% increase in HST travel time will decrease the probability of selecting the HST alternative by 1.81%.

Marginal effects. *Marginal effects* reflect the rate of change in one variable relative to the rate of change in another variable, calculated as $M_{X_{ikq}}^{P_{iq}} = \partial P_{iq} / \partial X_{ikq}$. Our result suggests that a €1 increase in price for HST will decrease its choice probability by 3.57%.

Market share. We are also able to test the changes in attributes impact on the choice probabilities for each of the alternatives. Halving the HST price will produce an estimated market share for the HST alternative of 81.8%, up from 25.8%, *ceteris paribus*. Doubling the HST price produces an estimated market share for the HST alternative of 0.25%, essentially down to nothing at all.

5.6.5 Consumer heterogeneity in willingness-to-pay

To account for the fact that different consumer have different preference, we use a mixed logit model estimation. A challenge in ML model estimation is selecting the random parameters and their distribution. We specified all parameters as random to accommodate correlations across alternatives and choice sets. First, we assumed that unobserved heterogeneity and preference heterogeneity were normally distributed around the mean.[29] We estimated these random parameters over the sample population using simulated Halton sequence draws with replications from the normal distribution.[30] We compare the results of the ML model with normally-distributed random parameters with the MNL model in Table 5-3.

Model issues. The ML model is statistically significant (χ^2 = 2146.20 with 20 d.f., p = 0.000) and a pseudo-R^2 of 0.224. We used a log-likelihood ratio-test to see whether the ML model fit better than MNL model. The test produces a χ^2 of 45.86 (i.e., -2 (-3,735.13-(-3,712.20))), which is larger than χ^2 = 19.68 with 11 d.f. This suggests the ML model fits

[29] The most popular distributions in ML model are normal, uniform, triangular, and lognormal. The normal distribution provides a good starting point for the analysis.

[30] We started our estimation with ten replications of the simulated Halton sequence draws. We increased the replications to 25, and the model fits better. Further increases to 50 or 100 yielded marginal improvement. Thus, we used 25 replications for our results.

our data better. The mean of each random parameter, β, is the average of the parameters drawn over the 25 replications from the normal distribution. All random parameters are significant at the .01 level except for *Refund Medium*. Among all random parameters, only dispersion (indicated as σ) of *Price* for the HST was significant. It has a standard deviation of 0.064, and a *Wald-statistic* of 5.455 (p = 0.000). Another significant random parameter is *Time Window* (after 9am) with a standard deviation of 0.816 (p = 0.001). This suggests heterogeneity in the parameter estimates over the population around the mean parameter estimate of *Price* and *Time Window*. The insignificant parameters indicate that the dispersion around the mean is statistically equal to 0, suggesting that all information in the distribution is captured within the mean. This is equivalent to treating them as fixed parameters.[31]

Lognormal random parameter estimate. Next, we estimated our model with Price as the only random parameter with a lognormal distribution. There are two reasons for doing this. The first is theoretical. Various studies suggest consumer preferences exhibit a long tail (Anderssen 2006, Clemons and Gao 2008), which is similar to a lognormal distribution. We test whether this characteristic is present. The second is technical. A lognormal distribution limits the parameters to non-negative values. The expectation of Price is negative, of course. Thus, we can force the sign of this parameter by creating a negative of Price parameter and then assigning a lognormal distribution to it in the ML model. The ML model is significant (log-likelihood = -3,719.92***, χ^2 = 2,130.76 with 12 d.f.) and pseudo-R^2 = 0.222, which is a slightly worse fit compared to the same model with a normal distribution. The random parameter Price has a mean and a dispersion that are significant at the $p < 0.001$ level. Our result is robust, and the lognormal distribution does not suffer from the large standard deviation that is generally unacceptable for most of the studies. Specifying a constrained distribution will help to resolve this issue though (Hensher and Greene 2003, Hensher et al. 2005).

[31] We re-estimated the model with only the *Price* and *Time Window* as random parameters, the model has a slightly better fit with log-likelihood = -3,710.537*** (χ^2 = 2,149.53 with 13 d.f.) and pseudo-R^2 = 0.225.

Variables	MNL Model		ML Model	
	Coefficient	Standard Error	Coefficient	Standard Error
$Price_{HST}$ (β)	-0.175***	0.006	-0.269***	0.025
$Price_{HST}$ (σ)			0.064***	0.012
$Price_{Current}$ (β)	-0.217***	0.008	-0.325***	0.031
$Price_{Current}$ (σ)			0.006	0.011
$Time_{HST}$ (β)	-0.033***	0.003	-0.048***	0.006
$Time_{HST}$ (σ)			0.002	0.002
$Time_{Current}$ (β)	-0.036***	0.003	-0.057***	0.007
$Time_{Current}$ (σ)			0.002	0.002
TimeWindow -- All Day (β)	0.249***	0.037	0.402***	0.066
TimeWindow -- All Day (σ)			0.036	0.263
TimeWindow -- After 9am (β)	-0.076**	0.038	-0.140***	0.054
TimeWindow -- After 9am (σ)			0.817***	0.213
Refund -- High (β)	0.287***	0.037	0.376***	0.056
Refund -- High (σ)			0.371	0.228
Refund -- Medium (β)	0.040	0.038	0.066	0.053
Refund -- Medium (σ)			0.014	0.229
Reservation (β)	0.160***	0.025	0.224***	0.037
Reservation (σ)			0.132	0.151
HST 1	-1.452***	0.128	-2.141***	0.293
HST 2	-1.424***	0.129	-2.077***	0.290

Notes: 16,605 obs., MNL Model: LL = -3,735.1***, χ^2 = 1,721.0, 9 d.f., pseudo-R^2 = 0.219. ML Model: LL = -3,712.2***, χ^2 = 2,146.2, 20 d.f., pseudo-R^2 = 0.224. Signif.: = $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$. HST1 and HST2 are alternative product choice specific constants. β indicates the usual estimated coefficient, while σ indicates the estimate of the coefficient of dispersion.

Table 5-3: ML model results with normal-distributed random parameters

Willingness-to-pay. *Willingness-to-pay* in our context is the amount of money a consumer is willing to pay to save a unit of time spent on traveling, or β_{Time} / β_{Price}. In the ML model, β_{Price} is a random parameter. We must construct willingness-to-pay values from lognormal distribution of this parameter. The empirical distribution of individual-level willingness-to-pay is shown in Figure 5-8.

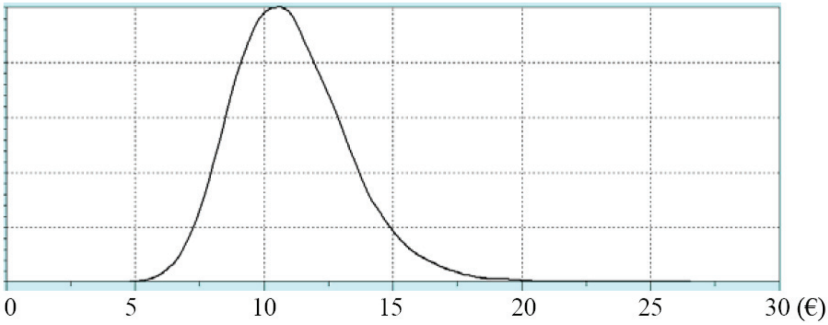

Figure 5-9: The long tail of individual level consumer willingness-to-pay

We can see that most consumers are willing to pay around €11.0 per hour, consistent with the literature (Hensher et al. 2005). Our results demonstrate that fully-informed consumers exhibit great heterogeneity in what they are willing to pay. They are willing to purchase the new product with *Price* ranging from €5.0 to €26.5. It is critical for firms to take into account of this consumers' response toward their pricing and revenue management strategy. Firms that fully exploit this heterogeneity in consumer responses can tailor product offerings to satisfy their individual customers better and generate higher levels of willingness-to-pay. In this situation, firms can create better revenue while consumers simultaneously enjoy higher surpluses.

5.7 Conclusions

Drawing on hyperdifferentiation and resonance marketing theories, this research empirically tests the trading down and trading out behavior in the hyperdifferentiated public transport market. Consumer informedness plays a critical role in determining consumers' willingness-to-pay. With the use of smart cards and mobile devices, service providers are more informed of the consumers individual demand preferences and can therefore better leverage the effective use of hyperdifferentiation and resonance marketing. Based on choice theory and using a stated choice experiment, our study provides an empirical assessment of how service providers can explore the attribute space and design their service offerings to capture the most profitable responses.

Consumers have different values, thus allow firms to differentiate their service offerings along their value dimensions that are attainable. Resonance marketing requires understanding the demand side, so that the firm knows what each customer segment wants to buy, and how much each segment is willing to pay, and can incorporates consumer behaviors into their revenue management decision making. Through consumer informedness, strategies such as resonance marketing can reduce the role of price in consumers' shopping decisions and help the firms to gain sustainable competitive advantage.

Our results suggest there is a *long tail* in consumers' willingness-to-pay in the public transport market. This is an important empirical finding for two reasons. First, we provide evidence to show that consumer preferences are not equally distributed, but instead map to the long tail proposed by Clemons and Gao (2008). This long tail in willingness-to-pay drives the long tail in product sales. Second, the key issue is not about the long tail of the distribution, but rather the long tail of informed consumer choices. Information on service attributes and levels were available to all consumers in our experiment. So they could make informed decisions about what they want and express precisely what they were willing to pay for it. This service choice decision is driven by the enhanced information endowment.

The ML model offers the ability to determine the sources of heterogeneous consumer preferences. We further tested three different covariates as sources of heterogeneity related to Price. The origin-destination city-pair is an important source of preference heterogeneity. We also see that the number of interchanges that occur due to the introduction of the new HST is another source of preference heterogeneity for price. Consumers that have to make more interchanges for making the use of HST services for part of their journey are more sensitive to price changes. This result suggests that having a true origin pickup-destination delivery service will be appeal to some. A third source comes from payment ownership. Many commuters and business travelers in our study can have their travel expense reimbursed by their employers. Our results show that those who pay on their own are more sensitive to price changes. So the HST service provider should consider establishing strategic partnerships with major employers to help subsidize employee travel funding so that their additional HST costs can be covered.

Chapter 6 Informedness Through Learning and Customer-Centric Revenue Management

6.1 Introduction

The objective of this chapter[32,33] is to better understand, in an environment with increased firm and consumer information, how firms can exploit their service attribute space to create alternatives that profitably influence consumer choices and capture the most profitable consumer responses, where both revenue production and capacity utilization are considered. We develop a theory-based re-conceptualization of the process of customer-centric revenue management to provide a basis for integrating service attribute bundling and capacity management.

With the increased availability of information, firms are able to understand more about consumer demand and make better-informed decisions on the design of customized products and service offerings for specific consumer segments. The traditional approach to product design involves targeting the mass market to attract the largest number of consumers. Today though, firms are designing and differentiating their services for a smaller number of consumers. They are willing to pay more for what they buy, and benefit from product and service offerings that represent the long-tail of consumer demand (Anderssen 2006, Clemons et al. 2006, Clemons 2008, Clemons and Gao 2008). To tailor services that suit these small groups of consumers, firms need to understand the heterogeneous preferences of consumers in their markets. Products and services can be described as a bundle of attributes or features. For example, an airline ticket consists of price, an origin-destination city-pair, departure and arrival times, service class, and various ticket exchange and refund options. Some of these service attributes

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[32] This chapter is based on Kauffman, R.J., Li, T., van Heck, E., and Vervest, P. 2008. Integrating and Jointly Optimizing Service Attribute Bundles and Capacity Management in Service Systems. Paper presented at the *Eighteenth Annual Workshop on Information Technologies and Systems*, Paris, France. 2008.

[33] An earlier version of this chapter has appeared as Li, T., van Heck, E., Vervest, P., Voskuilen, J., Hofker, F., and Jansma, F. 2006. Passenger Travel Behavior Model in Railway Network Simulation. In Perrone, L.F., Wieland, F.P., Liu, J., Lawson, B.G., Nicol, D.M. and Fujimoto, R.M. (ed.), *Proceedings of the 38th Conference on Winter Simulation*, Monterey, CA, USA.

cost more to produce and others less. For example, there are natural differences in passenger load factors based on the day of the week. As a result, it usually costs more for the airlines to serve customers who travel during the weekend, than Tuesday to Thursday. The question is: How do firms design their service offerings to capture the most profitable consumer responses, considering the revenue generated from consumer demand as well as capacity management concerns? Previous research asserted that "there has been very little published research on joint capacity allocation and pricing decisions in the revenue management context" (McGill and van Ryzin 1999, p. 244).[34]

We will use the *rational expectations theory* (Muth 1961, Lucas 1972, Lucas 1975) and the *adaptive learning theory* (Sargent 1993) to examine the value expectations formation of public transport service providers when they make revenue management strategy decisions. These theories allow us to treat pricing and revenue management decision making over a longer time horizon spanning multiple forecast periods and permitting optimization of cross-business process activities.

The revenue management literature[35] suggests that most revenue management systems have been based on a *product-oriented approach*, where demand is modeled as a series of requests for a product (Talluri and van Ryzin 2004b, van Ryzin 2005). In contrast, there is an emerging stream of research that suggests a need to shift from models of product to models of consumer behavior (Talluri and van Ryzin 2004a, van Ryzin 2005). This *customer-centric approach* requires an understanding of what influences consumer choice and how decisions are made. Demand is modeled as a series of requests for a service. This contrasting view challenges the thinking of senior managers. They should not ask: "How many customers should we accept or reject?" Instead, they should ask: "Which alternatives should we make available to consumers to profitably influence

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[34] Revenue management includes capacity management, pricing, and reservation control (Weatherford and Bodily 1992, McGill and van Ryzin 1999, Talluri and van Ryzin 2004b). A study on a joint pricing and inventory control analysis for the newsvendor problem can be found in Lau and Lau (1996). A more general treatment of price and capacity for profit maximizing firms is provided by Gaimon (1988).

[35] A taxonomy of revenue management and more general perishable asset revenue management problems is provided in Weatherford and Bodily (1992). Some discussion on the recent development of revenue management can be found in (McGill and van Ryzin 1999, Boyd and Bilegan 2003, Geoffrion and Krishnan 2003a, 2003b, Fleischmann et al. 2004). There are relatively few studies that consider consumer behavior in the study of revenue management, with just a few exceptions, including Talluri et al. (2004a) and Garrow et al (2007). Garrow and Koppelman (2004) examine multinomial and nested logit models of airline passengers for no-show and standby behavior. Studies on revenue management in the railway industry are also rare; a couple exceptions are Ciancimino et al. (1999) and Kraft et al. (Kraft et al. 2000).

the choices they make? This shift requires changes in a firm's marketing and operational strategies, and in product development and positioning too.

