Price Discrimination in Service Industries

Anja Lambrecht, London Business School

Katja Seim, Wharton School, University of Pennsylvania

Naufel Vilcassim, London Business School

Amar Cheema, University of Virginia

Yuxin Chen, Northwestern University

Gregory S. Crawford, University of Warwick

Kartik Hosanagar, Wharton School, University of Pennsylvania

Raghuram Iyengar, Wharton School, University of Pennsylvania

Oded Koenigsberg, Columbia Business School, Columbia University

Robin Lee, Stern School of Business, New York University

Eugenio J. Miravete, University of Texas at Austin & CEPR

Ozge Sahin, Ross School of Business, University of Michigan

Contact Person: Anja Lambrecht, London Business School, Phone: +44 70 2000 8645, Email: alambrecht@london.edu

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1 Introduction

Across industries, firms now offer access to virtually identical services under different pricing structures. This includes services as diverse as communications (e.g., mobile telephony), media and entertainment (e.g., cable TV), transport (e.g., flights), and utilities (e.g., electricity). These industries are typically characterized by differentiated providers, heterogeneity in consumers' valuation and usage, few possibilities of reselling or arbitrage, and price as a key characteristic of the service. As a consequence, price discrimination is common, typically involving nonlinear pricing or bundling.

This prevalence of new and complex price discrimination strategies has inspired intensive research in marketing, economics, and operations research. The work to date has started to shed light on substantive and methodological challenges in the choice of such strategies. Substantively, research aims to understand what drives customers' offering and usage choices, how firms should structure pricing plans, and their impact on profitability and welfare. Methodologically, much of this research applies a canonical framework that assumes or estimates heterogeneous consumer tastes for products and derives or simulates optimal pricing strategies implied by that heterogeneity. However, complications in accurately modeling consumers' choice decisions between alternative offerings arise from complex, often nonlinear, pricing structures. Furthermore, consumers' uncertainty and learning introduces dynamics into their behavior over time and feedback effects can arise between price structures and both usage behavior and costs. Most of the literature relies on economic models of consumer decision-making, but recent research suggests that deviations from rational choice may significantly affect both consumers' and firms' decisions.

This paper has two goals. First, we survey the existing literature on price discrimination in service industries. In scope, we limit ourselves to models of nonlinear pricing and bundling like those typically applied and analyzed in such industries. We introduce the benchmark approach commonly used in the literature and summarize the existing results on the profitability and welfare effects of price discrimination. We also survey areas of high current research activity. Second, we highlight four areas we feel are the most fruitful avenues for future research. The first is to better understand pricing-structure

dependent preferences, for example in the setting of even more varied nonlinear pricing structures or in the context of bundling. The second focuses on the need to identify dynamics in usage decisions. Third, we suggest further exploring consumer learning under complex pricing structures. Fourth, we find it increasingly necessary to explore optimal nonlinear price schedule in a competitive setting.

2 The Existing Literature

The existing literature analyzing price discrimination generally takes one of five different approaches. The benchmark approach, widely applied in economics, assumes firms maximize profits facing heterogeneous consumer tastes. Recent work has broadened that framework, considering at least four extensions: (1) heterogeneity in tastes over multiple products, resulting in a wide array of bundling strategies; (2) the role of uncertainty in affecting the accuracy of consumer choices and implications for optimal prices; (3) pricing-mechanisms dependent costs and networks; and (4) behavioral effects of multi-part tariffs such as tariff-dependent preferences (e.g. a consumer's willingness to pay for a product may depend on the tariff structure offered by firms). We begin with an outline of a simple economic framework that highlights the modeling assumptions underlying the benchmark approach. We then turn to applications based on it, before discussing the four more recent approaches that build on the basic model.

2.1 The Benchmark (Heterogeneity) Approach

2.1.1 Framework

Research analyzing price discrimination in service industries is typically based on a common set of benchmark assumptions. These include that consumers have heterogeneous tastes for products, i.e., when individuals have significantly different willingness to pay for the same product or service, or equivalently when at the same price, they purchase very different amounts; the discriminating firm has some degree of market power (in service industries commonly due to product and/or producer differentiation); and opportunities for resale are limited. In these situations, nonlinear pricing arises as a

potentially profitable strategy for firms to pursue when they can identify demands of different consumer types and rank them from high to low valuation, even though sellers do not know the willingness to pay of a given consumer.

