

## **REVENUE MANAGEMENT AS AN EVOLVING SERVICE-SCIENCE RESEARCH DOMAIN**

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### **ABSTRACT**

Service industries have been evolving as the major industries in the global economy and need support from research on issues related to service science and management to promote further growth and extend the expansion boundaries. This paper discusses previous investigations concerning the interwoven field of revenue management and service science and examines several crucial issues associated with theoretical and empirical studies regarding this interwoven field, including consumer choice, global price responsiveness, and information structure to provide suggestions for designing a research framework. Finally, research directions and suggestions are presented for future research.

### **1. INTRODUCTION**

Production and exchange are the two major elements which interweave the core framework of a global interactive economy. Real goods and services are produced with inputs of real goods and services already produced for the ultimate goal of providing benefits to consumers through a process of successive transactions which take place at costs measurable by the quantities of real goods and services needed for the successive transactions to be undertaken. Obviously, production and exchange are unlikely to take place without services provided and consumed. Services of various types appear to play a dominant role in the operation of a global economy in that they are not merely the final commodities for consumption, but the inputs for production and exchange as well. Service industries, each as a collection of firms providing an identical type of service, have been evolving as the major industries with the expansion of production, exchange, and consumption in the global economy.

Decisions made by providers and consumers with regard to production, exchange, or consumption are related to service management. Service providers need to take into consideration revenues, costs, and benefits

associated with their production and exchange decisions, while in their decision making consumers consider the major factors such as the costs on specific services they desire to acquire and the benefits associated with them. The expenditures spent by service consumers are the revenues acquired by service providers, which implies the importance of consumer behavior and decision-making to revenue management for service industries. As mentioned by Chiang, Chen, and Xu (2007), in order to assure business competency and maximize revenue firms provide and manage service packages for different market segments by acquiring information regarding customers' behavior and value functions in designing managerial strategies and revenue management systems with applications of appropriate combinations of strategies such as price, quality, purchase restrictions, information revelation, and distribution channels. This paper is to review previous investigations concerning the interwoven field of revenue management and service science and addresses several crucial issues associated with theoretical and empirical studies regarding this interwoven field, including consumer choice, global price responsiveness, and information structure to provide suggestions for future research on revenue management with incomplete information.

Representatives of traditional industries applying strategies of revenue management include transportation, hotels, and rental car industries. These traditional industries can be characterized by a common type with attributes concerning their costs, products, and demand. Firms in these industries need to bear significantly high fixed costs for a long term of operation while incurring small variable costs for operation in the short run. Their products are perishable in the sense that the commodities available to customers at one point of time will no longer exist at the next point of time. The demand for the products can be characterized by a significantly changing stochastic process. With technological innovations and changes in managerial contexts, traditional manufacturing and retailing industries also engage in adopting RM strategies to promote revenues, accompanied with such

emerging industries as restaurant, entertainment, healthcare, IT and internet, and apartment-renting service industries. Research results concerning design of feasible and optimal RM strategies and related issues for various types of industries have been reported by researchers and practitioners concerned with issues related to industrial operation outcomes associated with revenue-generating (e.g., Arora and Fosfuri, 2005; Chen, Lin and Hsieh, 2008; Gal-Or et. al., 2006; Geng, Stinchcombe, and Whinston, 2005; Harris, 2007; Kimms and Muller-Bungart, 2007; Sundararajan, 2004). Embedded commonly in the analytical frames of these studies are pricing and consumer response, information structures, and solution concepts. In the following sections, attention will be drawn first to some of the crucial issues related to consumer choice and global price responsiveness, while a measure-theoretic perspective of information, taken in important analytical frameworks, will be discussed.