We employ a multi-method research design (Brewer and Hunter 1989). We use a *stated choice experiment* to examine consumer behaviors toward service attribute bundles[36,37,38] and estimate their willingness-to-pay. To demonstrate the efficacy of the customer-centric approach, we develop an *agent-based simulation* based on the activity-based theory to model consumer travel behavior and evaluate performance impacts of service attribute bundles. This multi-method approach combines the advantages of modeling consumer demand at a disaggregated level with the ability to integrate it with the optimal management of operational capacity to evaluate the impacts of service attribute bundle design strategies over time and space. Our research effort is in line with the claim of McGill and van Ryzin (1999, p. 244) "The most promising direction for improvement of forecasting accuracy is in detailed empirical studies of the behaviors of different passenger types in response to changes in fare product offerings."

The remainder of this chapter is organized as follows. We first discuss the theories of rational expectations and adaptive learning that shape our view, and propose the customer-centric approach for revenue management. Next, we explain the research methods, including our modeling effort, the stated choice experiment, and the simulation design. Subsequently, we present the econometrics analysis of the experiment results and the performance evaluations of a number of service attribute bundle designs using our

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[36] Dating back to Stigler (1963), economists have long known that bundling can be an effective way for a multiproduct monopolist to increase profits when it has limited information about individual consumer preferences. This is because bundling reduces heterogeneity in consumer valuation, enabling a monopolist to price discriminate better, while still capturing residual demand. Other work has extended the bundling literature to consider multiple goods as well as multiple consumer types (Armstrong 1996). In the last decade, interest in bundling strategies has increased, especially in the sales of information goods (Bakos and Brynjolfsson 1999, Bakos et al. 1999, Bakos and Brynjolfsson 2000, Hitt and Chen 2005).

[37] The present bundling literature has so far focused on bundling of different products, rather than on the bundling of different service attributes. Knowledge of consumer willingness-to-pay is critical in deciding which attributes should be included and what the impacts of various marketing strategies will be. The literature on choice theory and consumer preferences can aid us to understand this.

[38] Another relevant concept to our service attribute bundling is hedonic pricing. *Hedonic prices* are estimates of the value that different product aspects contribute to consumer utility or pleasure. According to Berndt (1991, p. 117), "implicit in the hedonic price framework is the assumption that… a particular commodity can be viewed as consisting of various … bundles … of a smaller number of characteristics or basic attributes. … [T]he *hedonic hypothesis* is that heterogeneous goods are aggregations of characteristics. Moreover, implicit marginal prices of the characteristics can be calculated as derivatives of the hedonic price equation with respect to levels of the characteristics." Brynjolfsson and Kemerer (1996) use a *hedonic model* to estimate the influences of network externalities, standards, features and time trends on the prices of microcomputer spreadsheet software.

simulation. Finally we develop a number of propositions and conclude this chapter with an assessment of the theoretical perspectives and a discussion on the multi-method approach.

6.2 Rational Expectations and Adaptive Learning

We formulate the basis for using the theory of rational expectations to explain the revenue management strategy-setting behavior of service providers and the related formation of the expectations in their decision making, especially as it relates to prices. By allowing learning to take place in the managerial environment of revenue management decision making by assumption (as is no doubt true in the real world), we are able to use another related theory, *adaptive learning theory*, to examine how service providers reach a certain level of expectations about the performance improvement over time that is associated with price-setting in an environment of constrained schedules and capacity.

Rational expectations. The *theory of rational expectations* was first proposed by Muth (1961) and is now recognized as a seminal work from the early 1960s. The ideas have been used to describe many economic situations where the outcome is influenced partly by what people expect to happen. Muth (1961, p. 316) states that "expectations … are essentially the same as the predictions of the relevant economic theory." The theory of rational expectations suggests that economic agents will base their expectations and subsequently make their decisions on the "true" structural model of the economy. Muth demonstrates that these expectations are the same as the conditional mathematical expectations based on the "true" probability model of outcomes in the economy. The subjective expectations are related to past information available to firms and are informed predictions of future events. There are two assumptions on which the theory of rational expectations is based. First, economic agents form their beliefs based on a given set of information. And second, their expectations will be conditioned on all available information. Lucas (1975) interprets the main premise of rational expectations as reflecting the idea that every economic agent optimally utilizes available information in forming expectations.

The Nobel Laureate in Economics, Robert Lucas also contributed several seminal papers (1972, 1975) that pushed the theory of rational expectations to the forefront of current economic thought in the 1970s (Sheffrin 1996). Through his work and the work of others, the theory has been popularly applied in various applied contexts. They include: developing an understanding of output and inflation in macroeconomics (Lucas 1972, Lucas 1975, Sargent and Wallace 1976); IT investment and technology adoption (Au and

Kauffman 2003, 2005), product diffusion of durable goods (Narasimhan 1989), monetary policy and labor contract (Fischer 1977), and financial market forecasting (Caves and Feige 1980, LeBaron et al. 1999). According to rational expectations theory, negotiations between workers and firms will be influenced by the expected level of inflation, and the value of a share of stock is dependent on the expected future income of that company that is represented by the stock in the financial markets. The well-known efficient market hypothesis also uses the theory of rational expectations as one of its bases (Caves and Feige 1980). The theory suggests that economic agents act upon information available to them, exploit all profit opportunities, and then develops trading rules that reflect all available information that would enable a financial investor to earn excess profits.

Service providers form their new revenue management strategy based on a given set of information, including the demand information, supply information, and performance information. Rational expectations theory assumes that service providers' expectations in the context we are studying will be conditioned on all available information and will be in synch with the optimal forecast, as the best guess about the future is based on the use of all available information. The related performance outcomes depend on what service providers expect to happen in their operating environment or the expectations they have about the efficacy of the new revenue management strategies they deploy. In forming their expectations, service providers try to forecast what will occur based on information that allows them to achieve higher profits. The price levels they select for the service attribute bundles they make available will be influenced by the expected level of demand, the schedules they can achieve and the capacity utilization they believe will materialize.

Adaptive learning. Rational expectations theory is based on a very strong assumption, which requires economic agents to have full knowledge of the structure of the relevant models and their parameter values. This has been pointed out by a number of studies, which various authors have argued may be too strict (Sargent 1993, Au and Kauffman 2003, 2005). Instead, based on a weaker assumption of prior knowledge and information, an alternative perspective called *adaptive learning*, has been suggested by Sargent (1993). With a basis in the idea of *bounded rationality* of Simon (1957), adaptive learning assumes that economic agents initially may not know the exact information they need to predict outcomes in the economy. Nevertheless, they are willing and able to learn over time, and as a result they are also able to update their expectations about relevant parameter values on the basis of newly-received information.

Adaptive learning suggests that service providers can utilize available decision-related information efficiently, and learn the true value of an appropriate revenue management strategy over time to meet their objectives. Because service providers have limited cognitive resources and organizational information processing capabilities, it typically is hard for them to obtain a solution that deals with all of the information that is available. By allowing learning on the part of managers to take place over time, the adaptive learning perspective permits service providers to increase the likelihood of obtaining nearer-to-optimal joint pricing and capacity solutions. This means if service providers do not know the true demand model, through the use of available information, they will learn over time about the parameter values they need to more fully understand. As a result, their expectations will become nearly identical to those that reflect the parameters of the "true" model, and make better future demand and performance forecasts.

This process involves a longer time horizon and a multi-period decision making setting. We can think of this in terms of the following five steps. First, service providers will collect information for a number of performance indicators of the current situation (e.g., revenue, capacity utilization, customer volume) against their previous levels of performance. Second, they will collect new information regarding consumer willingness-to-pay under the revenue management strategy that is specified earlier. Third, they will analyze the new consumer willingness-to-pay information against their current pricing choices, attribute bundles for services, and capacity utilization. Fourth, they will adjust their pricing and revenue management strategies based on the new information they receive. Finally, they will further adjust their expectations about the future demand forecast, the efficacy of their pricing and service attribute bundle choices, and see what comes out in terms of business performance. Typically, the process will be iterative in that service providers will go back to the second step, and collect more new information, and see what further adjustments are appropriate.

This process will not finish until all interested customers are able to purchase the travel services that maximize the value they take away based on what they receive in return. This is synonymous with what is called a *rational expectations equilibrium,* a state within which the service providers will have no additional incentives to adjust the joint pricing-capacity strategy to improve potential benefits.[39] This decision and learning process involve an ongoing process and usually span a longer time horizon. Information on prior performance indicators serves as continual feedback to current expectations.

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[39] A *rational expectation equilibrium* is defined in terms of two functions. One is concerned with the selling strategy of a monopolist, which maximizes the present discounted value of profits, given the price and purchase expectation function associated with potential buyers. The other one describes how the buyer's expectations are fulfilled relative to the realized path of production of products or services (Stokey 1981).

Through learning, service providers are able to eliminate errors from their decision rules and can adjust their forecasts to begin to understand the basis for perceiving more stable (or at least recognizable) patterns in the future.

6.3 The Customer-Centric Approach

Next we will explain in theoretical terms why the dominant product-oriented approach of the past is now rapidly becoming inappropriate and why the customer-centric approach that we have proposed offers opportunities for future innovations in revenue management. We will also discuss what this means in the public transport industry. For example, we will explain why the so-called *four-step model* in demand forecasting in transport industry is inappropriate. We will also consider why there is a need to shift to *activity-based demand modeling*. Finally we will discuss the role of simulation methods in order to establish some exploratory and indicative results to illustrate the benefits of our approach.

6.3.1 From product to customer-centric revenue management

Product-oriented revenue management. A growing body of research notes that most of the revenue management systems so far have been based on independent demand models (Talluri and van Ryzin 2004a, van Ryzin 2005, Riddell 2006). Demand is modeled as a series of requests for a product or a service. These requests are independent of the service attributes and the alternative services that a firm offers (van Ryzin 2005). This is also reflected by the data collection of modern firms. As an example, airlines have so far mostly collected data on product level, either origin-destination itinerary or booking classes. There are two limitations to this approach. First, the product-oriented approach does not acknowledge the influences of other alternative services and other attributes of the alternative services that consumers may choose in lieu of the focal service offered. For example, a customer's choice of buying a business-class airline ticket for a specific origin-destination city-pair depends largely on the price of the business-class ticket. However, at the same time, this decision is also influenced by the fares and the restrictions of the tickets of other classes that are available to this customer at the time of purchase. Second, the product-oriented approach overlooks the fact that buying a service is a consequence of a series of purchase decisions. Firms need to know not only what customers finally will buy, but also they need to have the capability to learn what customers intend to buy, what alternative services are available to them, when and how frequently they will buy them, and how much they are willing to pay.

Customer-centric revenue management. The new *customer-centric approach* to revenue management requires a shift from models of product demand, which is simplified as a series of product requests, to models of customer behavior, which requires an understanding of what influences consumer choice and how their decisions are made (van Ryzin 2005, Riddell 2006). It has become critical for firms to incorporate consumer behavior in their next generation of revenue management systems. This customer-centric modeling approach starts with modeling the choice decision of a customer at a particular point in time. A *choice decision* is typically composed of three elements: a decision maker, a set of alternatives, and a decision protocol. A *decision protocol* refers to the generation of a *choice set* selected from a *universal set*, and a choice that is selected from the choice set. Several authors have pointed out the importance of adopting a customer-centric approach (Garrow and Koppelman 2004, Talluri and van Ryzin 2004a, van Ryzin 2005, Riddell 2006). See their quotes in Table 6-1.

Author(s)	Quotes about the need for customer-centric revenue management approach
Garrow et al. (2004)	"Ironically, few airlines use passenger data or directional itinerary information in forecasting models…"
van Ryzin (2005)	"To overcome the limitations of revenue management current demand models, then, requires thinking of customers as the fundamental unit of demand."
Riddell (2006)	"And now, the traditional practice of revenue management … has to change with the times. What's needed is a shift from an inventory focus to a customer focus."
Westermann (2006)	"Airlines are aware that the assumption of class independence of demand was artificial and not really appropriate …"

Table 6-1: Quotes about the need for customer-centric revenue management approach

We compare the difference between the product-oriented approach and the customer-centric approach in Table 6-2.

Characteristics	Product-Oriented Approach	Customer-Centric Approach
Modeling focus	Product-oriented modeling	Customer-centric modeling
Model of demand	Independent demand models: demand is modeled as a series of requests for a product and independent from the market environment	Models of customer behavior: what influences customers' choice and how the decisions are made
Revenue management principle	Accept/reject customers' product requests	Create alternatives to profitably influence customers' choices
Data collection requirement and use of technologies	Traditional survey method is mainly used to collect product level data	Emerging technologies (e.g., Internet, GPS) that support the collection of micro-level customer behavioral data
Use of simulation	Analytical method are predominant and simulation is generally in an aggregated demand level	Simulation is possible in a disaggregated and individual customer level

Table 6-2: Product-oriented approach and customer-centric approach for revenue management

6.3.2 The four-step and activity-based models of demand

We now explain why we need to shift from product-oriented modeling to customer-centric modeling to improve the effectiveness of revenue management in the public transport industry. Until now, travel demand in this setting has largely been forecasted based on deterministic models that consist of four aspects of daily travel: the number of trips, the origin and destination of the trip, the mode of travel, and the route of travel. This is the *four-step model* (Ben-Akiva and Lerman 1985). The first step is *trip generation*. It determines the frequency of origins or destinations of trips in each zone by trip purpose, as a function of land uses and household demographics, and other socio-economic factors. The second step is *trip distribution*. This matches origins with destinations, often based on *gravitational model* function. The third step is *mode choice*. This computes the proportion of trips between each origin and destination that uses a particular transportation mode. This final one is *route assignment*, which allocates trips between an origin-destination city-pair to a particular mode of travel.

We find two main pitfalls of this four-step model that make it inappropriate. First, the four-step model is *customer-independent*. In the four-step model, each trip is analyzed independently from the other trips made by the same individual. Thus, a journey that consists of several trips cannot be identified and associated with the customer who made this journey. Hence, the customer, who is essentially affected by revenue management strategy, "disappears" in this modeling approach. Second, the four-step model is *time-independent*. Demand generation in the four-step model results in a passenger flow between an origin-destination city-pair over a day or a year, and thus decouples the model from the time-of-day. The drawback of this decoupling is that the impacts of pricing strategies that involve time-of-day-differentiated pricing cannot be modeled effectively.[40] Furthermore, the customer-independent and time-independent character of the four-step model negatively affects the forecasting accuracy. This is critical to effective infrastructure capacity planning. Another study by Flyvberg et al (2006) has reported that a large number of such forecasts tend to be highly inaccurate: "for nine out of ten railway projects passenger forecasts are overestimated; the average overestimate [of demand] is 106%. For 72% of rail projects, forecasts are overestimated by more than two-thirds."