To help fix ideas, consider two individual types, a low valuation consumer type, θ_L, and a high valuation consumer type, θ_H. The proportion of low valuation customers in the population is λ. This is known to the seller although he cannot identify whether a particular customer is high or low valuation. The seller incurs a constant marginal cost of production, c. In the simplest nonlinear pricing model, the seller offers two two-part tariffs to induce consumers to self-select into the product that best satisfies their tastes. A two-part tariff consists of a fixed access fee A and a unit charge of p. This pricing is common in many service industries where consumers pay a monthly fee for subscription and subsequently incur charges according to their monthly consumption. Thus, the seller offers the two options $\{A_1, p_1\}$ and $\{A_2, p_2\}$ in order to maximize his expected profits:

(1) $\Pi = \lambda[A_1 + (p_1 - c)q_1] + (1 - \lambda)[A_2 + (p_2 - c)q_2]$,

where q_1 and q_2 are the amounts purchased by low and high valuation customers, respectively. Setting prices for the two options requires accounting for the consumers' usage responses under the two tariffs. For this, the seller needs to know his consumers' demands that we derive from the indirect utility function:

(2) $V(p, A, \theta) = \theta v(p) - A$,

which represents the maximum willingness to pay of consumer of type θ=$\{\theta_L, \theta_H\}$ when confronted with a two-part tariff with fixed fee A and unit charge p. Using Roy's identity, we can obtain the demand of the consumer as

(3) $q = -\theta v_p(p)$.

In solving this problem, the seller does not only have to account for the distribution of consumers, but also for how they respond to the offered options. For instance, the seller may find it optimal to concentrate in the high end of the market and to exclude low-valuation customers if the proportion of

low-valuation customers, λ, is sufficiently low relative to the difference in willingness to pay between high and low valuation customers.

The optimal solution satisfies two constraints. If λ is large enough, the first constraint that the seller faces is that of participation of all consumers. Since high valuation customers always enjoy a larger surplus from consumption than low valuation ones, it suffices to ensure that low valuation customers participate in the market, which is an individual rationality constraint:

(4) $\theta_L v(p_1) - A_1 \geq 0$.

Next, the design of the options has to prevent consumers from arbitrage; that is the high-valuation customer should not find it in his own best interest to choose the tariff option targeting low-valuation customers. This incentive compatibility constraint is:

(5) $\theta_H v(p_2) - A_2 \geq \theta_H v(p_1) - A_1$.

The results of this constrained optimization problem are well known (see *Tirole* 1988 or *Wilson* 1993). The optimal tariff is one that (1) is efficient (in the sense of achieving marginal-cost pricing) only for the high-valuation consumer, (2) associates higher fixed fees with lower per-unit charges, and (3) sets the unit price difference to the ratio of high to low-valuation customers:

(6) a. $p_1 > p_2 = c$

b. $A_1 < A_2$

c. $p_1 - p_2 = \frac{(1-\lambda)}{\lambda}$

The difference between A_1 and A_2 is determined by the shape of individual preferences, V, and the incentive compatibility constraint. In equilibrium,

(7) $A_1 - A_2 = \theta_H v(p_1) - \theta_H v(c)$.

This basic setup can be generalized in many ways. The seller is not limited to offering two tariff options; additional options could be offered at a profit if we can identify sufficiently large proportions of consumers of different valuations. This tariff design problem becomes more complicated since many

more alternatives need to be evaluated (see *Wilson* 1993). With a continuum of consumer types, the optimal tariff is a fully nonlinear, increasing, and concave function.

There is enormous variety in the types of pricing strategies that fall into this framework. Examples of strategies commonly applied in communications and utilities markets include linear pricing (*Sundararajan* 2004), the two-part tariffs exposed above (*Danaher* 2002; *Narayanan, Chintagunta and Miravete* 2007; *Economides, Seim and Viard* 2008), three-part tariffs with access and usage prices along with a specified "free" usage allowance (*Lambrecht, Seim and Skiera* 2007, *Iyengar, Ansari and Gupta* 2007a), and flat-rate tariffs (see *Lambrecht and Skiera* 2006 for an overview of early work on pay-per-use vs. flat-rate pricing).