## 2. CONSUMER CHOICE

Traditionally, analysis of consumer choice is based on the formulation of maximizing behavior in economics and management. As mentioned by Sen (1996), maximizing behavior is different from nonvolitional maximization and the fundamental relevance of the choice act has to be placed in a central position in analyzing behavior. The specific features of an individual's act of choice may include the identity of the chooser, the set of items or the menu, as presented by Sen, over which choice is being made, and the set of social relations and norms which may influence choice of social actions. A set of comprehensive outcomes should include the entire choice process and a chooser's preferences over a set of comprehensive outcomes should be distinguished from the conditional preferences over culmination outcomes given the acts of choice. There may exist responsibility associated with choice, which can influence the ranking of the narrowly-defined outcomes and the chooser's decision. The specific features of the *act* of choice may influence a chooser's preference and choice function representing her preference. Theoretical or empirical studies in the line of research on revenue management and service science need to consider these specific features of the *act* of choice in a process perspective. Researchers have attempted to represent the choices of economic agents, in particular the consumer, the supplier, and the governments, in a process perspective to analyze the sequential interactions among these agents and extend understanding of related issues beyond static analysis (e.g., Balachander, 2001; Gul, Sonnenschein and Wilson, 1986; Ma and McGuire, 1997; Milgrom and Roberts, 1982; Rubinstein, 1982).

With regard to one more significant feature in the

act of choice, Sen (1996) noted that the act of choice may be subject to the inescapability or urgency of choice in that a chooser may have to arrive at a reflected judgment by balancing conflicting considerations at the time of choice. The feature of choice inescapability or urgency may add to the complexity of the process of choice. Furthermore, Sen mentioned that serious problems may arise in the characterization of maximization behavior as optimization, as commonly adopted in much of economic analysis. A maximizing act of choice only requires choosing an alternative that is not judged to be worse than any other and optimization is quite unnecessary for maximization.

Within a revenue management context, interaction among consumers, such as arbitraging behavior, may bring complexities to the feasibility of the strategies service providers may adopt. As mentioned by Tirole (1988) as examples of consumer choice in the presence of mutual interaction, with the transferability of the commodity, the introduction of quantity discounts would provide consumers with an incentive to harvest arbitraging benefits in the absence of transaction costs in that only one consumer buy the product and resell it to other consumers. Whenever a variable quantity of consumption of the arbitrated good is linked with a fixed quantity of consumption, two-part tariffs can be applied to limit the arbitraging behavior. Another difficulty with which service providers may be confronted is the type of consumer choice in the form of transferability of demand between different packages or bundles of service commodities offered to consumers of various tastes. In order to increase revenue, providers of service commodities may target a specific package of service commodities for consumers of a specific type and want to make sure that consumers of a specific type indeed choose the package designed for them but not the packages designed for other types of consumers. In order to induce consumers to make choices as desired in the absence of information about the exact type of each individual consumer, service providers may provide incentive-compatibility constraints on the set of packages and use self-selection devices so that each consumer would not have an incentive to switch from the package of service commodities designed for him to other packages designed for other types of consumers.

## 3. GLOBAL PRICE RESPONSIVENESS

Consumer responsiveness to price is frequently adopted to refer to consumer choice in confrontation with price schemes set by service providers and represented by the quantitative measure of price elasticity. In the perspective of revenue management, service providers may be concerned with price

adjustment to increase revenue. While a decrease in price may lead to an increase in the quantity purchased by the consumer, the change in the total revenue received by the provider is ambiguous. The responsiveness of consumers to price as measured by price elasticity provides an intuitive explanation for the phenomenon. For a product whose demand is inelastic with respect to price, the percentage change in the quantity demanded will be smaller than the corresponding percentage change in price and the magnitude of a decrease in price will more than offset the magnitude of the corresponding increase in the number of units sold, bringing about a decrease in revenue and thus a change in revenue in the same direction as the price change. On the other hand, with elastic demand, the percentage change in the quantity demanded will be larger than the corresponding percentage change in price and the magnitude of the corresponding increase in the number of units sold will outweigh the magnitude of a decrease in price, leading to an increase in revenue and thus a change in revenue in the reverse direction as the price change.

Given the responsiveness of consumers to price, it would be more likely for the region of high price to correspond to elastic demand, while inelastic demand may be more likely to lie in the region of low price. As implied by the responsiveness of consumers to price, in order to promote revenue it would be more feasible to lower price in the region of high price, while to raise price would be more likely to contribute to revenue in the presence of low price. Researchers have examined how providers adjust price and other strategies such as quality and scarcity in response to consumer responsiveness to price in various interactive managerial contexts (e.g., Chambers, Kouvelis, and Semple, 2005; McAfee and Velde, 2008; Stock and Balachander, 2005).