The development of the activity-based model provides an alternative approach (Chapin 1974, Miller 1996, Bowman and Ben-Akiva 1997, Kitamura et al. 2000). The *activity-based model for demand estimation* is based on the activity and travel demand theory (Miller 1996, Bowman and Ben-Akiva 1997). It overcomes the problem inherent with the four-step model, where demand is forecasted in isolation from the consumer behavior. This other approach assumes that the demand for travel is derived from the demand for performing activities (e.g., having to be at work, meeting someone at the theater in the evening, going on a weekend trip with your family, etc.) at specific times and locations. So travel demand is a result of different decisions that are made by individuals. These different decisions include household and individual decisions, mobility and lifestyle decisions, activity scheduling decisions, and implementation and rescheduling decisions (Ben-Akiva and Lerman 1985). The activity-based model is seen as a preferred method for travel demand forecasting when there is a willingness to consider the organization of human activities in time and space (Kitamura et al. 2000).

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[40] The following pricing-related research in the public transport industry provides a good overview of some of the related issues that have been studied. For example, the concept of a "travel card" in public transport is discussed in White (1981). Consideration of the theory and practice of pricing in railway passenger transport can be found in van Vuuren (2002). *Time-based zone pricing* for public bus systems has been investigated in Philips et al. (1999). *Route-based differentiated pricing* of Mass Transit Railway in Hong Kong was studied in Li et al. (1994). *Direction-dependent prices* in public transport is examined in Rietveld et al. (2002). The impact of alternative fare structures on train overcrowding can be found in Whelan et al. (2004). And demand and revenue implications of an integrated public transport policy in Madrid, Spain is examined in Matas (2004).

6.4 Integrating Service Attribute Bundling and Capacity Management

We now develop a theoretical model that integrates and optimizes service attribute bundling and capacity management so that we are able to jointly treat service revenues and operating capacity in terms of available seats.

6.4.1 Service attribute bundling

Choice theory suggests that the value of different service attribute can vary dramatically from one person to the next. A viable strategy to set prices is according to the value a customer places on the service attribute information. One way to do this is to offer the attribute in different levels designed to appeal to different types of customers. By doing this, customers make their own decisions about how to segment themselves. The service attribute level they choose reveals the value they place on the level. This allows firms to gauge a consumer's willingness-to-pay for a specific bundle of non-price attributes. To distinguish the differences in services, firms need to determine which service attributes or features will be highly valuable to some customers but of little value to others. Then they need to create the capability to deliver the right attributes and set appropriate prices for them. The goal is to get each customer to pay the highest possible price for the service, thus maximizing the overall revenue. This provides a way to serve the larger market because the firm tailors the same service core to the needs of different buyers.

6.4.2 Service choice model specification

Based on the random utility model, in our modeling effort, we assume that customer i will select service j from all alternative services only if this service maximizes his utility or minimizes his disutility. Since we cannot directly observe the utility offered by each service to each customer, we assume that the customer's utility of a service is a function of the observable service attributes. Mathematically, the utility U of the customer i selecting service j can be written as: $U_{ij} = \beta_i X_{ij} + \varepsilon_{ij}$. In this expression, X_{ij} is the vector of the observable service attributes of service j from the perspective of customer i, and β_i is the vector of estimated coefficients. The latter weights the importance of different service attributes such as price and restrictions on travel times. ε_{ij} represents the utility differences that result from all of the unobservable factors, and is similar to the error term in an econometric estimation model. The distribution of the stochastic part ε_{ij} is assumed to be independently and identically distributed. The service j is selected by customer i if and only if $U_{ij} > U_{im}, \forall j \neq m$.

Each service is defined by its attributes, which contribute to the total utility of that service. These attributes can be grouped into *price* P, *service amenities* S, and *restrictions* R. Service amenities refer to the positive attributes related to the quality of service received by the customer with the service purchase. In the railway industry, service amenities include preferred seat reservations, Internet access onboard, the availability of a travel lounge, and combined train-and-taxi door-to-door service. The restrictions refer to the negative attributes of the service, including the time restrictions of the ticket, the required advanced booking, and cancellation and refund limitations. Thus, the utility for customer i from transport service j can be represented by its generalized cost to the customer, or in disutility terms related to some baseline value, in the general functional form

$$U_{ij} = f(X_P, X_S, X_R).$$

We can therefore calculate the predicted probability of a customer i who chooses a particular service j out of J available services by using

$$\Pr_i(j) = \frac{\exp(\beta_i X_{ij})}{\sum_{j=1}^{J} \exp(\beta_i X_{ij})}, \text{ for } j = 1 \text{ to } J.$$

Here, β is a parameter indicating the *utility-modifying effect* of independent variable on the probability of choosing one over another. To take into account service alternative-specific variables X_{ij} and consumer-specific variables Z_i, such as an individual's trip duration, travel purpose, origin-destination, and demographical information, we use a multinomial logit (MNL) model (Ben-Akiva and Lerman 1985, Train 2003). Its functional form is given by:

$$\Pr_i(Y_j = 1) = \frac{\exp(\beta_i X_{ij} + \gamma_j Z_i)}{\sum_{j=1}^{J} \exp(\beta_i X_{ij} + \gamma_j Z_i)}$$

where β_i indicates the separable effect of a service alternative-specific variable on the probability of a consumer choosing one service over another. The γ_j coefficients capture the effects of service j relative to the base service.

The ideal situation for a service provider is to provide services that give the highest utility to the consumers and create the highest satisfaction. However, this is far from being realistic in a capacity-constrained industry such as the public transport industry.

The capacity constraints limit the service provider's ability to provide transport service supply to the level that consumers demand. We now look at how the consumer choice model can be integrated into service provider's overall objective where the cost of supply is also considered.

6.4.3 Joint optimization of service offerings and capacity management

In the public transport industry, the goal of the service provider is to use the set of transportation network resources to provide efficient transport services. The objective is to maximize total social welfare – not profit. This is the primal problem in this context. A second objective consistent with the first is to minimize total cost, while making sure that the provision of acceptable services to the public is always above a pre-specified level. We refer to this as the dual problem, since solving it usually involves simultaneously providing a solution for how to maximize total social welfare. In this context, peak loading has long been a problem for service providers though. They are fully of the need to reduce peak travel requirements and increase capacity utilization across their entire service schedules (Abkowitz 1981). Peak demand train capacity is expensive to provide due to the peak-load requirements, and train mobility is restricted due to congestion problems on the road. The peak-demand time-generated revenues typically do not cover the costs of peak-demand time service provision. It is inefficient to increase capacity to meet this demand when the overall peak capacity is adequate. To minimize the total cost, transport service providers want to spread the demand during the course of the day.

Traditional pricing schemes provide no incentive to passengers to change their time of travel, other than the level of crowding that they encounter. This means that some time-constrained customers are forced to endure uncomfortable conditions. In general, demand for the railway transport during the peak hours is relatively inelastic, while the demand for off-peak is elastic (van Vuuren and Rietveld 2002). Motivation plays an important role for this. Travelers, in particular commuters and business travelers, usually do not have many alternatives and cannot easily switch to other modes of transport or other departure times or another route. This is often possible for leisure travelers, of course. This results in relatively low price elasticity of demand during the peak hours. The objective of demand management is to persuade (at least) some less time-constrained travelers to change the time of their travel – either earlier or later –to relieve peak-demand time crowding. Customers self-select their preferred services based on their departure time flexibility. Giving discounts to travelers during the uncongested off-peak times may yield much less opposition than an extra punitive fare for peak-hour travelers. In this context, it is a service provider's responsibility to design new service offerings with attractive non-price attributes that will persuade consumers to change their travel behavior in a manner that the transport firm desires.

In time-based price differentiation, for each time period t, the associated revenue from each consumer segment i is R_{it}. Here i indicates a consumer group where the consumer preference is rather homogenous. This consumer group can be very small and can extend all the way to the individual level. The segment revenue R_{it} is derived by multiplying the price level of the service at time period t, P_t, by consumer segment demand D_{it}, so that $R_{it} = D_{it} \bullet P_t$. D_{it} is a function of service *price* P_t, *service amenities* S_t, *restrictions* Rs_t, and *consumer-specific variables* Z_i, that is $D_{it} = f(P_t, S_t, Rs_t, Z_i)$. The cost of producing services is influenced by a number of factors such as schedule constraints, physical constraints, and control policies. It varies by different time-of-day and is denoted as C_t. To calculate the profit at each given time period t, we sum the revenue of each consumer segment and subtract the service production cost at time period t. Hence, the objective of the firm is to maximize the total profit by summing up all the periods of the profit over a time horizon of T:

$$\text{Maximize } \sum_{t=0}^{T} \left(\sum_i f(P_t, S_t, Rs_t, Z_i) \bullet P_t - C_t \right)$$

subject to $0 \le P_t \le P_{\max}$ with $t = 1, 2, 3, \ldots, T$ and $i = 1, 2, 3, \ldots, I$

In this maximization function, T is 24 hours for one day of operations, I is the total population, and P_{max} is the maximum price that the service provider can charge for a given service.

In other words, the objective is to maximize revenue subject to being able to produce the level of capacity that will permit the service provider to have the feature bundle tickets to service the amount of demand. The level of the utility that firms can achieve is constrained. It is too expansive to produce enough capacity to accommodate the peak-demand. On the other hand, if service providers produce too little capacity, it will not be sufficient to meet the revenue opportunities with service production. It is important to understand *shadow price*, which is the change in the objective value of the optimal solution obtained by relaxing the constraints by one unit. This is the maximum price that service provider is willing to pay for an additional unit of capacity. If the shadow price is greater than the value of the change in the consumer welfare, then the service provider will wish to build additional capacity to increase services.

Providing customers with services involving attribute bundling, if the features are carefully chosen, will attract and possibly even delight customers. However, the capacity constraints that service providers face also need to be taken into account. Service providers need to recognize that there is a cost side of the equation when they attempt to maximizing customer utility and willingness-to-pay in transport service revenue terms. Maximizing profit is optimal as a first-best solution, since it achieves the optimal utilization of the transport system by changing user behavior to behavior that is considered to be optimal based on the perspective of welfare of the transport system. More important, according to the revenue management literature, is to study consumer behavior and estimate the impact of consumer decisions on firm demand, revenues, and operations. By monitoring how the market reacts to new service offerings, firms can gain insights into how they value new service attributes. This allows firms to continually refine their service designs for high profitability, to satisfy customers at certain levels while minimizing their cost function. It is important, in this context to evaluate three demand effects: *customer volumn*, *revenue*, and *capacity utilization*. Managers can then decide with confidence whether to use passenger volume maximization, revenue maximization or load maximization when they adjusting service offerings. The process is illustrated in Figure 6-1.

6.5 Methodology

6.5.1 The stated choice experiment

We will explain our stated choice experiments in the following three phases: the identification of determinant attributes and specification of attribute levels; the experimental design; and the presentation of the experiment to the study participants.

Identification of determinant attributes and specification of attribute levels. To make the stated choice experiment approach as effective as possible, it was necessary to minimize the number of attributes to mitigate the cognitive requirements of a choice task: only the most important attributes could be included. The final set of selected service attributes are: *Price* (€), *Time Window* (AM and/or PM) and *Usage Restriction* (number of days).

Experimental design. Once the attributes and levels were finalized, the number of choice sets and the number of alternatives in each choice set had to be specified. The design of the attribute levels, as illustrated in Table 6-3, is based on current operations and internal discussions with the research sponsor's staff. All of our experimental designs are orthogonal, and all used standard fractional factorial designs as their starting points (Louviere et al. 2000).

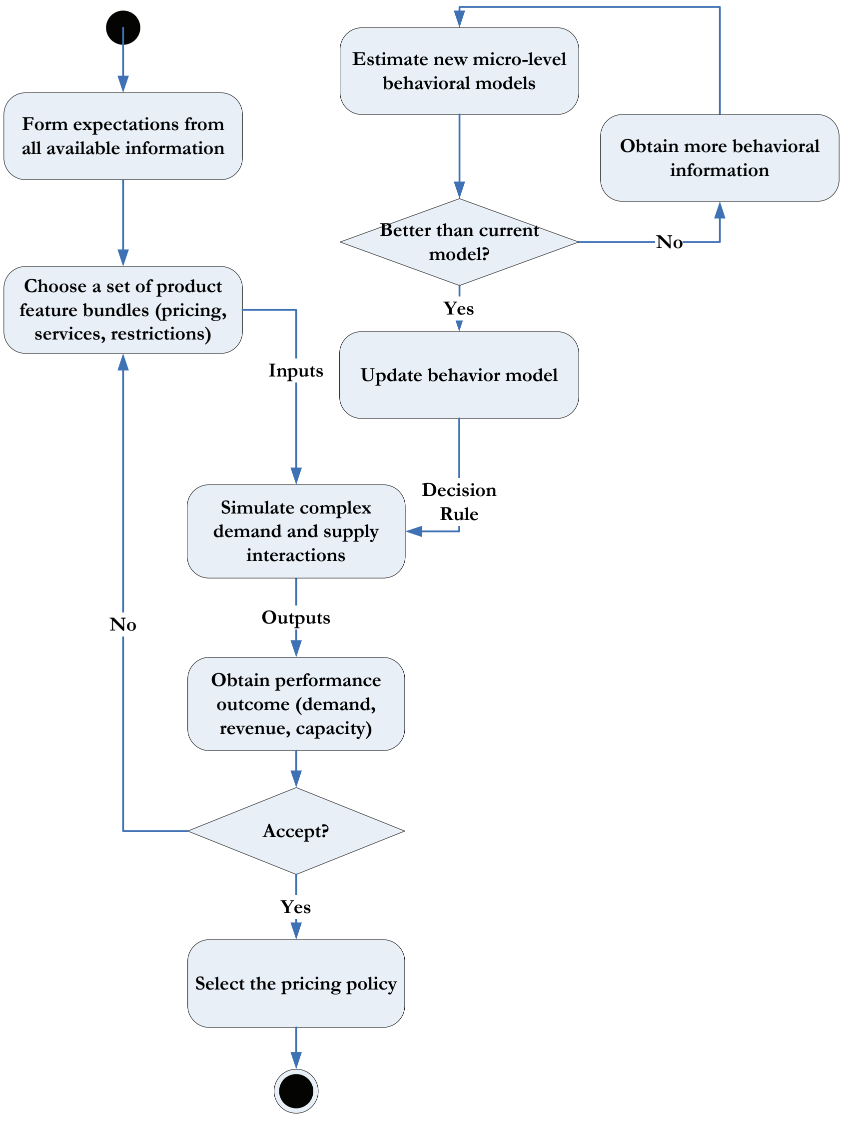

Figure 6-1: A flow chart of joint optimization of service attribute bundling and capacity management

Presentation of the experiment to study participants. The survey questionnaire consists of three parts. The first part includes questions on respondents' travel behavior, their travel purpose, travel distance, product ownership, travel frequency, etc. The second part includes three choice experiments. Depending on the product ownership that respondents specified in the first part, the respondents are directed into three experiments: a *subscription experiment* (for subscription users), a *discount card experiment* (for discount card users), and a *single ticket experiment* (for single/return ticket users). Each respondent is presented with eight choice sets. A sample choice set in the subscription pricing experiment is in Table 6-4. Each of these choice sets consists of two alternative services. Service A is a more expensive service without restrictions, and Service B is a less expensive service with restrictions on time validity and maximum usage. The start and end of the validity of AM and PM time periods were varied independently around the reference times of 8am and 5pm. The respondent can choose either of these two alternatives or choose the option of not taking the train. The third part of the survey centered on the acquisition of demographic information: age, gender, educational level, car ownership, and employment status.