2.1.2 Applications: Nonlinear Pricing

Theoretical models of nonlinear pricing find generally that, relative to linear prices, firms are better off, some consumers are better off and others worse off, and aggregate consumer and total welfare effects are ambiguous, depending on the relative share of winners and losers among consumers and between consumers and firms (*Katz* 1983). The economics, marketing, and operations research literatures analyzing price discrimination have therefore empirically explored nonlinear pricing under a multitude of alternative pricing schemes by tailoring the assumptions of our modeling framework to a specific market. An early application by *Bousquet and Ivaldi* 1997 is emblematic of this approach in empirical work. They analyze the demand for, and optimal pricing of, telephone usage in early 1990's France. They specify a univariate distribution of tastes for telephone calls in the population, derive the demand for calls implied by this distribution based on the two-part tariff then in use by France Telecom (FT), and estimate the parameters of this distribution based on a sample of over 4,000 households. They infer FT's marginal and fixed costs and calculate the optimal nonlinear tariff. Broadly similar approaches have since been used to evaluate the effects of alternative tariffs for Broadway shows (*Leslie* 2004), and the optimal pricing of cell phone plans (*Iyengar, Jedidi and Kohli* 2007b).

Managerial practice has since moved to more complex pricing structures that require extensions of existing models. For example, firms may employ pricing structures that result in consumers' monitor not only overall service usage but also measure the variability and timing of use, e.g. cellular service providers may charge higher rates during certain times of the day. Similarly, B2B telecom service providers often employ percentile-based billing schemes in which the monthly charge is a function of the 95th percentile of usage. Here, a customer pays for peak usage levels rather than "typical" usage levels.

Such pricing schemes may be a congestion-avoidance technique in systems with resource constraints, i.e. where a customer's use of resources imposes a negative externality on others (*Mendelson and Whang.* 1990; *Westland* 1992; *Gibbens and Kelly* 1999). However, even in the absence of congestion considerations it may be optimal for firms to employ such schemes. *Hosanagar, Chuang, Krishnan and Smith* 2008 develop a pricing model for a monopoly B2B telecom provider and show that percentile-based billing is an effective form of price discrimination. The authors document its use by several providers, but also highlight that some firms abstain from percentile-based billing and seek to differentiate their services on the basis of simpler and more transparent pricing schemes.

The analytical methods underlying optimal nonlinear pricing have also been used to analyze quality (product) choice (*Mussa and Rosen* 1978). *Crawford and Shum* 2007 apply these techniques to measure the extent of quality degradation in the provision of cable television service, *McManus* 2007 tests for and finds evidence of quality degradation in the market for specialty coffee. Similarly, *Hosanagar, Krishnan, Chuang and Choudhary* 2005 use these techniques to jointly study pricing and resource allocation for Internet media delivery services. *Koenigsberg, Kohli and Montoya* 2010 also use related methods to analyze optimal package sizes (and prices) for products that deteriorate over time.

2.2 Extensions

Several extensions of the benchmark framework above have recently attracted significant amounts of research activity. These include accounting for consumer heterogeneity in environments

where firms sell multiple products simultaneously, consumer uncertainty and learning, tariff-dependent costs, and behavioral responses to multi-part tariffs.

2.2.1 Extension I: Selling Multiple Products as Bundles

One extension to the simple model presented in Section 2.1.1 considers that firms sell an array of products or services; that is, that q is not necessarily a scalar, but at times a vector of products or services. This opens the possibility of firms offering discounts when individuals purchase combinations of the different products or services, i.e., bundling. Bundling strategies commonly applied in media markets (such as TV) include pure bundling with a single price for a full bundle of all offered products (*Stigler* 1963), mixed bundling with separate prices for each product, but also a (typically lower) price for a bundle of all offered products (*Evans and Salinger* 2005), and menus of bundles (*Crawford* 2000; *Crawford and Yurukoglu* 2011).

The effects of alternative pricing strategies depend on detailed assumptions about the structure of preferences, costs, and the nature of competition in the studied market. Early theoretical studies analyzing the bundling of just two goods convincingly demonstrate that either pure bundling or pure component pricing can be optimal under monopoly depending on the nature of preferences and marginal costs for components (*Adams and Yellen* 1976, *Schmalensee* 1984), while mixed bundling is always weakly more profitable than both the options in the absence of pricing or menu costs (*McAfee, McMillan and Whinston* 1989). Recent research has extended these ideas to allow for multiple goods and shown that, if preferences for goods are symmetric and log-concave, bundling is more profitable than component sales whenever mean tastes for components are high relative to marginal costs (*Bakos and Brynjolfsson* 1999; *Fang and Norman* 2006). The intuition for these results is due to the homogenizing effects of Laws of Large Numbers (LLN): bundling reduces the variance of preferences, permitting greater surplus extraction and increasing profits as long as average consumer surplus is high. These incentives continue to apply in competitive markets, with important knock-on effects for entry barriers and thus business and marketing strategy (*Bakos and Brynjolfsson* 2000; *Nalebuff* 2004).