Chambers, Kouvelis, and Semple (2005) studied the competitive behavior in a duopoly with respect to quality and price in a two-stage game by using a surplus utility function characterized by a uniformly distributed price sensitivity parameter, transformed from the net utility function with a taste parameter as employed by Moorthy (1988) and later by Ronnen (1991) and Lehmann-Grube (1997). By offering a signaling explanation for the optimality of pricing and product-scarcity strategies, Stock and Balachander (2005) showed how a pricing strategy would be designed in accordance with a product-scarcity strategy and a high-quality seller may credibly signal the quality of its product to uninformed customers by optimally choosing to make the product scarce. Considering a good that is valueless if not sold by a terminal period, McAfee and Velde (2008) examined a dynamic pricing problem adapted from Gallego and van Ryzin (1994), with the constant demand elasticity assumed to be

larger than one. They followed Gallego and van Ryzin to construct the Bellman equation for the problem and demonstrated that the monopoly prices are socially efficient with constant elasticity of demand. As they mentioned, the result is attributable to the nature of marginal revenue with constant elasticity of demand. To achieve his goal, the monopolist equates marginal revenue across time. With constant elasticity of demand, prices and marginal costs are proportional to each other and equating one equates the other. Since efficiency requires equating the expected prices charged across time and the solution to the monopoly problem entails selling all the units, this result demonstrates the coincidence of monopoly and perfect competition with constant elasticity and fixed supply. The coincidence of monopoly and perfect competition with constant elasticity and fixed supply, as pointed out by McAfee and Velde, was discovered by Stiglitz (1976) in another context, in which a resource with a fixed supply, such as oil, copper, and iron, must be allocated over time.

Within a global interactive context, prices of substitutes and complements are taken into consideration not merely by consumers of various types in making their consumption decisions, but by providers in designing their revenue management strategies as well. Even with the narrowly-defined outcomes such as a commodity vector containing a set of commodities which can be partitioned into two disjoint subsets with one containing domestic commodities and the other containing foreign commodities, exchange rates play a crucial role in both consumer choice and provider revenue-management in the presence of such factors as the price competitiveness of domestic commodities relative to foreign commodities. The basket of commodities relevant to the decision-making of both consumers and providers may be used to measure the price competitiveness of domestic commodities relative to foreign commodities by a real exchange rate, a price-adjusted nominal exchange rate, as computed by  $e_r = eP^*/P$ , where  $P^*$  and  $P$  represent relevant indexes of foreign and domestic prices, respectively. For a country as a whole, one of the major revenue management tasks confronting a government is the problem of keeping a trade balance, which is equivalent to bringing  $M^* - e_r M$  to equality, where  $e_r$  represents the relative price of imports in terms of domestic goods and converts quantities of foreign goods  $M$  into their equivalent in domestic goods  $e_r M$ . The competitiveness of domestic goods in international markets may be partially examined by the change in the real exchange rate. While domestic goods would become relatively expensive as compared with foreign goods with a reduction of  $q$  and the competitiveness of domestic goods in international markets is thus

worsened, an increase in  $q$  indicates that imports become more expensive and improves domestic competitiveness in international goods market. As stated by Rivera-Batiz and Rivera-Batiz L (1994) with regard to Marshall-Lerner condition, a domestic currency depreciation would have a positive direct effect on the trade balance if the sum of the price elasticities of demand for domestic exports and imports exceeds one. As the price responsiveness of domestic demand for foreign commodities and that of foreign demand for domestic commodities are large, it would be likely for a country to generate more revenues than payments on imports with a domestic currency depreciation. Similar concepts may be applied to examine issues associated with revenue management in service industries with  $P^*$  and  $P$  computed on the basis of a standard basket of service commodities in deriving and representing the price competitiveness of domestic service commodities relative to foreign service commodities. Furthermore, within a global interactive context, information regarding exchange rates and domestic and foreign prices and demand are indispensable to the decision making of both service consumers and providers.

#### 4. INFORMATION STRUCTURE

Researchers have attempted to understand conflict and cooperation within an interactive managerial context with states evolving over time. As mentioned by Myerson, (1991), in a well-defined interactive framework such as a game the decision-makers are generally assumed to be rational and intelligent in the sense that a rational decision-maker makes decisions consistently in pursuit of his own objectives and an intelligent decision-maker knows everything about the situation and is able to make any inferences about the situation. Furthermore, he noted that it may never be satisfied that all individuals are perfectly rational and intelligent and individuals may learn in the process of interaction. While Myerson stated "each of these adjectives is used here in a technical sense that requires some explanation" (p. 4), the concept of intelligence was not adequately explained and his explanations appeared to be based considerably on a measure-theoretic framework.