Attribute	**Definition**	**Levels**
Price	Subscription service price	• Level 1: X_1 more than now • Level 2: X_2 more than now • Level 3: X_3 more than now • Level 4: X_4 more than now
Usage restriction	# days allowed to use the subscription service	• Level 1: Unlimited usage • Level 2: Up to 5 days a week
Time Window – AM Peak Start	The starting time of the AM peak	• Level 1: 06:30 • Level 2: 07:00 • Level 3: 07:30 • Level 4: 08:00
Time Window – AM Peak End	The ending time of the AM peak	• Level 1: 08:00 • Level 2: 08:30 • Level 3: 09:00 • Level 4: 09:30
Time Window – PM Peak Start	The starting time of the PM peak	• Level 1: 15:30 • Level 2: 16:00 • Level 3: 16:30 • Level 4: 17:00
Time Window – PM Peak End	The ending time of the PM peak	• Level 1: 17:00 • Level 2: 17:30 • Level 3: 18:00 • Level 4: 18:30

Notes: The levels of the *Price* attribute (X) are disguised, but still will give the reader a sense of the relationships that we are exploring in this study.

Table 6-3: Attributes and levels of the time-differentiated stated choice experiment

Travel Service Attributes	Service A	Service B
Price	€56	€45
Time window	Entire day	Not valid between 7:30-9:00 and 16:00-18:30
Usage restriction	Unlimited	Maximum five days a week

Given these choices, which service would you choose?

1. Choose A.
2. Choose B.
3. Don't buy any of these services.

Table 6-4: A sample choice set in a time-differentiated stated choice experiment

6.5.2 Behavioral revenue management simulation

Transport networks, particularly in metropolitan cities or more so on a country-wide scale, are complex systems that often involve several thousand passenger vehicles and millions of passenger journeys. The related networks are composed of a large set of stops and stations, and lines and tracks. Considering the complexity of such a system, we have chosen to use simulation to study the demand effects. We used a real-life case to collect consumer information to provide simulation input. A major passenger railway service provider plans to introduce a new pricing scheme after the current implementation of electronic ticketing using smart card technologies. There is a strong need to find a way to evaluate the impacts of the proposed new tariffs on revenue, passenger volume, and capacity utilization. As the first step in this direction, the service provider conducted focused group interviews, a quantitative survey and a stated choice field experiment to understand their customers' travel preferences. We estimated consumers' service choice models using the field experiment dataset. And these models are used in the product selection module of the simulation to calculate the utility of each service. Using Monte Carlo methods, in the simulation a service is selected in a random draw using the predicted probability derived from the service utility.

6.6 Analysis and Results

We next introduce the relevant variables. These include service attributes, customer characteristics, journey characteristics, and flexibility variables that we used in four empirical models. The reason to include these variables is to understand the influences of factors on consumer service choice. We will then present and discuss the empirical results.

6.6.1 Models and variables

The dependent variable is *service choice*. It equals 1 for the service being chosen and 0 otherwise. The independent variables are price, time window, and usage restriction. We measured *price* as the cost per month paid by the consumer. We considered the fact that some consumers receive reimbursement from their employers. The higher the price, the less likely he chooses the alternative service. We used *time window* to refer to the validity of the service. It is expressed as time restrictions associated with lower price, such as "a service that is 40% cheaper but not valid 7-8 in the morning and not valid 17-18:30 in the afternoon." For example, let's assume there is a customer who usually travels 7:20am to work and comes back at 17:30. To make use of such a service, he needs to either shift 20 minutes earlier or 40 minutes later in the morning, and 30 minutes earlier or one hour later in the afternoon. We call this *time displacement* in comparison to the customer's preferred departure time. There is a limit in how much time displacement a customer can absorb. The more time displacement customer needs to accept, the less likely he will choose this restricted service. Purchasing a service that has lower price indicates consumers accept time restrictions and agree to shift their departure times from their preferred ones. We calculated this time displacement or penalty for both morning and afternoon and obtained four variables: *time penalty AM early*, *time penalty AM late*, *time penalty PM early*, and *time penalty PM late*. We used *usage restriction* to indicate the number of days that a service is permitted to be used. The more restrictions a service has, the less likely it will be chosen by consumers.

We use three categories of control variables: customer characteristics (gender, age, car ownership), journey characteristics (duration, travel frequency, service class, and travel purpose), and flexibility. Scheduling flexibility has strong influences on customers' departure time choice. Customers self-select their preferred services based on their departure time flexibility, which can include work flexibility, family flexibility, flexibility in connecting trains and transit. The more flexible a customer's activity, the more likely he will choose the cheaper service associated with more restrictions. We summarize the variables and definitions in Table 6-5.

Variable	Type	Definition
Time penalty – AM early	Numeric	Time penalty of earlier departure due to AM restriction.
Time penalty – AM late	Numeric	Time penalty of later departure due to AM restriction
Time penalty – PM early	Numeric	Time penalty of earlier departure due to PM restriction.
Time penalty – PM late	Numeric	Time penalty of later departure due to PM restriction.
Price	Numeric	Monthly cost paid by respondent
Usage restriction	Categorical	Number of days
No service	Categorical	Dummy variable for choosing no service
Restricted service	Categorical	Dummy variable for choosing the restricted service
Trip duration	Numeric	Trip duration
Travel frequency	Categorical	Travel frequency
Service class	Categorical	Service level, first or second class
Travel purpose	Categorical	Purpose of travel including work, business, study, shopping, family, and event
Work flexibility	Categorical	Flexible working hour or having constraints at work
Family flexibility	Categorical	Flexible at home or having home/family constraints
Flexibility train connection	Categorical	Flexible in choosing different train connections
Flexibility transit connection	Categorical	Flexible in choosing different transit connections
Age	Categorical	Age group of the respondent
Gender	Categorical	Male or female
Car ownership	Categorical	Number of cars a respondent has

Table 6-5: Variables and definitions

6.6.2 Stated choice experiment empirical results

Next we will discuss the model estimation results.[41] We estimated our MNL models using *maximum likelihood estimation* (Ben-Akiva and Lerman 1985, Louviere et al. 2000) and summarize the results in Table 6-6.[42] The Baseline Model 1 consists of only the independent variables that appear in the stated choice experiment choice set. In Model 2, we include three interaction effects based on age, gender, and car ownership. In Model 3,

[41] 626 respondents participated in the choice experiments. Each respondent was presented with 8 experiments and 3 choice alternatives per experiment. This yields 626 × 8 × 3 = 15,024 observations.

[42] Our econometric estimation involved a *conditional logit model*. This allows us to analyze how the choice among service alternatives is affected by the characteristics of the alternatives that vary across cases (Long and Freese 2006). We estimated all four models with all variables and computed their significance. We then reran the models with just the variables that were significant, and presented their results here.

we include three other interaction effects from journey characteristics: travel duration, travel frequency, and service class. In Model 4 we add four consumer travel flexibility variables to the estimation. We computed these models in a cumulative fashion, to demonstrate the predictive effects of additional variables and the stability of the service attribute coefficients. Overall, we have good statistical fit of all the models, with *log-likelihoods* from -3,291.50 to -3,239.20. The pseudo-R^2s of all the models are larger than 0.4 with $p < 0.001$. Hosmer and Lemeshow's *goodness-of-fit test* also gave a significance of p.

Variables	**Baseline model**	**Model 2 with customer characteristics**	**Model 3 with trip characteristics**	**Model 4 with flexibility**
Time penalty – AM early	-0.008**	-0.008**	-0.007***	-0.007**
Time penalty – AM late	-0.018***	-0.017***	-0.021***	-0.021***
Time penalty – PM early	-0.010***	-0.010***	-0.010***	-0.010***
Time penalty – PM late	-0.010***	-0.011***	-0.011***	-0.011***
Price	-0.004***	-0.004***	-0.004***	-0.004***
Usage restriction	-0.253***	-0.255***	-0.258***	-0.261***
No service	-2.208***	-2.206***	-2.206***	-2.205***
Restricted service	-0.797***	-1.034***	-0.866***	-0.826***
30<Age<49 × Restricted service		0.120	0.078	0.069
Age above 50 × Restricted service		0.591***	0.591***	0.591***
Trip duration > 60min × Time penalty AM late			0.004***	0.004**
Service class × Restricted service			-0.520**	-0.499***
Business × Restricted service			-0.512**	-0.543***
Study × Restricted service			-0.337***	-0.347***
Flexibility train connection × Restricted service				0.164
Flexibility transit connection × Restricted service				-0.644***
Log Likelihood	-3291.50	-3275.86	-3247.78	-3239.20
χ^2	721.57	724.22	745.77	761.24
AIC	6598.99	6571.72	6523.57	6632.28
Pseudo-R^2	40.2%	40.5%	41.0%	41.1%

Note: 15,024 obs. Significant (in parentheses): = * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 6-6: MNL model results in the time-differentiated pricing experiment

We estimated the baseline model using all service attributes. We computed the odds ratios for Price, Time Penalty AM Early, Time Penalty AM Late, Time Penalty PM Early, Time Penalty PM Late, Usage Restriction and two dummy variables Restricted Service and No Service. All variables had negative signs indicating negative effects on service choice. Corresponding p-values were computed indicating significances at $p < 0.05$ level or better. The results show that an increase of €1 in a new and more restricted service will reduce the odds of a consumer choosing this service by 0.4%.

We added three demographic variables, age, gender, and car ownership, in Model 2 to show their effects on consumer service choice. The model has a pseudo-$R^2 = 0.405$ with $p < 0.001$. Its goodness-of-fit is $p < 0.001$, indicating it fits the data well. It also fits better than the baseline model, because the log-likelihood ratio test produces a $\chi^2 = 31.27$ with 2 d.f. All variables have the right signs. Age (> 50 years) was significant at $p < 0.01$. The results show that the odds of choosing a restricted service for customers older than 50 years is 6.7 times as high as the odds for customers younger than 29 years. This indicates that senior customers are more likely to make tradeoffs and accept the restricted services, *ceteris paribus*. (See Figure 6-2.) However, Gender and Car Ownership were not significant.

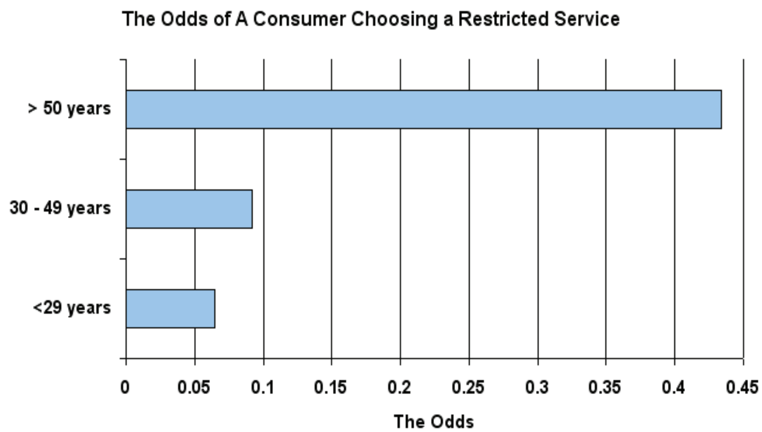

Figure 6-2: The odds to choose restricted service by age

To extend the model, we included journey characteristics in Model 3: Trip Duration, Service Class, and Travel Purpose. Model 3 has a better fit compared to Model 2 with a *log-likelihood ratio test* of $\chi^2 = 56.16$ with 4 d.f. The interaction effect between Trip Duration (> 60 minutes) and Time Penalty AM Late was significant ($\beta = 0.004$, $p < 0.01$). (See Figure 6-3 dotted line.) This indicates customers who travel for a longer time are more sensitive to the time displacement of departure later in the morning. Our results show that more than 85% of subscription users are commuters, who have to start work at a specific time. This means that leaving home later in the morning will result in arriving at work late, which is not preferred by long-distance travelers who travel more than 60 minutes. The other two levels of Trip Duration (< 30 minutes and 30-60 minutes) are not significant. The interaction effect between Service Class and Restricted Service was also significant (β = -0.520, $p < 0.05$). So customers who travel in first-class obtain less utility from services with restrictions. This is because most first-class customers can be reimbursed for their travel expenses by their employers. So they naturally are less price-sensitive and willing to spend more to meet their desired arrival times and need for comfort. We also found that customers who travel for a Business Purpose (β = -0.512, $p < 0.05$) or a Study Purpose (β = -0.337, $p < 0.01$) are less willing to purchase restricted services. Travel Frequency and Travel Purpose involving shopping, family, and events are not significant at the $p < 0.10$ level.

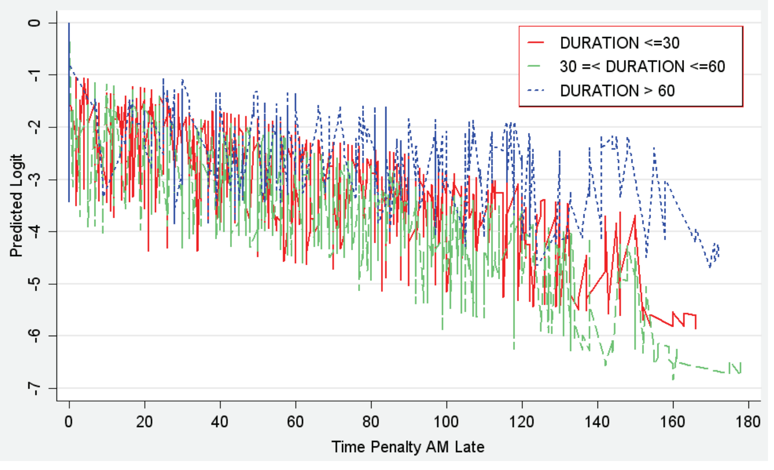

Figure 6-3: Predicted logit value with interaction of trip duration and time penalty

To explain why some consumers are more price-sensitive to service restrictions, we added flexibility variables. The *log-likelihood-ratio test* for Model 4 compared to Model 3 is 17.17 with 2 d.f. Flexibility with Transit Connection (β = -0.644, $p < 0.05$). It has a significant effect when we interacted it with the restricted services. Customers who have constraints in connecting transport modes are less inclined to choose them. Flexibility involving home, family, and train connection were not significant.

We also evaluated multicollinearity and heteroskedasticity. Pair-wise correlations for the explanatory variables were all low. Also, all variance inflation factors were below 10, so there is no evidence for multicollinearity. In addition, according to Hensher et al.

(2005), multicollinearity is not a problem for full orthogonal-designed stated choice experimental data, because the columns are independent.