Empirical work measuring these effects in particular settings is much more limited, in large part due to the challenge of identifying tastes for bundle components based only on observations of purchases of bundles alone. *Crawford* 2008 estimates demand for bundles of cable television channels and finds that, consistent with the LLN effect described above, including many of the top-15 cable television channels significantly increases the elasticity of the bundle demand curve (and never reduces it). *Crawford and Yurukoglu* 2011 extend this analysis by incorporating information about individual household viewing of television channels (thus solving the identification problem posed by insufficient information about components of channel bundles) as well as introducing a model of bargaining that lets them predict the impact of unbundling on the marginal costs paid by cable systems.

In sum, the majority of the empirical research highlights the practical challenges of evaluating alternative bundling strategies when firms offer many products. Interestingly, however, recent work by *Chu, Leslie and Sorensen* 2011 suggests that simple pricing strategies such as having price depend on the number, rather than the actual mix, of products purchased tends to closely approximate the profits from mixed bundling. This suggests that firms may possibly benefit little from an in-depth analysis of bundling options if they are instead able to implement such simplified strategies.

2.2.2 Extension II: Uncertainty and Learning

One implicit assumption of the model presented above is that the choice of the tariff option and the consumption level is simultaneous (through the application of Roy's identity). In practice, this is not the case. Individuals first subscribe to a particular tariff plan and later decide how much to consume. This makes discriminating among different consumers more difficult because they themselves are uncertain about their consumption. Consumers' uncertainty regarding their future demand adds complexity to the problem of firms designing optimal options, which has proven to be a fertile area of research.

Miravete 2002b estimates a structural econometric model of demand for fixed-line telephone service for a provider that offers a two-part tariff and a flat-rate tariff, allowing for uncertain future consumption. He shows that a monopolist in this setting may discriminate among consumers by offering a

menu of optional calling plans. Consumers' uncertainty over future usage particularly affects their tariff choice when firms offer three-part tariffs, as *Lambrecht et al.* 2007 show in the context of broadband Internet access. They use a model of discrete tariff choice and continuous usage decisions and find that when firms offer three-part tariffs that include a usage allowance, it is ex-ante optimal for rational but uncertain consumers to choose a tariff with a higher usage allowance than would be optimal if they were not uncertain over their usage. Uncertainty decreases consumer surplus and increases firm profits. One implication of this insight is that firms can use usage uncertainty as a second dimension to price discriminate, in addition to average usage.

If consumers are uncertain over their usage, an important question is whether they are capable of making the correct choices; that is whether they can properly evaluate the incentive compatibility constraint in Equation (5) above and whether they learn about their uncertainty. *Miravete* 2002a finds that customers are good at sorting into optimal tariffs, actively engaging in switching tariff options even though potential savings are very low. *Narayanan et al.* 2007 make use of a structural estimation model with Bayesian updating and show that this switching is asymmetric: conditional on overpaying, switching from measured telephone service (a two-part tariff) to flat service occurs faster than the other way around. Thus, different types of tariffs reveal more information than others for consumers to optimize their tariff choice. Together, these two papers illustrate that customers are uncertain about their demand, but learn about this uncertainty over time. In the context of mobile telephony, *Iyengar et al.* 2007a study consumer learning more broadly and find that consumers simultaneously learn about service quality and usage, both of which significantly affect choice behavior.

Ketcham, Lucarelli, Miravete and Roebuck 2011 extend these insights beyond information and communication industries. They confirm the importance of consumer learning in the drug benefit plans of Medicare Part D for elder citizens. Different plans enhance welfare by targeting individuals with different medical needs and coverage depends on the medical conditions of the enrollees. However, the need for a consumer to evaluate so many alternatives may trigger the use of deceptive pricing practices or simply lead to loss of efficiency due to lack of cognition, uncertainty, or risk aversion. Despite the complexity of

this environment this research finds that individuals who pay in excess during the first year of the program quickly switch to other options in the second year. This results, in general, in a substantial reduction of their out-of-pocket expenses in drugs. Similarly there is little support for the hypothesis of inertia in plan choice. The key insight here is that even in complex environments consumers are generally able to optimize their behavior over time. This is important for regulators since it means that concerns about consumers' inability to make correct choices may often be misplaced.