Human intelligence appears to be associated with information and knowledge. Theoretical perspectives of information and ideas applied to tackle problems associated with information tend to be constructed with measure-theoretic concepts. As mentioned by Billingsley (1986) with regard to partial information, with a probability measure space of the triple  $\{\Omega, F, P\}$ , where  $\Omega$  is a nonempty outcome

space and  $P$  is a probability measure defined on  $F$ , a subclass  $\tilde{A}$  of  $F$  corresponds heuristically to partial information and the concept of information can be represented in terms of partitions. For  $\omega$  and  $\omega'$  in  $\Omega$ , if, for every  $A$  in  $\tilde{A}$ ,  $\omega$  and  $\omega'$  belong both to  $A$  or  $A^c$ , the two outcomes can be viewed as  $\tilde{A}$ -equivalent. In this perspective, the  $\tilde{A}$ -partition partitions  $\Omega$  into sets of equivalent points. Furthermore, as noted by Billingsley, the  $\tilde{A}$ -partition coincides with the  $\sigma(\tilde{A})$ -partition because  $\tilde{A}$ -equivalence and  $\sigma(\tilde{A})$ -equivalence are the same thing. For fixed  $\omega$  and  $\omega'$ ,  $\omega$  and  $\omega'$  are  $\tilde{A}$ -equivalent if they are  $\sigma(\tilde{A})$ -equivalent. On the other hand, the class of  $A$  such that  $\omega$  and  $\omega'$  lie either both in  $A$  or  $A^c$  is a  $\sigma$ -field. This  $\sigma$ -field contains  $\tilde{A}$  and hence  $\sigma(\tilde{A})$  if  $\omega$  and  $\omega'$  are  $\tilde{A}$ -equivalent, so that  $\omega$  and  $\omega'$  are also  $\sigma(\tilde{A})$ -equivalent. As implied by the properties, with the information in  $\sigma(\tilde{A})$  an observer is meant to know not the point  $\omega$  drawn, but the equivalence class containing it. In defining strategies for a game with a correlating device with similar measure-theoretic concepts, Fudenberg and Tirole (1992) stated the concept of a correlating device as a triple  $\{\Omega, \{H_i\}, P\}$ , where  $\Omega$  is a state space corresponding to the outcomes of the device and  $P$  is a probability measure on the state space  $\Omega$ . An information partition  $H_i$  is a partition of a finite set  $\Omega$  and assigns an  $h_i(\omega)$  to each  $\omega$ , where  $h_i(\omega)$  consists of those states that an economic agent regards as possible with the true state  $\omega$ . An economic agent is poorly informed and he has no information at all beyond his prior if his partition is the one-element set  $\Omega$ .

Theoretical or empirical research can be conducted within a measure-theoretic information structure by examining outcome spaces, information partitions or probability measures with regard to research problems. A general outcome space can be viewed as a joint outcome space formed by the Cartesian product of the nature, demand, and supply outcome spaces. A nature outcome space may include such uncontrollable exogenous outcomes as weather, weather-related outcomes, and outcomes related to social and economic contexts with such components as cultures, tax structures, operation regulations, and political states. For the demand and supply sides, a

demand outcome space may include such elements as consumer preference, income, location, beliefs and belief-updating mechanism in addition to consumption externalities, while a production outcome space may include technologies, facility operation states, labor types and productivities, materials and quality, and production externalities. A corresponding probability measure may be defined on a field in the joint outcome space of the expanded probability measure space.

## 5. CONCLUSION

With the expansion of production, exchange, and consumption, service industries have been evolving as the major industries in the global economy and need support from research on issues related to service science and management to promote further growth and extend the expansion boundaries. The research topics and areas appropriate for immediate research interests on this evolving academic and practical domain may include, but not limited to, pricing of services, quality management and quality signaling, service standards management, customer relationship management, production and operations management of services, location and facility planning, service delivery, service supply chain management, service delivery process, E-commerce and operations, information technology and communication in services, healthcare management, insurance and healthcare management, and contracts and mechanism design. In this paper, some of the crucial issues associated with consumer choice, global price responsiveness, and information structure have been examined to provide suggestions for future research on revenue management with incomplete information and to induce further repercussion in the line of research on service science and management.

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