6.6.3 Simulation results

We initialized the supply simulation with a pre-defined railway network that consists of more than 100 different train lines and nearly 400 stations. To demonstrate the efficacy of the simulation, we focused on a number of trains operating between three major stations A, B, and C, in our experiment. The physical distances between the station pairs are 18.7 kilometers (A to B) and 59.3 kilometers (B to C). The actual timetable of these trains is used. Different trains are assigned with different capacities based on the maximum number of seats. We initialized the demand simulation with 200 customers. For each customer in the simulation, we assign a 24-hour activity plan that contains activity type, location, timing, and tolerance. A customer typically starts his day from his home location that is specified by geographic coordinates.

Simulation inputs are different service attribute bundle designs. We experiment four scenarios.[43] In Scenario 1, the pricing parameters are based on the current practice of the service provider. That is the price is 40% lower after 9:00. In Scenario 2, we define a pricing strategy as a 40% price increase between 7:00-9:00 and between 17:00-19:00, and a 40% price reduction between 9:00-17:00. In Scenario 3, we define the pricing strategy as a 40% price increase between 8:00-9:00 and between 18:00-19:00, and a 40% price reduction between 9:00-18:00. In Scenario 4, price is 80% higher between 7:30-9:30 and between 17:30-19:30, and 80% lower between 9:30-17:30. (See Figure 6-4.)

[43] These scenarios are developed to test the sensitivity of the simulation. In a more refined setting, we wish to compare three major categories of service attribute bundle designs: *Volume Scenario* that aims at achieving higher passenger volume, *Revenue Scenario* that aims at increasing service revenue, and *Capacity Scenario* that aims at improving capacity utilization.

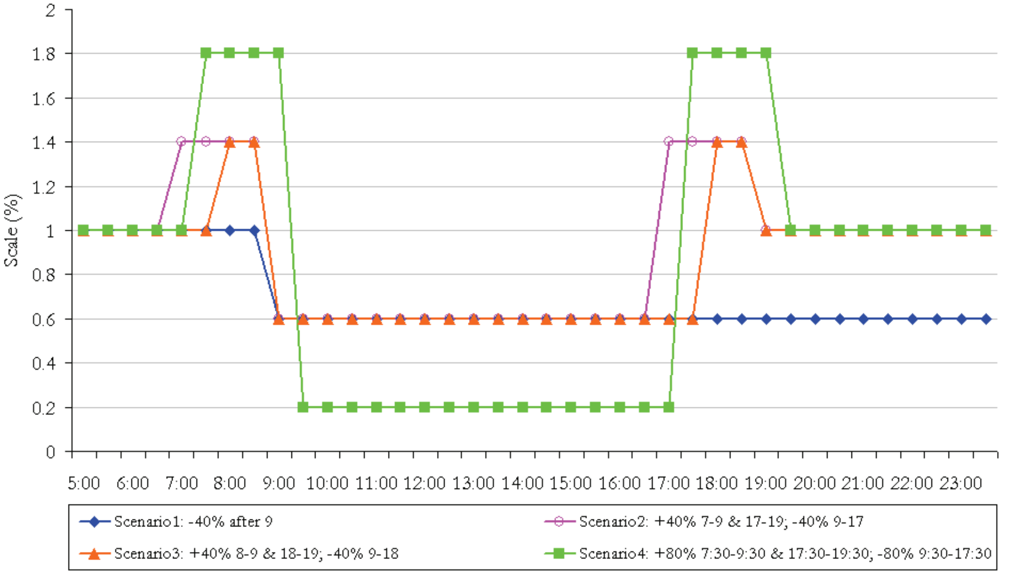

Figure 6-4: An illustration of simulation input

We present the simulation results in terms of number of trips for these four scenarios. (See Figure 6-5.) Each scenario runs for 10 times and the simulation time for each run is 30 days. In each run, the same random number seeds are used.

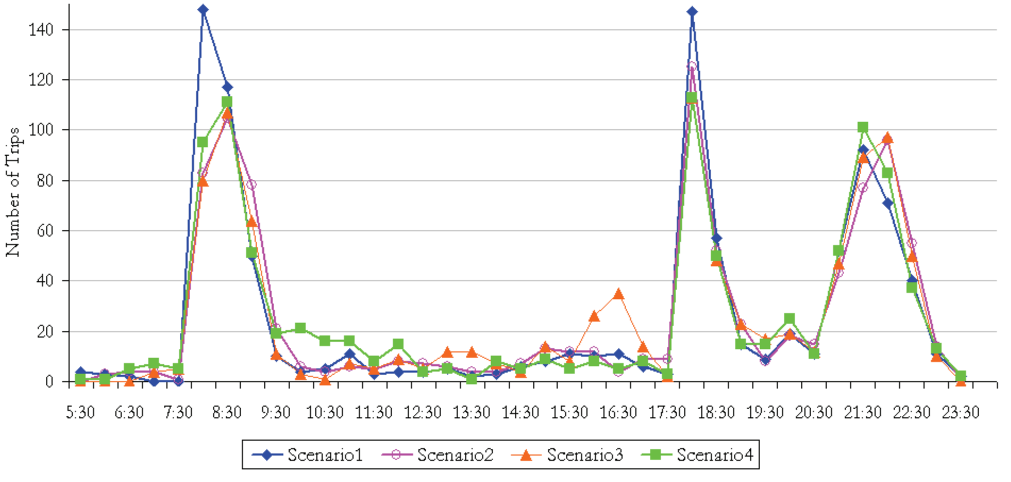

Figure 6-5: Simulation outputs for four pricing scenarios: number of trips

The current activity list contains three activities: home, work, and shopping. This explains the three peaks we observed from the graph. Compared to the baseline Scenario 1, in Scenario 2 and Scenario 3 we increased peak hour price for 40% while lowered off-peak price for 40%. We can clearly see that the morning peak demand is lowered and shifted toward a later departure time that is centered around 8:30. We also see a drop of total number of trips around the afternoon peak hours due to the price increase. However, we do not see a clear shift of demand toward off-peak hours as we expected. The reason could be that the price differences between peak and off-peak hours are not large enough to stimulate departure time shifting behaviors.

Thus, in Scenario 4 we further increased the peak hour price to 80% higher and reduced off-peak price to 80% lower. The result shows that some morning peak hour customers shift to the off-peak hours between 9:30-11:30. Although we do not observe further demand reduction compared to the 40% increase that we experimented in Scenario 2 and Scenario 3. We demonstrate that this pricing policy is effective to stimulate customers to adjust their departure times by traveling earlier or later to avoid the high cost.

6.7 Propositions for Customer-Centric Revenue Management

In this section, we will develop five propositions and demonstrate the efficacy of our theoretical perspectives and methods.

Based on our research, we did an analysis to identify factors that influence the efficacy of customer-centric revenue management. Our propositions are intended to theorize about the decision making process that occurs within customer-centric revenue management environments. This leads us to assert:

> **Proposition 1 (The Customer Behavior Choice Model Proposition).** *Service providers will continue to examine factors that influence consumer decision making and model their choice behavior for alternative products and services to understand their demand preferences. This model of demand is necessary to shift revenue management strategy from product-oriented approach to a customer-centric approach.*

The more common used product-oriented approach to revenue management has a number of limitations. It is independent from the market environment and does not take into account the service alternatives that customers consider at the point of purchase. Thus, it fails to answer questions such as how the changes in travel service attributes (e.g., a refund option, a required weekend stay) will affect consumer demand for each travel service. It also says little about how this will impact capacity utilization. To overcome these limitations, service providers should focus on a more customer-centric approach, where customers are modeled as creating the fundamental units of demand. Instead of asking which customer requests should be accepted or rejected, service providers ask questions about which alternatives should be created to profitably influence consumer choice.

This requires service providers to examine the factors that influence consumer choice. It is important for service providers to understand the alternative products and services, including price and associated restrictions that consumers are presented with at the time they make a purchase decision. Next, service providers will model consumer choice and the process of decision making. The issues here include what customers intend to buy, when and how frequently they buy it, how much they are willing to pay, and under what conditions they make these decisions. Service providers then can model choice behavior using a random utility model (e.g., the multinominal logit model, the nested logit model, the mixed logit model, etc.) to examine choice outcomes and estimate the related consumer preferences.

Proposition 2 (The Customer-Centric Data Proposition). *Service providers will focus on collecting customer-centric data rather than only product-centric data.*

Modern ITs allow service providers to collect and store large amounts of data. Statistical methods and algorithms permit them to process and analyze these data as well. Raw data can be transformed into actionable market information. But the question is what data to collect? For example, airlines collect and organize their data based on booking class, fare code, or origin-destination, among other key variables. These product-centric data have a practical advantage: firms sell products and use sales transactions to understand market demand. However, the products they offer are not a constant over time. For example, the airlines may change their daily schedules or their origin-destination itineraries. The related market conditions may also change over time. There may be more competing alternatives available, and competitors may change their prices too. To move away from the product-centric model, service providers should collect customer-centric data. They will need to use different data sources, such as shopping data, clickstream data, purchase histories, loyalty program data, and customer panel data. Service providers can then use these data to model consumer behavior.

Proposition 3 (The Service Differentiation Proposition). *Service providers will attempt to capture consumer willingness-to-pay and identify the relevant customer profitability gradients for each micro-segment. This allows them to tailor differentiated products and services, both in temporal or spatial service differentiation terms, to efficiently shift demand away from high-demand periods and location to those with lower demand.*

A *customer profitability gradient* refers to the presence of extreme differences in profitability between a company's best and the worst customers (Clemons et al. 2002a, p.

22). An increased understanding of consumer preferences allows a firm to explore its service attribute space, design its services to better capture consumer willingness-to-pay, and take advantage of the consumer profitability gradient identified for each of the micro-segment. Differences in profitability exist because there is a difference in the firm's cost to serve customers (Clemons and Thatcher 2008). Peak-hour travelers are more expensive to serve than off-peak travelers. If service providers have more knowledge of consumer willingness-to-pay to shift their departure times, they can tailor time-differentiated services to influence customer departure time choices. And if service providers have more knowledge on consumers' willingness-to-pay to shift their route selection, they can tailor spatially-differentiated services to change consumer route choices. This applies to any value-added services that service providers would like to design to capture the most profitable customer value gradient.

Proposition 4 (The Integration of Service Attribute Bundling and Capacity Proposition). *Service providers will base their pricing and revenue management decisions on the highest social welfare that can be achieved. This results from a combination of servicing consumer demand, generating revenue, and achieving strong capacity utilization, instead of just capturing the highest level of revenue. This will be achieved by integrating and optimizing service attribute bundling choices into managerial decisions about operational capacity.*

A service provider's objective function is to achieve the highest social welfare. We calculated by multiplying service price with the demand of the service, and then summing over consumers in different segment groups. Demand is a function of price, service amenities, and restrictions. Decisions on service attribute bundle choices will lead to the travel service that a service provider actually sells. The choices that a firm makes will be subject to being able to produce the level of capacity that permits the service provider to accommodate the consumer demand. In other words, the level of the utility that service providers can achieve on behalf of their customers will be constrained by their production capacity.

In a complex network environment such as a transportation network where there are dynamic and stochastic factors at work, it is difficult to use analytical models to capture realistic consumer behavior while at the same time understanding the impacts of behavioral outcomes on capacity. Simulation is an often used method to study this complexity. It allows service providers to integrate consumer choice models and capacity supply, and simulate their interactions to optimize various performance outcomes.

Proposition 5 (The Adaptive Learning Proposition). *Service providers will utilize all available information efficiently to establish an initial basis for expected value of their performance,* *and then continue to obtain new information over time to learn about the optimal value of the firm performance.*

This proposition suggests that the service provide demonstrates *adaptive learning* in their operating and competitive environments. This proposition is based on rational expectations and adaptive learning. The latter term means because of the bounded rationality, firms may not know the exact information to predict the future outcome. However, they are willing to learn over time and update their expectations based on the newly-received information (Sargent 1993). The theory suggests that service providers will make efficient use of all information that becomes available to them and will be essential in establishing an understanding of baseline performance. Because of their managers' and organizations' limited information processing capabilities, service providers will be limited in how well they can optimize when they need to make decisions. They will learn to use more appropriate model specifications, and in the process learn more about their customers' behavior. Over a longer period of time, they will leverage the information that they receive to come closer to estimating the "true" values of the essential forecasting indicators to make their organizations' performance meet their objectives.

Taken together, the five propositions theorize about the decision making process for customer-centric revenue management: the service providers gather all available information on consumer behavior and capacity supply, examine all factors that influence consumers' decision making, and model their choice process. Then they tailor differentiated services to capture the most profitable market segments, evaluate their performance on demand, revenue, and capacity against the prior indicators, continue gathering new information, and learn about what they can do to achieve near-optimal performance value.

6.8 Conclusions

Assessment of the theoretical perspective. Using multiple theoretical perspectives, we re-conceptualized the process of customer-centric revenue management to provide a basis for service attribute bundling and capacity management. The theory of rational expectations suggests that service providers form their expectations of the future service attribute bundles and capacity management policies on all supply and demand information available to them. They exploit all opportunities that could yield optimal future performance, and then develop their pricing and service attribute bundles that reflect the information used. The performance outcome depends on what they expect to happen in their operation environment, and the expectations they have about the new joint optimization of service attribute bundles and capacity management. In other words, decisions on the service attribute bundles will be influenced by the expected level of customer demand or passenger volume, operating revenue, and capacity utilization they believe will materialize.

This is an ideal situation that assumes all available information can be used. However, in reality, service providers have limited cognitive resources and organizational information processing capabilities. It is generally hard, if not impossible, to use all available information to make decisions. This is in line with arguments based on bounded rationality (Simon 1957). The theory of adaptive learning suggests that service providers are genuinely willing and able to learn over time. As a result of this, they will update their expectations about relevant parameter values on the basis of newly-received information. For example, more accurate information of their capacity supply and more detailed information of their customers' travel behavior. As a result of this learning process, the service providers' expectations will come closer to the "true" consumer behavioral model. This will allow them to make better future demand and performance forecasts.

Any product or service can be described by its characteristics or attributes. Choice theory suggests that the extent to which a decision maker values or expresses utility depends upon the nature and levels of these characteristics. Thus, to understand customer preferences for different service attribute bundles, we need to consider the relative benefits that consumers attach to various features of the services that are available to them at the time of purchase. With the stated choice experiment method, we present multiple service attribute bundles in a choice set to decision makers, and ask them to evaluate all of the alternatives and choose the most preferred one. In this setting, consumers are fully informed of the different service attribute bundles and are able to decide what they want, evaluate the available choices well, and decide to pay what they think the service is truly worth. As a result, we are able to measure the unique effects of each of the attributes and their corresponding levels relative to the consumers' choice decisions.