2.2.3 Extension III: Pricing Mechanism dependent Costs and Networks

Recall that the papers we survey here assume or estimate the distribution of consumer preferences for products and firms' costs and then examine the profit and welfare effects of alternative price structures. A maintained hypothesis in the vast majority of these papers is that costs don't change under these alternatives. Recent research, however, suggests this is unlikely to be universally true.

One of the contributions of *Crawford and Yurukoglu* 2011 is to estimate the effects of unbundling on the prices (costs) paid by cable systems to TV channels. The most popular U.S. sports channel, ESPN, currently earns about $4.00 per month for each of the roughly 90 million US households (HHs) that purchases a bundle including it. If forced to be sold a la carte, some of these HHs will not subscribe and ESPN is likely to charge more to HHs that do. As a result, unbundling channels would increase consumer welfare *at existing marginal costs*, but unbundling and the consequent renegotiation of fees paid to upstream television channels increases these costs by an average of almost 150%. While some consumers are estimated to win and others lose, on average there is a slight negative effect. Indeed, bundling with low costs and unbundling with high costs arise as two different equilibria in this setting (*Rennhoff and Serfes* 2009). The important new insight here is that, in addition to implementing price discrimination, firms can use bundling to better manage their cost structure.

In addition to input costs, the industry's entire network of supply relationships can change with unbundling. To understand how differences in pricing mechanisms can influence negotiations between firms with market power, *Lee and Fong* 2011 develop a dynamic model of network formation with

transfers. General applications include buyer-seller networks and bilateral oligopoly, but they use it to analyze provider-insurer negotiations in healthcare markets. The analysis highlights how the fixed-fee pricing of most insurance plans and the fact that patients do not internalize the variance in costs across different healthcare providers gives an incentive for insurers to exclude certain doctors and hospitals from their networks. In turn, they use the model to understand how the introduction of "narrow-network" health plans (insurance products which limit access to doctors or hospitals in exchange for lower premiums) affects insurers' costs not only via potentially lower negotiated rates, but also – by expanding the set of "bundles" of health providers consumers can choose from – providing additional instruments that can be used to direct consumers towards lower cost providers.

2.2.4 Extension IV: Behavioral Effects of Multi-Part Tariffs

In line with standard economic theory, the research summarized to this point assumes preferences are invariant to pricing structures. Existing research in marketing and psychology, however, suggests that pricing structures may also influence consumers' perception of value. For instance, studies have shown systematic effects of (1) payment schedules (i.e., monthly vs. annual) on service usage and retention (*Soman and Gourville* 2001), (2) price endings (i.e., prices ending in the digit 9) on consumers' purchase decisions (*Anderson and Simester* 2003; *Thomas and Morwitz* 2005) and (3) payment mechanisms (i.e., cash vs. credit) on consumption (*Soman* 2001). Overall, this research stream suggests that "pricing can transform, as well as capture, the utility of an offer" (*Bertini and Wathieu* 2008, p. 236).

Such "behavioral effects" have begun attracting significant attention in price discrimination research as well. *Lambrecht and Skiera* 2006 analyze the choice between multiple three-part and flat-rate tariffs. The study is unusual in that it combines usage data from a European broadband internet access provider with survey data of its customers. The authors find a preference for flat-rate tariffs that is not justified by purely economic considerations, the so-called "flat-rate bias" and analyze its causes (they find evidence for a "taximeter effect", an "insurance effect" and overestimation of usage). For a firm, customers with a flat-rate bias are highly profitable: since they choose a tariff with a greater than optimal

access price, they "overpay" but since they value a flat-rate beyond usage considerations they are not more likely to churn than customers whose tariff-choice is optimal ex-post.

A possible alternative explanation for consumers' choice of flat-rate tariffs lies in their usage uncertainty. It is often optimal for customers who are uncertain about their future usage to choose a tariff with a greater usage allowance than if they were not uncertain over their usage. However, *Lambrecht et al.* 2007 find evidence for a flat-rate preference even after accounting for this usage uncertainty. They identify this in a structural model that explicitly models usage uncertainty in a customers' utility function while including a tariff-specific indicator to measure the extent of a flat-rate preference.

This research exclusively focuses on the effect of tariff structure on choice. New research examines whether tariff-specific preferences also affect usage. *Ascarza, Lambrecht and Vilcassim* 2010 explore how pricing plans affect usage of mobile telephony in an emerging market where the provider introduced three-part tariffs in addition to the existing two-part tariffs. The authors observe tariff choice and usage behavior for customers who switched from a two-part to a three-part tariff as well as for customers who did not switch. The raw data suggests that as a result of switching to a three-part tariff, customers' usage increased above and beyond what the change in the budget constraint would predict. They propose that the included or "free" minutes of the three-part tariff open up a new attribute to the customer that increases usage beyond the levels predicted by standard economic theory.

The authors estimate a joint model of tariff choice and usage that accounts for customers' valuation of the "free" consumption. Since they observe usage before and after switching as well as customers who switched and customers who did not switch, they can disentangle the effect of "free" consumption from alternative explanations such as the change in the budget constraint or random usage shocks. The proposed model reflects usage significantly better than only adjusting for a change in the budget constraint: more than 80% of the switchers have a positive valuation for the new attribute. The results also provide evidence that over time, customers learn about their valuation of the new attribute. While this provides evidence that different tariff structures may be perceived differently by consumers, more broadly it raises the question of how consumers react to "free" elements in other contexts.

Iyengar, Jedidi, Essegaier and Danaher 2011 similarly analyze the impact of tariff structure on preferences and on firm profitability. They use data from a field experiment where the firm offered a pay-per-use tariff (i.e., a linear tariff) as well as two-part tariffs. The authors develop a utility-based model of consumer usage and retention of a subscription service that allows the model parameters to vary with the type of pricing structure faced by the customer (pay-per-use vs. two-part tariff). Their results indicate that consumers have a lower utility for two-part tariffs compared with pay-per-use tariffs, resulting in both lower retention of customers and lower usage of the service. This negative impact of two-part tariff pricing on retention and usage is true even after controlling for income effects, heterogeneity across customers, and observable and unobservable time-varying factors. They refer to this as the "access fee effect". This access fee effect leads to an about 10% lower annual retention rate, and an around 38% decrease in usage relative to the pay-per-use tariff, after controlling for income effects. Surprisingly, despite higher churn and lower usage, the two-part tariff is still the profit-maximizing tariff for a firm.

The results by *Ascarza et al.* 2010 and *Iyengar et al.* 2011 raise the question what guides consumers' intra-month usage decisions. New research examines this question. In lab experiments, *Leider and Sahin* 2011 study consumers' intra-month dynamic usage decisions. Interestingly, a majority of individuals correctly use a near-optimal threshold heuristic to make consumption decisions. However, individuals are too aggressive in using free calls. When they have free calls, even among those who correctly use a threshold policy, 40% - 65% of people answer more calls than is optimal, and 65% - 70% of people have a lower payoff than the optimal policy. These errors are primarily driven by an undervaluation of future consumption opportunities, either an underestimation of the number of high value calls or an overestimation of the number of low value calls (or both).

Leider and Sahin 2011 find more than half the participants willing to prepay for free calls at no discount and 20% are willing to overpay. The willingness to pay significantly increases between the first time and the last time individuals complete the cell phone usage experiment. Individuals most willing to prepay are also those who are least willing to pay for each usage when they do not have free calls. This suggests that participants with a higher value for free calls exhibit a stronger "taximeter" effect. It can

possibly explain why *Ascarza et al.* 2010 find that usage under three-part tariffs exceeds what would be predicted based on prior two-part tariff usage and a change in the budget constraint.

Further effects appear when analyzing actual intra-month usage data. *Yao, Mela, Chiang and Chen* 2011 use data from a field experiment conducted by a mobile phone company to examine consumer minute by minute usage dynamics within a month with a dynamic structural model. The data include customer minute consumptions under three-part tariffs and their minute consumptions under flat-rate tariffs prior to being switched to the three-part tariffs. Those unique features of their data enable the researchers to estimate discount factors for consumers that are normally unidentifiable in dynamic models. This also helps to answer the question whether consumers might exhibit hyperbolic discounting behavior in their dynamic management of intra-month calling minutes given the uncertainties in consumption utilities of future calls. They find evidence that the discount rate of consumers is much smaller than the typical value (e.g., 0.9) commonly assumed in estimating dynamic models.