On the efficacy of the joint stated choice and simulation analysis methods. We used a mathematical representation to describe the joint optimization of service attribute bundles and capacity management. Realistic operational models for the study context are likely to be very complex, as we know from the recent Edelmann Prize research in applied operations research that studied other operational aspects of the a large public transport network in Europe (Kroon et al. 2009). Considering its complexity, in particular the interaction between demand and supply, traditional analytical modeling methods may prove ineffective. As a result, we decided to use to combine the results from our stated choice experiments with a computational simulation. The latter permits us to control the experimental conditions through multiple replications and achieve strong internal validity. To mitigate external validity concerns, we derived consumer decision rules from our stated choice experiment data sets, and utilized our field study knowledge from a transport service provider in setting parameters such as railway networks, timetables, carriers, and baseline pricing levels.

First, to understand consumer choice behavior, we employed a stated choice experiment method (Louviere et al. 2000). This method presents hypothetical service attribute bundles, including different service attributes and associated levels, to consumers and asks them to state their preferred choice among all available bundles. This allows service providers to measure the effects of consumer trade-offs among service attributes, exploit consumer heterogeneity and their willingness-to-pay. Further, they are able to assess market responses toward their pricing and revenue management strategy that is reflected in their service attribute bundles.

Second, we also developed a computational simulation to demonstrate the feasibility and effectiveness of customer-centric revenue management. This simulation is also used to evaluate the performance impacts of service attribute bundles on customer demand, revenue, and capacity utilization. We summarize three advantages of our simulation method compared to the widely-used four-step model for demand forecasting. First, our simulation exhibits customer-dependent characteristics, which permits us to model customers' behavioral response to alternative service attribute bundles in revenue management strategy. Second, in contrast to the four-step model, where there the lack of time is a problem and prevents us from understanding customer demand at different time-of-day, simulation method permits us to characterize demand at any given time period. This is critical for the evaluation of peak-spreading policies such as time-differentiated pricing. Third, the four-step model forecasts demand based on socioeconomic characteristics of each geographic area. This site-specific characteristic of the model limits its ability to be transferred from one context to another (Kitamura et al. 2000). Our simulation is essentially activity-based and the travel demand is generated as a result of people's desire to conduct certain activities at a specific location. So the simulation is generalizable and can be used for other transport networks too.

Summary. With the increased availability of customer information that could be collected from mobile ticketing technologies and extensive large-scale surveys, more and more public transport service providers are devising pricing and service attribute bundles to capture the most profitable consumer response. They also are keen on evaluating the performance impacts of these polices. The objective of this chapter is to model and understand public transport demand in an environment with increased supplier and consumer information. This research focuses on how public transport firms can design service attribute bundles of their service offerings to capture the most profitable consumer responses. A related objective is to integrate the solution approach that is adopted for optimizing service attribute bundle design with downstream operational decision making related to capacity management.

To our knowledge, the related research on joint capacity allocation and pricing decisions in revenue management has been lacking (McGill and van Ryzin 1999). At the same time, there is a growing interest in research on approaches and systems to support the implementation of revenue management from both the scientific community and business practice (van Ryzin 2005, Riddell 2006). Using a multiple theoretical perspective, we combined the theories of rational expectations and adaptive learning from economics, random utility theory and stated choice from marketing, consumer informedness from information systems, activity-based travel behavior from transportation science, and revenue management. We employed a joint stated choice experiment and simulation method to demonstrate the efficacy of integrating service attribute bundles and capacity management decision making. The experiments allow us to estimate consumer choice models. We used simulation method to demonstrate the customer-centric model of demand that provides a quantitative evaluation of the effects of pricing and service attribute bundles scenarios. We reported on the results of the stated choice experiments and applied econometric modeling methods to understand consumer choice behavior in an experiment. We leveraged a simulation test bed and presented illustrative simulation results for a number of relevant public transport demand and service attribute bundle pricing scenarios. In addition, we presented five propositions that were intended to theorize about decision making of customer-centric revenue management.

Chapter 7 Conclusions, Limitations and Future Research

The objective of this research is to improve the understanding of the role of information in the decision making of revenue management, in particular, the business value of informedness in revenue management. In this chapter, we will provide a summary of the main findings of the three empirical studies, which are subsequently synthesized in the theory of informedness in revenue management. Next, we will discuss the contributions of this research to the literature and to management practice. Finally, we will point out the generalizability of our findings, the limitations of our results, and add some final words on future research.

7.1 Summary of Main Findings

The central question of our research is why and how informedness impacts firm performance. To answer this question, we divided it into three detailed questions and provided answers in three empirical chapters that cover firm informedness, consumer informedness, and informedness through learning.

Firm informedness and value creation. Chapter 4 answers the first question: Why does increased firm informedness advance firms' revenue management? And consequently what are the impacts on firm performance? Using multiple cases, this empirical chapter investigates the value creation process of mobile ticketing technologies and their enablement to revenue management strategies. We conclude Chapter 4 with the following findings:

- Mobile ticketing technologies have unique product, process, and usability characteristics compared with the traditional ticketing channel. They increase firms' information capability in terms of both information quantity and information quality.
- Firms can create value through the use of mobile ticketing technologies in three ways. First, benefiting from the installed electronic gating infrastructure, mobile ticketing technologies reduce fare evasion, offer customer convenience, and reduce operational costs. Second, the technologies enable firms to collect more

detailed customer information, which increases firms' abilities to design price and service differentiation strategies to create value. Third, mobile ticketing systems provide micro-payment infrastructures that permit other service providers to adopt them. As a result of this, service providers can increase their transactional efficiencies and expand their services quickly into other industry sectors.

- Firms that use more sophisticated mobile ticketing technologies, such as smart cards and mobile devices, and have real-time and complete information of customers' actual travel are more likely to adopt price differentiation and service expansion.
- Firms that adopt advanced mobile ticketing technologies and employ price differentiation and service expansion strategies are more likely to have higher performance gains compared to the ones that use only the cost reduction strategy.

Consumer informedness and heterogeneous behavior. Chapter 5 answers the second question: Why does consumer informedness impact consumer behavior and enable resonance marketing? How can we characterize consumer responses toward revenue management strategy? Using two stated choice experiments, we empirically demonstrated heterogeneous consumer preferences and their willingess-to-pay. We conclude Chapter 5 with the following findings:

- Consumer informedness plays a critical role in determining consumers' willingness-to-pay. In the presence of increased information, some consumers will exhibit stronger preferences for choosing the cheapest product (evidence of trading down behavior), whereas other consumers will exhibit stronger preferences for choosing products that best fit their needs (evidence of trading out behavior).
- With the availability of smart cards and mobile ticketing technologies, service providers will be informed of consumers' individual demand preferences and, thus, can better leverage the effective use of hyperdifferentiation and resonance marketing. From this base, they can work toward better accommodating consumer behavior in their revenue management decision making.
- Service providers can explore the relevant service attribute space, design their service offerings to capture the most profitable responses, and implement an information-based strategy to profit from the available customer profitability gradient.

- Further, firms that take into account the behavioral responses of their consumers when designing revenue management strategy will achieve higher firm performance, as well as higher customer satisfaction.

Informedness through learning. Chapter 6 answers the third question: How do firms capture the most profitable consumer responses while integrating both demand and supply conditions where the capacity has constraints? Using both a stated choice experiment and a simulation, we explored the opportunity to devise service attribute bundles to capture profitable consumer responses. We conclude Chapter 6 with the following findings:

- In order to shift revenue management strategy from a product-oriented approach to a customer-centric approach, service providers will continue to examine factors that influence consumer decision making and to model their choice behavior for alternative products and services to understand their demand preferences. In order to do this, service providers will collect all available information including consumer demand information and capacity supply information. In particular, they will collect more and more customer-centric data compared to product-centric data.

- Service providers will attempt to capture consumer willingness-to-pay and identify the relevant customer profitability gradient for each micro-segment. As a result of this, they will tailor differentiated products and services, both in temporal and spatial service differentiation terms, to efficiently shift demand away from high-demand periods and locations to those with lower demand.

- Service providers will base their pricing and revenue management decisions on the highest social welfare that can be achieved. This results from a combination of servicing consumer demand, generating revenue, and achieving strong capacity utilization, instead of just capturing the highest level of revenue. This will be achieved by integrating and optimizing service attribute bundling choices into managerial decisions about operational capacity.

- Service providers utilize all available information efficiently to establish an initial basis for the expected value of their performance, and then continue to obtain new information over time to learn about the optimal value of the firm performance. Thus, they are said to demonstrate "adaptive learning" to their operating and competitive environments.

7.2 Theory of Informedness in Revenue Management

To answer our initial question, why more information improves firm performance, this dissertation develops a theory-based explanation: informedness. Our definition of informedness further refines a perspective set forth by Clemons (2008), so that it covers both firm informedness and consumer informedness. It is not a static view, but a dynamic one. Using the theory of adaptive learning, we argue that firms and consumers constantly improve their informedness through learning over a longer time span. We investigate these three aspects of informedness, firm informedness, consumer informedness, and informedness through learning, in three empirical chapters respectively. Taken together, our results suggest that increased firm informedness allows for real-time fine-grained observation and analysis of consumer behavior. As a result, firms have a better understanding of the demand side. They know what each customer segment wants to buy, and how much it is willing to pay. Firms can implement an information-based strategy to profit from the available customer profitability gradient.

Firms are engaging in hyperdifferentiation and resonance marketing strategies for a variety of reasons. First, complexity penalties are lower and firms can now hyperdifferentiate their products and services in ways that were never possible without IT. They also can communicate with the market easily, and emphasize the value propositions that enable customer retention. Second, competition discounts are greater, with the greater number of competing firms in the market. This helps them to maintain their market shares. With more information available to consumers, firms are able to increase the effectiveness of their competition discounts. Third, compromise discounts occur when consumers purchase a service that is different from what they would ideally like to purchase, and these are now greater too. When consumers become more aware of what is available, compromise discounts tend to go up. This prompts the firm to differentiate its products and services. Fourth, when consumers do not have full information about a product's attributes due to information asymmetries, the products will sell with uncertainty discounts to the consumers. Increased consumer information reduces the uncertainty discount, so the benefits of differentiation increase.

Consumer informedness is the degree to which consumers know what is available in the marketplace, with precisely which attributes and at precisely what price. This increased consumer informedness has increased competition among interchangeable commoditized products, and dramatically impacts existing markets. The enormous range of information that is readily available to consumers allows them to know exactly what is available and to fully express their preferences. Traditional strategies for products targeted at the mass market can be augmented through the recognition that increasingly informed consumers engage in trading down and trading out behavior. Subsequently, firms can work toward better accommodating consumer behavior in their revenue management decision making. In the presence of consumer informedness, strategies involving resonance marketing can de-emphasize the role of prices in consumer shopping decisions and help firms to gain sustainable competitive advantage, "… supporting the predicted move from a reliance on mass-market fat spots to a strategy based on profiting from high-margin sweet spots" (Clemons 2008).

In a capacity-constrained industry such as public transport, creating consumer delight is constrained by the costs of production. Some service attribute bundles are more expensive to produce than others because firms have limited operational capacity, which is mostly fixed and perishable. Thus, in order to maximize profit, or more specifically consumer welfare, firms need to combine their decisions of service attribute bundles with their capacity management, and jointly optimize this end-to-end process. This is not a one time process, but one that spans a longer time horizon. Firms will constantly update their supply and demand information, refine their consumer behavior models, and evaluate their expected performance impacts on demand, revenue, and capacity utilization. At the same time, consumers also learn firms' pricing and service attribute bundles and can, in the long run, fully express their willingness to pay. As a result of this iterative process, firms will optimally gauge consumers' interest and participation, so that consumers become part of the co-production of the system outcomes. This will lead to the highest firm profit while at the same time reaching the highest consumer delight.

Our theory of informedness is a theory for explaining and predicting. It helps in "[the] understanding of underlying causes and prediction, as well as description of theoretical constructs and the relationships among them (Gregor 2006)." Informedness examines the value of increased information on performance impacts, in particular, it explains why customer information obtained from smart cards or mobile ticketing technologies can improve the yield of transport networks. This theory predicts the role of information in the process of a firm's revenue management decision making. Using the informedness theory, our explanation adds an IS perspective to the existing relationship between revenue management strategy and consumer behavior in our initial conceptual framework in Chapter 2 (Figure 2-3). We argue that the true relationship is driven by firm informedness and consumer informedness in an iterative process. In addition, this iterative process usually spans a pre-specified time horizon until all parties reach the desired outcomes. Figure 7-1 illustrates this process in a full cycle.

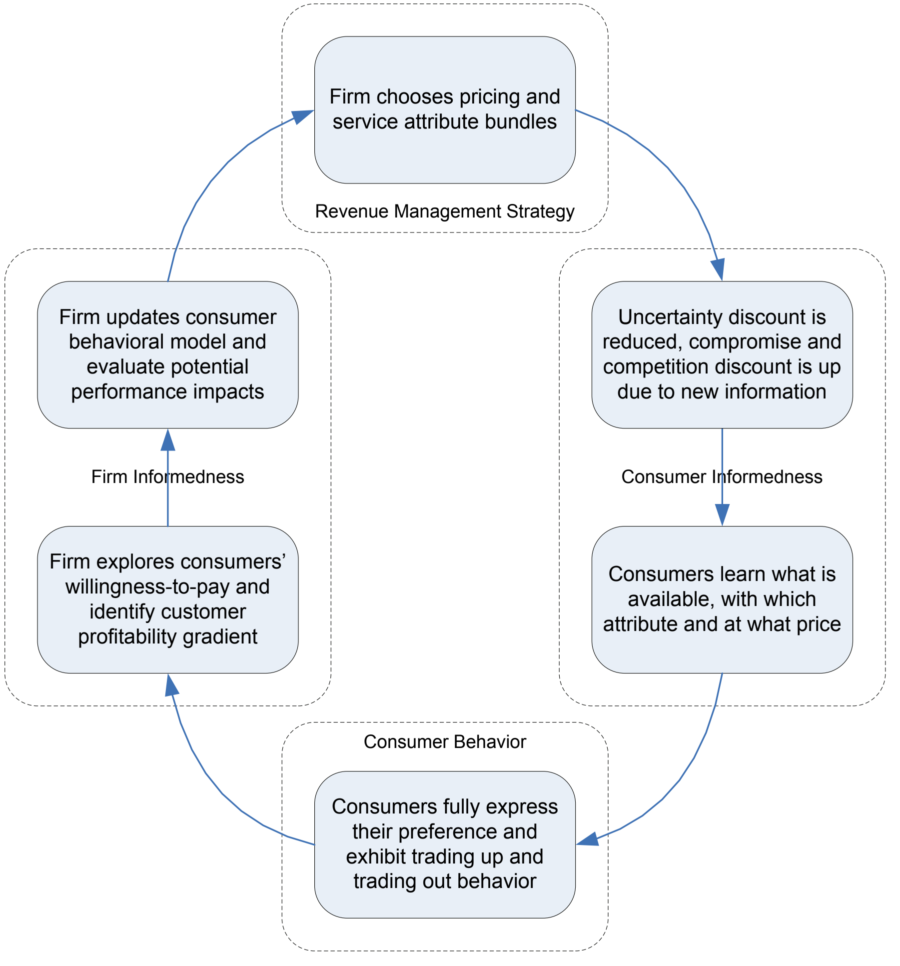

Figure 7-1: A model of informedness in revenue management

7.3 Contributions to the Literature

We have sought to balance theory, methods and modeling to contribute new knowledge to management science.

Contributions to theory. This research offers three major contributions to the existing theory in IS. First, drawing on resonance marketing and choice theories, we have developed a new *theory of informedness* that covers firm informedness, consumer informedness, and informedness through learning to understand how firms can optimally engage the participation of consumers to co-produce the desired performance outcomes.

As part of our theory development effort, we empirically tested the trading down and trading out hypotheses that were developed by Clemons (2008). Second, we added an IS perspective to the present understanding of revenue management and explained its decision making in terms of the informational characteristics of the process. We re-conceptualized the process of customer-centric revenue management that provides a basis for integrating service attribute bundles and capacity management to achieve joint optimization. Third, we developed a dynamic perspective that allows learning to take place in the decision making of revenue management that spans a pre-specified time horizon. We explain this end-to-end business process based on the theory of rational expectations and the theory of adaptive learning. Related research on joint capacity allocation and pricing decisions in revenue management has been scarce (McGill and van Ryzin 1999).

Contributions to methods and modeling. We employed multiple methods in the research, including a case study, a stated choice experiment, and a simulation. This offers two major contributions to the present literature. First, we introduced an innovative method – a stated choice experiment – to the IS domain (Louviere et al. 2000). Consistent with our theory, we set up experiments with consumers who are well informed of the service offerings so they make informed decisions. We were able to measure the unique effects of each of the service attributes and their corresponding levels relative to the consumers' choice decisions. This allowed us to explore consumer trade-offs among service attributes, and to exploit consumer heterogeneity and willingness-to-pay. Further, we were able to assess market responses toward firms' pricing and revenue management strategies that are reflected in their service attribute bundles. Second, we combined a stated choice experiment and a simulation to study the end-to-end business process of proposed customer-centric revenue management. We used stated choice experiments to understand consumers' behavioral responses toward service attribute bundles, and then developed a micro-simulation to demonstrate the efficacy of the proposed approach to joint service attribute bundle design and capacity management. The simulation is activity-based and provides decision makers with time-dependent, individual-specific, and site-generalizable demand forecasting capabilities. In particular, it can evaluate the performance impacts of service attribute bundles on customer demand, revenue, and capacity utilization. Our implementation and application of these two methods is a response to Hevner et al.'s (2004) call for engaging in research that combines design science with relevant behavioral science.

Finally, from an empirical modeling standpoint, we used advanced choice modeling – mixed logit – to probe consumer heterogeneity in willingness-to-pay. This technique permits us to derive individual-specific behavioral outputs, such as individual-specific elasticities and marginal effects.

7.4 Contributions to Management Practice

We discuss four managerial implications of this research: the importance of being informed, the importance of informing customers, the need to develop customer-centric and behavioral-savvy revenue management and resonance marketing strategy, and the importance of informedness in business networks.

First, firms should manage the informational challenge and should learn to strategize the fully-informed market environment in which consumers are fully expressing their preferences. Understanding customers' behavior is important for firms to exploit their service attribute space and tailor service offerings that customers truly want. Firms that can fully exploit consumers' willingness-to-pay along the long-tail will prosper as they "switch out of lowest-common-denominator mode and figure out how to address niches" (Anderssen 2006). Nevertheless, firms should effectively manage the costs when producing niche goods for the tail end of the distribution (Elberse 2008). Furthermore, firms that operate under capacity constraints need to know their product supply and resource allocation. Examples of capacity-constrained firms are utility companies that operate with fixed pipelines, telecommunication service providers that operate with limited bandwidths, and transportation firms that operate with a fixed and inflexible transportation capacity. Understanding how capacity is utilized in these environments has implications for decision makers in terms of what service attribute bundles they can design and how they impact firm performance.

Second, it is important to inform customers. Nowadays, the customer is an integral part of organizations. It is in these circumstances that information sharing with the customers is considered to be the upmost important task by the organizations which are climbing the customer relationship ladder (Gulati and Kletter 2005). Instead of only receiving customer information from customers, firms should also actively engage in activities to provide information to the customers so that the latter can make well-informed decisions.

Third, firms should develop customer-centric thinking in order to reap the benefits of revenue management and resonance marketing. Modern IT allows firms to retrieve real-time customer information, automatically analyze customer behavior, respond directly to customer requests, and provide customers with a highly customized experience. In order to facilitate these decision making processes, there is a need to develop solid learning and optimization routines. A number of methods used in this research can help firms in this regard to materialize the proposed customer-centric revenue management thinking and to engage in resonance marketing. First, for decision makers seeking feedback on how customers view their offerings, "choice modeling provides a … method of turning customer-driven feedback into profitable and sustainable strategies for retaining and capturing market share" (Verma and Plaschka 2005). Stated choice experiments can be used to help firms to understand how their customers make trade-offs among different service attributes and levels both within theirs and among their competitors' service offerings. Econometrics estimation techniques can be used to understand the factors that influence customers' choices and exploit willingness-to-pay. Simulation can be used as a test-bed to assess different strategies and evaluate performance impacts before implementing them in the market.

Fourth, to compete and succeed in a networked age, it is important for decision makers to know the business networks that their firm is embedded in (Vervest et al. 2005, van Heck and Vervest 2007). What do they need to know and why does it matter? First of all, decision makers need to know the network actors within their business networks, including the firm's customers, suppliers, alliances, and organizational subunits. Firms that engage these network actors and increase the longevity of these relationships can optimize their networks of relationships and achieve superior performance (Gulati and Kletter 2005). Second, it is important for decision makers to understand the network position (bridging position or closed position) of their firm within the network and its network structure. A growing stream of research in the strategy literature has demonstrated that network position has a strong influence on firm performance (Stuart 1998, Baum et al. 2000, Zaheer and Bell 2005). What decision makers know about the network, the notion of network horizon (van Liere 2007), influences their firm's network position, subsequently, it will also affect firm performance.

In our research context, the use of a mobile ticketing payment system enabled by smart cards allows public transport service providers to obtain more customer information in regard to the locations to and from which they travel, what time they travel, what ticket they purchase, and what transport mode they use, with far more precision. Truly informed service providers should use the improved information to explore customers' willingness-to-pay, and redesign their pricing structures and service offerings to meet the preferences of the customers. Service providers should move from engaging in "fat spot" to resonance marketing that explores customers' "sweet spot". Further, to understand how the change in demand affects capacity production, service providers should use techniques such as stated choice experiments and activity-based micro-simulations to understand the interplay between customers' travel behavior and operation of the transport networks. Our research demonstrates that customer-centric revenue management is possible for public transport service providers who engage customers and allow them to become part of the co-production of the performance of the transport networks.

7.5 Generalizability and Limitations

Creating the capability to the generalization about a phenomenon is viewed as a key benefit of theory (Gregor 2006). So first, we will discuss the generalizability of our theory of informedness. Next, we will address several important limitations for each empirical chapter.

Generalizability. The extent to which our theory is generalizable beyond the transport industry is a valuable consideration. Although we used the public transport industry as our research setting, we believe that our models, analyses, and findings can be applied across domains and to companies that are examining modern technologies to develop revenue management strategies. We believe that our theory of informedness can go beyond the firm and consumer setting to business-to-business environments. In situations where service providers structure IT services contracts, managers are often faced with the task of choosing contractual parameters such as service levels, pricing, quality, and contract duration. Decisions regarding parameter selection are important because they affect willingness-to-pay for the service. Our theory suggests that the more service providers learn about the contractual parameters, the more they are able to benefit from contracting. Further, the more they learn how their partner values these terms, the better they can refine their parameter selection and generate higher willingness-to-pay in the long run. This will affect the risk position of a portfolio of service contracts and overall profitability. Our proposed stated choice experiment may be useful for service providers to set up optimal contractual parameters to generate profitability while maintaining an acceptable level of risk exposure for the overall portfolio. We have yet to fully evaluate our model in other contexts. We recognize the difficulty in generalizing based on a study of one industry sector. Though we found support for our theory in the context of mobile ticketing in the public transport industry, we acknowledge more research is needed in other contexts.

Limitations of Chapter 4. We address three limitations in Chapter 4. (1) The measures of revenue and customer volume as well as reputation for performance impacts were subjective in the sense that we relied on the available data from press releases and news articles that were read by the authors. While we have been careful in assessing the potential biases inherently associated with such data, it would have been desirable to have more objective measures of performance. (2) This study does not distinguish between the operating environments of the service providers. It could be that some service providers have more commercial freedom compared to some others, and this would lead to a different (non)-profit-maximization agenda and operational boundaries. (3) We find that some performance effects cannot be explained by the choice of value creation strategy. Some choices of value creation strategy cannot be explained by the change in information capability. They may be driven by other competitive considerations, including organizational capabilities, sophistication of competition, a firm's chosen price and service profile, among other considerations.

Limitations of Chapter 5. We address four limitations in Chapter 5. (1) Our analysis suggests that more informed firms can have more precise estimation of consumer choices. However, using our data we cannot conclude that firm informedness has any causal effect on revenue growth. We can seek additional data in the environment when the smart cards are fully implemented so that we can tie revenue change or passenger volume change to the information obtained and used in the new pricing. This could strengthen the causality discussion. (2) In our experimental setting, all customers are fully informed. We do not change the level of informedness. Another extension to the current study would be to examine how varying different levels of consumer informedness could affect consumer choices and firm revenue. (3) In a stated choice method, choices are stated choices made in an experimental and hypothetical setting. In contrast, revealed preference method deals with revealed choices in the real world. It has higher external validity. Stated choice methods and revealed preference methods have different advantages and limitations. The use of both kinds of data provides better results (Bhat and Castelar 2002). (4) There is evidence that different segments may be noisy in their choices (Dellaert and Lindberg 2003, Adamowicz et al. 2008). This would affect consumers' price sensitivity, because noisy responses tend to make consumers less responsive to changes in attributes. It will be worthwhile to investigate this aspect for different consumer segments and learn how this would imply for trading down and trading out hypotheses.

Limitations of Chapter 6. We address four limitations in Chapter 6. (1) We used rational expectation equilibrium thinking to describe when the learning process terminates. However, our setting only satisfies part of the underlying assumptions. In the present public transport industry, consumers have limited alternatives. They are less likely to "negotiate" with the suppliers for the best service offerings. Therefore, the "game" between the consumer and the monopolists is less intense than in other commercial settings. (2) We did not include any social cost considerations in our optimization model. *Social cost* refers to the cost that other people have to bear for the disutility that occurs, which lowers consumer surplus. For example, in a fully occupied train car, every additional person that enters the vehicle will bring disutility to the other standing people. This is a *crowding externality* that other people have to bear when demand exceeds capacity in a capacity-constrained industry. Other examples of disutility relate to the punctuality of the transport service and the safety it provides. (3) In our modeling work, we formulated one overall objective function for the firm. However, in reality, a firm might have different objectives for different markets. A strategy for one market might be totally different from that for an alternative market. For example, in the airline industry, the objective for one market could be maximizing market share whereas in another market it may be improving load factor in booking. (4) This research is the first attempt to implement a behavioral revenue management system using the proposed customer-centric approach. We acknowledge that the simulation requires continued development and validation through several iteration cycles – "the build-and-evaluate loop" – to improve both the design process and the quality of the implementation.

7.6 Directions for Future Research

We will conclude this dissertation with some suggestions for a number of directions for future research, particularly focusing on the interweaving of IS and revenue management. These directions include information revelation and firm performance, informedness and network structure, strategic consumer behavior, strategic firm behavior, and revenue management and customer relationship management.

Information revelation and firm performance. The development of the electronic market permits firms to increasingly engage in real-life pricing experiments to exploit their consumers' willingness-to-pay in different price settings online. In the business-to-business sector, information exchange between buyers and sellers is very important. The level of transparency at which firms transact is typically a component of supply-chain strategy. For example, in procurement, buyers may provide different information about the bidding process, which will affect bidder behavior and the overall outcomes of the auction (Koppius 2002). Recently, studies on market transparency, product transparency, pricing transparency, and information transparency have proliferated (Granados et al. 2006a, 2006b, Granados et al. 2008). Information transparency is defined as the level of availability and accessibility of market information to its participants (Zhu 2004). Research shows that consumers have varying price sensitivities when facing different product transparency and price transparency options (Granados et al. 2006a, 2006b). An important future research direction would be to examine how varying different levels of consumer informedness could affect consumer choices and firm performance. How is consumers' willingness-to-pay affected by different levels of consumer informedness? What is the influence of the timing decision of the information revelation? And how will this affect firm performance? We suggest studying this in an experimental setting in which we can reveal different levels of information to consumers and then assess the impacts on their choice decisions.

Informedness and complex networks. The study of complex network topologies has become a rapidly advancing area of research in the past few years. Recent research has discovered that various complex systems (social, information, biological, and technological) have underlying structural properties governed by shared organizing principles (Albert and Barabasi 2002, Newman 2003). Barabasi (2002) states that graphs or networks have properties, hidden in their constructions, which limit or enhance our ability to do things with them. The current complex network research efforts have, in general, three aims: to highlight the statistical properties of the complex network and suggest appropriate ways to measure these properties; to create models of the network that can help us to understand the meaning of these network properties; and to predict what the behavior of the networked systems will be on the basis of measured structural properties and the local rules governing the individuals. According to Newman (2003), the scientific community has made an excellent start on the first two aims, the characterization and modelling of the network structure. However, the effects of structure on system behavior still remain largely unknown. In terms of structure, networks come in different forms: small-world networks, Erdos-Renyi networks, and Watts-Strogatz networks (Watts and Strogatz 1998, Watts 2004). The questions of interest would be: How does the structure of the network influence firm performance in capacity-constrained transport networks? How does network structure influence the emergent population-level choice? Do transport service providers that have higher informedness of their transport network structure have higher firm performance? How does this affect network performance? Future research can use techniques from statistical physics, complex networks, and social networks in the analysis of these networks, and to uncover surprising statistical structural properties that have an effect on their functionality, dynamics, robustness, and fragility.

Strategic consumer behavior. Customers will have more options available that expand their choice space, including what to purchase, when to purchase, and which channel to use. They are more likely to learn firms' strategies and game with the seller to maximize their gains. The next level of customer-centric revenue management should take into account of the strategic behavior of customers. We can use normative theories such as prospect theory to model the effects of behavioral biases (Kahneman and Tversky 1979, Thaler 1980). This will permit us to better understand the problem of utility maximization that has neglected some factors up to this point in our work. This includes the consumer's sensitivity to losses and gains, mental accounting (Thaler 1985), and perception of fairness (Bolton et al. 2003, Xia et al. 2004, Haws and Bearden 2006, Wirtz and Kimes 2007).