Recent analytical work by *Heubrandner, Lambrecht and Skiera* 2010, analyzes the effect of time preferences on the pricing of complementary durables and consumables, a setting where the pricing of physical goods uses two-part tariffs, a strategy more commonly used in service industries. Their results provide additional evidence that consumers' discount rates affect firms' optimal pricing strategies.

Firms can react by tailoring pricing options to such behavioral preferences. For example, *Iyengar et al.* 2011 find that a firm would over-charge customers for the access fee and under-charge them for the per-minute price if it ignores the access fee effect. Failing to correctly account for such effects leads to a reduction of around 10% in firm profit. *Ascarza et al.* 2010 find that the preference for "free" minutes translates into a 19.7% revenue increase. Similarly, *Leider and Sahin* 2011 show that the optimal pricing policy when facing customers that over-value free calls is (naturally) to offer a contract with free units, that is a three-part tariff. Doing so induces 54% of the market to pre-buy free units and leads to 15% higher revenues. Finally, *Cheema* 2008 shows the importance of behavioral effects in the context of bundling vs. partitioning of prices (i.e., into a base price and a surcharge). Using eBay data, he finds that surcharges lead to lower selling prices for low-reputation sellers, but not for high-reputation sellers.

Follow-up lab studies provide evidence that low seller reputation increases consumer sensitivity to surcharges, likely driven by inferences of seller motives (e.g., the high surcharge is being levied as a rip-off). In the market, this effect would damage the profitability of low-reputation sellers who offer partitioned prices. Consequently, he recommends low-reputation sellers avoid such an effect by bundling all charges in one price instead of offering partitioned prices. That choice and usage can be influenced by price structures beyond their budget impact, that consumers may have hyperbolic time preferences and make mistakes in dynamic consumption choices, and lastly, that consumers may respond adversely to unbundled prices all demonstrate the importance of behavioral factors in understanding consumer demand and designing optimal pricing policies. While research has pointed to potential strategies for how firms can deal with such effects, it has also become apparent that firms' pricing decisions may be much more complex in that they have to consider a number of additional parameters that have so far not fully been explored. We turn towards further exposition of these ideas in the section to follow.

3 Avenues for Future Research

Price discrimination in service industries is common due to the large degree of heterogeneity in consumer preferences for such products. Recent research confirms the importance of consumer heterogeneity in the design of nonlinear pricing strategies, and simultaneously highlights the importance of behavioral aspects to consumer decision making, such as tariff-specific preferences or hyperbolic discounting. The latter are typically not accounted for in models of nonlinear pricing or bundling common in the quantitative marketing and industrial organization literatures. At the same time, behavioral work in this area frequently focuses on the typical consumer response to given aspects of firms' pricing strategies, abstracting from the role preference heterogeneity plays in generating the behavior.

For the research considered here to have greatest impact in aiding firms in designing profit-maximizing pricing strategies or regulators in inducing firms to offer their welfare-maximizing equivalent, greater efforts need to be taken at entwining the insights from both strands of the literature. We have identified four specific areas where we believe such efforts are likely to be particularly fruitful.

(1) *Pricing-Structure Dependent Preferences*. Experimental research in behavioral marketing suggests consumer preferences of value can be significantly influenced by price structures (*Wathieu and Bertini* 2007; *Bertini and Wathieu* 2008). Recent research summarized here (*Ascarza et al.* 2010 and *Iyengar et al.* 2011) using data from the field support this conclusion. More work is necessary, however, to broaden the set of industries, behavioral effects, and pricing structures considered.

Little is known, for example, about how preferences are influenced by bundling. Measures such as "shipping-charge skepticism" point to different consumer preference for bundled versus partitioned prices (*Schindler, Morrin and Bechwati* 2005), but what of the products themselves? Do consumers get increased utility from having access to "free" products or services analogous to that found by *Ascarza et al.* 2010 for bundles of mobile phone minutes? Or do they have explicit preferences *not* to pay for products or services they *don't* value (e.g., "indecent" content in television bundles)? To the extent that these are important, a larger methodological problem arises in thinking about the measurement of welfare (and the development of public policies) when preferences shift with firms' choices. *Crawford and Yurukoglu* 2011 maintain the hypothesis of utility-maximizing consumers and find consumer surplus increases for some households under unbundled pricing. How should this claim be evaluated if consumer tastes can themselves change due to the unbundling being considered?