Strategic firm behavior. While electronic market features lower search costs more than physical markets do, the evidence to date suggests that consumers neither search extensively (Johnson et al. 2004) nor always search for the lowest prices online (Brynjolfsson and Smith 2000). Online sellers could benefit from the rational inattention of consumers by frequently making small price increases. They can actively and deliberately change prices in a random fashion so that consumers as well as competitors cannot ascertain their true prices. Random price changes and the avoidance of price competition with low-priced sellers can extract more revenue from loyal (uninformed) consumers. Is there evidence of online sellers randomly adjusting prices using a "hit and run" strategy? What are their incentives?

In conclusion, in the presence of current generation IT, we have studied the value of informedness in the context of revenue management with a customer focus. This has contributed to scientific knowledge and management practice. We believe that firms should strategize the informational challenge, make informed decisions, develop information strategy, and create transformational values to win in today's networked business.

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Chinese Summary

近年来广泛应用的现代信息和通讯技术给公司和客户提供了更加全面准确的市场信息，这些信息从而影响到企业战略的设定和消费者行为。消费者能够了解产品和服务的具体信息，包括其确切的属性和价格，从而准确地找到他们理想的东西，并愿意支付高价获取这些产品和服务。因此，企业越来越多地引入新产品，设计更加多样化和更精准的定位服务，使消费者能买到他们真正想要的东西。这一最新发展使公司比以往更好地确定以客户为中心的企业核心战略。

本博士论文研究的目的是要更好地理解信息在利润管理中的地位。利润管理(revenue management)是针对短期的需求管理，以促进灵活的实时分配，客户细分和价格优化。近年来日渐普遍的利润管理运用可归因于更公开的需求数据，由信息技术带来的更灵活的价格变动，和能处理大规模数据的决策支持工具的出现。我们引进“信息灵通”(informedness)这个概念，包括公司的“信息灵通”(firm informedness)和消费者的“信息灵通”(customer informedness)。公司的“信息灵通”不仅指公司了解多少客户信息，还指其了解客户需求，影响客户消费的能力。消费者的“信息灵通”指他们了解市场上有什么产品，产品精确的服务属性和价格。我们基于“消息灵通” 这一概念来评估有哪些因素在影响着利润管理。我们采用多种研究设计,包括案例分析(case study)，选择试验(stated choice experiment)和模拟仿真(simulation)。

首先，我们集中于企业层面，研究那些采用“消息灵通”概念的公司的价值创造过程。通过研究北美，欧洲和亚洲公司使用智能卡和移动通信技术的多个案例，我们调查了移动支付技术及其授权的收入管理战略的价值创造过程。我们发现，当企业使用先进的移动支付技术，如智能卡和移动电话，并拥有客户实际旅行的实时信息时，这些企业更有可能采用价格多元化和扩大服务的战略。与那些只使用成本节约战略的公司相比，这些公司有可能取得更好的业绩。

接着，我们聚焦于消费者，研究他们的消费行为和消费者“信息灵通”的影响范畴。使用选择实验，我们证明了多元化的消费倾向和支付倾向。我们发现，当市场上存在大量产品信息时，一些消费者倾向选择购买最便宜的产品 （证据为价格第一行为），而另一些消费者则倾向购买最适合自己的产品（证据为体验第一行为）。我们证明，有了智能卡和移动设备，企业将对消费者的个人特征和购买倾向更有把握，从而能更好地利用企业战略，如超多元化(hyperdifferentiation)和共振营销 (resonance marketing)。

最后，我们将目光放在一个公司和客户信息双重增加的大环境上，建议如何制定以客户为中心的战略来完善利润管理。使用选择试验和模拟试验，我们探讨如何在需求驱动和能力管理的前提下，通过制定服务项目来获取有用的消费者反应。我们发现，企业首先利用所有可用的信息有效地建立一个预期的价值，然后随着时间的推移继续获取新信息，来了解的公司的最佳价值。我们认为，公司可根据时间和空间的差异来定制不同的产品和服务，从而有效地将需求从旺季和热门区域转移到淡季和冷门区域。

总体来说，这项研究有助于完善时下这一广泛关注的理论，即信息技术和公司业绩与竞争及战略之间的关系。从理论价值的角度来说，这项研究提出了新的理论观点，即公司的"信息灵通"，客户的"信息灵通"，及通过学习获取的"信息灵通"，并重新定义以客户为中心的利润管理(customer-centric revenue management)的决策过程。从实际应用的角度来说，这项研究采用的方法论，模型和原则都能指导公司面对信息挑战，发展信息市场战略。

Nederlandstalige Samenvatting

De recente wijdverbreide toepassing van informatie technologie heeft in een ingrijpende verandering geresulteerd waar het de beschikbaarheid van informatie aan klanten en bedrijven betreft. Deze verbeterde informatie voorziening resulteert in veranderingen in zowel consumentengedrag als de strategie van bedrijven. Beter geïnformeerde consumenten weten precies wat er beschikbaar is voor welke prijs en tegen welke voorwaarden. Ze kunnen dus geïnformeerde beslissingen nemen, en eventueel besluiten tegen een meerprijs voor oplossing op maat te kiezen. Bedrijven spelen hier in toenemende mate op in, en bieden steeds vaker maatwerk oplossingen richting de klant. De klant heeft daarbij de eindregie om precies te beslissen wat hij/zij echt wil. Deze ontwikkeling heeft ertoe geleid dat ondernemingen beter dan ooit een klantgerichte strategie kunnen bepalen.

Het doel van het onderzoek in dit proefschrift is het verbeteren van het inzicht in de rol die informatie heeft in het nemen van *revenue management* beslissingen. Revenue management is korte termijn vraag management dat zich tot doel stelt te resulteren in een extra stuk flexibiliteit in real-time capaciteit toewijzing, een betere klant segmentering, en een optimalisatie qua beprijzing. De toegenomen adoptie van, en verdere ontwikkelingen in het vakgebied van revenue management in recente jaren hangen sterk samen met een toegenomen beschikbaarheid van data, het gemak waarmee prijzen veranderd kunnen worden door een toegenomen gebruik van IT, en de beschikbaarheid van beslissings ondersteunende optimalisatie programmatuur. We introduceren het concept van "*informedness*" opgesplitst in "*firm informedness*" en "*consumer informedness*". *Firm informedness* betreft dat wat een bedrijf weet over haar klanten en de mogelijkheid om te begrijpen wat klanten willen, om deze vervolgens in te kunnen zetten om te voldoen aan de wensen van de klant, en om hun bereidheid te betalen (positief) te beïnvloeden. *Consumer informedness* verwijst naar de mate waarin consumenten weten welke producten en diensten beschikbaar zijn. Daarbij weten zij welke voorwaarden en opties daarbij horen, tegen welke prijs. We gebruiken het begrip informedness om de performance van revenue management te evalueren. Daartoe gebruiken we een multi-methode onderzoeks ontwerp welke gebruik maakt van case studies, stated choice experimenten, en computer simulatie.

Eerst richten we ons op het niveau van de onderneming, waar we het waarde creatie proces beschouwen aan de hand van onze uitleg van firm informedness. We gebruiken meerdere cases van organisaties die smart cards en mobiele technologie hebben geadopteerd in Noord Amerika, Europa, en Azië. Hierin onderzoeken we specifiek het waarde creatie proces van mobile ticketing technologieën en de mogelijkheden die deze bieden om revenue management toe te passen. We concluderen dat bedrijven die meer geavanceerde mobiele ticketing technologieën gebruiken, zoals smart cards en mobiele apparaten, en in real-time over volledige informatie over de 'werkelijke reis' van klanten beschikken, meer geneigd zijn om prijsdifferentiatie en service expansie strategieën toe te passen. Voorts blijkt dat deze bedrijven vaker een behoorlijke performance toename laten zien, zeker vergeleken met bedrijven die alleen een strategie van kostenreductie hanteren.

Vervolgens richten we ons op de consument en bestuderen we consumentengedrag waarbij we de consumer informedness specifiek beschouwen. Middels stated choice experiments, laten we op empirische wijze de heterogene voorkeuren van consumenten zien en hun bereidheid om te betalen. We concluderen dat de aanwezigheid van meer informatie bij sommige consumenten leidt tot een sterke voorkeur voor het kiezen van het goedkoopste product – wat een bewijs is van het zogenaamde "trading-down" gedrag, terwijl andere consumenten een sterkere voorkeur hebben om exact die producten te kiezen die het beste aansluiten bij hun behoeften. Dit laatste is een bewijs van het zogenaamde "trading-out" gedrag. We laten zien dat de beschikbaarheid van smart cards en mobiele apparaten, bedrijven de mogelijkheid biedt beter te weten wat haar klanten willen, en daardoor beter gebruik kunnen maken van strategieën die het mogelijk maken om aan zogenaamde hyperdifferentie en resonantie marketing te doen.

Ten slotte concentreren we ons op een omgeving met een toegenomen *firm informedness* en *consumer informedness*, en suggereren we een revenue management aanpak waarbij de klant centraal straat. Met behulp van een stated choice experiment en een simulatie-experiment onderzoeken we de mogelijkheden om de service op een dusdanig manier aan te passen die een winstgevende klant interactie faciliteert, waarbij vraaggedreven revenue en capaciteit management wordt gebruikt. Bedrijven blijken alle beschikbare informatie efficiënt te gebruiken om te komen tot een initiële basis qua te verwachten bedrijfsprestatie. Vervolgens gebruikt men nieuwe en aanvullende informatie om over tijd tot verdere en betere inzichten te komen qua optimale bedrijfsprestatie. We betogen dat bedrijven hun maatwerk producten en services zo zouden kunnen aanpassen dat zij vraag kunnen sturen en verschuiven, weg van de periodes en locaties met een (te) hoge vraag naar periodes en locaties met een (te) lage vraag.

Resumerend draagt dit onderzoek bij aan de lopende discussie over IT en bedrijfsprestaties in de literatuur; meer specifiek de literatuur betreffende competitieve strategie en economische aspecten van informatiesystemen. De primaire theoretische bijdrage van dit proefschrift is dat het drie nieuwe theoretische perspectieven introduceert: *firm informedness*, *customer informedness*, en *informedness through learning*. Dit draagt bij aan een reconceptualisering van het beslissingsproces van customer-centric revenue management. Praktische bijdrage van dit proefschrift is dat het methoden, modellen en principes biedt die organisaties kunnen helpen om beter om te gaan met de informatiemaatschappij en haar uitdagingen, en strategisch juist om te gaan met een markt die veel meer dan ooit te voren op de hoogte is van de mogelijkheden.

About the Author

Ting Li was born on October 12, 1977 in Beijing, China. She studied her undergraduate degree in Industry Engineering Management at Beijing University of Technology. In 1999, she was selected for a one-year exchange program in the Netherlands. Soon after she finished her B.Sc. degree, she was awarded an IBM graduate scholarship and started her M.Sc. degree in the University of Amsterdam with a major in Computational Science. During the same period, she worked in IBM Global Services and obtained her M.Sc. degree with the subject of web services and grid computing in 2002. The same year, she joined General Electric and worked primarily as a Six Sigma blackbelt and project manager in the area of e-business in supply chains.

In 2004, Ting started her Ph.D. at the Department of Decision and Information Sciences at the Rotterdam School of Management, Erasmus University. In 2008, she spent six months as a visiting scholar in the W. P. Carey School of Business at the Arizona State University. Her research interests include the strategic use of information technology, pricing and revenue management, and business networks. Her work has been published in several edited books and is forthcoming in the *European Journal of Information Systems*. She has presented her work at various conferences including the Academy of Management, Workshop on Information Systems and Economics, Workshop on Information Technologies and Systems, Hawaii International Conference on System Sciences, Winter Simulation Conference, and Sunbelt. In 2007, she was invited to the doctoral consortium of the International Conference on Information Systems (ICIS). She currently serves as an ad-hoc reviewer for the *Journal of Management Information Systems*, *International Journal of Electronic Commerce*, and *Electronic Commerce Research and Applications*.

Next to her academic activities, Ting has also served on the organizing committee of the PREBEM (Ph.D. Researchers in Business Economics and Management) Conference in 2006 and the Smart Business Network Conference in 2008. Furthermore, she has been working as a pricing and revenue management consultant and project manager. She has also been a volunteer journalist for the Chinese Radio Amsterdam. Currently, Ting holds a position as an Assistant Professor of Information Management and Markets at the Rotterdam School of Management.

Selected Publications Related to This Dissertation

Kauffman, R.J., Li, T., van Heck, E., and Vervest, P. 2009. Consumer Informedness and Hyperdifferentiation: An Empirical Test of the "Trading Down" and "Trading Out" Hypotheses. In Sprague, R. (ed.), *Proceedings of the 42th Hawaii International Conference on Systems Science*, Big Island, HI, USA. IEEE Computer Society Press, Los Alamitos, CA, USA.

Kauffman, R.J., Li, T., van Heck, E., and Vervest, P. 2008. Consumer Informedness and Information Technology: An Empirical Study of Heterogeneous Consumer Choice Using A Stated Choice Experiment. *Twentieth Workshop on Information Systems and Economics*, Paris, France.

Kauffman, R.J., Li, T., van Heck, E., and Vervest, P. 2008. A Multi-Method Approach to Integrate and Joint Optimize Service Attribute Bundles and Capacity Management. *Proceedings of the Eighteenth Annual Workshop on Information Technologies and Systems*, Paris, France.

Li, T., van Heck, E., and Vervest, P. 2008. Information Capability and Value Creation Strategy: Advancing Revenue Management Through The Use of Mobile Ticketing Technology. *European Journal of Information Systems* (forthcoming).

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The recent pervasive adoption of advanced information technologies profoundly changes the availability of information to customers and firms. This improved information endowment has affected consumer behavior and poses new challenges for corporate strategy. This dissertation proposes new theoretical perspectives – firm informedness, consumer informedness, and informedness through learning – to re-conceptualize the decision making process in support of customer-centric revenue management. This research consists of three studies centered on smart card adoption by public transport operators. The first study examines the revenue management value creation process of the firm, using a theoretical perspective involving firm informedness. It uses multiple cases involving smart card implementation in Asia, Europe, and North America. The second study evaluates heterogeneity in consumer preferences and tests a new theory of consumer informedness using stated choice experiments. It finds evidence for trading down and trading out behavior and shows that the use of mobile ticketing technologies helps firms to build hyperdifferentiated marketing strategies. Finally, using a computational simulation, the third study explores the opportunity for devising service offerings to capture profitable consumer responses, to maximize demand-driven revenue and optimize capacity. Overall, this research introduces methods, models, and guidelines for organizations to strategize about how to conquer the informational challenges of revenue management, make informed pricing and capacity decisions, and create transformational value to win in today's competitive marketplace.

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