(2) *Dynamics in Usage Decisions*. *Leider and Sahin* 2011 and *Yao et al.* 2011 point out that, when faced with dynamic demand environments, consumers do not necessarily make fully rational choices. It is not clear to date how prevalent such limited rationality is in affecting behavior in dynamic environments more generally. For example, since offerings in service industries typically cover an extended time period, it would be useful to understand how consumer behavior adjusts to an approaching end of a coverage period, such as the end of a billing cycle, and how this depends on the attributes of the chosen pricing structure. The usage allowance of a three-part tariff affects consumers' intra-month usage behavior in possibly constraining consumption, which could have significant profitability effects. Methods geared at identifying heterogeneity in intra-period consumption decisions across customers and

how these interact with the attributes of the pricing structure offered by the firm may enable firms to design more customized contracts and promotions.

But many questions remain. For example, it would be valuable to understand how consumers react to receiving different degrees of information about their usage behavior. Would a text message to a consumer that they have approached the allowance lead to restricted intra-month usage? What would be the long-term effects on customer satisfaction and retention? And, importantly, would this aid consumers to learn about their own usage behavior and lead to overall better allocation of calls within a month?

(3) *Consumer Learning Under Complex Pricing Structures.* A possible concern with the increasing complexity of pricing structures is whether consumers are able to identify the best offering. Research discussed here provides some information to assess such concerns: consumers are found to have persistent preferences for certain structures and learn about the match quality of a pricing structure over time. It is less clear how (or whether) to encourage rapid consumer learning and how consumer learning varies with the tools providers offer. For example, do consumers learn quicker if firms provide them with specific tools or information such as regular updates about their choices and usage? What would be benefits for the firm of such strategies? For example, would such tools or information increase the preference for the specific firm?

The possibility of learning also introduces difficult identification issues that will have to be addressed in order to successfully integrate behavioral and heterogeneity-based approaches. For example, whether consumer behavior is persistently or just temporarily "in error" is critical to the profitability of alternative price schedules. Rich consumer-level panel data are likely to be necessary to hope to disentangle such effects. Similarly for the behavioral effects of alternative price structures: measuring responses to variation in tariffs will be necessary, ideally at the level of the individual consumer.

(4) *Competition.* A last important avenue for research concerns the role of competition. The demonstrated presence of systematic preferences for certain pricing structures likely affects provider choice and retention. Much of the research summarized to this point has analyzed price discrimination in settings that either explicitly or implicitly abstract from competitive effects due to the methodological

challenges of analyzing sophisticated tariff structures in equilibrium settings and to the difficulty of observing choice across different firms in empirical data. Recent research has begun to explore the optimal choice of nonlinear price schedules in competitive settings, though exclusively using heterogeneity-based approaches (*Rochet and Stole* 2002, *Borzekowski, Thomadsen and Taragin* 2009, *Seim and Viard* 2011; also see *Stole* 2007 for a recent survey on price discrimination and competition). Further research in this important area that integrates the insights of the behavioral literature is needed to adequately understand the incentives to price discriminate and their effects. For example, if consumers have preferences for certain tariff structures, "free" elements in a tariff, or bundled versus unbundled offerings, then how should firms optimally price discrimination in competitive environments?

4 Conclusion

Our review of price discrimination research in service industries has uncovered the need to more strongly integrate methods and insights from the two dominant approaches, quantitative marketing and industrial organization versus behavioral marketing. We conclude that such efforts are important to help firms to optimally design profit-maximizing pricing strategies for services, and regulators to induce firms to offer their welfare-maximizing equivalent. We have identified four areas of particular relevance. The first is to better understand pricing-structure dependent preferences, for example in the setting of even more varied nonlinear pricing structures or in the context of bundling. The second focuses on the need to identify dynamics in usage decisions. Third, we suggest further exploring consumer learning under complex pricing structures. Fourth, we find it increasingly necessary to explore optimal nonlinear price schedule in a competitive setting, accounting for the behavioral effects we discuss. We hope that this overview will guide future research in these four important areas.

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